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A NEW EDITION, COMPLETELY REVISED AND REWRITTEN

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OF

THE MEDICAL SCIENCES.

MOSS, CORSICAN.—*Mousse de Corse*, Codex Med.; *Helminthocorton*, Worm Moss, etc. The alga properly known by this name is *Alsidium Helminthocorton* Ag. (order *Florideæ*), a small, brown, marine plant, with a tufted thallus of simple or sparsely forked, pointed, thread-like branches, from 3 to 4 cm. long. It is a native of the Mediterranean Sea, and was formerly collected on the shores of the island of Corsica, from which it receives its name. The anthelmintic mixture, however, still to be found in European pharmacies under this name, includes, besides this, several other related algæ, among which species of *Ceramium*, *Polysiphonia*, *Gigartina*, etc., are commonly met with. There is nothing unusual in the composition of any of the above to explain their former reputation as vermicides; they contain iodine, bromine, soda, etc., in composition, and an abundance of vegetable jelly.

As a medicine Corsican moss is of the past. A decoction is occasionally given to children as a domestic remedy for lumbrici, etc. *W. P. Bolles.*

MOSS, ICELAND.—Cetraria. "Cetraria Islandica (L.) Ach. (Class *Lichenes*)" (U. S. P.). This is a good-sized terrestrial lichen, with an upright or ascending, long and narrow, leathery, wavy-margined, olive-green thallus, several times dichotomously branched or irregularly fan-shaped, with linear or cuneiform lobes. *Apothecia* shield-shaped on the upper surface of the thallus. This lichen grows in great abundance on the surface of the ground in open woods and heaths, and on mountain sides, in the arctic and the colder temperate regions of both hemispheres.

It is a valuable pasture plant in the extreme North, and is also employed as an article of human food in parts of northern Europe. Its medical employment is one or two centuries old.

Dried Cetraria is thus described:

From 5 to 10 cm. long, foliaceous, irregularly branched into fringed and channelled lobes, brownish above, whitish beneath, and marked with small, depressed spots; brittle and inodorous; when softened in water, cartilaginous, and having a slight odor; its taste is mucilaginous and bitter.

It should be freed from pine leaves, mosses, and other lichens, which are frequently found mixed with it.

Composition.—About two-thirds of it is *Lichenin* or *moss starch* $(C_6H_{10}O_5)_n$, a starch-like substance, structureless, soluble in boiling water, the solution gelatinizing upon cooling. It is an article of commerce as a gelatinous mass or a white powder. The properties of this substance are purely demulcent. *Cetrarin* or *cetraric acid* $(C_{18}H_{16}O_8)$ is the bitter principle, and gives to the drug its slight medicinal properties. It occurs in commerce in white masses of fine needle-shaped crystals, soluble in boiling alcohol, in alkalies, and very slightly in water. It is distinctly stomachic, like other bitters, and antiemetic. It also has the distinct property of increasing the red corpuscles of the blood. It is therefore in an exceptional manner tonic. Isolichenin is very similar to lichenin, but gives the starch reaction with iodine. It is apparently not active.

Iceland moss is a very useful demulcent, and has gentle tonic qualities, for which it is indebted to the two active principles above mentioned. It has no specific action upon the bronchi or lungs, and its value in bronchitis, etc., for which it is mostly prescribed, must be due to its combined demulcent and tonic actions. Dose, indefinite; a decoction is official.

Cetrarin is given alone for all except the demulcent properties, in doses of 0.01 to 0.02 gm. (gr.ij.–v.).

Henry H. Rusby.

MOSS, IRISH.—Chondrus. *Carrageen*. "*Chondrus crispus* Stackhouss, and *Gigartina mamillosa* J. Agarch (class *Algæ*)" (U. S. P.). A reddish-brown or purplish alga, with a flat, many-times forked or lobed thallus, of very variable appearance, sometimes with broad, flat, wedge-shaped, wavy, and incised, margined lobes, at other times with linear, roundish, blunt, or emarginate ones. It is from 5 to 20 cm. high, of a translucent, gelatinous consistence. The fructifications (cystocarps) are embedded in the substance of the thallus, along the smaller branches, where they can be felt as little, wart-like indurations beneath the surface. This alga grows abundantly along the rocky shores of Western Europe

Fig. 3575.—Irish Moss. (Luerssen.)

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and Eastern America, that is, on each side of the North Atlantic. It has for a long time served as an innutritious food, and as the basis of vegetable jellies for the table; it is also, in some localities, fed to cattle, and used as a stuffing for cheap mattresses. Its employment in medicine is of recent date, and entirely unimportant. It is collected on the c[illegible]where in Europe, also upon that of New England and elsewhere in America. For medical or table use it is bleached in the sun, washed, and dried.

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Description.—Irish moss shrinks considerably in drying, and if exposed to the sun, or repeatedly wet and dried, bleaches to a yellow color. It is, when dry, hard, horny, and brittle, but resumes its original size and consistence after long soaking in water. In boiling water it almost completely dissolves. Taste mawkish, mucilaginous, and more or less saline, according to the thoroughness with which it has been cleansed. It will make a stiff jelly with twenty or thirty times its weight of water.

Composition.—Chondrus consists chiefly of a mucilage, common also to many other algæ, swelling and nearly dissolving in water, and drying to a hard, transparent substance. It is precipitated by alcohol, and holds tenaciously about one-seventh its weight of mineral matter. It contains, in common with other marine algæ, minute quantities of iodine and bromine compounds.

Medical Employment.—For colds, coughs, and especially acute pharyngitis, a thin mucilage (decoction) made of Irish moss is a popular household remedy, and corresponds exactly with the mucilage of elm and flaxseed, made in the same way. It may be sweetened and flavored with lemon. Boiled with milk it makes an agreeable jelly ("blanc-mange"), often used as a sick diet, whose value depends on the milk.

W. P. Bolles.

MOSSES.—(Class *Musci.*) The true mosses, while very ornamental, and of great biological and botanical interest, are insignificant from an economic standpoint, while to the Materia Medica they yield not one important substance. Some of them, like Sphagnum and Polytrichum, have, upon totally unscientific grounds, been used domestically in menstrual disorders. Others, like *Funaria hygrometrica* Hedw., have some reputation as expectorants, the effect probably depending chiefly upon the syrup used as a vehicle. Many have been very useful, in the absence of more refined agents, as substitutes for tow, oakum, and lint. The preceding, much used under the title of Mosses, are not of this class at all.

Henry H. Rusby.

MOUNTAIN SICKNESS. See *Altitudes, High.*

MOUNTAIN SPRINGS.—Lancaster County, Pennsylvania.

Post-Office.—Ephrata. Hotel.

Access.—Viâ Reading Railroad. Trains leave Reading Terminal, at Twelfth and Market Streets, Philadelphia, daily, except Sundays, at 10 A.M. and 4 P.M., arriving at the springs at 12 41 and 6:45 P.M.

This pleasant resort is located on the western slope of the Ephrata Mountain, one of the highest points of land in Lancaster County. Many charming features of climate and scenery are united here. The visitor will find pure air, a comfortable and well-kept hotel, excellent fishing, and delightful surroundings at this summer resting-place. The water of the Mountain Springs is celebrated for its purity and sparkle. It has not been analyzed, but we are credibly informed that it contains iron and carbonic acid gas. The springs discharge about three thousand gallons per hour. *James K. Crook.*

MOUNT CLEMENS MINERAL SPRINGS.—Macomb County, Michigan.

Post-Office.—Mount Clemens. Hotels.

Access.—From Detroit viâ Chicago and Grand Trunk Railroad, twenty miles northeast. These waters are very strong brines, as shown by the following analyses made by Prof. S. P. Duffield:

One United States Gallon Contains:

Solids	Mount Clemens Mineral Well. Grains.	Media Spring. Grains.	Soolbad Spring. Grains.
Calcium carbonate	0.98	91.0	Trace.
Magnesium carbonate	.7	.7	Trace.
Iron carbonate	5.6	....	
Sodium sulphate		....	
Calcium sulphate	106.56	14.3	44.0
Potassic salts	....	Trace.	Trace.
Sodic salts, Calcic salts, Magnesic salts	....	11,741.0	11,181.0
Iron sulphide			
Sodium chloride	11,900.0		
Calcium chloride	934.5		
Magnesium chloride	648.48		
Magnesium iodide	.07		
Magnesium bromide	6.37		
Iron	....	8.5	Trace.
Alumina	23.47	29.0	11.21
Silica	27.6	28.0	
Bromide	....	8.5	Trace.
Iodide	....	.07	.05
Ammonia	....	Trace.	Trace.
Organic matter			
Total	13,654.33	11,921.07	11,236.26
Gases.	**Cubic inches.**	**Cubic inches.**	**Cubic inches.**
Hydrogen sulphide or dihydric sulphide	40.00	40.00	33.00
Carbonic acid	5.85		
Nitrogen	Present.		

These waters resemble those of Achsel-Mannstein, in Bavaria. It is necessary to dilute them both for internal use and for bathing. They have acquired considerable reputation in the treatment of scrofulous disorders of the skin, bones, and joints, and for the improvement and even cure of paralysis when the disease depends chiefly upon innervation without decided lesion of the brain or spinal cord. Cases of chronic rheumatism with stiffened joints and obstinate cases of neuralgia may also find relief. The waters are used commercially.

James K. Crook.

MOUNT DESERT, MAINE.—The island of Mount Desert, the largest one on the New England coast, lies off the coast of Maine, nearly midway between Portland and Eastport, about one hundred and ten miles east of Portland and forty miles southeast of Bangor. It is a very popular summer resort and has wide notoriety.

The island has an area of about one hundred square miles, and is fourteen miles long and eight miles wide at the widest part. A chain of mountain peaks extends across it from southeast to northwest, these peaks being separated from one another by deep gorges and ravines, which at several points descend below the level of the sea.

The average elevation above the sea-level is almost 500 feet, and Green Mountain, the highest point, is 1,527 feet in height. The coast line is bold and rocky and much indented. "Somes Sound," a fiord of the sea seven miles long, runs up to nearly the centre of the island, cutting through the centre of the mountain range. The various indentations, or bays, furnish many good harbors, such as Bass Harbor, Southwest Harbor, Northeast Harbor, Seal Harbor, and Bar Harbor—the finest of all, lying upon the broad Frenchman's Bay.

The island is well wooded with pine, balsam, and spruce, although numerous fires have made sad havoc with the forests. Inland, in the valleys and high up among the mountains, are many beautiful lakes and ponds, the most extensive being Eagle Lake at the foot of Green Mountain, Echo Lake, Jordan's Pond, and Long Pond.

Lying about Mount Desert are numerous smaller islands which are attractive and picturesque, the principal of

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which are the Porcupines at Bar Harbor, the Cranberry Islands, near Southwest Harbor, and Bear, Baker's, Duck, Greening's, and Sutton Islands. "The western sides of the mountain range slope gradually upward to the summits, but on the east they confront the ocean with a series of stupendous cliffs" ("Appleton's General Guide to the United States and Canada").

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The island is of granite formation, exhibiting evidences of the great glacial movement; and the soil is dry and porous. On the northern side the mainland is separated from the island only by a narrow stream, and a bridge affords communication between the two. The scenery of the island is most attractive, varied, and grand, affording innumerable delightful excursions by land and by sea. Good roads and footpaths extend in every direction, and in the town of Eden alone there are one hundred and twenty miles of excellent road. The reader is referred to the various guide books for an enumeration and description of the many excursions and various points of interest. Mount Desert has become such a popular resort that every facility is afforded the visitor for enjoying and exploring its beauties. Local steamers run from one point to another of the island; hotels and boarding-houses of various prices abound; and the island can be easily and comfortably reached either by rail or by boat from Boston and Portland.

Bar Harbor is the most frequented and fashionable resort, and the cottage life has quite supplanted that of hotels and boarding-houses. Here beautiful and luxurious cottages abound, and in the season the social life resembles that of New York or Philadelphia in winter.

Every kind of outdoor and indoor diversion is afforded. There are many clubs and churches of various denominations. The Kebo Valley Club offers opportunities for golf on its attractive grounds, and sometimes during the summer the North Atlantic Squadron pays a visit to Bar Harbor, and during "Squadron Week" social gayety is at its height.

The water supply of Bar Harbor is taken from Eagle Lake, two hundred and forty feet above the village, and is abundant and pure. There is also an extensive and thorough system of sewerage. There are adequate protection against fire; many shops and good markets; excellent postal, telegraph, and telephone accommodations; two banks; a good police force; an intelligent and efficient board of health, and good medical service. The streets are lighted by electricity, which is also furnished to private residences.

Northeast Harbor and Seal Harbor are much frequented by "cottagers," and at the former is the attractive Episcopal Church founded by Bishop Doane of Albany. Southwest Harbor is beautifully situated at the entrance to Somes Sound, and is a favorite resort for those desiring a more quiet and simpler life. Indeed, almost any portion of the island has its especial attractions for the summer resident, and one can visit the island year after year and always find some new portion to explore. "On the coast of America it (Mount Desert) has no rival, except, perhaps, at the bay of Rio Janeiro" (Appleton, *loc. cit.*).

Through the kindness of William Miller, Esq., of Bar Harbor, who made the observations, and the chief weather forecaster at Boston who placed them at my disposal, the following compilation has been made of the climate of Mount Desert. In general it may be said that the summer climate is a cool, invigorating one, with a fair number of clear days and the average amount of rain for this latitude. Fogs are not infrequent and they sometimes last for several days or even a week.

There are no recorded observations of the humidity, but it cannot be very different from that of Eastport on the same coast, about eighty miles to the northeast. There the average relative humidity for July is 78.7 per cent.; August, 78.9 per cent., and for the year 76.3 per cent. The variations in temperature are considerable, and the air is apt to be chilly and damp. Such a climate would hardly be suitable for the delicate, for those who had a tendency to or were suffering from pulmonary or bronchial troubles, or from neuralgia. For any one who needs the influences of a bracing, cool, summer climate, or for a convalescent from any acute disease, who is well on the road to recovery, it can be recommended. It is also useful in some cases of neurasthenia and insomnia.

Some patients who are subject to hay fever find immunity on the island at one or the other harbors, especially at Northeast Harbor. *Edward O. Otis.*

MOUTH, DISEASES OF. See THE APPENDIX.

MUCOID DEGENERATION. See *Degenerations, etc.*

MUCOUS MEMBRANES: INFLAMMATIONS OF.—The subject of inflammations of the mucous membranes is treated in this article in only a very general way. The specific inflammations (diphtheria, tuberculosis, syphilis, rhinoscleroma, gonorrhœa, erysipelas, influenza) will be discussed under their respective heads; the object of this article being to include only the simple nonspecific forms of inflammation of these structures according to the definition of inflammation as given by Ziegler—namely, a tissue lesion accompanied by circulatory disturbances, an exudate, and tendency toward repair.

ETIOLOGY.—Although inflammations of different mucous membranes have somewhat different etiological factors, all have to a varying degree a common etiology.

The causes of inflammations of the mucous membranes are direct or indirect. Among the indirect causes are changes in temperature, gout, rheumatism, bad hygiene, decayed teeth, diseases of the circulatory, digestive, or respiratory systems, reflex influences, and idiosyncrasy.

The direct causes of inflammations are thermal, electrical, chemical, mechanical, neoplastic, and bacterial.

The application of hot or cold liquids and instruments to the mouth, pharynx, vagina, or urethra may cause a stomatitis, pharyngitis, colpitis, or urethritis. Breathing of hot air may cause a tracheitis or a bronchitis.

Electricity, applied by means of an electrical sound to the œsophagus or urethra, may cause an inflammation of the mucosa.

Certain chemicals, both organic and inorganic, produce inflammation when they come in contact with mucous membranes. The irritating substance may be mineral acids, alkalies or salts, gases, organic compounds, and

CLIMATE OF MOUNT DESERT ISLAND, MAINE, LATITUDE 44.38° N., LONGITUDE 68.36 W., FOR THE YEARS FROM 1896 TO 1901. OBSERVATIONS OF WILLIAM MILLER, ESQ., OF BAR HARBOR.

Data.	January.	April.	June.	July.	August.	September.	October.	Year.
Temperature (degrees Fahrenheit)—								
Average or normal	21.08°	42.4°	59.48°	65.9°	64.9°	58.6°	48.5°	39.4
Average range	19.3	21.7	22.8	22.2	22.2	22.0	21.3	
Mean of warmest	30.7	53.6	71.1	77.2	76.3	70.1	59.3	
Mean of coldest	11.4	31.9	48.3	55.0	54.1	48.1	38.0	
Highest or maximum	49.0	72.8	86.3	90.5	89.0	87.6	73.8	
Lowest or minimum	– 11.5	18.6	37.8	45.0	43.8	33.2	21.4	
Precipitation—Average in inches	5.60	3.14	2.85	3.86	3.28	3.77	4.62	
Wind—Prevailing direction	N. W.	E.	S. W.	S. W.	S. W.	S. W.	S. W.	S. W.
Weather—								
Average number of clear days	11.2	15.1	16.5	18.3	17.6	15.3	14.3	
Average number of partly cloudy days	8.2	6.3	7.5	6.0	6.5	7.8	8.3	
Average number of clear and partly cloudy	19.4	21.4	24.0	24.3	24.1	23.1	22.6	

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bacterial toxins. Nitric, sulphuric, or hydrochloric acid, sodium or potassium hydroxide, and nitrate of silver will cause a stomatitis, rhinitis, or pharyngitis, and, if the irritants are swallowed, an œsophagitis and gastritis may follow. Gases (hydrogen sulphide, ammonium sulphide, chlorine) cause an inflammation of the respiratory tract or the pharynx. The organic compounds and the toxins produce marked effects on the digestive tract. These poisons are taken into the body as such or they result from decomposition of food or are germ excretions. If the irritation produced by these substances is marked, a gastritis or an enteritis will follow.

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The mechanical agents which cause inflammation are foreign bodies. Poorly fitting pessaries may cause colpitis, an improper plate in the mouth a stomatitis, or masturbation may cause a urethritis. Trauma of any sort is a direct etiological cause of many non-purulent inflammations of mucous membranes, and is the avenue of entrance of germs, so that it is a predisposing factor of many purulent inflammatory conditions. Of the foreign bodies, dusts of certain trades (mining, marble cutting, painting, milling) cause a chronic inflammation of the respiratory tract. The introduction of foreign bodies into the vagina, uterus, bladder, or nose will produce similar conditions unless they are removed.

Bacteria are the most important etiological agents of inflammation. The germs may be saprophytic or pathogenic, causing inflammation by decomposition, or becoming virulent and pathogenic. The pathogenic bacteria produce inflammation by means of their toxins which act as irritants.

CLASSIFICATIONS OF INFLAMMATIONS OF MUCOUS MEMBRANES.—The factors which enter into inflammatory phenomena are the tissue lesion, circulatory disturbance, the exudate, and the tendency toward repair. Based upon this the following classification of inflammations of mucous membranes is offered.

Inflammations of Mucous Membranes.
- Acute.
  - Catarrhal.
  - Muco-purulent.
  - Purulent.
  - Fibrino-purulent.
  - Fibrinous.
  - Hemorrhagic.
  - Gangrenous.
- Chronic.
  - Hypertrophic.
  - Atrophic.

According to the amount of the reaction on the part of the connective-tissue elements, the general division of inflammations into acute and chronic is made. The term acute is applied to those inflammations in which the fixed connective-tissue cells have not begun to show a reactive change other than the sudden defence needed to protect themselves from the injurious agents. No fibroblasts or angioblasts are seen in sections of such inflammatory processes.

According to the lesion and exudate which they show the acute inflammations of mucous membranes may be divided into catarrhal, muco-purulent, purulent, fibrino-purulent, fibrinous, hemorrhagic, and gangrenous.

Sooner or later, if the irritation causing the inflammation continues, the fixed connective-tissue cells, especially the endothelium, show a reactive change, and form a fibroblastic connective tissue, which later becomes firm scar tissue.

Chronic inflammations of mucous membranes are divided into *hypertrophic* and *atrophic*, depending upon the changes in the mucosæ themselves. Chronic hypertrophic inflammations are characterized by hypertrophy of the epithelial elements of the mucosæ such as occurs in chronic hypertrophic rhinitis or in chronic endometritis. In chronic atrophic inflammations, on the other hand, the glands and epithelial lining cells undergo atrophy such as occurs in chronic atrophic gastritis.

Acute Catarrhal Inflammation.—Any mucous membrane (mouth, nose, pharynx, larynx, etc.) may be the seat of a catarrhal inflammation. On macroscopical examination, the surface of the mucous membrane presents a shiny, glistening coating due to a thick, stringy, more or less homogeneous exudate. Sections of these mucous membranes show that their epithelial cells are swollen and the cell protoplasm is replaced by a finely granular or slightly stringy homogeneous substance (mucin), which stains deeply with Delafield's hæmatoxylin. The nuclei of these cells are pushed to one side or toward the base of the cell and stain faintly with nuclear stains. The epithelial cells lining the glands show a similar change. The submucosa is œdematous and may show an infiltration of leucocytes and few red blood cells. The œdema and the leucocyte exudate may extend into the muscular layers.

FIG. 3376.—Acute Catarrhal Bronchitis. *a*, Ciliated cells; a_1, deep cell layers; *b*, goblet cells; *c*, markedly mucoid cells; c_1, mucoid cells with mucoid nucleus; *d*, desquamated mucoid cells; *e*, desquamated ciliated cells; *f*, layers of drops of mucus; f_1, layer of stringy mucus and pus corpuscles; *g*, excretory duct of a mucous gland filled with mucus and cells; *h*, desquamated epithelium of the excretory duct; *i*, intact epithelium of the excretory duct; *k*, swollen hyaline basement membrane; *l*, connective tissue of the mucosa, partly infiltrated with cells; *m*, dilated blood-vessel; *n*, mucous gland filled with mucus; n_1, lobule of mucous gland without mucus; *o*, migrating cells in the epithelium; *p*, cellular infiltration of the connective tissue of the mucous glands. (Ziegler.)

Acute Muco-Purulent Inflammation.—Change of temperature, some irritating dusts or gases will produce in mucous membranes, especially of the respiratory tract, an inflammation characterized by a light yellow, semitranslucent, slightly stringy fluid exudate which is tenacious and adheres to the mucous membrane. The mucosa is swollen and the vessels are injected. Microscopically the picture presented is the same as that in a catarrhal inflammation, with the exception that a more marked leucocyte infiltration exists in all the layers and the exudate contains more leucocytes than does that of the catarrhal form.

Acute Purulent Inflammation.—Bacteria are the most frequent causes of this form of inflammation of a mucous membrane, but certain foreign bodies and drugs will produce identical phenomena. Foreign bodies in the nose, œsophagus, or bladder will cause a purulent rhinitis, œsophagitis, or cystitis. Turpentine or phenol in the mouth will produce a similar condition, and bacteria will cause a purulent inflammation of any mucous membrane. Macroscopically, the mucous membranes affected with acute purulent inflammation are reddened and swollen

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and their surfaces are covered with a thick yellowish or greenish-yellow, semifluid, opaque exudate. Microscopically, the epithelial cells lining the mucosa show a simple coagulation or liquefaction necrosis. The exudate is composed of cell débris, desquamated epithelial cells, and necrosing leucocytes. The connective tissue of the mucosa and submucosa, and often of the muscular layer, shows a marked leucocyte infiltration which may contain a varying number of red blood cells, and the vessels are congested and the connective-tissue fibres are swollen, due to œdema.

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Acute Fibrino-Purulent Inflammation.—The same agents which cause a purulent inflammation may cause a fibrino-purulent condition, depending upon the lesion produced. Cystitis which follows sounding of the bladder or results from an enlarged prostate or from calculi is very frequently a fibrino-purulent inflammation; and a foreign body in the vagina or rectum may cause a similar condition. The mucous membrane is covered by a yellowish-gray or greenish, tenacious exudate which adheres to the surface and when it is pulled off leaves a reddened surface. The mucosa is thickened and reddened, and the submucosa and muscular coats are œdematous and congested. Sections of the organ affected with fibrino-purulent inflammation show an exudate made up of a varying amount of stringy, granular, or hyaline fibrin, which forms a network enclosing desquamated epithelial cells and collections of necrosed or necrosing leucocytes. The epithelial cells of the mucosa are desquamated and show fatty degeneration, cloudy swelling, or necrosis. In the subepithelial connective tissue of the mucosa and in the submucosa are masses of leucocytes which may be degenerating and which are surrounded by œdematous connective-tissue fibres.

Acute Fibrinous Inflammation.—The ordinary pus germs in the rectum, vagina, mouth, pharynx, or nose may produce an acute fibrinous inflammation. Fraenkel's pneumococcus and Friedländer's pneumobacillus will produce on the tonsils and in the pharynx, larynx, and nose a similar condition; furthermore, this form of inflammation is the cause of death in cystitis due to enlargement of the prostate or to calculi, and fibrinous proctitis or enteritis may follow prolonged rectal feeding in cachectic individuals. The difference between this form of inflammation and fibrino-purulent inflammation is shown in the character of the membranous exudate. In the

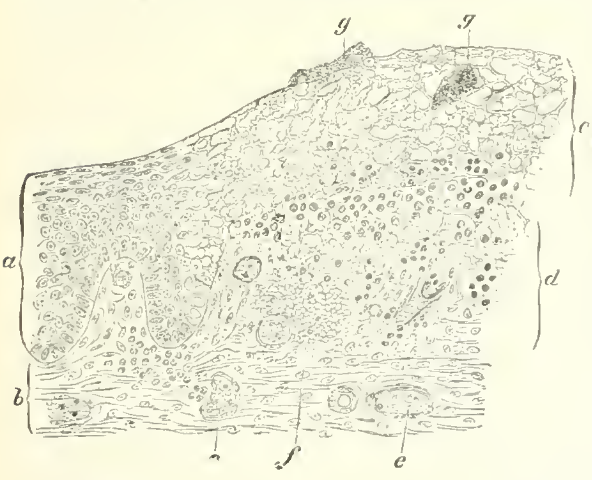

FIG. 3377.—Acute Fibrinous Inflammation of the Uvula. *a*, Normal epithelium; *b*, connective tissue of the mucous membrane; *c*, reticulated fibrin; *d*, connective tissue of the mucosa infiltrated with fibrin and round cells, and partly necrotic; *e*, blood-vessels; *f*, hemorrhage; *g*, masses of micrococci. (Ziegler.)

former the color of the membrane is pearly white or light yellow streaked with red, and the membrane itself is spongy and adherent to the surface, and when it is forcibly removed it leaves a reddened surface, usually differing from the diphtheritic membrane due to the Klebs-Loeffler bacillus in the fact that the latter can be withdrawn only with great difficulty and leaves a depressed surface which looks like an ulcer. Microscopically, the mucous membrane which is the seat of an acute fibrinous inflammation is covered with an exudate composed of granular, stringy, or hyaline fibrin, which forms a firm network enclosing few leucocytes, red blood cells, and desquamated epithelium. The epithelial cells lining the mucosa show a simple or coagulation necrosis, and

FIG. 3378.—Chronic Atrophic Enteritis. *a*, Glandular layer reduced to one-half its height; *b*, muscularis mucosæ; *c*, submucosa; *d*, muscularis; *e*, mucous membrane entirely atrophied. (Ziegler.)

the nuclei do not stain; fine threads of fibrin separate the epithelial cells and extend deep into the submucosa; leucocytes and red blood cells are scattered throughout the mucosa and submucosa and to a slight extent in the muscular layers, and the connective tissue of all the layers is markedly œdematous.

Acute Hæmorrhagic Inflammation.—The poisons produced by putrefaction outside of, and taken into, the body, cause a hemorrhagic gastritis and enteritis. Turpentine and croton oil in large doses produce a similar condition. The mucosæ vary in color from dark red to brown and are greatly swollen, and the contents of the stomach and intestine are streaked with fresh and decomposed blood. Microscopically, the epithelial cells lining the lumina show cloudy swelling, fatty degeneration, simple necrosis or coagulation necrosis; the spaces between the epithelial cells are occupied by œdema and red blood cells, the connective tissue of the mucosa and submucosa shows a varying number of red blood cells scattered or collected in small masses, and all the blood-vessels are greatly congested.

Acute Gangrenous Inflammation.—The bronchi frequently become the seat of this form of inflammation; in some of the cases the disease having originated by the penetration of an ulcer from an œsophageal diverticulum into the bronchi, while in others it represents a simple extension of a gangrenous process in the lung. The presence of foreign bodies in the nose, œsophagus, or vagina, or the occlusion of the nutritive vessel of any mucous membrane, or a simple trauma may eventuate in an acute gangrenous inflammation. The condition is accompanied by foul odors, caused by hydrogen sulphide, ammonium sulphide, etc. The mucosa in the early stages resembles that of acute purulent inflammation, with the exception that the pathological changes are more marked. In the later stages the mucosa may slough away and the necrosis may be so extensive that the deeper layers are involved.

Chronic Hypertrophic Inflammation.—This form of inflammation is most often found in the uterus, but hypertrophic rhinitis is common. The mucous membrane is thickened and varies in color from gray to gray-pink; the glands of the affected mucous membrane become hypertrophic and some become cystic; and, finally, the connective tissue of the mucosa becomes increased in bulk.

Chronic Atrophic Inflammation.—The prolonged use of alcohol will cause this condition in the stomach, and caries of some part of the bony framework of the nose or the mere presence of a foreign body somewhere in the nasal cavities is competent to produce chronic atrophic rhinitis. The mucosæ are thin and in the stomach the outer layers become atrophic; the glands of all surfaces

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affected show marked atrophy and their epithelial cells show mucous degeneration; and the connective tissue of the mucosa and submucosa is greatly increased and may cause constriction of the lumina of some glands. In the latter event these glands become cystic, and the muscular coats undergo marked atrophy.

Frederick H. Baldwin.

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MULLEIN. See *Scrophulariaceæ.*

MULTIPLE PROGRESSIVE HYALOSEROSITIS.—DEFINITION.—An inflammatory affection of the serous membranes, of chronic and progressive development, characterized by a peculiar overgrowth of fibrous tissue with hyaline metamorphosis.

This disease is a very remarkable one, and, judging from published cases, somewhat rare. Examples have been recorded in Germany and Austria chiefly by Hamboursin,[1] Weiss,[2] Curschmann,[3] Vierordt,[4] Riedel,[6] Rumpf,[7] Pick,[8] Schupfer,[9] Siegert,[10] Schmaltz and Weber,[11] Rose,[12] Strajesko;[14] in England by Hale White[5]; in America by Nicholls[15] and Herrick.[16] It is only lately that a complete study of this disease has been attempted (Nicholls), and now that special attention has been called to it we may expect in the near future to have many more cases recorded, for the disease is probably not so rare as has been thought.

The affection may begin in various ways, so that differing clinical types are produced. Sometimes the capsule of the liver is chiefly affected, and it is to this class of cases that the terms "diffuse chronic hyperplastic perihepatitis," "chronic deforming perihepatitis," "Zuckergussleber," have been applied. In other cases it is the pericardium or the pleura that is first involved. Nevertheless, in whatsoever way the disease may begin, or in whatever part it may attain its greatest intensity, it is to be noted that the process is everywhere essentially the same, since it becomes diffuse and involves one serous membrane after another in a steady progression. Consequently the term *multiple progressive hyaloserositis*, denoting as it does an inflammatory process at once chronic and continuous, and emphasizing the peculiar hyaline change which is so striking an element in the anatomical picture, is perhaps the most suitable term to employ.

DISTRIBUTION.—The disease appears to be widely disseminated, being found in all countries and all climes; sex appears to have but little importance; the cases hitherto recorded have been chiefly in males. With regard to age, the youngest patient affected was aged four, the oldest eighty years; those below middle age are probably the most likely to be affected.

FIG. 3379.—Section of Liver, Showing well the Glisson's Capsule Thrown into Folds, with the Deposit of Hyaline Fibrous Tissue upon the Surface. (Nicholls.) (Winckel objective No. 5, without eyepiece.)

MORBID ANATOMY.—Two types of the affection have been described, the sporadic and the diffuse. Except for peculiarities in localization and extent, these forms are, anatomically speaking, essentially the same. The characteristic lesion is the formation of isolated nodules or continuous sheets upon the serosæ of a pearly white material having a dense, cartilaginous consistency. This substance has been compared to the sugar upon a cake (*Zuckerguss*) and to porcelain. When forming a definite membrane it varies in thickness from a few millimetres to from 1 to 5 cm., and can be readily stripped off the subjacent organs without injury to their substance. On section the membrane has a semitranslucent, almost gristly appearance.

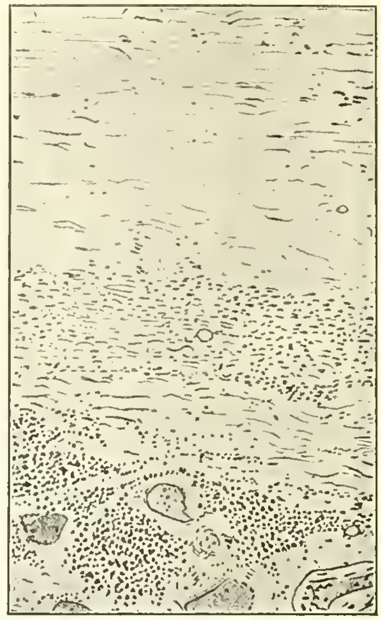

FIG. 3380.—Section of Peritoneal Membrane in the "Zuckerguss" condition, Showing Perivascular Leucocytosis and Hyaline Degeneration of the Superficial Fibrous Tissue. (Nicholls.) (Camera lucida drawing; Reichert objective No. 3.)

In the sporadic form the material usually forms flattened plaques, but may occur in elevated or even polypoid nodules. The favorite sites of localization are the capsules of the spleen and liver, the diaphragm, and the pleuræ. When affecting, as the process usually does, more than one serous sac, no order of involvement is absolute, but combinations are numerous.

With regard to the diffuse form, in the majority of cases the capsules of the liver and spleen, the pericardium and the lower portions of the pleuræ are involved. It is the rule also for more or less implication of the general peritoneum to occur. This results in induration and contraction of the great omentum and the mesentery; the omentum is frequently converted into an irregular tumor-like mass or a thick fibrous cord crossing the abdomen transversely. The contraction of the mesentery leads to dislocation of the intestines so that they lie bunched up along the spinal column. Bands of adhesions, fibroid and velamentous in character, are found connecting adjacent structures and are likely to be met with between the liver and spleen and the diaphragm and between the coils of intestines. While all or most of the serous membranes are involved in the process, they do not all present the same grade of affection. Thus, while one membrane presents the typical "icing" appearance, the other serous sacs may be obliterated by simple fibroid adhesions or traversed by bands, or in other cases may contain a fibrinous or fibrino-purulent exudation.

In the perihepatic form, where the brunt of the disease falls upon the liver and diaphragm, the liver is usually diminished in size and much altered in shape, becoming somewhat globular; the edges are rounded and the anterior border is often rolled back upon the upper surface. The gall-bladder is usually contracted and enclosed in a dense mass of hyperplastic tissue. The surface of the liver, after the investing crust is removed, which may readily be done, is smooth or at most slightly uneven. On section the organ usually shows brown atrophy, fatty degeneration, with some passive congestion. Cirrhosis of the organ does not occur as a rule; at most there is a slight thickening of the septa passing in from the capsule. The spleen is often enlarged, generally covered with the "icing" membrane, and deformed. With regard to the pleuræ, the right is as a rule more seriously involved than the left; the bases of the sacs are the sites of election

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for the process. The lungs are usually atrophied and partially collapsed. Chronic adhesive pericarditis, or, more correctly, mediastino-pericarditis, is frequently found. More rarely an acute exudative pericarditis is present, and more rarely still the pericardium may be normal. Occasionally the pericardial sac is only partially obliterated, and when the adhesions are denser on the right side toward the diaphragmatic surface. Calcareous deposits are sometimes met with in the adhesions. The heart is often small and may show the results of pericardial adhesion, namely, dilatation and insufficiency of the valves.

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The kidneys in most instances show no special abnormality except possibly congestion. In a few cases interstitial fibrosis has been found. The digestive tract shows but little disturbance; the stomach and colon may be found adherent to adjacent parts. A duodenal ulcer was found in one case. Icterus is never present, unless the case is complicated by cirrhosis of the liver or by obstruction to the common bile duct. As complicating conditions which hasten the fatal termination, acute pneumonia, pericarditis, pleurisy, peritonitis, and osteomalacia may be mentioned. A striking feature of the diffuse form is ascites, which is usually extreme. The ascitic fluid is of pale straw color, high specific gravity, containing flakes of fibrin, and has all the appearances of an inflammatory exudate. Anasarca is usually not marked until toward the end.

In addition to the form just described it should be stated that an increasing number of cases of serositis of this hyperplastic type are being reported as due to tuberculosis. It is beginning to be recognized that tuberculosis is not necessarily destructive, but, on the contrary, may be constructive;—instead of extensive caseation and softening we may have the formation of a hyperplastic hyaline membrane with little or no caseation. In many cases it is only the discovery of the specific bacillus which will reveal the true nature of the process. It used to be thought that cases of the perihepatic or "Zuckergussleber" type, to which Curschmann first drew attention in his classical paper, were never due to tuberculosis; but this is certainly incorrect. Recently Strajesko (*loc. cit.*) and James B. Herrick (*loc. cit.*) have recorded typical cases undoubtedly of tuberculous origin.

Hyperplastic tuberculosis of the serous membranes is in my experience not very uncommon, but it is certainly rare for it to attack the capsule of the liver, the pericardium, and the right pleura in such a way as to simulate Curschmann's "icing" liver and atrophic cirrhosis. The lesions produced are not unlike those of the simple or non-tuberculous form, the main difference being that the process is not so liable to be concentrated on any special organ, but is more generalized over the serosæ. Again, ascites is usually less marked and fibroid adhesions are more numerous. The membrane produced is rarely smooth and glistening, but is covered with fibrin and shaggy adhesions. A hypertrophic fibro-hyaline membrane may be produced also in this form, but in it caseous masses can generally be made out, disclosing the etiology of the case; the caseation may, however, be very trifling.

FIG. 3381.—Tuberculous Perihepatitis. The illustration shows the thick hyaline and caseous membrane produced in the chronic hyperplastic type. (Nicholls.)

Microscopically the membrane in the simple form is composed of parallel laminæ of connective tissue showing marked hyaline thickening of the fibrillæ. In the deeper portions newly formed capillaries can be made out with some perivascular leucocytosis, and "Mastzellen" are numerous. *Macroscopically* the membrane has all the appearance of an organizing deposit upon the serosæ,—a deposit in which hyaline degeneration constitutes the most striking feature. In the tuberculous form the connective-tissue fibrillæ interlace freely, and there are usually multiple areas of caseation with numerous giant cells. Hyaline degeneration is also present, but is rarely so marked as in the simple form. Tubercle bacilli can usually be demonstrated readily on making smears from the deposit.

In the tuberculous form, unlike the first variety, the liver is usually enlarged and often shows signs of miliary tuberculosis with slight interstitial fibrosis. Old tuberculous foci are usually found in the lungs, pleuræ, and peribronchial glands. The case often terminates with a generalized miliary infection.

Etiology and Pathogenesis.—Two views have been advanced as to the causation of the disease. The first is that of Pick, who regards the primary condition as an adhesive pericarditis which leads to portal obstruction and the so-called "cardiac" cirrhosis of the liver, eventually resulting in ascites and thickening of the liver capsule. The objections to Pick's view briefly are, that cases occur in which pericardial adhesion is absent, and in most of the recorded cases it has been shown that portal stasis was not present; nor, again, does the development of the physical signs accord with what should occur were Pick's view correct. It must be said that all those who have carefully studied the question are agreed that the overgrowth of fibrous tissue and the ascites are due to an inflammatory process involving the various serosæ. Most cases give a history of some previous acute inflammatory disease, and the development of the lesions can usually be traced from one serous membrane to another. Cases have been known to follow acute rheumatism, typhoid fever, whooping-cough, measles, malaria, and perityphlitis. The transmission of the infective agents from one serous sac to another takes place by means of the lymphatics. In the tuberculous form, which is anatomically strictly comparable to the simple type, the true nature of the disease is of course obvious. With regard to the ultimate nature of the process in the simple form, some little doubt must still exist; but it is probable that micro-organisms of low virulence are at work.

The inflammatory process usually begins in the peritoneal cavity in the form of a hepatitis or perihepatitis, or, more rarely, about the stomach and duodenum; it extends to the right pleura and eventually to the pericardium. Next in frequency, the primary lesion is a chronic pericarditis with adhesion extending to the right pleura and thence to the peritoneum; more rarely still, chronic pleurisy may extend to the liver capsule. The process is accompanied by an exudation of sero-fibrinous fluid into the abdominal cavity, which fluid tends to be abundant owing to the involvement of the absorptive surface of the peritoneum by the dense fibrous deposit, and also from the fact that the contracting fibrous masses sometimes lead to pressure upon the inferior vena cava and portal vein, thus promoting ascites. The liver gradually diminishes in size, and the spleen becomes enlarged in the later stages when passive congestion be-

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comes marked. Gout and alcoholism appear to have little to do with the process. Syphilis has been known to produce chronic adhesive and membranous peritonitis (Lancereaux), but as yet no case of multiple hyaloserositis has been recorded as due to this cause.

Clinical Course.—The sporadic form being entirely of pathological interest and giving rise to no characteristic symptoms may be dismissed from consideration. In the diffuse variety, the most striking clinical symptoms are those to which Curschmann first drew attention, namely, shortness of breath, slight general weakness, and a gradually increasing and refractory ascites. The resemblance to atrophic cirrhosis of the liver is striking. Most cases begin insidiously and give a history of indefinite disturbance from the first, such as anorexia, dyspnœa, and epigastric pain. In other cases the disease begins acutely with fever, rigors, and epigastric pain, during which time the liver region becomes tender and swollen. The affection ultimately becomes chronic and periods of latency alternating with exacerbations are the rule. According to the manner of onset we can recognize two main types: first, the *perihepatic*, and second, the *mediastino-pericardial*.

In the first, after more or less evidence of involvement of the liver capsule, such as pain and tenderness in the right hypochondrium, with or without fever, ascites develops and the liver is found to be enlarged. It is frequently observed later that one or both of the pleural cavities contain fluid, or the mobility of the lungs is impaired by adhesions. Finally, in most cases, although exceptions occur, there develop evidences of adhesion of the pericardium, and dilatation of the veins of the neck, chest, and arms may be noted. As the disease becomes well established the liver becomes smooth, hard, and gradually contracts, while the spleen steadily enlarges and may become palpable. Anasarca appears only in the later stages.

In the second type, the earliest signs are referable to an indurative mediastino-pericarditis, namely, pain in the chest, cough, palpitation of the heart, dyspnœa, cardiac dilatation, and possibly the pulsus paradoxus and systolic retraction of the chest wall. Signs of pleural effusion or adhesion appear and the process eventually spreads to the liver capsule. As before, the liver is large and smooth, but contrary to what occurs in the perihepatic form, anasarca is an early, though it may be a transient sign. As time goes on the liver decreases in size and ascites makes its appearance.

In all forms, eventually, paracentesis becomes necessary and must be repeated at gradually diminishing intervals. The condition of the liver and spleen can be made out only after free tapping. Digestive disturbances when present are trifling, such as anorexia, constipation, or diarrhœa; jaundice does not occur in uncomplicated cases. Albuminuria is found occasionally and is attributable to passive congestion of the kidneys. Fever is usually absent except during an exacerbation or complication. The disease is essentially chronic, lasting for from two to sixteen years. The sufferers may not be seriously incapacitated for work for long periods, but the condition proves singularly refractory to treatment and relapses are frequent. Death occurs usually from some acute complication, lobar pneumonia, or peritonitis.

The tuberculous form of the disease, as the cases of Strajesko and Herrick have shown, may occasionally present almost exactly the clinical picture of the "icing" liver of Curschmann's description. Little is known of this form as yet, but, so far as my experience goes, the only differences between the simple or non-tuberculous and the tuberculous forms are, that in the latter the liver remains enlarged to the end, fever is more constant, and the disease tends to run a more rapid course. In fact, most cases of tuberculous origin run a course very similar to that of chronic tuberculous peritonitis, with the addition of evidence of the involvement of the other serous membranes. There is little in the physical signs to suggest a chronic hyperplastic lesion rather than an exudative one in these cases, unless the liver capsule is chiefly involved. Unlike what takes place in the non tuberculous form, ascites is rarely extreme and sacculation of the abdominal fluid is more likely to occur. Usually, too, the disease begins with signs of tuberculous involvement of the lungs, pleuræ, peribronchial glands, or, in the female, the tubes and ovaries.

Diagnosis and Prognosis.—The diagnosis lies between chronic hyperplastic perihepatitis, atrophic cirrhosis of the liver, and carcinoma of the peritoneum, for in all there may be ascites, more or less abdominal pain, and, in most, induration of the great omentum. The combination of extreme ascites with relatively little anasarca, an adhesive pericarditis, pleural exudation, or adhesion, particularly if on the right side, should always arouse a suspicion of multiple progressive hyaloserositis, and especially perihepatitis.

Perihepatitis is differentiated from atrophic cirrhosis by the fact that portal congestion does not occur except

Table of Differential Diagnosis.

Special features.	"Zuckergussleber."	Atrophic cirrhosis of liver.	Chronic tuberculous peritonitis.	Carcinoma of peritoneum.
Age	Occurs about middle life or later.	Oftenest about middle age	Commonest between ages of twenty and forty.	Occurs late in life.
Sex	Slight predominance in favor of males.	More frequent in males	Predominates in females	More frequent in females.
Previous history	Often a history of acute pericarditis or perihepatitis.	History of alcoholism, syphilis, or digestive disturbances.	Often a chronic cough; diarrhœa, or general tuberculosis.	In some cases a history of cancer of stomach or ovaries.
Alcoholism	No influence	Frequently present	Unimportant	Unimportant.
Syphilis	No influence	Occasionally present	Unimportant	Unimportant.
Heredity	No influence	Unimportant	May be family taint	Unimportant.
Incidence	Acute becoming chronic or insidious from the first.	Insidious	Onset may be acute or insidious.	Insidious.
Chronicity	Cases last for years	May last for years	Prolonged	Fairly rapid course, with cachexia.
Fever	Generally absent except during exacerbation or some complication.	May be afebrile; when present is slight.	Usually slight, often absent	Rarely absent; due to complications.
Pain	Indefinite and trifling	Trifling	Apt to be troublesome	Variable.
Digestive disturbance	Trifling or none	Constant; dyspepsia, nausea, vomiting, gastric hemorrhage, melæna.	Fairly common	Often marked.
Ascites	Constant and extreme	Constant	Never extreme; may be absent; may be hemorrhagic.	Moderate grade; may be hemorrhagic or pseudochylous.
Anasarca	Constant but slight	Relatively slight	Trifling	Slight.
Jaundice	Absent in pure cases	Occurs in twenty-seven per cent. of cases.	May occur exceptionally	Common, when liver is involved.
Liver	Not cirrhotic; at first enlarged then small, smooth	Cirrhotic; at first enlarged, then small and warty.	Often enlarged	May be enlarged, with nodules.
Spleen	Gradual enlargement	Gradual enlargement	Nothing special	Nothing special.
Omentum	Thickened and contracted.	Normal	Often matted up	Often matted up.

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much later on and is never marked; secondly, severe digestive disturbances, such as dyspepsia, vomiting, hæmatemesis, and melæna, are not present. Jaundice does not occur except in the rare event of a mixed cirrhosis accompanying perihepatitis, a case of which has been recorded by Rose.[12] The liver is never warty; signs due to cholæmia do not occur. Further, the great omentum is nodular and contracted, while in cirrhosis it never is.

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In carcinoma of the peritoneum, when the liver is enlarged, jaundice is often present, the course is fairly rapid, cachexia and digestive disturbances are marked. There is usually some evidence of cancer of the stomach or ovaries.

Having diagnosed the presence of chronic perihepatitis, it is next necessary to determine if it be tuberculous or not. In the tuberculous form ascites is rarely so extreme; abdominal pain and tenderness are apt to be more marked and the liver is enlarged throughout. Careful examination of the lungs, lymphatic glands, testes, ovaries, and Fallopian tubes, as well as of the urine, fæces, and sputum, should be made. In suitable cases tuberculin injections should be tried. The preceding table presents in a convenient form the main points characterizing the various infections likely to be confused. Diagnosis may, however, be very difficult and often impossible.

The prognosis should be guarded; the disease is essentially chronic and may last for years without seriously incommoding the patient. The simple form is steadily progressive and invariably fatal. The tuberculous form is also practically always fatal, but may possibly heal after suitable interference. Tuberculous cases and those complicated with adherent pericardium run a more rapid course than the others. The special risk to life arises from some intercurrent complication.

Treatment.—No specific medication has been devised. The chief point is to meet the symptoms as they arise. Pain may be relieved by hot fomentations and opium. To relieve the ascites, diuretics have been recommended, notably caffeine in doses of 0.1 to 0.15 gm. six to ten times daily; digitalis and diuretin may be tried. When ascites is extreme, tapping must be resorted to. Some cases, especially the tuberculous forms, may be benefited by laparotomy. Needless to say, the patients must be kept under the best hygienic surroundings.

Albert George Nicholls.

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MUMMIFICATION. See *Necrosis*.

MUMPS.—(Synonyms: Cynanche parotidæa; parotitis; parotiditis; Fr., *Oreillon*; Ger., *Ziegenpeter*.)

Mumps is an acute, infectious disease, self-limited, and characterized by inflammation of the parotid, and sometimes of the submaxillary and sublingual glands, with a tendency to involve the mammæ, testes, and ovaries.

Nature and Etiology.—Mumps prevails widely as an epidemic, and also occurs in the sporadic form.

It is propagated by a specific virus the nature of which has thus far eluded the search of bacteriologists. Numerous organisms have been found in the blood, saliva, and other secretions by Bordas, Capitan, Charrin, Boinet, and others, but the cultures obtained have failed to stand the crucial test of reproduction by inoculation. The disease is communicated by contact with the infected, and by the intermediation of various substances to which the virus adheres. The contagious principle is supposed to be chiefly transmitted by the breath, and is capable of reproducing the disease from the beginning of the parotid swelling up to ten days or two weeks after the fever has subsided. It is highly contagious. When the disease breaks out in schools, children's hospitals, or other institutions where large numbers of young people are congregated, few escape, unless protected by a previous attack. However, the susceptibility is not the same in all individuals.

It is quite rare in infancy and after the middle period of life, occurring chiefly in youth and early manhood. Males are more prone to attack than females. Like the diseases of the class to which it belongs, it rarely occurs more than once in the same individual.

It is more apt to prevail during the winter and spring, but epidemics have been observed at all seasons. Bad hygienic surroundings certainly favor its diffusion.

Morbid Anatomy.—The opportunity for post-mortem examination in cases of mumps, for obvious reasons, is very limited. On this account pathologists differ as to the seat of the morbid process; some locating it in the gland proper, and others in the periglandular connective tissue. Among those who maintain the glandular origin, some hold that it is rather the fibrous stroma which supports the acini than the acini themselves, which are primarily involved.

The weight of authority is in favor of the initial lesion being a catarrhal inflammation of the gland ducts, but the local swelling which gives character to the disease is unquestionably largely due to an infiltration of the surrounding cellular tissue. The swelling disappears by the absorption of the exudation, and only in very exceptional instances does suppuration take place.

Occasionally the glands remain enlarged for a considerable time, and, in very rare instances, the enlargement and hardening are permanent. Atrophy of the parotid and other affected glands has been observed as a result of an attack of mumps.

Symptoms.—The period of incubation varies greatly and is estimated by different authors at from seven to twenty days. Premonitory symptoms are, in most instances, either absent, or so mild as to attract little attention. When present they are those commonly met with in mild febrile attacks: chilliness, hot flushes, languor, anorexia, and sometimes vomiting and diarrhœa.

Very exceptionally the initial symptoms assume a grave character, and the disease is ushered in with high fever, profound depression, persistent vomiting, and, in children so predisposed, with convulsions.

Pain and tenderness in the region of one or both parotid glands, if not present from the beginning of the illness, speedily make their appearance, and are never delayed longer than twenty-four or thirty-six hours. Swelling appears simultaneously with the pain and tenderness. It is at first noticed in the depression between the mastoid process and the ramus of the jaw, and is confined to the gland. The adjacent cellular tissue is soon invaded and the tumefaction extends forward on the face and downward and backward on the neck.

The degree of enlargement varies greatly, being at times moderate and confined to the parotid region, and in other cases involving a large portion of the face and neck. When both parotids are involved and the swelling is fully developed the configuration of the face is peculiarly altered, the lower half of the face being enormously widened and the outline of the chin lost in the œdema of the neck. The swelling is firm, slightly elas-

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tic, and moderately sensitive to pressure. The head is fixed with the face directed straight forward, or, if but one parotid is affected, the head will be inclined to the diseased side. The skin usually preserves its natural color, but may be red and glossy. Slight desquamation may take place after the inflammation has subsided.

More or less fever is always present, lasting, in cases of moderate severity, not more than four or five days, but occasionally it is intense, protracted, and attended with delirium and prostration.

The œdema generally extends internally, affecting to a greater or less degree the mucous membrane of the tonsils and pharynx. The secretion of saliva may not be materially altered in quantity, but dribbles continuously from the half-open mouth.

Tinnitus aurium and earache are often experienced, and there may be a temporary or permanent impairment of hearing. The movements of the jaw are, of necessity, greatly impeded and very painful. Speech is difficult, and the voice is husky or muffled.

Mastication and deglutition are almost entirely suspended, the patient enduring the pangs of hunger rather than undergo the suffering required to satisfy his wants.

Mumps usually affects both parotids, but not simultaneously; the left is most frequently the first to become involved, and in from two to four days afterward, or even when the swelling has disappeared, the opposite gland becomes the seat of disease. Not infrequently the affection is limited to one side.

Very often the submaxillary and sublingual glands are affected conjointly with the parotids. Dr. Penzoldt, of Erlangen, records an epidemic of mumps which fell under his observation, in which there were many cases in which the disease process was almost wholly confined to the submaxillary glands.

The swelling reaches its height in from two to five days, remains stationary about forty-eight hours, and then rapidly subsides, making the duration of the attack from ten to fourteen days.

Complications and Sequelæ.—These relate especially to affections of the nervous and glandular systems. The tendency for the inflammation to invade by so-called metastases other and remote glands is a singular and interesting feature of the disease. As was originally pointed out by Niemeyer, it is probably not a true metastasis. The testes in males and the mamma and ovaries in females are the organs of special election. This complication is much commoner in males than in females, and less common in childhood than in adult life. When the testicle is invaded, it becomes swollen and painful, and there is often effusion into the tunica vaginalis, with œdema of the scrotum. Bruising of the testes is said to invite the disease.

The migration may take place at any period of the parotid swelling, which then usually subsides, but occasionally the two inflammations run their course together. Sometimes the inflammation of the parotid disappears suddenly before the advent of the metastatic affection; in this event, alarming constitutional symptoms are liable to supervene. There may be high fever, headache, delirium, or profound collapse, which promptly disappear on the appearance of the local lesion. The new affection runs a course very similar to that of the original disease, and lasts about the same length of time.

Atrophy of the testicles sometimes results, or their function may become impaired from occlusion of the spermatic duct.

Meningitis is in evidence in a very large percentage of the fatal cases of mumps. Various diseases of the nervous system have been recorded as complications (insanity, neuritis, hemiplegia, facial paralysis), but certainly in many, if not most, instances, they were mere coincidences.

Otitis media is not uncommon and occasionally terminates in permanent deafness. In a few cases a complete loss of hearing in one ear takes place without the slightest evidence of the presence of the inflammation in the corresponding middle ear; thus warranting the belief that the lesion—whatever may be its nature—must in these cases be located in the cochlea or in the auditory nerve at some point in its extra-labyrinthine course.

Albuminuria with convulsions has been noted.

Prognosis.—Mumps is a mild though painful disease, and almost invariably runs a favorable course. The inflammation of the parotid rarely leads to the formation of an abscess, contrasting, in this respect, strongly with the non-specific form of parotiditis which occurs in the course of typhoid fever and other maladies.

Occasionally a hard, painless enlargement of the gland is left, which persists for a variable time and disappears, but which in very exceptional instances may be permanent.

The Diagnosis is rarely attended with difficulty. The disease can scarcely be mistaken for any affection other than the non-specific inflammations of the parotid glands, which occur as complications of various constitutional diseases.

The comparative mildness of the general symptoms, the speedy resolution of the swelling, and the epidemic character of mumps, contrast strongly with the preceding severe illness and the inherent tendency to suppuration which constitute the clinical features of the non-specific or symptomatic parotiditis.

Treatment.—The treatment is purely symptomatic. The disease is self-limited and runs a definite course, uninfluenced by the administration of drugs.

The patient must remain indoors, preferably in bed, even in mild cases, until convalescence is assured.

On account of the difficulty in swallowing, the diet should be exclusively fluid. If there should be high fever, a bath or surface sponging with tepid water will be of service. Should there be much pain or restlessness, an anodyne, preferably Dover's powder or chloral, may be prescribed; otherwise refrigerant diaphoretics, such as a solution of bitartrate or citrate of potash, or the neutral mixture of the Pharmacopœia (see under *Potassium*), will meet all of the indications. External fomentations to the neck are both useful and grateful to the patient. Soap liniment, to which a little deodorized tincture of opium may be added, warm olive oil, or the tincture of belladonna and glycerin (ʒ i.–℥ i.), are eligible preparations for external use.

When metastasis to the testes or other glands takes place, the new affection should be treated in the same manner as if it had occurred independently of the parotid inflammation. The writer has obtained excellent results in orchitis from the inunction of guaiacol (ʒ i.) and lanolin (ʒ iij.–iv.). When it is applied from two to four times daily the pain and swelling usually promptly subside. If the onset of the metastasis is heralded by great prostration, or by alarming symptoms of any kind, stimulants must be freely given and warmth applied to the body.

A course of tonics is advisable should convalescence be tardy. *W. J. Conklin.*

MUSCARINE. See *Poisonous Plants.*

MUSCLE.—Histology of Muscular Tissue.—Muscular tissue (Lat., *Tela muscularis;* Ital., *Tessuto muscolare;* Fr., *Tissu musculaire;* Ger., *Muskelgewebe*) is the tissue in the animal body the physiological characteristic of which is its power of contracting in one direction, thus giving rise to definite movements. It is composed of structural elements, the length of which is usually much greater than the breadth. Muscular tissue in some form is present in all the groups of animals, except the *Protozoa.**

Anatomically or morphologically, muscular tissue is of two kinds: (A) *Striated or striped muscular tissue*, that in which the structural elements or fibres are marked by distinct transverse, and usually much less distinct, longitudinal striations. The structural elements are uni- or

* Among the *Protozoa*, the striated ectoplasm of some infusoria and the contractile stalk of *Vorticella* are perhaps physiologically muscular tissue, but they can hardly be so considered anatomically, since these organisms are supposed to be unicellular.

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multinucleated (Figs. 3383 to 3405). (B) *Smooth or unstriated muscular tissue*, that in which the structural ele-

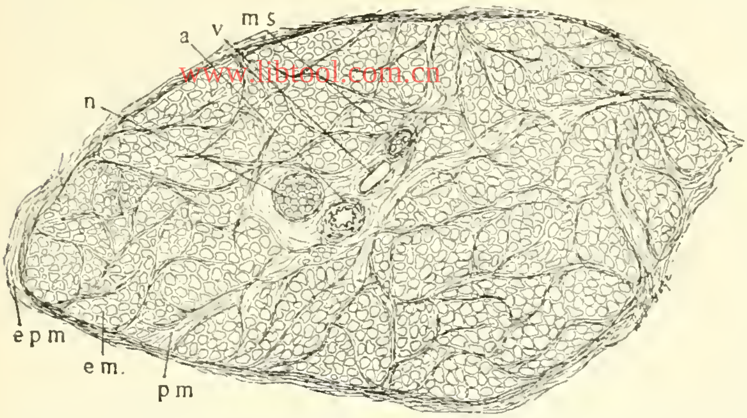

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FIG. 3382.—Transection of the Occipitoscapularis Muscle of the Cat, to show the Components of an Ordinary Striated Muscle. The whole muscle and the fascicles were outlined with the camera lucida at a magnification of about twenty diameters. The muscular fibres, the artery, vein, and nerve were not drawn to scale. (Drawn by Mrs. Gage.) *a*, Artery; *em*, endomysium, the connective tissue between the individual fibres; *epm*, epimysium, the connective tissue surrounding the entire muscle and giving off (*pm*) the perimysium, which combines the fibres into bundles of fascicles of various sizes; *ms*, muscle spindle; *n*, nerve; *v*, vein (*cf.* Figs. 3395, 3400).

ments are apparently homogeneous, or marked by fine longitudinal striations only. The elements are mostly uninucleated (Figs. 3406 to 3409).

STRIATED MUSCULAR TISSUE.—This, in man and many of the lower animals, is the so-called flesh or lean meat. It is usually collected into more or less distinct masses, termed *muscles;* and in every case, whether the muscle is in distinct masses or not, it is composed of structural or histological elements, which, when viewed lengthwise under a microscope, are characterized by an appearance of being composed of alternating dark and light segments (Figs. 3383 to 3404); this gives the elements their transversely striated appearance. Physiologically, striated muscle is characterized by the rapidity and energy of its contraction.

Distribution.—Striated muscular tissue is present in all vertebrates and in some members, at least, of all the great groups of invertebrates except the *Protozoa*. Structurally and physiologically, striated muscular tissue in vertebrates is of two kinds: (A) The skeletal, or the so-called muscle of animal life, which is mostly voluntary; (B) the cardiac, or the muscular tissue of the heart, and the other pulsating organs of the blood-vascular system. This is wholly involuntary, and belongs to the tissues of organic life.

Skeletal or Voluntary Muscular Tissue (muscles of animal life).—In man and the mammals, this tissue forms from forty to forty-five per cent. of the entire body weight. Its specific gravity is about 1.058. It is usually collected into distinct muscles, the ends of which are in most cases attached to some firm part (bone or cartilage) by means of fibrous connective tissue.

Distribution: In man and the mammals generally, this tissue forms the muscles of the trunk and extremities, those moving the globe of the eye and all those of the ear, those moving the lips, and those moving the skin (*platysma myoides* in man, the cutaneous muscles over nearly the entire body in many mammals). It is also present in the tongue, pharynx, larynx, the true sphincter of the urethra, and the ectal sphincter of the anus; in mammals possessing them, it is found in connection with Cowper's and the anal glands. In the œsophagus of man, the horse, and some other animals, striated muscle is usually present only in the pharyngeal half; in ruminants, the dog, cat, rabbit, house mouse, rat, and many other animals, it extends to, or nearly to, the stomach; and in the rat it is even continued upon the stomach from the cardiac end of the œsophagus. In many of the lower vertebrates, besides the muscles of the trunk and limbs, striated muscular tissue is found in situations where it is not present in man. *In birds*, in the iris and choroid; *in snakes*, around the poison glands; *in fishes*, in the wall of the stomach of *Cobitis fossilis* and *Syngnathus acus*, and in the intestine of *Tinca chrysitis;* in *amia* it forms a double layer over the surface of the lung-like air bladder, and is present in the trabecula-like cords within it; in *lepidosteus*, it is very abundant in the trabeculæ within the air bladder; in *polypterus* there is present an enclosing sheet of muscle for the air bladder as in *amia*.

Constituents of Striated Muscular Tissue.—These are: (A) the essential and characteristic, elongated and transversely striated muscular fibres (Figs. 3383 to 3396); (B) blood- and lymph vessels (Figs. 3382 and 3396); (C) nerves (Fig. 3382); (D) muscle spindles (Fig. 3400) (E) a considerable quantity of adipose and connective tissue (Figs. 3382 to 3385.) The connective tissue of a muscle has received special names according to its position in the muscle: (*a*) *epimysium* or *perimysium externum* (Fig. 3382, *ep*). This is the connective tissue which forms a kind of envelope or sheath for the entire muscle, (*b*) *perimysium* (Fig. 3382, *p*). This is the connective tissue which extends into the muscle from the epimysium. It combines the fibres into bundles (*fasciculi, fascicles*, or *lacerti*) of various sizes, and separates the fascicles from one another; (*c*) *endomysium*. This is the minute network of connective tissue extending from the perimysium into the fascicles, and separating the individual fibres from one another. Finally, connective tissue, commonly in dense masses or tendons, serves to connect the muscles to other parts, usually bones or cartilages, which are moved when the muscle contracts.

Fascicles (fasciculi or lacerti) and their Relations in a Muscle.—In some muscles, as the sartorius, the muscular fascicles extend from end to end of the muscle. In such a case, if the muscle has a broad tendon of origin and insertion, the fascicles are usually nearly parallel and of nearly the same length. Where, however, one or both ends are fusiform, as in the biceps brachii and the gracilis of man, the central fascicles are considerably the longer. In penniform and bipenni-

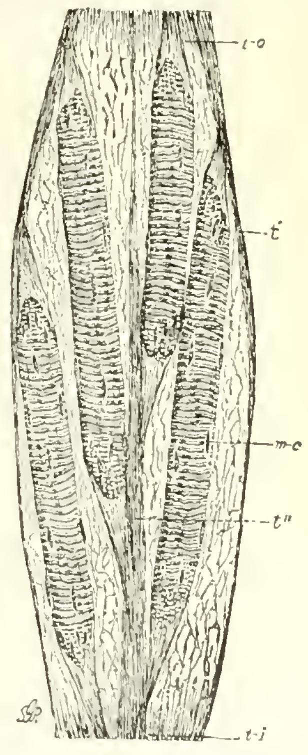

FIG. 3383.—Diagram to show the Arrangement of the Fascicles in a Bipenniform Muscle (*Biceps Brachii* of the Cat). Each fibre represents a fascicle. (Drawn by Mrs. Gage.) *m-c*, Muscle corpuscles; *t-i*, tendon of insertion; *t-o*, tendon of origin; *t'*, tendinous expansion over the surface of the muscle (it is thickest near the tendon of origin); *t''*, extension of tendon through the middle of the muscle. It thickens toward the tendon of insertion.

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form muscles the fascicles are placed obliquely to the long axis of the muscle, and extend for a comparatively small part of its entire length. In case of the bipenniform muscles—biceps brachii of the cat (Fig. 3383), rectus femoris of man—the tendon of origin and the tendon of insertion extend along the entire length of the muscle, on the surface, and also in the central part. This arrangement of the tendon in the penniform and bipenniform muscles renders it obviously impossible to expose the muscular substance in dissection so that it shall show to the best advantage. In most muscles the component fascicles are approximately parallel with one another, although not necessarily with the long axis of the muscle. In bipenniform muscles the fascicles are parallel with one another on the same side, but at an angle with those of the opposite side (Fig. 3383); they are likewise oblique to one another in the fan-shaped muscles like the pectorals and the latissimus.

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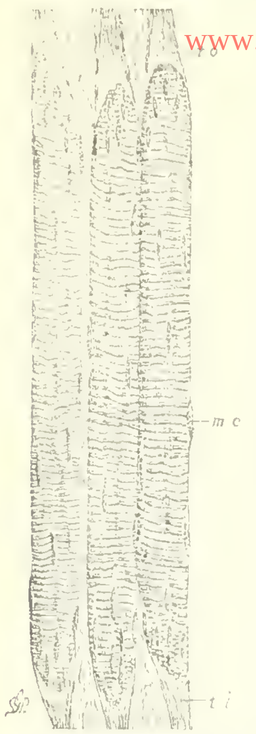

Fig. 3384. Diagram of a striated Muscle in which the Fascicles are composed of but One Length of Fibres, which are of nearly Equal Length. It also represents a muscle in which the fibres are parallel and extend from end to end of the muscle. (Drawn by Mrs. Gage.) *m-c*, Muscle corpuscle; *t-i*, tendon of insertion; *t-o*, tendon of origin.

Fibres and their Arrangement in a Fascicle.—It was long supposed that the individual fibres forming a fascicle were coextensive with it, and therefore, except with the penniform and bipenniform muscles, with the muscle itself. It was shown, however, by Rollett,[1] Herzig, and Biesiadecki,[2] that the fibres may end within a fascicle, being attached to a tendon at but one extremity, or at neither. It is now believed that a fibre rarely exceeds from 40 to 100 mm. in length, while a muscular fascicle may be, in some cases, ten or twenty times that length, or even longer. In man and some of the larger animals Felix[6] has isolated fibres from 120 to 130 mm. in length, although he found the majority of the fibres much shorter. If the fascicle is not over 40 mm. long, the fibres usually extend parallel with one another from end to end of the fascicle; and where the fascicle is parallel with the long axis of the muscle, and the muscle itself does not exceed 40 mm., the individual fibres likewise extend its entire length (Fig. 3384), as in the occipitofrontalis and many other muscles of the cat, the stapedius, intercostals, and some other muscles in man. Where, however, the fascicles considerably exceed 40 mm. in length, the fibres which originate in the tendon of origin or insertion by blunt ends, terminate by fusiform ends at different levels within the fascicle (Fig. 3388, *A*). Where the fascicles greatly exceed 40 mm. in length, part of the fibres originate and terminate as just described, while those which fill the intervening space are tapering and slender at both ends (Fig. 3388, *B*). In most cases in which the fibres become tapering and end within a fascicle, each tapering end is applied closely to a fibre of full size (see Fig. 3388 and below, under Termination of the Fibres).

In small animals, like the common mouse and bat, in which none of the muscles attains a length of 40 mm., one would naturally expect all the fibres to extend the entire length of the muscle; but from an extended investigation of the house and field mouse, of the mole and bat and English sparrow, it was found by Susanna P. Gage[3] that while many of the fibres did extend the entire length of the muscle, many others ended within it either with simple tapering points or with several branches, and even by anastomoses with other fibres (Fig. 3389). Herzig and Biesiadecki found in the muscles of the frog some of the fibres extending the entire length of the fascicle, while others terminated within it. As stated above, the fibres in a fascicle are approximately parallel, and the fascicles, composed of but one length of fibres (Fig. 3384), show the same number of fibres in transection at any level, and each fibre is of nearly the same diameter throughout its entire length, except at the extreme ends (Fig. 3384). In a fascicle composed of two or more lengths of fibres, the number of fibres varies in transections made at different levels, and the same fibre is not of uniform diameter throughout its entire length (Fig. 3388). Independently, however, of the tapering ends of the fibres in fascicles composed of two or more lengths of fibres, the several fibres of a fascicle in all forms of muscles vary greatly in diameter, and there is also a great difference in the number of fibres in the different fascicles (Figs. 3382, 3411). The coarseness or fineness in texture of a muscle to the naked eye, depends mostly on the relative abundance of the perimysium and the *number and the size* of the fibres in the component fascicles (Figs. 3382, 3416).

Termination of Striated Muscular Fibres.—(A) *Termination in Tendon.*—The most common mode is in a dense, usually rounded or flattened mass of connective tissue called a tendon. This is always less bulky than the muscle, and consists of a continuation of the connective tissue of the muscle, and of the special minute tendinous prolongations of the individual fibres which reach the tendon (Figs. 3383 to 3385). All muscular fibres ending in tendon, or apparently directly upon some hard part—bone or cartilage—terminate as just described, without

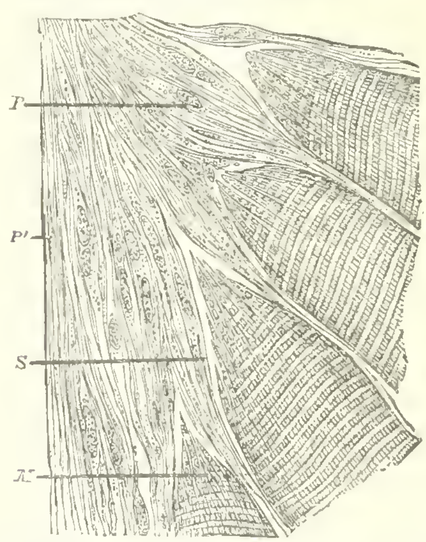

Fig. 3385. To show the Attachment of Muscle to Periosteum (apparent direct attachment to bone), also an Oblique Muscular Attachment. From the scapula of a cat. Magnified 500 diameters. (Heitzmann.) *M*, Tendinous ends of a striated muscular fibre (four are shown); *P*, perimysium; this intermingles with the periosteum, and with the short tendinous prolongations of the individual fibres, serves as a tendon; *P'*, periosteum; the perimysium and tendinous prolongations of the muscular fibres intermingle with the fibres of the periosteum and become lost in it; *S*, sarcolemma; apparently continued as part of the tendinous prolongation of the fibre.

regard to the angle of attachment; there is simply a difference in the length of the tendinous prolongations of the fibres (Fig. 3385).

When a muscular fibre reaches a tendon, the sarcous substance (see below) ends bluntly (Figs. 3383 to 3388). In some cases the end is divided into several short finger-

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like processes, and in most cases the supply of nuclei in the muscular and tendinous substance is abundant. Whatever the form of the terminal part of the sarcous substance, the fibre appears to be directly continued by a bundle of tendinous tissue, which soon loses itself in the general mass of the tendon (Figs. 3383 to 3388). This appearance is clearly seen in the dead muscular fibres of all the animals examined, both in sections and in isolated fibres. When the muscle is stained with acid fuchsin and picric acid, the muscular substance is yellow and the tendinous substance pink. The appearance is then that the tendon fits into all the crevices at the end of the terminating fibre as if the muscle end with its terminal processes had been inserted into a plastic tendinous substance. The tendinous substance is also extended along the sides of the fibre and merges into the endomysium (Fig. 3387). It was long held by most histologists that this appearance indicated that at its termination in a tendon the sarcous substance merges directly into tendinous substance, and with the sarcolemma (see below), forms the tendinous insertion of the fibre. At the present day, however, many histologists believe that the sarcolemma of a muscular tibre is continued around the end of the fibre, and that the tendon is simply cemented to it (Fig. 3386). The sarcolemma has never been separated from the tendon, so that, if this view is correct, the connection between the sarcolemma and tendon is more intimate than that between the sarcolemma and sarcous substance. This interpretation is a natural, and almost necessary, outgrowth of the cell doctrine of Schwann[18] and his followers, which teaches, above all things, the independence of the individual structural elements. And these writers consider the sarcolemma a kind of cell wall; it must, therefore, necessarily entirely enclose the fibre, and the tendon be cemented to it at the end of the fibre. To the constantly increasing number of biologists who believe, not in the independence, but in the interconnection of the structural elements of the body, there seems no inherent improbability in the view that muscle may merge into tendon, and the sarcolemma become continuous with, and form part of, the tendon. The appearances obtainable by treating dead muscular fibres with various reagents, and by the study of living fibres, give, in the present state of knowledge, justification to either interpretation.

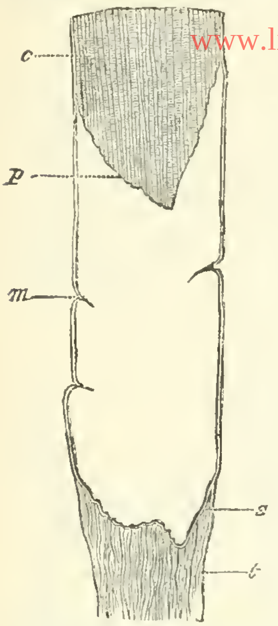

FIG. 3386.—Muscular Fibre from the Gastrocnemius of the Frog, to show the Termination of a Muscular Fibre in Tendon. Magnified 140 diameters. (Ranvier.) *c*, Muscle columns; *m*, a fold in the empty sarcolemma; *p*, retracted conical termination of the sarcous substance; *s*, sarcolemma reflected over the end of the fibre and adhering to the tendon; *t*, tendon.

(B) *Termination of Fibres within a Muscle.*—The statements of histologists concerning the termination of fibres within a muscle and the relations of the terminal ends are so various, or directly conflicting, that some of the more positive statements will be given before stating what seems, according to the writer's observations, to be the condition. Frey, 1880: "While it was formerly supposed that every transversely striated fibre continued throughout the entire length of its muscle, more recently numerous exceptions to this have been observed; that is, muscular fibres which terminate in a point, or some other form, at a greater or less distance from the tendinous extremity. Such primitive fasciculi have their connection with the tendon, to a certain extent, in the interstitial connective tissue." Klein, 1883: "The individual fibres have only . . . a relatively limited length, so that, following an anatomical fascicle from one point of its insertion to the other, we find some muscle fibres terminating, others originating. This takes place in the following way: The contents of a fibre suddenly terminate, while the sarcolemma, as a fine thread, becomes interwoven with the fine connective tissue between the muscular fibres." Landois, 1885: "Within a short muscle, *e.g.*, stapedius, tensor tympani (of man), or the short muscles of a frog, the fibres are as long as the muscle itself. Within longer muscles, however, the individual fibres are pointed, and are united obliquely by cement substance with a similar bevelled or pointed end of another fibre lying in the same direction." Schaefer, 1882: "In a long fasciculus a fibre does not reach from one tendinous attachment to the other, but ends with a rounded extremity, invested with its sarcolemma, and cohering with neighboring fibres."

According to the writer's observations on many different muscles of cats at all ages, and less extended observations upon human muscles and on those of the house mouse, the fibres which terminate within a muscle always do so with a very tapering end, the extremity becoming thread-like, and losing its striation. The muscle corpuscles (see below) are also numerous near the end, and in some cases the fibre seems to terminate as a branched corpuscle (Fig. 3388, *C*). Small lateral branches, some of them striated, were also present in many cases (Fig. 3388, *C*). Where the fibres were apparently undisturbed in their relations, the terminal part, for a considerable distance, was parallel and closely connected with a fibre of full size, the tapering end following accurately the outline of the fibre to which it was applied, curving outward over a muscle corpuscle (Fig. 3388, *m-c*), or when the large fibre was corrugated, following the curves accurately. Herzig and Biesiadecki[9] describe long lateral branches, some of which even anastomose in the intramuscular endings of fibres in the horse.

As shown in Fig. 3389, branched and even anastomosing terminations are not uncommon in the smaller animals, as the house mouse.

The fibres arising from the same tendon and terminating within a muscle may be of various lengths; in such a case the longer ones may apply their tapering ends to fibres of full size coming from the opposite tendon (Fig. 3388, *A*, 3389), while the shorter ones may either apply themselves to fibres from the opposite tendon, or to the longer fibres from the same tendon. In the latter case the shorter fibre has always been observed to terminate before the longer one commenced to taper. When a fascicle is three or more fibres in length, the fibres may be of various lengths, as stated above, but the fibres not joined to the tendon of origin or insertion are tapering at both ends. All the fibres lap sufficiently to apply their tapering end to fibres having their full diameter (Fig. 3388, *B*). In

FIG. 3387.—Two Adjoining Striated Muscular Fibres from the Proximal or Upper End of a Human Sartorius to show their Tendinous Connections. (Drawn by Mrs. Gage.) Magnified about 350 diameters. The tendon in each case seems to be a direct continuation of the muscular fibre, and to extend up on the side of the fibre for a short distance (*cf.* Fig. 3386).

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all the numerous preparations observed by the writer, the muscular fibres terminating within a muscle were always very slender and tapering at their termination

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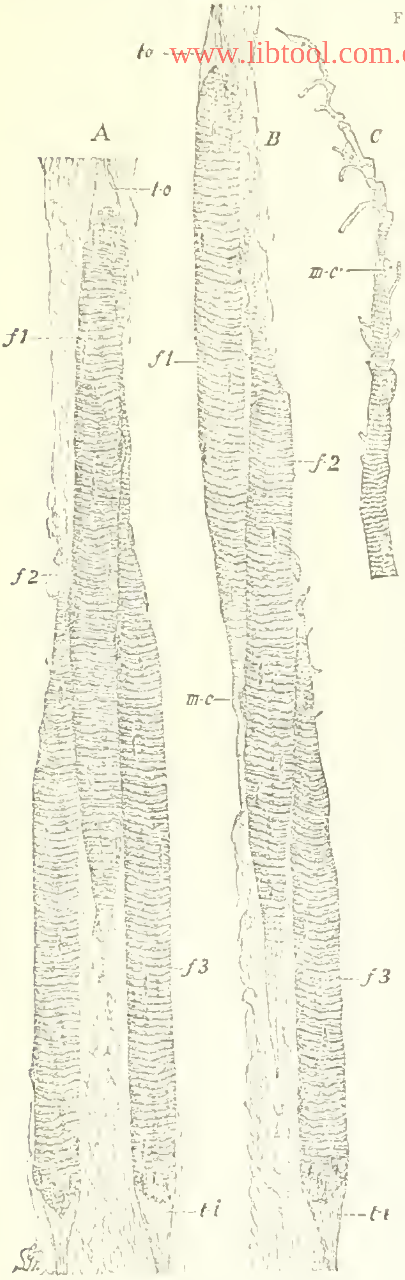

FIG. 3388.—Diagrams to show the Relation and Termination of Fibres in Fascicles composed of Two or more Lengths of Fibres. (Drawn by Mrs. Gage.) *A*, Fascicle composed of two lengths of fibres. The fibres terminate by rounded ends at the tendon of origin and insertion, and in the midst of the muscle by tapering ends which are applied to the other fibres, where they are of full size. *f* 1, Fibre arising at the tendon of origin and terminating in the midst of the muscle; *f* 2 and *f* 3, fibres of different lengths arising at the tendon of insertion and terminating in the midst of the muscle; *t-i*, tendon of insertion; *t-o*, tendon of origin. *B*, A fascicle composed of three lengths of fibres; only the ends reaching the tendons are rounded, the others are tapering and are applied to neighboring fibres, as in *A*. *f* 1, Fibre arising at the tendon of origin and terminating in the midst of the muscle; *f* 2, fibre with two tapering ends, both of which terminate in the midst of the muscle; *f* 3, fibre terminating by a rounded end in the tendon of insertion, and by a tapering end in the midst of the muscle; *m-c*, muscle corpuscle. This one projects beyond the surface of *f* 2, and the tapering end of *f* 1 curves over this corpuscle. A similar condition is shown in *f* 1, *A*; *t-i*, tendon of insertion; *t-o*, tendon of origin. *C*, The terminal part of a fibre ending within a muscle. Drawn with a camera lucida at a magnification of 425 diameters. The details of structure were determined with a $\frac{1}{18}$ homogeneous immersion objective, and added free-hand. *m-c*, Muscle corpuscle. The one to which the line extends projects markedly, and is in the angle formed by a lateral branch. The lateral branches are numerous, and some of them show distinct transverse striations. Just beyond the corpuscle to which the line extends the transverse striation ceases on the fibre. At the end is an enlargement or corpuscle, with a thread-like continuation.

(Fig. 3389) and two tapering ends were never seen to lap and be cemented together; but the slender termination of one fibre was almost invariably applied to a fibre of full size, and terminated before the supporting fibre commenced to taper. The apparent termination of a fibre by a rounded end within a muscle is due, in many cases at least, to the tearing and retraction of the sarcous substance, and sometimes also of the sarcolemma. In the great majority of cases observed, in which a fibre was in its natural relations to the other fibres, and seemed to end by a blunt or rounded extremity within the fascicle, the empty sarcolemma was traced to the other broken end. When the hollow sarcolemma appears of about the size of a muscular fibre (Figs. 3386, 3391), the true relations of the broken ends of the fibre are readily determined; but in many cases the stretched sarcolemma collapses and tapers to a point about midway between the severed ends of the sarcous substance, and often both the broken ends cannot be seen in the same field of the microscope.

(*C*) *Termination of Muscular Fibres in the Skin.*—The attachments of the cutaneous muscles to hard parts, and the terminations of the fibres within a muscle, are as described above for the ordinary muscles. At their cutaneous termination the fibres (in the cat at least) taper somewhat gradually, lose their transverse striation, and, finally, become indistin-

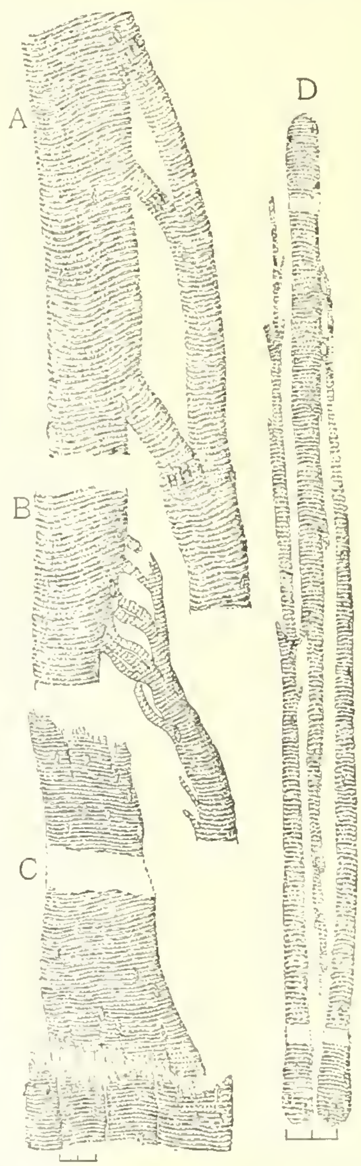

FIG. 3389.—Figures showing the Relations of Muscular Fibres in Small Animals. (From Susanna P. Gage.) *A*, An anastomosis of two fibres in the connecting branches of which are seen a number of longitudinal clefts. The smaller fibre ends with the upper branch. The larger fibre has its maximum size at the upper end, and from the lower part was traced 4 mm. to its tapering, branched intramuscular end, one of the branches forming an anastomosis with another fibre. (From the biceps femoris of a house mouse.) *B*, Termination of an intramuscular end by anastomosis. Anastomosing branches were given off for a whole millimetre, that is for the whole length of the tapering part. (From the biceps femoris of a house mouse.) *C*, Tendinous ends of the rectus abdominis of a house mouse. The two tendinous ends are shown in the upper fibre, which was 5 mm. long. Opposite the lower tendinous end of the large upper fibre are four smaller fibres from the next segment. *D*, Anastomosis of one tapering fibre with two others from the opposite tendon, showing in a typical way the relations of anastomosing, intramuscular ends to one another. The part between the breaks was 3 mm. long, while the whole muscle was 17 mm. long. The intramuscular ends are branched and two of them, after anastomosing, seemed to end freely. (From the biceps femoris of the house mouse.)

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guishable from the white fibres of the corium. In some animals, as the rat, the fibres at their cutaneous termination, in the lips at least, divide into several branches, which taper gradually or somewhat suddenly, lose their striation, and in some cases appear to terminate in connective-tissue corpuscles; in others they become indistinguishable from the white fibres of the corium (Fig. 3390).

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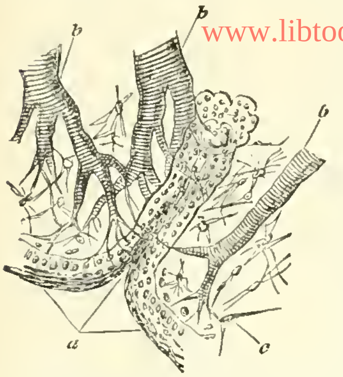

Fig. 3390.—Section of the Lip of the Rat through the *Musculus Levator Labii Superioris*, to show the Branching of the Fibres and their Termination in the Corium. (Busk and Huxley.[5]) *a*, Epidermis and aperture of a sebaceous gland; *b*, muscular fibres branching and terminating in the corium after tapering and losing their transverse striations; *c*, connective-tissue corpuscle.

(D) *Termination of Muscular Fibres in Mucosa.*—If one end of the muscle is attached to some hard part, or if the fibres terminate within the muscle, the attachment of the fibres to the tendon, and the termination within the muscle are as described above for the ordinary skeletal muscles. The ends of the fibres terminating in the mucosal corium, taper, sometimes branch, always lose their striation, and are lost in the fibrous tissue of the mucosa.

(E) *Termination of Striated Muscular Fibres in Hollow Viscera, and in Connection with Unstriated Muscular Fibres.*—In the œsophagus, urethra, etc., where the fibres for the most part have no connection with a definite tendon of origin or insertion, they end by tapering extremities, the tapering part being joined to fibres of full size, as the ordinary skeletal muscles (Fig. 3388). Where the striated fibres mingle with, and are gradually replaced by, unstriated fibres, as at the gastric or lower end of the œsophagus, the long tapering ends of the striated fibres are surrounded on all sides by the unstriated fibres, to which they seem to be cemented as the unstriated fibres are cemented to one another (Fig. 3406).

In all cases (skin, mucosa, hollow viscera, and in the interior of muscles where the fibres gradually taper to thread-like terminations), the sarcolemma, if present on the tapering ends, is so closely connected with the fibre that it is exceedingly difficult or impossible to demonstrate it; and near the end of the fibre the striation is so gradually lost that it is difficult or impossible to locate the exact termination of the sarcous substance and the beginning of the tendinous substance—if it may be so called. No one has ever been able to show a relation of the non-striated termination of the tapering fibres to the sarcolemma, anything like that shown in Fig. 3386; and according to Busk and Huxley,[5] such tapering fibres with non-striated endings furnish conclusive proof that the sarcous substance merges directly into tendinous substance. According to Beale, fibrous degeneration of the sarcous substance points in the same direction.

Branching of Striated, Skeletal, Muscular Fibres.—In the invertebrates striated muscular fibres frequently branch and anastomose, especially in the walls of the alimentary canal. In vertebrates these fibres rarely divide, except when terminating in mucosa or skin. Kölliker described tree-like branchings in the mucosal ends of the muscular fibres of the frog's tongue; and Herzig and Biesiadecki have described and figured muscular fibres from the frog's tongue which possess tree-like branches at both ends. According to Klein, branching fibres have also been found in the tongue of the newt, bat, sheep, goat, cat, and man. Salter[17] could not demonstrate them in man. Branched terminations in the tongue of mammals are certainly greatly in the minority, and are much more difficult of demonstration, than in the tongue of the frog. In the skin of the rat's lip branching fibres have been described by Busk and Huxley (Fig. 3390). Finally, the ordinary skeletal muscular fibres are sometimes dichotomously divided. This is especially evident in the tapering ends of fibres terminating within a muscle (Fig. 3388, *C*). Short finger-like divisions at the tendinous ends of fibres are common (Fig. 3387).

Structure of a Striated Muscular Fibre (*Primitive Fasciculus or Fascicle*).—The striated muscular fibres are the structural or anatomical elements of the skeletal or voluntary muscular tissue. They are cylindrical or prismatic in form, and rarely extend the entire length of a muscle, most of them being considerably shorter. In diameter, the general average in man is from 30 μ to 65 μ, being somewhat larger in the male than in the female; in the cat 25 μ to 90 μ; in mammals below man 45 μ; in birds 31 μ; in reptiles and amphibia, 56 μ; in fishes 100 μ; in insects 63 μ. The variations in size in the same animal are very great, *e.g.*, in man some of the fibres are 125 μ, while others are only 10 μ in diameter.*

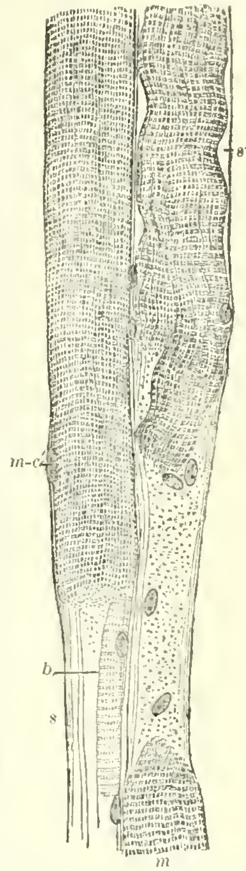

Fig. 3391.—Parts of Two Muscular Fibres from the Adductor Magnus of a Dog, to show the Sarcolemma between the Broken and Retracted Ends of the Sarcous Substance. Magnified 270 diameters. (Ranvier.) *b*, A thin layer of sarcous substance adhering to the sarcolemma. This sometimes adheres all the way around and gives a striated appearance to the sarcolemma; *m*, sarcous or muscular substance; *m-c*, muscle corpuscle. In the fibre at the right some muscle corpuscles have been separated from the fibre and remain in the empty sarcolemma; *s*, sarcolemma; *s'*, opposite a space between the sarcous substance and the sarcolemma.

Structurally, most of the fibres are composed of two very different parts—an enclosing membrane, sarcolemma, and the contractile or sarcous substance, which includes the muscle corpuscles.

Sarcolemma (*Myolemma, Primitive Sheath*).—It was shown by Bowman[4] and Schwann,[18] independently, that most striated muscular fibres are covered by a thin, elastic, and transparent membrane, comparable if not identical with, a cell membrane. It has not been demonstrated in the striated muscular fibres of amphioxus and petromyzon (Balfour), nor in many of the fibres of the tongue of man and other animals (Busk and Huxley[5]), nor in fibres of the eyelid and eyeball, nor in most of those of the myelo-hyoid of the green tree frog (Beale[3]). According to some writers it is not present in developing fibres, except near the end of development. In its chemical and physical nature the sarcolemma is quite similar to elastic tissue, so that when the dead fibres are dissected with needles, either before or after special chemical treatment, the sarcous substance (see below)

* It is not stated by the authors from whom the above figures were taken (Kölliker and Bowman) whether, in obtaining the diameter of the fibres, the cut ends, as seen in transections, were measured, or whether isolated fibres were measured, nor whether care was taken to avoid tapering ends of fibres terminating within a muscle. In the measurements given for the fibres of the cat by the writer, only isolated fibres were measured, and care was taken to measure them only where they were of full size.

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is more often torn than the sarcolemma, which remains intact and connects the severed ends of the sarcous substance (Fig. 3391). The sarcolemma, under favorable circumstances of light and preparation, does not appear homogeneous, but fibrillated and punctated, and in some cases there seems to be a connection between the sarcolemma and the endomysium. Occasionally, when the sarcous substance is torn and retracted, a thin layer remains adherent to the sarcolemma around part or the whole of the circumference. In such a case the sarcolemma appears striated, but much less opaque than the whole fibre (Fig. 3391). When the entire sarcous substance retracts, the sarcolemma appears like a hollow transparent sac, and is often folded (Figs. 3386, 3391). If the fibres are considerably stretched in preparation, the sarcolemma joining the broken ends of the sarcous substance may become very slender and appear like a tendinous termination. In most cases, however, the sarcolemma may be traced between the retracted ends of the sarcous substance, although both ends may not be visible in the same field of the microscope. Whether the sarcolemma simply encloses the sarcous substance as the finger of a glove covers the finger, or whether it has a structural connection with the sarcous substance, is not yet determined. According to the views of Krause, delicate partitions arise from the sarcolemma and pass entirely through the muscular fibre, dividing it into compartments. When the sarcolemma of insects is slightly raised from the surface of the fibre, it is wavy, and at the part of the wave nearest the sarcous substance a delicate process is seen to extend to the muscular substance. This appearance was pointed out and figured by Bowman, and may be seen with the greatest clearness in the muscular fibres of the larva of *corydalis*. The common appearance in vertebrate muscle is that shown in Figs. 3386, 3391, where the sarcolemma seems to be simply an enclosing sac.

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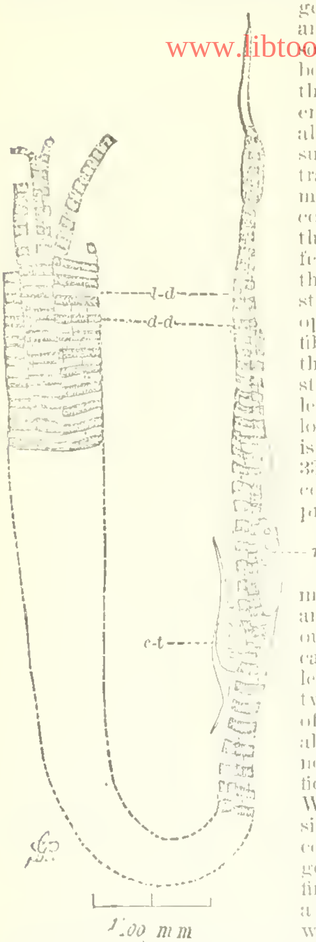

FIG. 3392.—The Terminal Part of a Muscular Fibre ending within a Muscle, to show the End of the Fibre, Isolated Fibrils, and the Various Discs which are sometimes seen in Mammalian Muscle. From the latissimus of a kitten five weeks old. The fibre is not striated beyond the swelling near the terminal end, and a striated branch is present on the right side just beyond the large muscle corpuscle. At the larger end the discs are displaced so that part of a dark disc is opposite a light disc. The entire length of fibre here shown is 0.95 mm. The intermediate part, indicated by dotted lines, is greatly abbreviated. Drawn with a camera lucida at a magnification of 800 diameters. All the details of structure were determined with a $\frac{1}{18}$ homogeneous immersion objective. (Drawn by Mrs. Gage.) *c-t*, Connective-tissue corpuscle partly covering the fibre; *d-d*, dark disc. This is very distinctly divided into two equal parts by a narrow light band (middle or Hensen's disc, compare Fig. 3393); *l-d*, light disc. This is divided into two equal parts by a narrow dark band (membrane of Krause, intermediate disc, compare Fig. 3393); *m-c*, muscle corpuscle. The cell body, nucleus, and nucleoli are all very distinct.

Sarcous Substance (*Muscular or Contractile Substance*).—The substance proper of the striated muscular fibres is divided into two constituents: (1) the more or less homogeneous, semiliquid intermediate substance or *sarcoplasm*, corresponding to the hyaloplasm of undifferentiated cells; and (2) the *fibrils* or sarcostyles, corresponding to the spongioplasm or network of many cells. The fibrils are arranged longitudinally, and are believed to be composed of thicker and thinner segments. The space unoccupied by the fibrils is filled by the sarcoplasm. As the thicker segments of the fibrils are opposite one another throughout the entire fibre, there is given the appearance of a dark segment or disc followed by a light segment when the muscle is studied under the microscope with transmitted light. The dark disc corresponds to the thicker part of the fibrils, and the light disc to the thinner part where the sarcoplasm is in greatest abundance. The longitudinal arrangement of the fibrils gives also the appearance of longitudinal striation; but this is usually less marked than the transverse striation. While the appearance of a striated muscular fibre is so evident and characteristic, the finer structure has proved one of the most difficult problems in histology.*

The difficulty of the investigation is greatly increased because it is so hard to distinguish between appearances which may be purely optical and those which are due to structural differentiation. The case is well stated by Bowman (1840): "The improvements which have taken place in the construction of microscopes appear, indeed, to have only afforded grounds for new differences of opinion"; and by Leydig (1885): "The complexity of structure of muscular tissue, and the fineness of its component parts give rise to so many doubts that one is often led to wish that it were possible to go beyond the present attainable enlargement and perfection of the microscopic image." The most varied animals are selected from which to obtain muscular tissue for this most difficult investigation; insects and crustacea are favorite objects, from the distinctness of the structural details in their muscular fibres. No matter what animal is chosen, it is too often assumed that the structure of all striated muscle is identical with that under consideration—an as-

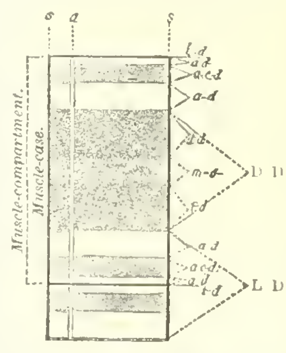

FIG. 3393.—Diagram to Show a Muscle Compartment, a Muscle Case, and the Discs into which a Muscle Compartment is divided, according to some Histologists. Modified from Engelmann. (Drawn by Mrs. Gage.) *Muscle compartment:* This one of the series of segments of which a striated muscular fibre is supposed to be composed. It includes one entire dark disc (*D-D*) and half a light disc at each end of the dark disc. It therefore corresponds in extent to a Bowman's disc. For those who accept the existence of Krause's membrane, it is the part of a muscular fibre between two such successive membranes. *Muscle case:* This, according to Krause, comprehends a sarcous element (muscle prism), with a limited amount of intermediate substance at the sides and ends. The whole case is enclosed by Krause's membrane at the ends, and a special membrane at the sides. In the figure, the muscle case is the part of the muscle compartment between s and *a*; *D-D*, *dark-disc*, composed of two dark bands (*d-d*) separated by a lighter disc (*m-d*), *middle disc of Engelmann*, or Hensen's disc. *L-D*, *light disc*. This is composed of two symmetrical halves, each half forming the end of a muscle compartment. Each half is composed of two light discs (*a-d*), and a granular disc (*ac-d*), the so-called *granular* or *accessory disc*, and the disc *i-d* (*intermediate disc*), the latter forming the boundary between two successive muscle compartments. Krause's membrane is usually said to consist of the intermediate disc and the two adjacent accessory discs, with the light discs between them.

* In the epidermis of *lampreys*, and perhaps also in some other fishes, there are large clavate cells which resemble very strikingly short pieces of striated muscular fibres. Not only is the agreement very marked, both in ordinary and polarized light, but the resistance of these cells to the action of caustic potash is like that of muscular tissue (Max Schultze, Arch. f. Anat. u. Phys., 1861, p. 281).

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sumption which often requires the imagination to fill out details not visible when muscle, other than that taken as the standard, is examined. From his own study, the writer believes that all the appearances described by original observers may be demonstrated, if muscles from a sufficiently great number of animals are studied both before and after the application of a sufficiently large variety of chemical agents, and if a microscope having sufficient range of magnification and excellence of image is employed.

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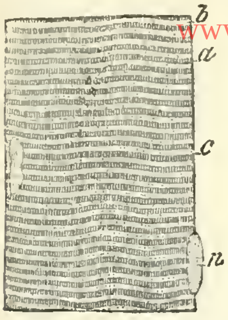

FIG. 3394.—Part of a Muscular Fibre from the Adductor Magnus of a Rabbit, to show the Appearance to an Extended Mammalian Muscular Fibre. Magnified 700 diameters. (Ranvier.) *a*, Dark disc; *b*, Krause's membrane or intermediate disc; *c*, light disc; *n*, muscle corpuscle seen in profile.

It was shown by Bowman,[4] whose paper in the "Philosophical Transactions," 1840, is the most prominent landmark for the histology of striated muscular tissue, that the fibres have a tendency to break up into fine fibrils (*primitive fibrillæ*), which extend parallel with the long axis of the muscle, and appear in structural details like the entire fibre, and that they may also break up into discs which are at right angles to the long axis of the fibre. In breaking into discs (*Bowman's discs*), the plane of cleavage is through the middle of the light disc (Figs. 3392, 3393;) each disc of Bowman is therefore composed of an entire dark disc, with half a light disc at each end. These appearances were considered by Bowman to indicate, not the existence of fibrils and discs in the living muscle, but of minute rounded or angular particles (*Bowman's sarcous elements*), which form the true contractile part of the fibre; and that these are connected together on all sides by a more fluid and non-contractile substance, sarcoplasm—that connecting the sarcous element end to end into fibrils—differing somewhat from that connecting them side by side into discs, as is shown from the fact that the reagents causing the muscle to divide into fibrils do not cause it to break readily into discs, and those causing the fibre to divide into discs do not cause it to break readily into fibrils. When, however, the cementing materials at both the sides and ends give way, the sarcous or ultimate elements of the fibre are, according to Bowman, isolated. Bowman's views were so simple, and so in accordance with observed facts, that they were almost universally accepted. There is, however, great difficulty in deciding what should be considered a primitive fibril composed of a single row of sarcous elements placed end to end, as it is possible to separate a fibre into fibrils so small that the structural characters are difficult of determination. The term *sarcous element*, to indicate the ultimate structural and contractile part of a muscular fibre, has been retained by most histologists, although the interpretation of what constitutes a sarcous element varies with almost every original investigator.

The following are a few of the more important modifications or enlargements of the views of Bowman upon the intimate structure of striated muscular tissue:

(A) *Action of Polarized Light.*—It was shown by Bruecke (1857) that the sarcous elements of striated muscular tissue are *anisotropic* (doubly refractive), and act like positive uniaxial crystals, while the intermediate substance is *isotropic* (singly refractive). As the sarcous elements retain their anisotropic character apparently unchanged during the shortening and broadening of contraction, Bruecke supposed that they were not simple but compound bodies, and he applied the term *disdiaclasts* to what he considered the elementary particles composing the sarcous elements, thus borrowing the terminology of Bertholin, who used this term to designate the hypothetical crystals of calc spar. On the whole, it cannot be said, however, that polarized light has been of material aid in comprehending the structure and action of muscular tissue.

(B) *Muscle Compartments, Additional Discs.*—It was shown by Bowman that, in addition to the broad light and broad dark discs, there sometimes appeared a narrow, dark line in the light disc and a narrow light band in the dark disc (Fig. 3392). The dark line in the light disc was also figured and described by Busk and Huxley, who considered it a disc composed of a row of minute sarcous elements. It has also been insisted on by Sharpey and Martyn, and later by Krause. Krause interpreted it as a continuous membrane (*Krause's membrane*, intermediate disc), extending from the sarcolemma and dividing the muscular substance into compartments (*muscle compartments*) which apparently correspond exactly in extent to the discs of Bowman (Fig. 3392). The view that Krause's membrane is a real structure, which extends from the sarcolemma through the fibre, thus making a complete partition, is supported by the fact that when the sarcolemma of insect muscle is partly torn from the fibre, delicate processes are often seen to extend to or toward the sarcous substance from the sarcolemma opposite the middle of the light disc. This appearance has not been observed and figured for mammalian muscle. The view of a continuous membrane making a partition in the fibre at regular intervals is opposed by the fact that a worm has been seen to move along within the sarcous substance from end to end of the fibre. Furthermore, the sarcous substance of the fibre closed up behind the worm, and the fibre appeared as before and still showed unmistakable contractions. Also, that in living and contractile muscular fibres of insects, which are apparently uninjured, the discs sometimes become displaced for a short distance along a sharp line, so that a dark disc is opposite a light disc. The displacement of the discs is shown in Fig. 3392, but here it might have been due to the traction exerted in preparation, and hence does not bear upon this question as does the displacement of the discs in the living and uninjured fibre.

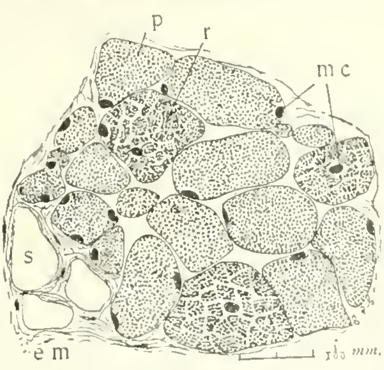

FIG. 3395.—Fascicle of Human Striated Muscle to show the Diversity in Size of Fibres, the Muscle Columns, and the Position of the Nuclei. (Drawn by Mrs. Gage.) Magnified about 350 diameters. *em*, Endomysium or connective tissue between the individual muscular fibres. In the lower left-hand corner some of the fibres are absent, the endomysium alone showing. *mc*, Muscle corpuscles. In muscular fibres with much sarcoplasm and evident muscle columns, some of the nuclei are in the middle of the fibre instead of at the surface; *p*, pale fibre with evenly distributed fibrils, and little sarcoplasm, and the nuclei all at the surface; *r*, red fibres showing abundant sarcoplasm and evident muscle columns. Some of the nuclei are in the middle of the red fibres; *s*, spaces from which the muscle fibres have been removed to show clearly the surrounding endomysium.

Besides the discs just considered, German investigators have described others which are shown in the diagram (Fig. 3393).

(C) *Muscle Cases.*—Besides the muscle compartments Krause considers that each sarcous element (muscle prism) is entirely enclosed by a membrane (Krause's membrane) forming the end, and a special membrane forming the sides (Fig. 3393).

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(D) *Cohnheim's Areas, Muscle Columns.*—Cohnheim, in 1863, showed that in transections of frozen muscular fibres, there appeared dark polygonal areas (Cohnheim's areas), surrounded by narrow light lines. He supposed that the dark areas were the cut ends of sarcous elements, and the light intermediate substance was the lateral cementing material. It was found, however, that a Cohnheim's area might be far too large to represent a section of a single sarcous element, and the area often showed a punctated appearance, hence arose the conception that in a striated muscular fibre the fibrils are arranged in bundles (*muscle columns*, Kölliker; *primitive muscular cylinders*, Leydig, Fig. 3386), something as an entire muscle is made up of fascicles (Fig. 3382), and that Cohnheim's areas represent sections of the bundles of fibrils (muscle columns), so that a transection of an entire muscular fibre has the same general appearance as the transection of an entire muscle. This is most striking in fibres with a large amount of sarcoplasm (Fig. 3395).

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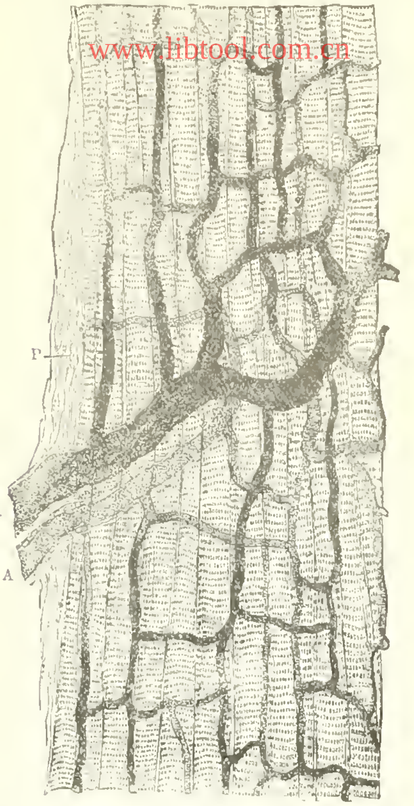

Fig. 3396. Blood-Vessels of Striated Muscular Tissue. From a cat. Magnified 300 diameters. (Heitzmann.) *A*, Artery; *P*, perimysium; *V*, vein.

(E) *The Reticulated Arrangement of Contractile Substance.*—Heitzmann[9] (1873) introduced a new idea as to the structure of striated muscular tissue—viz., that, like simple protoplasm, the sarcous substance is made up of a reticulum of the true contractile matter, the meshes of this reticulum being filled by a more fluid intermediate substance. According to this view, the reticulum is so arranged that the nodal or crossing points (sarcous elements) are at regular intervals both transversely and longitudinally, the transverse row giving the appearance of a continuous dark disc, and the longitudinal row of a fibril. The light disc is traversed by the filaments of the reticulum, which pass between the nodal points. This hypothesis, with unimportant modifications, is now adopted by many histologists, and appears to be most in harmony with the latest views concerning histological structure.

(F) *Red and Pale Muscle.*—It has been known for a long time that some muscles, independent of their contained blood, are red and others pale. Ranvier[14] drew especial attention to this fact and pointed out an easy object for study in the semitendinosus of the rabbit for red muscle and the semimembranosus for pale muscle. Structurally the red muscle is characterized by abundant sarcoplasm, so that the fibrils are not very compact; the nuclei are not all at the surface, but some of them are between the well-marked muscle columns. The longitudinal striation is evident. With pale muscle the sarcoplasm is relatively small in amount, the nuclei are at the surface and the longitudinal striation is not well marked. In man the red and pale fibres are frequently intermixed in the same muscle (Fig. 3395). Muscle tissue called upon for almost constant contraction, like the diaphragm, has also much sarcoplasm.

Vascular Supply of Striated Muscle.—As in other tissues, the blood- and lymph vessels of muscular tissue do not enter the structural elements or fibres, but are in the connective tissue surrounding them.

(A) *Blood-vessels.*—The blood-vessels of this tissue are very numerous, and are estimated to contain one-fourth of the blood in the entire body. As a rule, each muscle receives two or more arteries, and gives off a corresponding number of veins. The larger vessels run in the perimysium, and send small branches into the fascicles, where they break up into a characteristic, parallelogrammic network of fine capillaries, the longer part of the mesh extending parallel with the fibres. The capillaries are the smallest in the body, many of them being smaller than the blood corpuscles of the animal to which they belong. In man the size varies from 3.5 μ to 6.5 μ (Kölliker, 1867) (Figs. 3382, 3396). It was shown by Ranvier that in red muscle the transverse branches of the capillary network and the smallest veins often possess saccular dilatations which are supposed to serve as reservoirs of oxygenated blood to supply the muscles during a long-continued contraction, or to act as receptacles during a maximal contraction.

(B) *Lymphatic Vessels.*—The lymphatic vessels of striated muscular tissue are supposed to be numerous. They lie between the fibres in the perimysium and endomysium, and are said by Klein "to have the shape of continuous long clefts or channels."

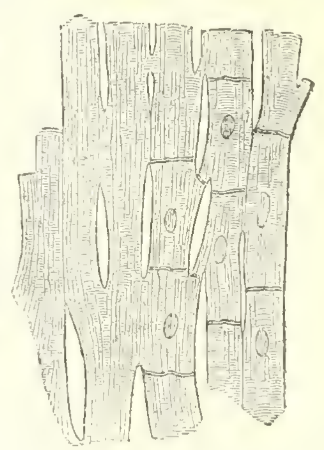

Fig. 3397.—Cardiac Muscular Tissue from a Warm-blooded Animal, to show the Form, Branches, and Relations of the Cardiac Muscle Cells. On the right the limits of the separate cells with their nuclei are exhibited somewhat diagrammatically. Magnified. (Schweiger-Seidel.)

Nerves of Striated Muscle.—The nervous supply of striated muscle is exceedingly abundant, and consists of both motor and sensory fibres. The special terminations of the nerves in the tissue will be considered under Nerves (*q.v.*).

Muscle Spindles.—Bodies of fusiform shape discovered by Kölliker[11] (1862) in the breast muscle of frogs. About the same time Kühne found similar bodies in mammalian muscles. It was discovered also that these spindle-shaped bodies contained one or more striated muscle fibres. The muscle fibres within the spindle were named by Kölliker, Weismann's fibres, in honor of their discoverer. The more common designation, however, is *intrafusal fibres*.

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A muscle spindle consists of a thick, fusiform envelope of laminated fibrous tissue, somewhat comparable with the capsule of the Pacinian bodies. In the long axis of this fusiform envelope, and frequently passing through its entire extent, is a bundle of small muscle fibres. Entering at one of the poles and near the middle two or more nerve fibres join the spindle. The sheath of Henle of the nerve fuses with the wall of the spindle. Blood-vessels and lymphatics are also present (Fig. 3400).

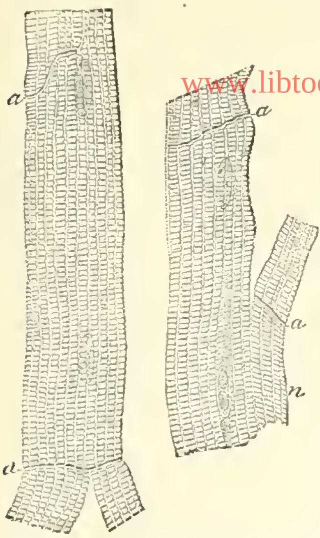

FIG. 3398.—Cardiac Muscle Cells of the Left Ventricle of a Dog, showing the Form, Branches, Nuclei, and striæ of the Cells. The longitudinal, transversely striated bands in each cell represent muscle columns. Magnified 600 diameters. (Ranvier.) *a*, Intercellular cement at the junction of the cells; *n*, nucleus. The one opposite the *n* shows a conical mass of unstriated protoplasm at each end.

These muscle spindles are most frequently found near a nerve and a blood-vessel (Fig. 3411, *D*). In mammals they vary from 1.5 to 10 mm. in length, and from 0.15 to 0.4 mm. in diameter. Sometimes the spindles are compound, two or three being placed side by side, or end to end.

The muscular fibres (intrafusal fibres) in a spindle vary in number from one to twenty; but a number varying from three to ten is most common in mammalian muscle. In size they are usually much smaller than the ordinary fibres of the muscle in which they are situated. This is more marked in adult than in new-born animals. The size of the intrafusal fibres varies from about 5 μ to 20 μ in diameter. They are characterized by coarser striation and the nuclei are in many cases in the middle of the fibre instead of at the circumference. Frequently also in the middle of the spindle the nuclei are so numerous that the striation is lost or obscured (Fig. 3400, *A*).

FIG. 3399.—Cardiac Muscle Cells, showing their Form, Branches, Nuclei, and Striæ. From the heart of a young rabbit.* Magnified 425 diameters. (Schaefer.) *a*, Line of junction between the cells (intercellular cement); *b*, *c*, branches of the cells.

The significance of these bodies has been much discussed, and various conclusions have been reached. Experiments by Sherrington and others make it almost certain that the bodies are innervated by both motor and sensory nerves, and the belief is becoming general that they are in some way connected with the muscular sense (Batten[2]) (Huber and DeWitt[20]).

CARDIAC MUSCULAR TISSUE.—*Distribution.*—Cardiac muscular tissue is present in the heart of all vertebrates, and, so far as has been investigated, in all those parts of the blood-vascular system exhibiting rhythmical pulsations, as the *conus arteriosus* of amphibia and many fishes, and the great veins next the heart in mammals.*

In the cold-blooded animals, fishes, amphibia, and reptiles, cardiac muscular tissue is composed of striated cells which are much longer than broad, and which as a rule are considerably branched and contain a single nucleus (Figs. 3401–3404).

In warm-blooded animals—birds and mammals—cardiac muscular tissue is in the form of anastomosing segments or fibres with nuclei at more or less regular intervals along the fibres.

By caustic potash and other dissociating agents it is easy, in the new-born and young, to separate the cardiac meshwork into segments which are usually branched and with a single or double nucleus in each segment (Figs. 3399, 3413–3415). These segments with their branches have the appearance of cells, and are so considered by

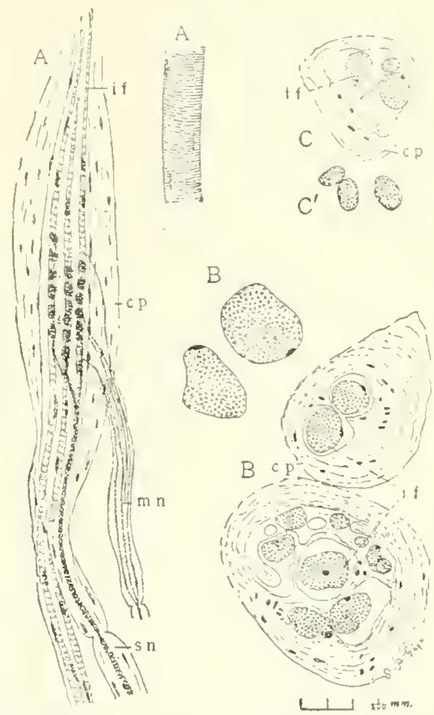

FIG. 3400.—Muscle Spindles. (Drawn by Mrs. Gage.) *A*, Longitudinal view of a muscle spindle from the striated muscle of the rabbit (modified from Kölliker); *cp*, connective-tissue capsule with nuclei; *if*, intrafusal striated muscular fibres in the long axis of the spindle—near the middle they are thickly nucleated; *mn*, motor nerve distributed to the spindle; *sn*, sensory nerve entering near the pole of the spindle. The sensory nerve is usually very large. *A′*, An ordinary muscular fibre of the rabbit drawn at the same scale as the spindle to show the comparative size and fineness of striation. *B*, Transection of a compound muscle spindle from the human sartorius magnified 350 diameters (*cf.* Fig. 3410, *D*); *if*, intrafusal muscular fibres. Two were present in the upper and nine in the lower spindle; the diversity in size is well shown in the lower spindle; *cp*, connective-tissue capsule of the spindle, this appears to be composed of nucleated laminæ something as in the Pacinian bodies. *B′*, Two ordinary striated fibres near the spindle and drawn at the same scale for comparison. *C*, Transection of a muscle spindle from the sartorius of a child at birth. Magnified 350 diameters (*cf.* Fig. 3410, *C*); *if*, intrafusal fibres; *cp*, connective-tissue envelope or capsule. *C′*, Three ordinary muscular fibres near the spindle and drawn at the same scale for comparison. They are no larger than the intrafusal fibres.

most anatomists. In the adult it is much less easy to separate the heart muscle into these cell-like masses. In sections parallel with the so-called fibres, appearances

* This figure appeared in Quain's "Anatomy," eighth edition, p. 119, but the source was not given. On inquiry, Dr. Schaefer informed the writer that the cells are from the heart of a young rabbit.

* According to the investigations of Ranvier, the muscular tissue of the rhythmically pulsating *lymph hearts of amphibia* is in structure like the ordinary skeletal muscles, except for a greater tendency to branch; also, like the skeletal muscles, its motor nerves are paralyzed by curare.

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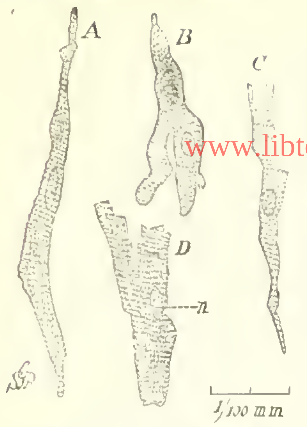

FIG. 3401.—Cardiac Muscle Cells from the Ventricle of a Minnow, to show the Forms of the Cells with their Branches, Nuclei, and Striæ in the *Teleostean Fishes*. *A*, Cell approximately fusiform in outline; *B*, branched cell, which appears granular rather than regularly striated; *C*, cell with depression, in which a rounded end like the branch of *B* fits when the cells are in their normal relations (compare the middle cell and its relations in Fig. 3415); *D*, cell approximating in shape the cardiac muscle-cells of warm-blooded animals; *n*, nucleus. In cells *A*, *C*, the transverse striæ distinctly cross the nucleus.

like those in Fig. 3397 are readily obtained if one omits the apparent division into cells. In the adult, the heart seems to be made up of a sponge-work of muscle substance. It is believed by some of the later investigators (v. Ebner and Heidenhain) that in the course of development the muscle cells form a kind of syncytium, and that in the adult at least no true cell boundaries are present.

Intimate Structure.—Whatever may be the true interpretation of the cellular nature of adult heart muscle, the intimate structure is comparable with red rather than with pale skeletal muscle, that is, the sarcoplasm is relatively abundant, and the longitudinal striation usually quite evident. The nuclei are always in the muscle substance and not at the surface (Fig. 3405).

A *sarcolemma* like that of skeletal muscle is not present, but the large amount of sarcoplasm forms not only a mass within the fibre but a kind of mantle over the surface, and this gives the appearance of a sarcolemma. As the so-called Krause's membrane seems to pass from the surface of this sarcoplasmic mantle across the muscle substance, the likeness is quite striking to insect muscle. The sarcoplasmic mantle is often

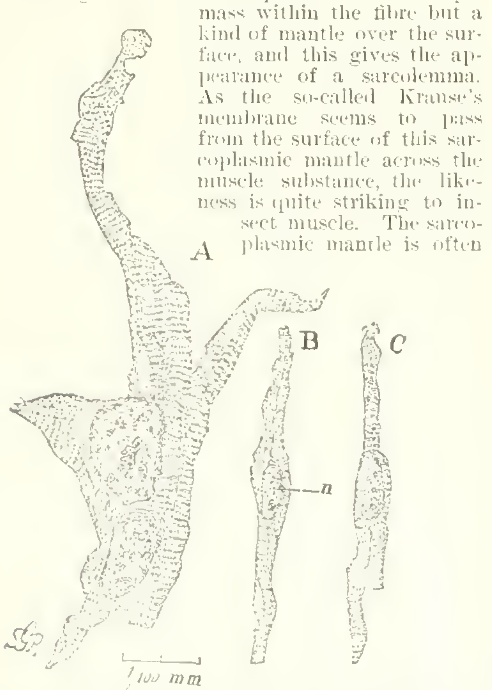

FIG. 3402.—Cardiac Muscle Cells from the Ventricle of *Necturus lateralis*, to show the Various Forms of Cells and their Structural Details in a *Perennibranchiate Amphibian*. *A*, Large branched cell with two nuclei which contain numerous nucleoli. Near the end of the longest branch the regular transverse striation is replaced by irregularly arranged granules. Large cells like this are common in the heart of *Necturus*; they are plate-like, as was determined by a profile view; *B*, *C*, cells of approximately the same thickness as breadth; they form the great bulk of the heart, and usually are branched; *n*, nucleus with nucleoli.

wavy also, and the Krause's or intermediate membrane seems to be attached to the hollow of the wave.

Blood- and Lymph Vessels of Cardiac Muscular Tissue.—The vascular supply of this tissue is very copious. The cardiac muscle cells are enclosed in a parallelogrammic network of capillaries, and the rootlets of its veins are formed by the union of several capillaries at the same point. The larger veins possess valves in man and the higher mammals at least. The lymphatics are numerous and consist of passages and spaces in the intermuscular connective tissue (perimysium) which communicate with the subpericardial lymph vessels.

Nerves of Cardiac Muscular Tissue.—Myelinic and amyelinic nerve fibres and small ganglia are very numerous

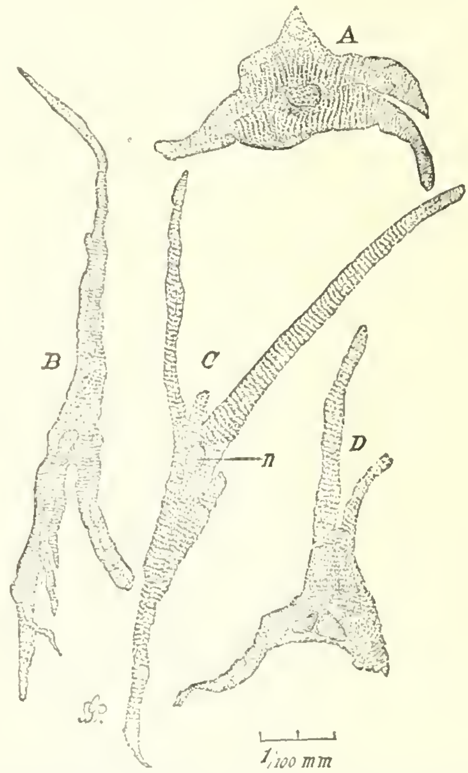

FIG. 3403.—Cardiac Muscle Cells from the Ventricle of a Toad (*Bufo lentiginosus*), to show the Various Forms of Cells and their Structural Details in an *Anourous Amphibian*. The striation is rather fine throughout, and toward the ends is, in many cases, replaced by irregularly arranged granules. *A*, *D*, Broad-branched cells. Cells of this kind are plate-like, as was determined by causing them to roll over so that a profile view could be obtained; *B*, *C*, branched cells of approximately the same thickness as width. Both these cells would be nearly fusiform if the lateral branches were removed; *n*, nucleus. In *D*, two nuclei are present.

in the heart. The fibres extend in every direction between the muscle fibres. The special mode of their termination will be discussed under *Nerves* (*q.v.*).

SMOOTH OR UNSTRIATED MUSCULAR TISSUE.—This is the contractile tissue in the animal body, composed of elongated, mostly uninucleated, fusiform cells or fibres, which are arranged in membranes, sheets, plexuses, or scattered bundles, in the various organs.

Distribution.—This tissue is present in many invertebrates and in all the classes of vertebrates. In man and most mammals it is found in the following situations: (A) *Throughout the alimentary canal*: (1) muscularis mucosæ; (2) muscular coats of the stomach and intestines, part of the œsophagus, and in the œsophageal accessory muscles; (3) as membranes or scattered bundles in the ducts of the salivary glands, in those of the pancreas and of the liver, in the intestinal villi, and in the gall-bladder.

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(B) *Respiratory organs:* in the trachea, bronchi, infundibula, and, according to some authors, in the alveoli of the lungs. (C) *Urinary organs:* in the medullary portion of the kidney (Jardet[10]), in the calyces and pelvis of the kidney, in the ureter, urinary bladder, and urethra. (D) *The generative apparatus:* (1) *male*, in the dartos of the scrotum, epididymis, vas deferens, vesiculæ seminales and musculi ejaculatorii, prostate, Cowper's glands, and the corpora cavernosa; (2) *female*, in the ovary, Fallopian tubes (oviducts), in the uterus and all its ligaments, in the vagina, corpora cavernosa; in the nipples, and the surrounding areolæ. (E) *Vascular system:* in the endocardium, semilunar valves, middle coat of almost all the blood-vessels and larger lymphatics, in the adventitia of some arteries and veins, and in some of the lymphatic glands. (F) In the capsule, and in many mammals also in the trabeculæ of the spleen. (G) *In the skin* in connection with the sweat and ceruminous glands, and forming the arrector pili. (H) *In the eye and its vicinity*, the *musculus orbitalis et palpebralis* of H. Mueller, in the orbital fissure and forming the ciliary muscle (tensor choroideæ or muscle of accommodation), the sphincter and dilator of the pupil.

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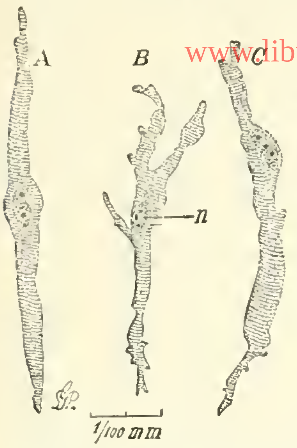

FIG. 3404.—Cardiac Muscle Cells from the Ventricle of a Young Alligator, to show the Various Forms of Cardiac Muscle cells and their Structural Details in the Heart of a Reptile. *A*, Fusiform cell; *B*, *C*, branched cells. These make up nearly the entire mass of the heart, very few being simple spindles like *A*; *n*, nucleus in which the nucleoli are very distinct.

Figs. 3401 to 3404 are at a uniform magnification of 500 diameters. The drawings were made with a camera lucida, and the finer details of structure were determined with a $\frac{1}{18}$ homogeneous immersion objective, and added free-hand. (Drawn by Mrs. Gage.)

Constituents of Unstriated Muscular Tissue.—These are: (A) The contractile or muscular fibre cells or fibres forming the essential elements. (B) Connective tissue forming a kind of perimysium which surrounds the muscular tissue and, penetrating between the fibres, combines them into bundles. (C) Blood- and lymph vessels and nerves.

Relations of the Fibres.—The fibres forming a bundle or fascicle are cemented to one another throughout their entire extent, lapping and interlacing so that apparently solid bundles or membranes without fissures are formed (Fig. 3406). As a rule, there are no distinct tendons for unstriated muscular tissue, since in muscular membranes which entirely surround an organ, tendons would be unnecessary; and in other cases the close relations of the fibres to the surrounding fibrous tissue, and the commingling of its perimysium with the surrounding fibrous tissue, serves to connect the muscles to the part to be acted upon. In special and rare cases, tendons appear to be formed by the insertion of single unstriated fibres into the fork of an elastic tissue fibre.

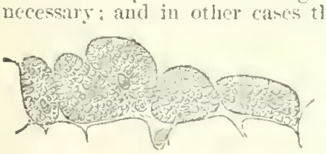

FIG. 3405.—Transection of Five Cardiac Muscle Cells, to show the Form and Relations of the Cells in Section, and the Central Position of the Nucleus in Three of Them. In the other two the section was not at the level of the nucleus. The minute dark areas in the cells represent sections of muscle columns (Cohnheim's areas). Magnified 550 diameters. (Ranvier.)

Intimate Structure of Smooth or Unstriated Muscular Fibres (muscular or contractile fibre cells, smooth or plain muscular fibres or muscle cells, non-striped or non striated muscular fibres, unstriped or unstriated muscular fibres or muscle cells, involuntary muscular fibres, fibre cells, or muscle cells). As stated above, smooth or unstriated muscular tissue is composed of special fibres or cells which form the essential and contractile part of the tissue. They are also its anatomical or structural elements, and are in general fusiform, sometimes branched, and usually contain but a single nucleus (Figs. 3406, 3409). The fibres vary greatly in size, ranging from 30 μ long and 4 μ wide to 230 μ long and 15 μ wide. In the gravid uterus they may attain a length of 500 μ. Those of the vascular system are usually smaller than those in other situations, and they are almost invariably of very irregular outline (Fig. 3408).

Nucleus.—The nucleus is usually oval in outline (rod-shaped in those of the vascular system), and averages about 15 μ to 20 μ long and 4 μ to 10 μ wide. It extends lengthwise of the cell, and often contains one or more nucleoli (Figs. 3406, 3408, and 3409). A complex intranuclear network has been described by recent authors. At each end of the nucleus there is in many cases a conical mass of granular matter; this is supposed to be protoplasm not yet differentiated into contractile substance.

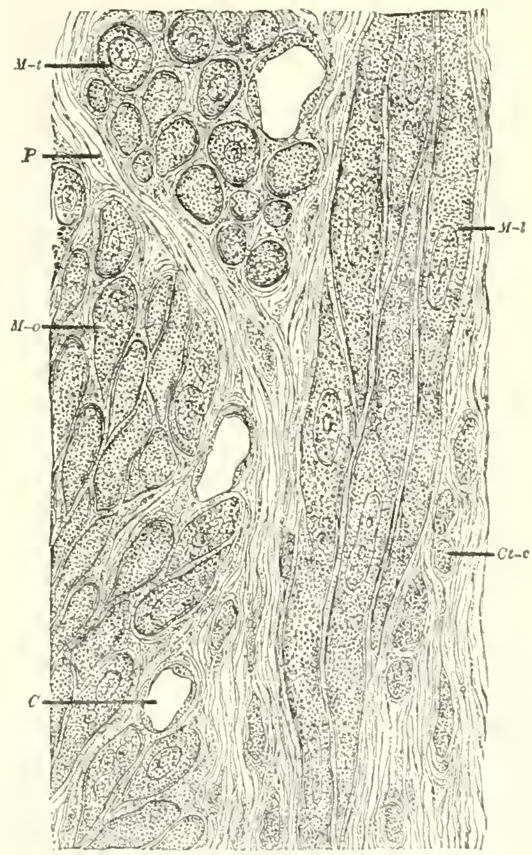

FIG. 3406.—To show the Form and Relations of Smooth Muscular Fibres in their Length and in Direct and Oblique Sections. From the human uterus shortly after delivery. Magnified 500 diameters. (Heitzmann.) *C*, Capillary (the cut ends of two other vessels are shown in the figure; *Ct-c*, connective-tissue corpuscle, or plastid in the perimysium; *M-l*, smooth or unstriated muscular fibres shown lengthwise and in their normal relations to one another; *M-o*, ends of smooth muscular fibres cut obliquely; *M-t*, ends of smooth muscular fibres cut transversely; *P*, perimysium, or interstitial connective tissue.

Contractile Substance of the Smooth or Unstriated Muscular Fibres.—In the fresh condition, and after many methods of preparation, the smooth muscular fibres appear homogeneous, except for a few scattered granules, the nucleus, and the slight amount of granular matter at

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its ends. Under favorable conditions of preparation and light, the body of the fibre appears no longer homogeneous but distinctly fibrillated, the fibrils extending parallel with the long axis of the fibre, and being therefore of varying length (Fig. 3409). They are very fine and appear like a skein of thread, being in many superimposed layers, and not in a single layer, as is shown in Fig. 3409. These fibrils are supposed to be the true contractile parts of the fibre. Between them is a limited amount of clear intermediate substance. According to some authors, the fibrils are directly connected with the intranuclear network.

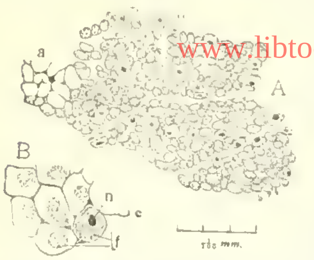

FIG. 3407. Transection of Part of the Circular Muscular Coat of the Human Duodenum. (Drawn by Mrs. Gage.) This shows the cut ends of the plain muscular fibres and their combination into fascicles. Magnified about 350 diameters. *A*, Camera lucida drawing; *a*, connective tissue between the fibres, the fibres having fallen out—it is a kind of endomysium; *n*, nucleus. A nucleus appears in only part of the cells as only a few are at the level of the section. Compare the longitudinal views in Figs. 3406, 3408, and 3409. *B*, Enlarged view to show the connective tissue between the cells and that the muscle fibres have shrunken considerably. The one at the left is shown unshrunken. *c*, connective tissue between the fibres; *f*, muscle fibres, one shrunken and one unshrunken; *n*, nucleus in the unshrunken fibre.

Sarcolemma. — A thin, homogeneous, elastic sheath or sarcolemma is described by some authors as enclosing the individual smooth muscular fibres (Fig. 3409, *B*). An equal, or greater, number of authors deny the presence of a special envelope or sarcolemma for the smooth muscular fibres of vertebrates.

Blood- and Lymph Vessels of Unstriated Muscular Tissue. —The blood-vessels are less numerous than those of the striated muscles, but they have the same general arrangement, the capillaries forming a network with square or parallelogrammic meshes. The lymphatic vessels have been most investigated in the muscular tissue of the uterus and intestine, where they are in the form of passages and lacunæ which anastomose between the fibres.

Nerves of Smooth or Unstriated Muscular Tissue.—These are abundant and consist of myelinic and amyelinic fibres, which are in many situations in the form of a plexus with ganglia. The special distribution to the individual muscular fibres, and the termination of the nerves, will be discussed under *Nerves* (*q.v.*).

FIG. 3408.—Smooth or Unstriated Muscular Fibres of the Vascular System, to show their Irregular Form and the Rod-shaped Nucleus. From the thyroid artery of man. Magnified 340 diameters. (Schaefer.) *n*, Nucleus.

HISTOGENESIS OF MUSCULAR TISSUE.—Muscular tissue of all forms in vertebrates is developed from cells of the mesoderm or middle germinal layer. The cells are at first rounded and indistinguishable from others of the mesoderm. It is only later, when approximately in the position of the future muscle, that they assume the characteristic form and appearance of the structural elements of the special kind of muscular tissue to which they give rise.

Histogenesis of Striated, Skeletal Muscular Tissue.—The muscles of the trunk are without doubt mainly or entirely derived from special masses of mesodermal cells—*muscle plates* or *myotomes* (*protovertebræ* of older writers). These appear on the dorsal aspect of the embryo, and give it the first appearance of being composed of a series of segments. According to some writers, all the skeletal muscles are derived from the muscle plates, those of the limbs being outgrowths or diverticula of the muscle plates; but working over an exceptionally large collection of human and mammalian embryos of all ages, Bardeen and Lewis[1] could in no case demonstrate definite processes of the myotomes growing into the limb buds. They do not deny the possibility of the entrance of scattered cells from the myotomes entering the limb protons, but the appearance is that the muscles of the limbs arise by a differentiation of a part of the mesenchyma, making up so large a part of the developing limbs.

Cellular Origin of the Muscular Fibres.—All are agreed that the muscular fibres are derived from mesodermal cells; but there are two views as to the number of cells entering into the formation of a single muscular fibre. These are: (A) That they are *multicellular in origin.* This view originated with Schwann,[15] and is at present held by a considerable number of investigators. It teaches that each striated muscular fibre arises by the fusion of several cells arranged in a row, the nuclei of the fused cells remaining as the muscle corpuscles. The entire fibre is therefore, according to this view, a multicellular structure or *cell complex.* (B) That they are *unicellular in origin.* This view originated with Remak,[15] and is the one adhered to by most later writers. It holds that each striated muscular fibre originates from a single cell, the nucleus of which divides repeatedly with the growth of the cell. According to this view, the muscle corpuscles are formed by the division of the original nucleus, and the entire fibre is an enormous *multinuclear cell.*

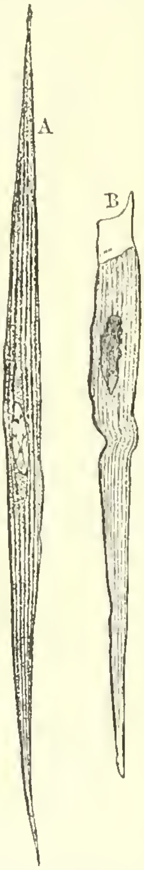

FIG. 3409.—Smooth, or Unstriated Muscular Fibres, to show the Fibrillated Structure and the Intranuclear Network. From the small intestine. Highly magnified. (Schaefer.) *A*, An entire cell or fibre, showing the fusiform shape, the longitudinal fibrillation, the oval nucleus with its intranuclear network, and the conical mass of granular protoplasm at each end of the nucleus. The fibrillæ appear coarse and as if in a single layer; in an actual specimen they are very fine and in many superimposed layers. *B*, A broken fibre, to show the presence of a sheath-like covering or sarcolemma projecting like a hollow sac from the broken end.

Whether the muscular fibres are of multicellular or unicellular origin, the later course of development is as follows: The elongated granular spindles, which are to become muscle fibres, show first a faint longitudinal striation at the entire periphery or at one side, and later a transverse striation; or the two striations appear simultaneously. The nuclei and the unstriated protoplasm occupy the centre or one side of the fibre (Fig. 3412). Gradually the entire protoplasm becomes striated, and in birds and mammals most of the nuclei reach the surface of the fibre; but in the cold-blooded vertebrates they are scattered throughout its entire thickness. Glycogen is very abundant during the later stages of development.

Sarcolemma.—According to Schwann, this is formed by a union of the cell walls of all the cells originating the fibre, the parts of the cell walls which originally came in contact in the interior having disappeared. Others hold that this is the cell wall of the single cell originating the fibre; and still others agree with Busk and Huxley that in the earlier stages of development nothing like a cell wall or

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sarcolemma is present, but that it is an after development, and arises by a transformation of the protoplasm at the surface of the fibre into formed material or a kind of cuticula. The view of Busk and Huxley seems to be most in accordance with the general teachings of histogenesis and growth.

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Growth and Fluctuation in Size of Striated Muscular Fibres.—There are two marked changes in muscular fibres during their development in the embryo: (1) The cells pass from the ordinary reticulated condition of protoplasmic cells to the striated condition; (2) they increase in number until about the time of birth, and the sarcoplasm or undifferentiated part of the cell grows proportionally less, and the striated part gradually greater in amount, while the nuclei increase in number, and in mammals and birds gradually migrate to the surface.

Fig. 3410.—Sections of the Human Sartorius Muscle at Different Ages to Indicate the Change in Size. (Drawn by Mrs. Gage.) The sections were made through the proximal (upper) third in each case, and all were photographed at exactly the same scale. The drawings are from tracings directly from the photographs. The sections are placed with the corresponding edges looking in the same direction. Magnified about 4.5 diameters. *A*, Section from a fœtus 92 mm. long; *B*, section from a fœtus 140 mm. long; *C*, section from a female child at birth; *D*, section of the sartorius of a woman seventy-two years old; *ms*, muscle spindles. There are eight of these in this cross section. Their position is indicated in solid black (*cf*. Fig. 3382 and 3400).

The fibres at about the time of birth are more uniform in diameter than in earlier stages or in the adult (Fig. 3411, *A–D*).

Until recently investigations have not been made to determine whether the increase in the total size of a muscle from the new-born to the adult was due to an increase in the size only of the individual fibres or to an increase *both in size and in number*. That the size of the individual fibres is greatly increased (three to five times) is very evident to any one who examines new-born and adult muscle under the microscope (3411, *C–D*). But whether or not the fibres are increased in number as well as in size with the increase in bulk from the embryo to the adult (Fig. 3411), requires a most laborious investigation, and it is necessary in the investigation to keep in mind the possible difference in size of a fibre at different parts of its length, and to the fact that many fibres end by pointed or branched terminations wholly within the muscle, never reaching either tendon of origin or of insertion (Figs. 3388, 3389); also to the possible longitudinal shifting of fibres during the growth of the muscle in length. During the last five years careful investigations have been undertaken by Meek[13] and by MacCallum[12] to determine the changes taking place from birth to maturity. The work of Meek was directed to the lower animals with special reference to the elucidation of the principles underlying the most economical and satisfactory rearing of animals for food. He found that during growth there was an actual lessening, in a given cross section, of the number of fibres in a muscle, amounting in many cases to more than one-half.

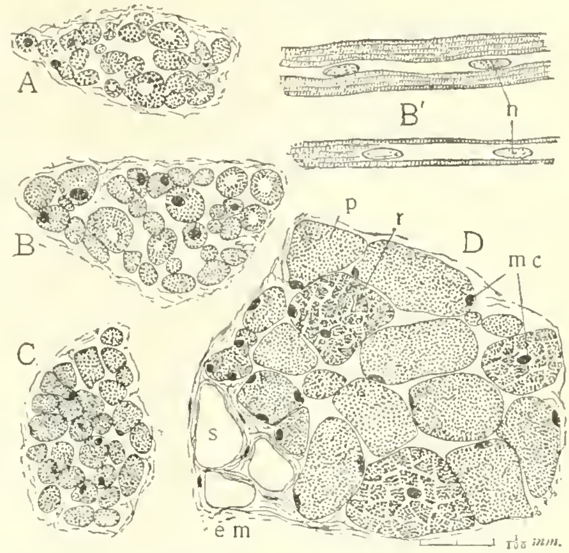

Fig. 3411.—Sections to show Fascicles of Striated Muscle at Different Stages of Development. (Drawn by Mrs. Gage.) Magnified about 350 diameters. *A*, Transection of a fascicle of the sartorius of a human fœtus 92 mm. long; *B*, fascicle of the sartorius of a human fœtus 140 mm. long; *B′*, two fibres from *B* in longitudinal section to show the striation of the fibrils and the central nuclei (*n*); *C*, transection of a fascicle of the sartorius muscle of a female child at birth. Here the nuclei are at the surface in most cases, and the fibres are more compact and more uniform in size than in *A*, *B*, or *D*; *D*, transection of a fascicle of the sartorius of a woman seventy-two years old. It will be noted that the fibres show great diversity in size. The drawing is diagrammatic only in showing some red fibres with abundant sarcoplasm. In the original the fibres were all of the pale variety. *em*, Endomysium surrounding the fibres; *mc*, muscle corpuscles; *p*, pale fibre with evenly distributed sarcoplasm and fibrils; *r*, red fibres with abundant sarcoplasm and evident muscle columns.

In the following table the kitten at nine days is taken as representing the normal number of fibres—one hundred per cent. It will be noticed that the number of fibres in a given cross section of a muscle decreases as the age increases, and that the mother possessed the smallest

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number of fibres, although the sectional area of the muscle was very much greater than that in any of the kittens. The results obtained from the vole, rat, and sheep were equally striking.

Table of the Number of Striated Muscular Fibres in a Cross Section of the Biceps Brachii of the Cat (Felis domestica) at Different Ages. All from the Same Family. (Meek.[13])

Age.	Sex.	Area of section.	Number of fibres.	Percentage of fibres.
9 days	Male	8.4 mm.	83,514	100
20 days	Male	8.1 mm.	64,108	77
240 days	Female	22.8 mm.	37,830	45
3 years 5 months.	Female (mother of above).	41.5 mm.	32,039	38

In the investigations of MacCallum on human muscle, especially the *sartorius*, while a marked decrease in fibres was not noticed, it was brought out with great clearness that the increase in cross section of the muscle was due to the increase in size of the individual fibres, and not to an increase in number. Naturally an investigation of this kind is not so satisfactory on human beings as the same rigorous methods cannot be adopted as with the lower animals, where a whole family may be investigated. Individual variation within a single litter is considerable, but where specimens must be taken from different families, the variation would naturally be greater.

In the lower animals it was found that the decrease in number was greater with a muscle called upon for great exertion than in one less actively employed; and as a natural sequence, the muscles of the right side showed a greater decrease in fibres than the corresponding muscles of the left side, although the actual bulk of the muscles on the right is usually greater than that on the left.

The conclusions of Meek are as follows: "Up to the time of birth, in at any rate the higher mammals, perhaps in all *vertebrata*, hyperplasia characterizes the growth of muscle; while after or about birth hyperplasia ceases, and extra-uterine life brings about a selection of some of the fibres at the expense of their neighbors. In other words, during extra-uterine life muscle, according to its position, suffers more or less a reduction in the number of its fibres, the degree of which is expressive of its functional importance. The surviving elements are at the same time greatly hypertrophied, and the extent to which this takes place is also expressive of the work which the muscle performs, or of which it is capable."

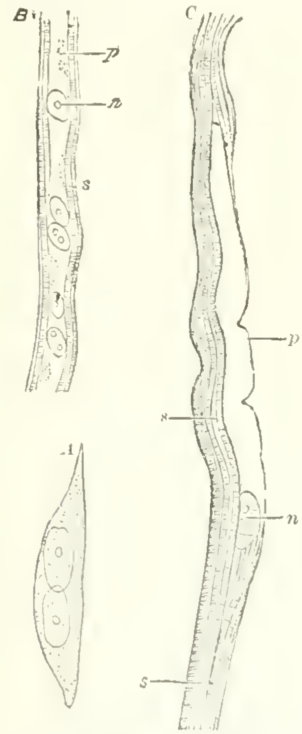

Fig. 3412.—Developing Striated Muscular Fibres, showing Different Stages of Development and Different Positions of the Unstriated Protoplasm. *A*, Elongated cell with two nuclei; the longitudinal striation is beginning to show on the right side. From a fœtal sheep. (Wilson Fox.) *B*, Developing muscular fibre, showing both longitudinal and transverse striations at the periphery, and a central unstriated cylinder of protoplasm containing several nuclei. From a human fœtus near the third month (Ranvier.) *n*, Nucleus (there is usually a mass of glycogen near each nucleus); *p*, central unstriated protoplasm; *s*, peripheral striated substance; *C*, developing muscular fibre, showing a lateral position of the unstriated protoplasm. From a three months' human fœtus. (Ranvier.) *n*, Nucleus; *p*, unstriated protoplasm at one side of the fibre; *s*, striated sarcous substance with longitudinal and transverse striations.

This figure is almost identical with the one of developing striated muscles published by Schwann[5] in 1839 (Pl. XIV., Fig. 3).

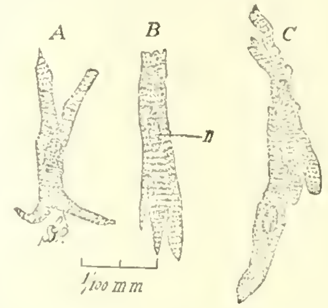

Fig. 3413.—Cardiac Muscle Cells of the Left Ventricle of a Newly Hatched Chick, to show the Form and Structure of the Cells, their General Appearance being like that of Adult Cold-blooded Vertebrates. *A*, Branched cell; *B*, cell with proportions nearly like those of the adult; *C*, two cells in their natural relations, the lower end is fusiform and the transverse striation obscure; *n*, nucleus. In all the cells the striations extend across the nucleus.

While the above investigations indicate clearly that in passing from birth to maturity the increase in size of the individual fibres determines the increase in size of the muscle as a whole, the decrease in number of the fibres in a given cross section may be due, in part at least, to a mechanical displacement along the long axis of the muscle as it increases in length. This mechanical displacement might also account for the fibres with two tapering ends (Fig. 3388, *B*). While it is conceivable that the decrease in number in a given cross section may be due to a longitudinal displacement, and not to an actual disappearance of fibres, the fact that in the more active muscles of the right side the apparent diminution in fibres is considerably greater than in the corresponding muscles of the left side, where the length is practically the same, can be explained only on the hypothesis that there is an actual decrease in the number of fibres during growth.

An elucidation of the processes involved in the disappearance of fibres during growth, and in the every-day occurrence of use-hypertrophy and disuse-atrophy, belongs to the domain of physiology and still awaits investigation, although Morpurgo and Schiefferdecker have made a beginning.

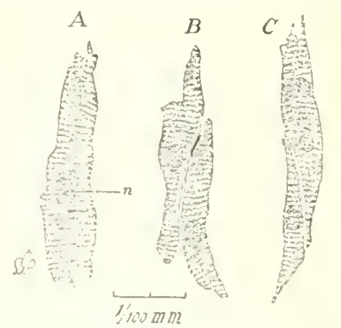

Fig. 3414.—Cardiac Muscle Cells from the Left Ventricle of a Kitten Three Weeks Old, to show the Form of the Cells, their Structural Details, and the Commencement of a Close Union between Two of them. *A*, Large cell possessing nearly the proportions of those of the adult; *B*, two cells in their natural relations; about opposite the nucleus of the upper one the cells are closely united as in the adult (compare Figs. 3397, 3403); *C*, two cells in their natural relations, the upper one has two nuclei; *n*, nucleus. The transverse striations cross the nucleus in all the cells.

Histogenesis of Cardiac Muscular Tissue.—This originates, like the other muscular tissue of the body, from mesodermic cells which are at first rounded and indistinguishable from the surrounding cells. These premuscle cells increase in size and elongate and become spindle-shaped. They contain a large nucleus and reticulated protoplasm. The reticulum is at first irregular, but later it becomes more regular; and when the cell has assumed a spindle shape, the appearance is given of clear bodies with rather definite outlines, arranged in somewhat regular longi-

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tudinal rows. These clear bodies are the sarcoplasmic discs of MacCallum.[12] As the cells continue to elongate, the striated fibrils so characteristic of striated muscular tissue appear in the cells, always appearing first near the periphery and gradually fill up the cell, so that finally the entire mass is pervaded by them (Figs. 3415, 3405).

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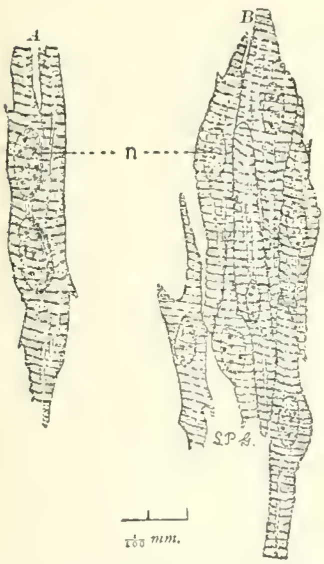
The further differentiation, besides the complete fibrillation of the cell body, consists in great increase in size, the production of branches or processes, and the fusion, apparent or real, of neighboring cells at various points to produce the anastomosing fibres of adult heart muscle. It is a very interesting fact that the heart beats rhythmically and vigorously for a considerable time before there is any sign of the striated fibrils in the cells.

Fibres of Purkinje.—In the heart of many adult animals (especially ruminants; also in the heart of the pig, horse, dog, cat, hedgehog, marten, and some birds; also, according to Gegenbaur, sometimes in the human heart) there appear, in the muscular substance next the endocardium, chains or groups of cells with a granular, nucleated central part and a striated periphery (Fig. 3417). These cells are supposed to be cardiac muscle cells in course of development into those of the ordinary, elongated, adult form, with branches and striation of the entire contents.

Histogenesis of Smooth or Unstriated Muscular Tissue.—The cells which develop into unstriated muscular tissue are derived mostly from the splanchnic layer of the mesoderm. The cells are at first rounded and granular; they elongate in two directions, thus forming the characteristic fusiform, smooth, or unstriated muscular fibres. The development of the longitudinal fibrillation has not yet been traced. The physiology of muscular tissue will form a separate article (*q.v.*).



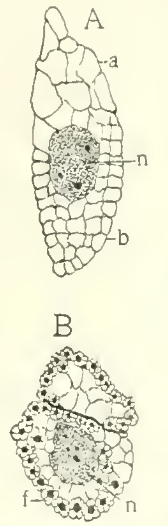


FIG. 3415. Cardiac Muscle Cells of the Left Ventricle of a Child at Birth (Full Term), to show the Form of the Cells, their Structural Details, and their Relations to One Another, and their General Agreement with those of Cold-blooded Vertebrates. *A*, Large cell with two nuclei; this cell has nearly the proportions of those of the adult; *B*, group of cells in their natural relations; at the right of the middle cell are two spaces or fissures (compare Fig. 3397). *n*, Nucleus. The transverse striations cross the nuclei in all the cells, and each nucleus possesses several nucleoli.

Figs. 3413 to 3415 are at a uniform magnification of 500 diameters. The drawings were made with a camera lucida, and the finer details of structure determined with a $\frac{1}{18}$ homogeneous immersion objective, and added free-hand. (Drawn by Mrs. Gage.)

FIG. 3416. Cardiac Muscle Cells from Embryo Pigs. (From MacCallum,[12] slightly modified.) *A*, Longitudinal section of a cardiac muscle cell from an embryo pig 10 mm. long. In the upper part of the figure the meshwork of the reticulum is irregular and represents a somewhat earlier stage of development. In the lower half of the figure the reticulum is regular and the sarcoplasm is arranged in rows of disc-like bodies. *a*, Irregular reticulum; *b*, regular reticulum; *n*, nucleus; *B*, cross section of two cardiac muscle cells from an embryo pig of 20 mm. The upper cell is cut above or below the level of the nucleus, while the lower cell is cut through the nucleus. *f*, Striated fibrils appearing at the periphery, the sarcoplasm forms kind of a mantle or coating for the fibrils; *n*, nucleus of the lower cell.

METHODS.—Isolation of the structural elements for all forms of muscular tissue is accomplished by soaking the tissue from one to three days in a mixture of 23 c.c. of

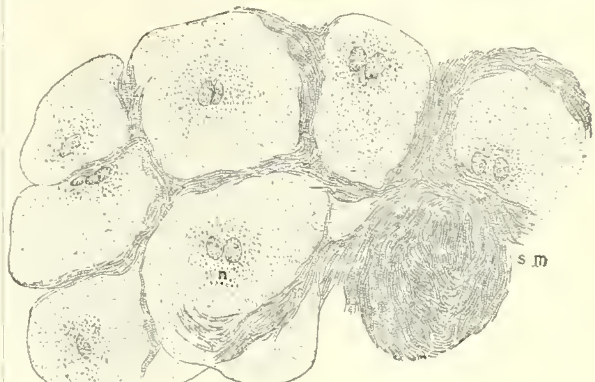


FIG. 3417.—Fibres or Cells of Purkinje from the Heart of a Sheep. Magnified about 300 diameters. (Modified from Ranvier.[14]) At the left the cells are shown in optical section with the peripheral striated fibrils between the cells. On the right is a cell viewed from the surface to show the striated mantle covering the whole cell. *n*, nucleus. Most of the cells contain two nuclei; *sm*, striated mantle at the surface of the cells.

concentrated nitric acid and 77 c.c. of water, and then for a day or more in a half-saturated solution of alum with five per cent. chloral hydrate. For cardiac muscle, soaking in a mixture of 40 gm. caustic potash and 60 c.c. water for fifteen to sixty minutes proved more satisfactory for isolation than the acid. Cardiac muscle must be perfectly fresh in order to obtain satisfactory results.

Acid specimens were mounted permanently in a mixture of glycerin, 75 c.c.; picrocarmine solution, 25 c.c. Permanent preparations of the caustic-potash specimens were obtained by washing away the caustic potash with a sixty-per-cent. solution of acetate of potash. The cells may be kept in this indefinitely, and mounted in this or in glycerin or glycerin jelly. For the fibrillation of the smooth muscular fibres, a piece of the perfectly fresh muscular coat of the small intestine of a cat was kept from one to three days in 100 c.c. of twenty-five-per-cent. alcohol, containing three-fourths of a gram of picric acid. Preparations were mounted in seventy-five-per-cent. glycerin. Serial sections were made to determine the relations of the striated muscular fibres to one another throughout the entire length of a muscle, and to determine the relative size and number of the fibres in a fascicle at different levels.

(For the general methods of histological investigation, the reader is referred to the article on *Histological Technique*, vol. iv.)

BIBLIOGRAPHY.—The bibliography of muscular tissue is so extensive that it would be out of place to give it all in a work of reference like the present. For a more complete discussion of special points, and for the bibliography, reference may be made to the following: *Human Anatomy:* Allen, Gerrish, Gray, Morris, Quain. *Histology and Histogenesis:* Böhm - Davidoff - Huber, Heitzmann, Klein, Kölliker, Leydig, Piersol, Prudden, Ranvier, Schaefer, Stricker. *Embryology:* Balfour, Hertwig, Kölliker, Kollmann, Minot. For monographs one is referred to special papers in the transactions of learned societies, and in the anatomical and embryological periodicals. The bibliography is given in the *Anatomischer Anzeiger, Bibliographie Anatomique;* "Ergebnisse

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Simon Henry Gage.

MUSCLE, PATHOLOGY OF.—

I. Striated Voluntary Muscle.

From the pathological point of view, the important points to be considered in the structure of striated voluntary muscle are the amount of interstitial connective tissue, the size and shape of the muscle fibres, the striation, and the number and position of the nuclei. Normally the endomysium, or the connective tissue separating the individual fibres, is small in amount, while that separating the fasciculi is considerably larger in amount, varying in different portions of the muscle. The distinctness of the striation depends somewhat on the method of fixation and preparation of the tissue, but in well-fixed preparations the fibres show a distinct transverse striation, due to the difference of refraction of the fibrillar and interfibrillar substances of the fibres, the ultimate fibrils being anisotropic, while the sarcoplasm is isotropic. In cross sections, the muscle fibres present irregular lighter and darker areas, due to the arrangement of the fibrils in columns, known as muscle columns, with a larger amount of sarcoplasm between the columns than is found between the individual fibrils. The muscle fibres are large, showing normally in cross section a diameter of from 10 μ to 100 μ, while they often attain a length of 12 cm. Their free ends are usually pointed, while the end attached to tendon is rounded. The nuclei of white muscle fibres are situated immediately under the sarcolemma and are very numerous, a cross section of a muscle fibre presenting from one to four or five nuclei. The nuclei of red muscle are situated in the sarcoplasm between the muscle columns. Marked variations occur in the number of nuclei, however, as has been pointed out by Morpurgo and Bindi and others. In young muscles, the nuclei are more abundant and more uniformly distributed than in adult muscle. In small adult muscles the nuclei are more abundant than in the larger fibres, while in the large irregular fibres the number is very variable and much smaller than in the smaller fibres or the embryonic muscle. Hence growth of muscle is not accompanied by corresponding increase of nuclei, the small fibres with high coefficient of growth preserving the juvenile character of nuclear abundance. These are the fibres which change most in the process of activity hypertrophy, the abundance of nuclei corresponding to a greater reserve of growth energy.

Under different pathological conditions, any one of these factors may be materially altered. The connective tissue may be increased or diminished in amount. The muscle fibres may be larger or smaller than normal and may change their shape and their relation to each other. The striation may become indistinct or even be lost altogether, the fibres assuming a granular or homogeneous appearance, while the nuclei may be greatly increased in number and very irregularly grouped, so that some sections will contain large numbers of nuclei, while others contain none. The muscle fibres may segment into short discs, or may break up longitudinally into small slender fibrils, which may remain attached at one extremity, giving the appearance of a branching of the parent fibre. The pathology of striated muscle has recently been treated by Professor Warthin in the *American Journal of Pathology*, and with some modifications I have made use of his classification in the following discussion.

Congenital anomalies of muscle concern largely the realm of gross anatomy. Supernumerary muscles may be found or certain muscles may be lacking. Occasionally the origin or insertion of a muscle varies from the normal. Such anatomical variations are considered in a separate article. (See *Muscles, Anomalies of.*)

Circulatory Disturbances.—Voluntary striated muscle has a very rich blood supply; numerous arteries break up into rich, long-meshed plexuses of capillaries, which surround the muscle fibre, each cell being in contact with several capillaries. The free anastomoses of these vessels easily compensate for any local obstructions, thrombosis, or embolism, and prevent any deleterious results, unless an infective embolus is the cause of the obstruction, in which case an abscess results. "In cachectic conditions, fevers, etc., in which the nutrition of the muscle is lowered, an anæmic necrosis may result from arteriosclerosis, deficient heart action, local compression, infiltrations, etc. Such anæmic infarctions are seen in senile gangrene, decubitus, etc." (Warthin). Psoas infarcts, associated with bed-sores, may result from long continuance of the recumbent posture, in which case the main arteries of the muscle may contain obturating thrombi or may show a proliferating endarteritis. In this condition, the entire muscle may undergo Zenker's necrosis, appearing white and translucent, but usually hemorrhages are scattered through the muscle and the necrosed area is surrounded by an extensive extravasation of blood. Scar tissue may replace the necrosed tissue, attempts at regeneration of the muscle fibres being frequently found; if the area becomes infected, however, a psoas abscess may result.

Anæmia of muscle may result from general anæmia or it may be local in origin, being caused by obstruction in the nutrient arteries, compression or arteriosclerosis. The muscle is pale and either soft, as when the affection is local, or dry, when the process is part of a general anæmia. The muscle may, however, be brown from increase of pigment.

Hyperæmia usually disappears shortly after death, the passive hyperæmia occurring only in the rare cases of extreme vascular stasis, while the congestive form is found in the neighborhood of inflammatory areas. Œdematous muscle is softer and moister than normal muscle, and on microscopic examination clear vacuoles are seen in the protoplasm of the muscle cells, while the connective tissue is much looser than under normal conditions, the connective-tissue fibres being separated by accumulations of clear fluid. In severe cases, the muscle fibres may undergo liquefaction.

Hemorrhages in muscle are far from uncommon; they may result from trauma, from convulsive contractions of the muscle, from increased blood pressure, or from degenerative changes in the vessel walls or in the surrounding muscle. Such changes are common in typhoid or typhus fever, in septic conditions, pernicious anæmia, etc., while small hemorrhages are frequent in the acute infections, phosphorus poisoning, leukæmia, and pernicious anæmia. As a result of the hemorrhage, the muscle fibres are pushed apart and may be destroyed, if the hemorrhage is large. The muscle liquefies or undergoes a coagulation necrosis. Blood clot becomes organized and a pigmented scar remains, only a few regenerated muscle fibres usually replacing a portion of the connective tissue of the scar. The connective tissue

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may, however, develop into cartilage and bone, as in some of the cases of traumatic myositis ossificans.

Retrogressive Changes.—Changes in size of the voluntary muscle fibres are among the commonest changes met. Under circumstances of increased nutrition, whether from the general condition or from systematic muscular exercise, the muscle fibres increase in size and we have a true *hypertrophy* of the muscle, while under the opposite conditions of disuse or diminished use of muscle, or when the general nutrition is lowered, the fibres undergo *atrophy*, the diminution in size varying with the degree of the unfavorable conditions. These conditions of true hypertrophy and of simple atrophy are usually transient, the fibre being restored to its normal appearance on the restoration of the normal conditions. If, however, the exercise be continued too long or be carried to an excess, the hypertrophied muscle may become atrophied, and simple atrophy may lead to degenerative changes. Simple atrophy, in its simplest form, occurs in old age, but it is also seen in cachectic states, such as tuberculosis, carcinoma, etc., and it may result from compression of the nutrient arteries. Macroscopically, atrophic muscles appear paler, dryer, and firmer than normal. A brown pigment, hæmofuscin, probably a product of the sarcoplasm of the muscle fibre, may develop in the fibres, giving them a brown color. In some cases, the fibres undergo *hydropic degeneration*, serous atrophy, in which the muscle appears moist and soft.

The clinical aspect of the muscular atrophies will be treated under a separate heading. Regarding the pathological aspect of the muscular atrophies, we may say that atrophic degenerations may be neuropathic, depending on lesions in the spinal cord, or they may be primary or myopathic. In the former case, some of the most interesting changes are those which occur in the spinal cord; the cells of the anterior horn are atrophied and show degenerative changes and the pyramidal tracts are involved. The degeneration may even be traced to cells in the medulla and motor cells of the cerebral cortex. In the myopathic form of muscular atrophy, or the so-called muscular dystrophy, the nervous system shows no essential changes, although varied and irregular alterations are described by certain authors, such as atrophy of the posterior root ganglion cells, some cytoplasmic changes in the ganglion cells of the spinal cord, etc. None of these changes, however, is found uniformly in all cases of muscular dystrophy, and the disease is therefore believed to originate in the voluntary muscle and is probably due to some congenital anomaly of development. Kollaritz describes atrophy of the motor cells and of the fibres of the substantia grisea centralis around the spinal canal, these changes occurring especially in the cervical and dorsal regions. The peripheral nerves were intact. He believes that the changes in the cord and in the muscle occur together and that both probably depend on faulty development. Atrophy of the motor cells is especially characteristic both in his cases and in those of Erb, Schultze, Preisz, Frohmeier and others. This may readily be explained as the result of faulty development, and the development of muscles might well stop if at a certain age the motor nerve cells thus atrophied, while it is not unreasonable to suppose that the motor nerve cells might undergo secondary atrophy, as the result of this degeneration of the muscle fibres. While it was formerly believed that the primary dystrophies could be distinguished microscopically from the neuropathic atrophies, it is now generally conceded that there is no essential difference in the pathological picture presented by the two classes of the disease. The idea that the dystrophies could be differentiated by the fact that the atrophy was uniformly preceded and accompanied by hypertrophy of the muscle fibres has been practically overthrown by the recognition of the fact that in both the neuropathic and myopathic atrophies the atrophy may be preceded by hypertrophy, the fibres being enlarged to a variable extent before the atrophy sets in, and even at the height of the atrophic process some enlarged fibres may be found among the many atrophic cells. In neuropathic atrophy, however, the localization of the degenerative process varies according to the localization of the lesion in the cord.

In a case of traumatic transverse myelitis resulting from an injury to the cord in the lower dorsal region, the psoas muscles showed the most extreme degree of degenerative changes, while the lumbar muscles and the leg muscles contained bundles of extremely atrophic fibres, and the muscle cells of other bundles were normal in size, appearing hypertrophied by contrast with the atrophied fibres. In the psoas muscles, most of the cells were very small, appearing scarcely larger in cross section than involuntary muscle cells. No transverse striation could be observed in any of the fibres and the cross sections appeared either homogeneous or finely granular. Some, however, were vacuolated, some showing very little of the protoplasmic substance of the fibre, appearing to consist of nucleus and sarcolemma, the intervening space being clear. A few of these fibres in cross section presented no nuclei; in the majority, however, one or two deeply stained, relatively large nuclei were seen near the end of the oval cell, while some showed a crescent or corona of nuclear substance at the periphery. Many cells were seen containing numerous nuclei, which were often hyperchromatic and appeared as a dense, fused mass of deeply stained chromatic substance. These giant cell forms or sarcolytes were especially numerous in some fields, while in others very few were found. In longitudinal sections, longitudinal and transverse cleavage could be observed, and in many areas long, narrow, spindle-shaped cells were seen, which contained long rows or chains of deeply stained nuclei. There was also a marked increase of connective tissue, often accompanied by a deposition of fat, especially in the increased connective tissue of the endomysium. This picture may be taken as the typical picture of muscular atrophy, varying in degree, but little in character. The increased connective tissue, the fibrillar forms mentioned, and the multinuclear, giant-cell forms have been the subjects of much discussion. Durante, Kroesing, and others, upholding the view of embryological development of muscle advocated by Hoffmann, Waldeyer and others, that the striated muscle cell is a syncytium developed by the fusion of numerous spindle-shaped cells of the mesoderm, describe the longitudinal cleavage or fibrillation of the muscle fibre as a return to the embryonic condition. They state that these fusiform fibres may form new muscle fibres, but usually degenerate and mingle with the connective tissue, acquiring all its characteristics. To this tissue Kroesing gives the name myogenous connective tissue or connective-tissue state of the muscle fibres. He states that the increase of connective tissue in muscular atrophy is due to the formation of this tissue rather than to an increase of true connective tissue. In preparations stained by Mallory's differential stain for connective tissue, however, it may be plainly seen that this tissue gives the reaction of true connective tissue, so that we may conclude that, if it be derived from muscular tissue, it has acquired, not only the morphological, but also the chemical characteristics of connective tissue. It seems more probable, however, that the muscle degenerates on account of the poor nutrition of the tissue, and that the increase of connective tissue is due to the well-known tendency of connective tissue to replace lost tissues and to fill spaces where it is needed. The fate and significance of the multinuclear forms have been considered by many authors and have been generally regarded as attempts at regeneration. Fujinami, however, believes that in purely degenerative processes, cells morphologically identical with the myoblasts of regenerating muscle may be found, and that in these cases they should not be interpreted as having a regenerative significance, but rather as degenerative forms. While this point seems to need further investigation, Fujinami's view receives confirmation from the fact that these multinuclear forms are quite as numerous in the most extreme degree of muscular degeneration, where no tendency to repair

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seems to be present or is to be expected, as in areas less severely affected.

Progressive muscular dystrophy, in its simple form, presents a very similar pathologic picture to that described for neuropathic atrophy. The pseudohypertrophic form, however, is characterized by a marked formation of adipose tissue, formed probably from the proliferated cells of the endomysium, although Kroesing states that it arises from a metaplasia of the muscular tissue into adipose tissue. This myogenous adipose tissue is distinguished from true adipose tissue by the presence of fragments of muscle or by remains of muscle structure or arrangement. In this form of atrophy, as in the others, the muscle fibres are more or less atrophied. A true hypertrophy of the muscle may, however, accompany the increase of connective and adipose tissue, as in the case reported by Durante, in which many of the cells attained a diameter of 180 μ; the nuclei were greatly increased in number, being arranged either in long lines or in a circle surrounding the fibre. Vacuolation and granular degeneration were also noted in these fibres. Durante believes that the muscular hypertrophy in this case was congenital or was developed in early life, while the degenerations and elephantiasis were probably of much later growth.

Thomsen's Disease, or Myotonia Congenita, is a special form of muscular dystrophy, which is hereditary and congenital and affects numerous members of the same family. It is characterized clinically by the occurrence of tonic cramps, when the patient attempts to move. A case recently described by Koch may be taken as typical of the affection. The patient was twenty-one years old and his musculature was well developed. The principal symptom of the affection was stiffness, slowness, and difficulty of motion, especially when first beginning to move, but wearing off later as the effort was continued. This symptom had been noticed since early childhood. The cramps are usually painless and may affect the limb muscles, the eye muscles, and the muscles of mastication, but the extremities are the parts most involved. The involuntary muscles are spared. Cold and nervousness may cause an increase of the affection, while systematic muscular exercise is beneficial. The affection is rarely cured, although it does not endanger the life of the patient. Erb describes an increase of the interstitial connective tissue, with marked hypertrophy of the muscle fibres. The finer details of structure may also be slightly altered, the striations being less distinct than normal, the fibres appearing more homogeneous, but often vacuolated. Koch describes a longitudinal cleavage of the muscle fibres, causing an increased number of fibres. He states that amitotic division of the muscle nuclei was observed, resulting in the formation of the long, slender cells containing rows of nuclei, such as are observed in degenerative and regenerative processes.

DEGENERATIONS.—While the various forms of muscular degeneration have been variously classified, it may be

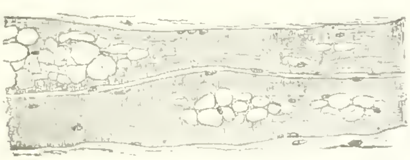

FIG. 3418. Hydropic Degeneration of Voluntary, Striated Muscle. (Ziegler.)

noted that they all tend to occur together, wherever the muscle is exposed to unfavorable conditions. Progressive muscular atrophy, whether of nervous or of muscular origin, may be accompanied by any or all of the degenerative processes, while inflammations, injuries of muscle and tumors are all, to a greater or less extent, surrounded by areas of degenerated muscle. One of the most common and at the same time the most serious degeneration affecting striated muscle is the *granular or proteid degeneration*, also known as *cloudy swelling*. The fibre is usually enlarged, the striations are less distinct, the cell appearing distinctly granular. The granules are not fatty, since they do not react to osmic acid nor dissolve in ether or chloroform; they dissolve in acetic acid. Durante distinguishes two forms of granular change—one, which we may regard as physiological, due to excessive activity of muscle, and analogous to the granular change in gland cells during secretion. The fibres are enlarged and the striations are indistinct on account of the thickened layer of granular sarcoplasm lying between the sarcolemma and the fibrils. This condition is usually transitory, the cell returning to its normal state as soon as the conditions which caused the change have been altered. If, however, the cause persists, the

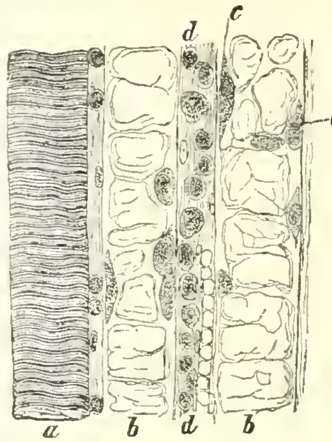

FIG. 3419.—Zenker's Waxy Necrosis. (Ziegler.)

cell may undergo fatty degeneration or liquefaction or coagulation necrosis. The second type is a true degeneration, leading to the death of the cell, and occurs in cachexias, infectious diseases, myositis, and other muscular affections.

Hydropic degeneration of voluntary muscle occurs especially in suppurative inflammations, chronic œdemas, etc., and is characterized by the presence of clear vacuoles in the protoplasm. Fresh muscle thus affected appears pale and watery. It may be distinguished microscopically from simple œdema of muscle by the fact that the muscle nuclei stain poorly in case of degeneration.

Fatty degeneration occurs in an extreme degree in cases of phosphorus poisoning and to a less degree in tuberculosis, in fevers, intoxications, etc. The muscle cells show fat globules in their protoplasm, which therefore appears peculiarly reticular. These may merge into larger fat droplets. These cells stain poorly in eosin, so that a fibre undergoing fatty degeneration appears hazy and mottled, while, after treatment with osmic acid, the droplets show the characteristic black reaction. The muscle nuclei may also show the characteristic degenerative changes.

In cases of inflammations, fevers, intoxications, and in the neighborhood of malignant tumors may be found fibres undergoing *simple necrosis*; these are larger than normal, show no transverse striations and no nuclei, and the entire fibre takes an indifferent bluish-red color, when stained with hæmatoxylin and eosin. In chronic œdema, suppurative inflammation, etc., the muscle fibres may undergo *liquefaction necrosis*. The fibres at first appear enlarged, vacuolated, or granular, and finally dissolve in the fluids in the surrounding tissues. Zenker has also described a *waxy or hyaline necrosis* of the muscle fibres, occurring in typhoid fever. It may also occur in any severe fever, in acute tuberculosis, in sepsis and variola, and also in wounds, inflammations, and to a limited degree in all the pathological processes which may result in the degeneration of voluntary muscle. If the degeneration is of wide extent, the affected muscle is soft, white and translucent, resembling fish-flesh. The softening may lead to more or less extensive hemorrhages in the muscle. The muscles most frequently severely affected are the psoas, the abdominal muscles, and the muscles of the thigh. The muscle fibres are of irregular size and form, many of them being swollen. The cross striation is lost, at least in many areas, and a peculiar

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hyaline or waxy mass appears in the protoplasm, the fibre finally breaking up into irregular hyaline masses, which are afterward absorbed. The hyaline mass usually stains poorly with the ordinary stains, but may resemble fibrin in its reaction to Weigert's fibrin stain, while in the Van Gieson stain it may react like colloid. The hyaline mass may fill the entire cell or occupy only certain areas, these peculiar homogeneous areas being surrounded by granular sarcoplasm, while some areas may appear striated and quite normal. The nuclei may entirely degenerate, while in milder cases they may proliferate and lead to the regeneration of the muscle fibre. A leucocytic infiltration of the intermuscular connective tissue may precede or accompany this degeneration. In senile gangrene, decubitus, infective inflammations, burns, freezing, and in lowered nutrition of the skin and subcutaneous tissues, the voluntary muscles may undergo gangrenous changes, the muscles becoming brownish, black, or greenish in color, breaking up into shreds or liquefying, or, if exposed to the air, undergoing mummification. Microscopically, the muscle fibres present the picture of liquefaction or coagulation necrosis, the fibres losing their form and striation. A marked leucocytic infiltration accompanies this process, while blood pigment and crystals of cholesterin and triple phosphate are often found. In mummification, the cells shrink and lose their form and nuclei and finally appear like horn. Not unlike a liquefaction gangrene is the degenerative process described by Hoen as occurring in the striated muscle fibres of the uvula. This is characterized by a bleb-like change, associated with pigment formation and nuclear proliferation. The sarcolemma is raised by the vesicles, each of which contains a nucleus, so that the liquefying process seems to begin in the undifferentiated sarcoplasm surrounding the nucleus. Cross striation can still be seen in places, but the longitudinal striation is replaced by wavy and undulating lines, due to the twisting of the fibrillæ. The final stage of the degenerative process shows masses of large blebs, containing small, large, and misshapen nuclei, with pigment, through the middle of some of which runs a shadow suggestive of a muscle fibre. Even in such a mass, some fibrils may be found which still show striæ.

Fragmentation and Fibrillation.—In necrosis and in most of the degenerative and other pathological states of muscle, fibres may be found which are breaking up either longitudinally into long fusiform fibrils, or transversely into irregular plates or discs of muscle substance. Often the fibril can be traced to the point where it joins the parent fibre. The process results in the atrophy of the main fibre, while the fibril which has been split off may either develop into a new muscle fibre, as in the regeneration of muscle by the proliferation of its nuclei, or it may still further degenerate, either shrinking into threads so that the tissue closely resembles fibrous connective tissue, or undergoing fatty degeneration and forming a tissue resembling adipose tissue. Warthin states that "*amyloid degeneration* of voluntary striated muscle is rare and occurs especially in the muscles of the tongue and larynx. The deposit begins in the capillary walls of the endomysium and may extend around the sarcolemma, causing an atrophy of the fibre. The atrophic fibre then appears as if surrounded by a glassy hyaline substance. Ultimately the fibre disappears and the confluence of the deposit leads to the formation of nodular masses." The presence of pigment in voluntary muscle fibres, in the so-called brown atrophy, has already been mentioned. The pigment, known as hæmofuscin, appears as brown or yellow granules in the neighborhood of the nuclei and it indicates a degeneration of the muscle substance. The degenerative processes in voluntary muscle caused by experimental section of the nerve have been well described by Ricker and Ellenbeck. Chromatin granules appeared in the nucleus on the twenty-third day. The nuclei appeared shorter and broader, even spherical, with loosening of the chromatic network. The muscle and nuclei showed œdematous changes. The division of the nuclei was by direct fragmentation, no mitotic figures being found. The authors regard this nuclear fragmentation as a degenerative process, not leading to the regeneration of the muscle. The muscle fibres showed atrophy, but very slowly developing, while the protoplasm showed vacuolation and transverse cleavage, with diminishing distinctness of striation. There was at first an increase in the amount of fat in the intermuscular connective tissue, followed by diminution. The muscle was at first hyperæmic and œdematous, but later became anæmic. There were also an increase of connective tissue and a narrowing and hyaline deposition in the intermuscular capillaries. The changes were believed to be due to disturbances of circulation rather than to direct influence of nerve section.

Schujeninoff has carefully studied the processes involved in the *calcification* of striated muscle, both experimentally in animals and by observation of men. He concludes that the lime salts are deposited in muscle under certain conditions, as after the suture of a wound in the muscle. The calcification takes place after the fibres have undergone a colloid degeneration. When the lime salts are absorbed, the calcified fibre disappears. The calcification of muscle is therefore a local, secondary process, which stands in relation with the local disturbance of circulation.

Regeneration of Voluntary Muscle.—In embryonic life, striated muscle fibres develop from mesodermic cells, each fibre being formed by endogenous proliferation of the nuclei of a single cell. This is the view advanced by Remak, Schultze, Kölliker, Zenker, and many others, who contend that the growth both in length and thickness takes place by this nuclear proliferation, while the protoplasm changes into the contractile substance of the muscle fibre. This view is opposed by Hoffmann, Waldeyer, Kroesing, Durante, and many others, who believe that the muscle increases in length only by endogenous division of the nuclei, while the increase in thickness is brought about by the apposition and fusion of numerous fusiform cells. Experimental degeneration of muscle has been brought about by tenotomy, by neurotomy, and by sectioning the muscle fibre itself. Numerous experiments have also been undertaken in the transplantation of portions of muscle taken both from the same animal and from other animals, even those of a different species. Salvia transplanted muscle from a rabbit to fill the space made by removing portions of a dog's muscle. He states that the result was perfectly satisfactory, as the new muscle replaced the old perfectly both anatomically and functionally. Others have claimed equal success in similar experiments, but Capurro, in a series of experiments recently reported, gained results which were only partially satisfactory. The result of transplanting free pieces of muscle was negative. By using only a portion and leaving a pedicle attached during the union, he was able to secure satisfactory functional results. He observed degenerative changes in the muscle, such as simple atrophy, Zenker's necrosis, fibrillation, increase of connective tissue, leucocytic infiltration, etc. In these cases, as well as in wounds of muscle, granulation tissue is first formed. The muscle nuclei proliferate, both by mitotic and by amitotic division, and buds of sarcoplasm containing the new nuclei grow out from the ends or body of the muscle fibre into the granulation tissue. These buds at first show no striation, but contain many large nuclei and appear like epithelioid cells. Then in the sarcoplasm, fibrils are formed and thus the fibre becomes striated. Several new fibres may be formed from one bud or myoblast. In addition to these myoblasts, free multinuclear cells are formed, known as sarcolytes. These are not in connection with the original fibre, and while some may form new fibres or unite either with the old fibre or with new ones, most of them probably undergo fatty degeneration or necrosis. The sarcolytes may resemble the myoblasts in section and give the appearance of regenerative effort, even when the conditions are so unfavorable that no attempt at regeneration is to be expected. A perfect regeneration of muscle appears to be possible only when the contrac-

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tile substance is but slightly injured and the sarcolemma and muscle nuclei are intact, as after freezing, after the degenerative changes of typhoid fever, sepsis, and trivial traumatic injuries in which but little of the contractile substance is lost. In more severe injuries the regeneration is only partial, muscle fibres growing out from the

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FIG. 3420. — Regeneration of Muscles, Myoblasts, and Sarcolytes. (Ziegler.)

ends of the old fibres into the granulation tissue which at first replaces the destroyed muscle (Warthin). Volkmann states that regeneration is functionally important only after typhoid fever and freezing, while after injuries the regeneration is so slight that function is not restored unless the wounds are small. Larger wounds heal by the formation of scar tissue, which is muscularized from both sides and ends, but only for a short distance. Transplanted pieces of muscle degenerate and are replaced by scar tissue, which is in the same way muscularized for a short distance from the sides and ends. Kümmel, however, reports a case in which he sutured the ends of muscle which were from 8 to 10 cm. apart, and secured almost perfect restoration of function after six months. The differences in the reported results may depend upon different nutritive or nervous conditions, but it would seem from the majority of the reports that, while voluntary muscle does regenerate by both mitotic and to a limited extent amitotic division, its power of proliferation is extremely limited and does not extend to the complete restoration of large areas of destroyed muscle fibre.

CHANGES IN THE MUSCULAR NERVE ENDINGS.—The subject of degenerative changes in voluntary muscle can scarcely be fully treated without some consideration of the changes occurring in the motor and sensory nerve terminations in this muscle. I am not familiar with any work reporting the changes in the motor endings in human muscle occurring under pathological conditions, but Huber has recently reported the results of some experiments on rabbits, in which he crushed the posterior tibial nerves, afterward studying the motor and sensory nerve endings in the interossei muscles by means of the *intra-vitam* methylene blue method. Till the end of the first day after crushing the nerve, the motor endings presented a normal appearance and the muscle responded to electrical stimulation of the nerve applied below the point of injury. During the second day, changes began to appear in the motor endings, ushered in by relatively large, usually round or oval, deeply staining enlargements, or varicosities, varying in number, size, and shape, which were found on the arborizations of the motor endings. These changes did not affect all the motor endings at the same time; but when a majority of all the motor endings in the muscle showed the nodular enlargements, the muscle failed to respond to electrical stimulation. At the same time the nerve fibre showed degenerative changes at its distal end. Later, the arborizations disappeared or failed to stain differentially, although the so-called sole plate sometimes stained a faint blue. The regeneration of these endings was observed about thirty days after the experiment, beginning with the formation of fine, varicose fibres ending in a small granule, and passing through various transition stages to an ending which is in every respect like the original ending. Not until numerous regenerated motor endings were found, did the muscle again respond to electrical stimulation. The neuromuscular nerve end-organs are the most interesting of the sensory nerve endings found in voluntary muscle and have been subjected to the most careful investigation. Sherrington sectioned the sciatic nerve, causing degeneration of the nerve fibres and complete atrophy of the muscle fibres, but found the intrafusal muscle fibres of the spindle well preserved and the striation retained one hundred and fifty days after the section. Eichhorst reports the presence of fat globules in the intrafusal muscle fibres of neuromuscular spindles in a case of phosphorus poisoning. Grünbaum found the muscle fibres atrophied and surrounded by hyaline substance in some of the spindles in a case of pseudo-hypertrophic paralysis, while Gudden observed atrophy of the intrafusal fibres in a case of alcoholic neuritis. Batten examined the condition of the neuromuscular spindles in cases of infantile paralysis, tabes dorsalis, myopathy, progressive muscular atrophy, and peripheral neuritis, and found the muscle spindles normal, except in one of the three cases of tabes examined. After injury of the brachial plexus, however, which resulted in complete loss of motion and sensation, he found changes in the spindles one year after the traumatism. The spindles were small, the intrafusal fibres were atrophied and granular with indistinct striation, while the nerve fibres going to the spindles were poorly stained. Batten therefore concludes that after injury or section of the nerve the neuromuscular spindles undergo degenerative changes in time, but much later than the surrounding muscle fibres. Laslett and Warrington found the spindles unaltered in a case of lead paralysis examined by them. Batten, in a series of experiments upon animals, showed early degenerative changes in the nerve terminations within the neuromuscular end-organs, with later changes in the form, calibre, and arrangement of the intrafusal muscle fibres, but he was unable to reproduce the fatty change of the intrafusal muscle seen by him in the case of tabes dorsalis. Huber, in the experiments previously described, found that the myelin of the large sensory nerve fibres going to the neuromuscular and neurotendinous end-organs showed segmentation, and that the nerve fibres within the organs were broken up into irregular, deeply staining fragments, which gradually disappeared. The changes in the sensory nerve end-organs did not, however, take place until the third day after the crushing of the nerve. No degenerative changes in the muscle fibres of the spindle were mentioned by him. Regenerating sensory endings were seen by him on the forty-first day after the experiment, but it was not until the end of the second month or the beginning of the third month that the nerve endings in these organs presented an appearance similar to that found in the normal organs. In the case of transverse myelitis previously described, the neuromuscular nerve end-organs showed œdema, the layers of the capsule being widely separated by clear fluid, and the muscle fibres also being crowded apart. The muscle fibres of the spindle did not, however, show any marked pathological changes. In the neurotendinous nerve end-organs, also, Cattaneo and others have demonstrated early changes in the nerve endings.

INFLAMMATIONS.—The inflammatory processes in voluntary muscle may be acute, subacute, or chronic. The true inflammatory conditions are largely interstitial, involving the connective tissue of the endomysium and perimysium and the capillaries, while the muscle fibres undergo degenerative changes as a result of the changed nutritive conditions brought about by the presence of the inflammatory exudate. The inflammations may be the result of the extension of an inflammation from neighboring tissues, or germs may be carried into the muscular tissue through the blood current. Traumatism, disturb-

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ance of nutrition, and vascular changes may also act as powerful indirect etiological factors. Myalgia or so-called rheumatic myositis or muscular rheumatism often affects the muscles of the back, neck, or the intercostal muscles. In most cases it is probably not a myositis but a neuralgia, due to slight twisting or laceration of some of the muscle fibres. Its one common symptom is pain in the muscles. It usually quickly subsides, often spontaneously. If necessary, anodynes or hot applications will generally give relief.

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In *acute parenchymatous myositis*, the muscle fibres show granular, hydropic, and fatty degeneration, Zenker's necrosis, fragmentation, fibrillation, etc. The endomysium contains large numbers of leucocytes and is œdematous, while the capillaries and blood-vessels are distended and filled with blood cells. If the degenerative changes in the muscle fibres are not too severe, recovery usually takes place with complete restoration of structure and function of the affected muscle. This comparatively mild form of inflammation occurs after slight injuries, in disturbances of circulation, in typhoid fever, and in the neighborhood of new growths. Trichina cysts, anthrax pustules and other irritating conditions may produce similar processes in neighboring muscles. A similar form of myositis has been called by Froriep *monomyositis*. It arises on a traumatic or infectious basis and may lead either to muscular abscess or to an indurative interstitial inflammation which ends either in repair or in the formation of a muscle tumor. The course may be acute, subacute, or chronic. The symptoms consist of extreme pain in the affected muscle, generally preceded by chill and slight rise of temperature. There are some swelling and œdema of the skin over the affected part, with swelling and extreme tenderness of the affected muscle, which soon becomes very hard. There is also contracture of the affected muscle, with some diminution of the electrical excitability. A more severe and generally fatal inflammatory affection is known as *primary acute polymyositis*. This is infectious in character and is accompanied by œdema and marked swelling of the overlying connective tissue and hyperæmia and even exanthema of the overlying skin. The clinical symptoms are fever, pain, tenderness, and loss of function in the affected muscles. These symptoms suggest trichinosis, and Hipp suggests the name pseudo-trichinosis. The resemblance indeed is at times so striking that a differentiation can be made only by removing portions of the affected muscle and subjecting them to microscopical investigation. This form of myositis is sometimes known as dermatomyositis, because of the simultaneous involvement of the skin and muscles. Polymyositis may also be hemorrhagic in character, since a marked extravasation of blood may be found between the muscle bundles. This usually runs a chronic course, death resulting from involvement of the heart. A case of this kind has been described by Bauer: The affection started with severe pains in the legs, after which swellings gradually developed in various regions of the body. The general condition was poor, sleep disturbed, appetite impaired; the patient had fever, and his face was reddened but not œdematous. The muscular swellings were painful, circumscribed, and surrounded by a doughy, indurated area. These showed areas of pigmentation surrounded by a violet zone. Death occurred from asthenia. At the autopsy, the muscle in places presented a brownish-red appearance, with punctate and linear pigmentation and in other places a waxy-yellow appearance. The muscle fibres were partly normal and partly degenerated with proliferation of the nuclei. These were separated by a hemorrhagic exudate, which in some places showed large numbers of leucocytes, so that a purulo-hemorrhagic effect was produced. In this case, the staphylococcus was found. In certain septic cases a diffuse, purulent infiltration of various muscles may occur, this condition being rarely regarded as primary and terminating in gangrene of the muscle. Ziegler describes a case of phlegmonous inflammation of the subcutaneous and intermuscular connective tissue near the pectoral muscle, resulting from an infected wound. Skin phlegmons, erysipelas, decubitus, and purulent arthritis may also cause similar suppurative muscular affections. The muscle is swollen and softened and may be mottled yellow, brown, red, and greenish in color. The pus infiltrates the endomysium and may burrow along the sheaths of the muscles for considerable distances. Small, circumscribed abscesses, either single or multiple, are found throughout the muscle in various regions in case of hæmatogenous infection. These small abscess cavities are filled with pus and tissue débris, and are surrounded by œdematous and degenerating muscle. These small abscesses may be absorbed or become encapsulated, while larger ones break and discharge their contents, being replaced by scar tissue, which gradually contracts and is partly replaced by new-formed muscle fibres. The scar tissue may undergo calcification, while the encapsulated forms may become either calcified or liquefied. On exposure to the air, this greenish-black, gangrenous muscle evaporates or undergoes mummification. Stierlin has described a case of septic total necrosis of muscles resulting from wound infection with obstruction of the artery and therefore interference with the nutrition of the part. The bacteria were gas-forming, putrefactive bacteria. Fragments of the necrotic muscle filled the abscess cavities. The entire process was limited to the musculature, the skin being unaffected. The connective tissue and lymph and blood capillaries were filled with innumerable cocci, forming a network around the muscle cells, which appeared in cross section as homogeneous red discs in which no nuclei could be seen. Very few cocci had penetrated the muscle cells. An *acute interstitial or productive myositis* may also be distinguished; it is progressive in character and generally passes into the chronic form. It

FIG. 3421.—Purulent Myositis, with Necrosis of Muscle. (Stierlin.)

occurs in typhoid fever, chronic irritations, etc. The primary changes are in the connective tissue, which proliferates and causes a secondary degeneration of the muscle fibres.

Chronic Myositis.—In progressive muscular atrophy, whether neuropathic or myopathic, there is a marked increase of the intermuscular connective tissue, so that the

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small muscle bundles are separated by thick bands of connective tissue, or the muscle may be entirely replaced by connective tissue. This constitutes the condition known as chronic interstitial myositis or fibrous myositis. It may also occur in the neighborhood of chronic inflammatory or irritative processes, as ulcers, tumors, parasites, foreign bodies, etc. It may also affect the muscles in the neighborhood of inflamed joints, as in inflammatory rheumatism, gout, etc. Acute purulent myositis may be followed by a condition in which the abscesses are walled in by granulation tissue and we may speak of it as a chronic purulent myositis. This occurs most frequently in the psoas muscle. While the condition may follow an ordinary pyogenic infection, it is far more common after specific infections, such as tuberculosis, syphilis, actinomycosis, glanders, gonorrhœa, leprosy, etc.

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Tuberculous Myositis may and frequently does occur in muscles in the neighborhood of a tuberculous abscess or some focus of infection, the process extending directly into the muscle from the infected area, as in the muscles surrounding a psoas abscess or caseating lymph gland, or in the intercostal muscles in pyothorax and in miliary tuberculosis of the pleura. Primary or hæmatogenous tuberculosis of muscle is, however, rare—a fact which is explained by the bactericidal action of the muscular fluid, which, as Tria states, is more efficient in its action than the fluids of any other tissues. Cases of hæmatogenous tuberculosis of the muscles have, however, been described by Habermaas, Müller, Delorme, Reverdin, and Lanz and Quervain, and Steinthal, the latter having collected eight cases of primary tuberculosis of the abdominal muscles. The tuberculous nodules found in the intermuscular connective tissue present usually a caseated necrotic centre surrounded by a zone of lymphocytes and epithelioid cells with some giant cells, and this is surrounded by a zone of lymphocytes and connective tissue. Blood-vessels are poorly developed in these areas. The muscle in the neighborhood of one of these areas may be normal, but is usually atrophied, while the muscle nuclei are increased in number and surrounded by a clear zone; the protoplasm of the muscle diminishes as the nuclei increase in number, so that finally the sarcolemma appears filled with nuclear masses. As the muscle degenerates, it is replaced by connective tissue into which the tuberculous foci extend. Here they consist of lymphocytes mostly, with a few epithelioid cells. According to Petit and Guinard, the tuberculous process originates in the intermuscular connective tissue, the degeneration of the muscle resulting from the presence of cells called myophages, which send processes between the contractile fibrils and gradually destroy them. In none of these cases were the tubercle bacilli demonstrated microscopically, but the history of the case, the microscopic appearance of the tissue, and the positive results gained by injecting the contents into guinea-pigs made the diagnosis unquestionable. Tuberculous myositis must be differentiated from syphilitic myositis, interstitial myositis, actinomycosis, echinococcus, and benign and malignant tumors. A tuberculous abscess may also be found in muscle, consisting of muscular and cellular débris surrounded by a thin wall of granulation tissue poor in blood-vessels.

Syphilitic Myositis may be diffuse or circumscribed. In the former case there is a primary diffuse infiltration of the connective tissue with a secondary degeneration of the muscle fibres. It occurs especially in the later stages of syphilis and attacks by preference the muscles of the extremities. It is characterized by a painful, indurated swelling of the affected muscle, which is easily differentiated from other muscular affections by its prompt response to antisyphilitic treatment. Muscle gummata, while not infrequent in the later stages of syphilis, have not often been described. They may, as in the case reported by Eger, develop many years after the syphilitic infection. If no regressive changes have taken place, they are usually indolent in their course, causing no pain, no disturbance of function, and no alteration in electric excitability, unless by their excessive growth they press upon nerves or blood-vessels. They are influenced more or less readily by the potassium-iodide medication. The large tumors may caseate, forming deep ulcers or abscesses, which heal readily but leave indurated scars, which may disturb the function of the muscle. In the earlier stages, the gummas consist of very vascular granulation tissue which may be mistaken for sarcomatous tissue, but later the characteristic three zones develop, the outer consisting of vascular granulation tissue, the inner caseated zone, and the intermediate zone of mature connective tissue. Giant cells may be present or absent. The rich blood supply, the absence of tubercle bacilli, and the response to antisyphilitic medication will readily differentiate these nodules from those of tuberculosis.

A *Case of Gonorrheal Myositis* involving the latissimus dorsi has been described by Ware. The microscope revealed a picture of interstitial inflammation, with cloudy swelling of the muscle fibres, though in some places the striation was still distinct. There was some proliferation of the muscle nuclei, showing a possible tendency to regeneration of the muscle fibres. The connective tissue was so greatly increased that the muscle fibres were crowded apart and compressed. No germs were found except the diplococci. This form of myositis is characterized by the intense sclerotic process, which is so marked a feature of gonorrhœal inflammation in other localities. The process generally heals by the formation of connective tissue, which usually undergoes resolution, although cases have been reported of ossification of the affected muscles. If an abscess forms, it is probably due to a mixed infection. The localization of gonorrheal myositis is probably generally due to extension from neighboring joints and bones, though it may sometimes result from metastasis.

Leprous Myositis.—Fujinami describes the changes which take place in voluntary muscle in cases of leprosy. The muscle is crossed by white strands consisting of connective tissue containing many fat cells and numerous brown pigment granules arising from degenerated muscle fibres. The muscle fibres are atrophied, showing either a very irregular arrangement of the striation or a granular and pigment degeneration. The nuclei are increased in number, enlarged, and very irregularly arranged, while many of them take the stain intensely and show indistinct outlines, so that they appear as fused, hyperchromatic masses. The changes are similar to those observed in muscular atrophy, in the neighborhood of tumors, in inflammatory processes, and are probably due, not to the direct action of the bacilli, but to disturbance of the nutrition of the muscle, perhaps brought about by chemical changes in the lymph caused by the growth of the bacilli. Colonies of leprosy bacilli are seen between the atrophic muscle fibres and in the connective tissue, and they are sometimes seen within the connective-tissue cells or leucocytes.

Actinomycotic Myositis is not at all common, but in rare cases a focus infected with the ray fungus may, either by direct extension or by metastasis, lead to an infection of voluntary muscle. The infection results in the formation of nodules of granulation tissue, which may undergo fatty degeneration or suppurate and form abscesses. The healing of these nodules leaves areas of induration which are not easy to distinguish from the scars of syphilitic myositis. An inflammatory affection of muscle may also be due to an infection with the *glanders* bacillus. This leads to the formation of many small, grayish abscesses, containing a thin fluid in which the germs are found. The muscle may become infiltrated with pus and chronic ulceration or abscess may result.

Animal Parasites.—Varieties of chronic myositis may also result from the presence of certain animal parasites, one of the commonest of which is the *Trichina spiralis*. When found in muscle, it is in the encysted stage of its development, which is known as a measle. The poorly cooked measly pork is eaten, the capsules dissolve in the gastric juice, the embryos develop in the intestine six or seven days after the ingestion of the meat.

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These pass into the muscles, showing a preference for the diaphragm, tongue, intercostal muscles, neck, larynx, and thigh muscles. The worm penetrates the muscle fibre, which degenerates, the fibrillæ appearing swollen, granular, and with indistinct striæ. The worm is soon surrounded by a clear, homogeneous capsule, which later becomes calcified. There are at first evidences of acute interstitial inflammation in the intermuscular connective tissue, which later disappear. The clinical symptoms consist of irregular fever, gastro-intestinal disturbances, typhoid symptoms, œdema of ankles, pain and tenderness in the muscles. Brown notes a marked leucocytosis in acute cases, the eosinophile cells being most markedly increased, reaching 68.2 per cent. of all the white blood cells present. Muscular changes take place similar to those in chronic myositis—increase of connective tissue, fibrillation and segmentation of the muscle fibres, with granular and hydropic degeneration of the muscle fibres, with proliferation of nuclei and thickening of the sarcolemma are the most marked changes noted. Death may result in the acute stage of trichinosis, or the worms may become encysted within calcified capsules and create no further disturbance, remaining innocuous during the life of the individual. The *Cysticercus cellulosæ* may sometimes be found encysted in muscle, the cyst being surrounded by a firm fibrous capsule, the whole being surrounded by a zone of inflamed muscle tissue. The *Echinococcus* may be encysted in muscle, although it is far more prevalent in the liver and lungs. The capsule is dissolved in the gastric juice, the embryo developing and making its way through the wall of the stomach or intestine and either passing through the portal circulation to the liver and thence to the heart and lungs, which are the regions infected in sixty-five to seventy-five per cent. of all cases, or wandering actively to the muscles and other regions. Gerulanos has recently collected from the literature two hundred and fourteen cases of muscle echinococcus, one hundred and ninety-five of which were single, while nineteen were multiple. Most of these were, however, very limited in number, while the cysts in the case described by Gerulanos were very numerous, varying in size from a pinhead to a man's head. Some of the largest had suppurated and contained masses of pus, while others showed the scolices and hooks, and others contained nothing except a clear yellowish fluid. The tumors were white, opaque, and either smooth or lobulated, surrounded by a fibrous capsule. The question of the origin of the multiple cysts is one of considerable importance. It is claimed by some that each cyst develops from a single embryo, by others that one cyst, containing an embryo is formed from which daughter cysts are given off; others believe that the rare cases of multiple echinococcus cysts are due to rupture of a fertile cyst and hence a reinfection of the surrounding tissues. Gerulanos, however, thinks that in his case at least the multiple infection was due to an active wandering of the embryos, which follow the paths of the loose connective tissue surrounding the large vessels, in the neighborhood of which these colonies were usually found. In the case reported by Scholtz, however, the hydatids were found on the outer side of the thigh, far removed from the great vessels. In several of the cases reported, trauma was described as an etiological factor, but probably, as Gerulanos suggests, the trauma has simply called attention of the patient to a latent tumor which has existed for a long time. The diagnosis of this condition must be based on the presence of an elastic, fluctuating, dense, slightly sensitive tumor. The sensitiveness will of course depend on the exact location of the hydatid. It must be differentiated from neoplasms and cold abscesses. The elasticity and fluctuation indicate fluid contents, while the lobulated, multilocular feeling and the history of the case will generally distinguish the echinococcus cyst from the cold abscess, although the cyst may also sometimes be smooth and spherical. The treatment consists in extirpation of the tumors.

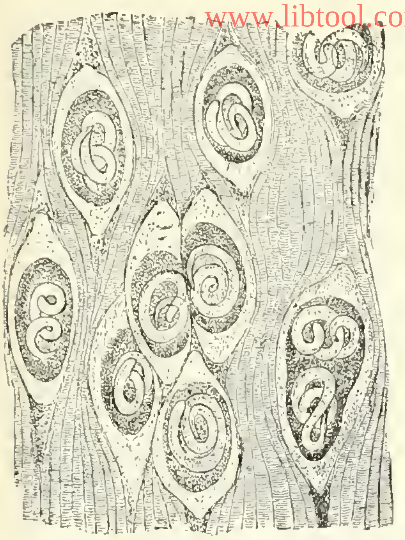

FIG. 3422.—Trichinæ Encysted in Voluntary Muscle. (Ziegler.)

MYOSITIS OSSIFICANS.—Myositis ossificans, as its name implies, is a disease in which an inflammatory affection of the muscles terminates in ossification. Long regarded as a pathological curiosity, it is still a comparatively rare disease, the character and etiology of which are not beyond controversy. Cases of pathological ossification naturally divide themselves into two great classes: those in which bone is formed in connection with bone, an abnormal activity of the cells of the periosteum being the apparent causative factor, and those in which bone is formed in the softer tissues, having no connection, primarily at least, with the skeletal bones or their periosteum. Myositis ossificans occupies a very prominent position in this second group of cases. Two types of this disease are sharply differentiated—a progressive and a stationary form. The progressive type, known as myositis ossificans progressiva, is distinguished from the localized form by the facts that many series of muscle groups are attacked, that it begins in youth and advances with occasional periods of apparent repose followed by exacerbations, which may or may not be attributable to any known exciting cause. This type is much more easily recognized than the second, so that most of the cases mentioned in the literature belong to it. The car-

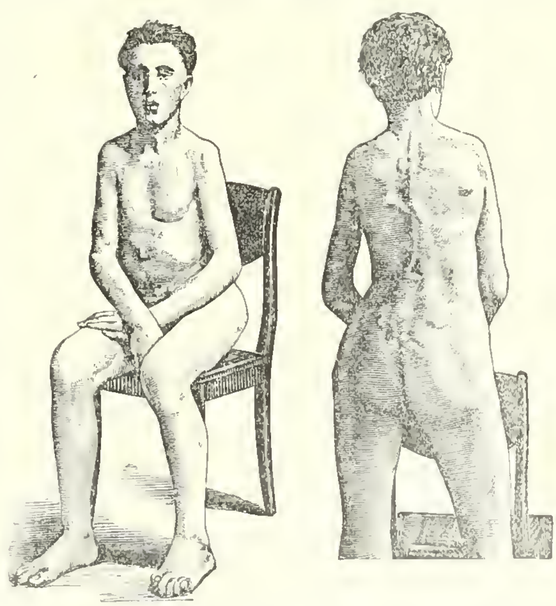

FIG. 3423.—Myositis Ossificans Progressiva, Showing Multiple Osseous Tumors, Forming an almost Continuous Ledge along the Spinal Cord, Fixation of the Head, Microdactylie, etc. (Bruennsohn.)

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liest cases of myositis ossificans progressiva were reported in the Philosophical Transactions of 1740. In the same journal in 1741, Copping gives the following graphic description of a case: "Das ganze Rückgrat war ein zusammenhängender Knochen, von dem sich ein scharfer Rand erhob, der wie eine Handhabe aussah, woran man das Skelet halten konnte. Es waren ihm jedes Jahr aus den Fersen Hörner gewachsen, wie die Sporen bei den Hähnen und die Ueberwüchse von Knochen waren in so grosser Menge da, dass es eben so schwer sein würde sie zu zählen als die Stalactiten in der Grotto der Calypso." In 1869, Münchmeyer, giving to the disease the name suggested by von Dusch, myositis ossificans progressiva, described the disease so accurately that little has been added to his description by later writers.

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He declares the disease to be a constitutional affection of slow course with periodical exacerbations followed by periods of apparent repose. The first disturbance of the muscle tissue begins with a marked infiltration of the intermuscular connective tissue, so that the name myositis ossificans interstitialis which has been suggested is not inappropriate; the second stage, that of connective-tissue induration, consists of an excessive growth of intermuscular connective tissue with destruction of the striated muscle as a result of pressure atrophy or fatty degeneration. The third stage is that of ossification, which begins in the centre of the affected muscle in the connective-tissue ground substance. The disease begins in youth with local swelling and later loss of function and ossification. Sometimes local and radiating pain is associated with it and also slight febrile reaction. The skin may be of higher temperature than normal and the connective tissue may be œdematous. The swelling may disappear after from two to four weeks, leaving the muscle hard and ossified, a condition which is sometimes temporary, but generally spreads to the origin and insertion of the muscle and remains permanent. With very few exceptions, the disease makes its appearance in the muscles of the back, especially in those of the upper portion of the back or of the neck. In connection with the neck muscles, the ligamentum nuchæ becomes ossified and the long muscles of the back generally form one mass of bone; later, the muscles of the scapulæ and the latissimus dorsi are involved; afterward the anterior muscles of the neck are attacked and then the deltoid and the muscles of the axial space. The final result is usually complete fixation of the head, immobility of the entire spinal column and ankylosis of the joints of both shoulders in the position of adduction, with fixation of the scapulæ. Still later, the muscles of the arm and forearm may become inflamed and the elbow-joint ankylosed; the muscles of the hand, however, possess almost complete immunity. In the further course of the disease the muscles of the pelvic girdle, the glutei, and then those of the lower limbs become involved; only at the last and in very severe cases does the disease extend to the muscles of the jaw and of the palate, while the face muscles usually remain intact. Münchmeyer notes the complete immunity of all muscles which are not attached to bone at both extremities, hence of heart muscle, of the diaphragm and sphincters, the muscles of the eye, of the tongue, the facial muscles, the muscles of the genital regions, and the muscles of the abdomen. This immunity is not, however, absolute, since Münchmeyer notes the occurrence of bony tumors in one case on either side of the chin, the location of which coincided with that of the triangularis menti. The disease rarely advances steadily; it is quite characteristic that there should be pauses which may last for years, the renewal of the process being either spontaneous or the result of some injurious influence. Deformities of a more or less severe degree, involving the position of the head, of the spine, and of the extremities result from the fixation of the joints, from the degeneration and loss of function of the muscles, and from the increase and subsequent contraction of the connective tissue. Münchmeyer closes his detailed description of this rare and terrible disease with the following vivid picture: "At first deprived of only a few not very necessary motions, the patient after a time can no longer carry food to his mouth, the hip and knee on one side become immovable, and finally walking becomes impossible. And during this whole long time, there is a constant alternation of hope, as each tumor disappears and as each pause occurs, and the sad feeling of bitterest disappointment as each new symptom appears, until finally all hope is gone, the mouth can no longer be opened, the food can be introduced only through an opening artificially made between the teeth; even swallowing and speaking become at times extremely difficult. The mental condition in a few cases indicates perfect resignation, but generally deep psychic depression prevails."

Although the disease is a comparatively rare one, a careful study of the literature has resulted in finding seventy-eight cases, most of which have followed the typical course which has been described. Exhaustive study of the literature of this disease has been made by Münchmeyer, Pinter, Pincus, Roth, and others, the results having been carefully tabulated by Pincus.

Little is known regarding the etiology of the affection. It occurs very generally in youth, with very few exceptions under fifteen, often in infancy, but Kronecker reports a case beginning at fifty-four. Males seem to exhibit a certain predisposition to the disease, nine of Münchmeyer's twelve cases being males and thirty of Roth's thirty-nine. Many factors are mentioned as predisposing to the disease, such as cold, damp, poor hygienic surroundings, insufficient nutrition, rheumatism, and other constitutional affections. A congenital predisposition is naturally suggested by the fact that it so universally occurs in early childhood, that it is so generally symmetrical in its development, and also by the fact that it is often accompanied by a curious congenital malformation. This is microdactylie, an ankylosis of the phalanges of the thumb, and a lack of one phalanx of the great toe on both sides. This malformation was first noted by Florschütz in 1873, since which time it has been observed in about seventy-five per cent. of all cases reported. While this is the most common abnormality noted in connection with this affection, other anomalies are mentioned, such as hallux valgus and other malpositions and incomplete development of the testis and other organs. Lexer has described quite minutely the microscopical appearance of sections taken from several tumors removed from two cases of myositis ossificans progressiva. Near the periphery of his preparations he finds quite normal muscle fibres. Nearer the centre, the muscle fibres are more or less degenerated, the cross striations lost, the muscle nuclei increased, so that the fibres in many cases resemble giant cells; the fibre is broken up, while the intermuscular connective tissue is increased and infiltrated with leucocytes, especially in the neighborhood of the capillaries. The connective tissue contains many cells of different forms, arising from division of the connective-tissue cells, which may be regarded as fibroblasts, while in some places may be seen cartilage cells with formation of hyaline cartilage. Nearer the centre the ground substance becomes denser, the former connective-tissue cells lie in small angular spaces, and the formative cells lie in rather regular rows on the dense tissue which comprises the osteoid trabeculæ. Later these become calcified and thus bone is formed. The fact that these tumors consist of true bone, often with all the structure of compact bone, is noted by many authors, who have not given so detailed a description of their findings as has Lexer. The degeneration of the muscle fibres, the increase of the connective tissue, and its infiltration with leucocytes are noted by all who have examined these tumors microscopically. Kissel, however, reports a case in which no osseous tissue was found, although the clinical picture was typical of the disease. The tumors showed only young connective tissue with remains of altered muscle. In his case some of the tumors disappeared, leaving no trace, while others broke down and a puriform liquid was discharged. This case improved somewhat under treatment and was regarded by Kissel as an incipient stage of the disease.

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The *prognosis* in this disease is undeniably very bad. The course is, however, very slow, interrupted by many pauses of longer or shorter duration, and death directly assignable to the disease is very rare. As a usual thing, the disease drags its slow course along, the patient becoming more and more helpless, all vital functions unimpaired, until some pulmonary complication or some other intercurrent affection closes the scene.

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Treatment seems practically useless; yet, as in all hopeless diseases, many remedies are tried, partly in hope of relieving the most painful symptoms, and perhaps partly in the hope that the diagnosis may be wrong. Among the remedies suggested are thyroid extract, phosphoric acid, sodium salicylate. In a few cases, extirpation of the tumor was attempted in the earlier stages. So unanimous is the opinion regarding the bad prognosis in this disease that we may well be doubtful of the correctness of the diagnosis in those cases in which cure or permanent improvement is noted.

The disease has something in common with muscular rheumatism, with the muscular dystrophies, with polymyositis acuta, and with the multiple osteomata, but the history of the case, the order of advance of the disease from one series of muscles to another, the symmetrical nature of the affection, with the characteristic deformities resulting from the progress of the disease, make the diagnosis easy, especially in the later stages.

Cases of myositis ossificans confined to single muscles or groups of muscles are less frequently noted in the literature, either because the disease is less easily recognized or because it seems less striking and worthy of note. A careful study of the literature has resulted in finding thirty-five cases. Some of these cases followed a single severe injury, as in the four cases reported by Cahen, in which the growth resulted from the kick of a horse. Other cases resulted from repeated injury or strain, under which heading we may include the ossification of the deltoid and arm muscles in soldiers and of the thigh muscles in riders. This perhaps includes far the largest number of this class of cases. Then we have ossification of muscles occurring in the course of a chronic inflammatory process, which may be rheumatic, syphilitic, or tuberculous.

Cahen describes a case in which, six weeks after a kick had been received, a bony tumor was found about 12 cm. long on the left thigh, corresponding to the position of the biceps. After the failure of other modes of treatment, the tumor was excised; after a short time the tumor returned and was again removed, this time with the periosteum, to which it had become adherent. The sections from these two growths present somewhat different appearances. At the periphery of the section of the first tumor and crowded by connective tissue containing many blood-vessels and large spindle cells, he finds muscle fibres which have undergone many degenerative changes—hyaline degeneration, increase of nuclei of sarcolemma, loss of striation, etc. Near the centre of the tumor, he finds irregularly arranged trabeculæ of bone, with an epithelium-like lining of osteoblasts, with many lacunæ and giant cells, and the spaces filled with a marrow extraordinarily rich in blood-vessels and connective-tissue cells. All through the preparation are scattered bits of muscle, the relation being so intimate that single muscle fibres are completely embedded in bone. In the sections from the second tumor, no muscle fibres are seen. There are three distinct zones: a zone of greatly increased connective-tissue cells, then a zone of small-celled hyaline cartilage, which, by ingrowth of blood-vessels and giant cells, is changed into bone. There is no distinct boundary between the cartilage and bone, the cells becoming smaller and losing their capsules while the intercellular substance becomes denser, more opaque, and stains bluish-red in the hæmatoxylin-eosin double stain. The development of bone in all cases investigated stood in direct relation with an increase of the intermuscular connective tissue.

Lehman describes the case of a woman of thirty-six years, who presented herself with a tumor in the thigh which had been developing at irregular intervals since her seventeenth year. The tumor was extirpated and with it the greater part of the biceps, which was involved in the tumor mass. Microscopical examination showed

FIG. 3424.—Microscopic Appearance of Muscular and Osseous Tissue, Removed from one of the Tumors in a Case of Myositis Ossificans. (Cahen.)

a large amount of adipose tissue, permeated by bands of altered muscle. The changes in the muscle were as follows: 1. Indistinctness or entire loss of cross striation; this condition is called "streifige Degeneration des Muskels." 2. Loss of longitudinal striation—homogeneous appearance of muscle. No true fatty degeneration was however noted. 3. Increase of muscle nuclei, as is seen in atrophied muscle. These changes are accompanied by proliferation of connective-tissue cells. The young connective tissue, in the course of its maturing, undergoes manifold changes until from it peculiar fibrous or osseous tissue is developed. The osseous tissue is typical compact bone except that the lamellar systems are irregularly arranged and differ materially in the size and age of the systems. In some portions of the tumor bone was found, in others musculo-connective tissue, and in others a tissue which forms a transition between bone and connective tissue and might be called osteoid, since the structure of bone is distinct, but calcification is incomplete. This case is interesting on account of the large amount of fat tissue developed among the degenerated muscle fibres, so that Lehman has named this a case of myositis ossificans lipomatosa.

The author has recently reported two cases of myositis ossificans limitata, the autopsies on which were performed by Dr. Warthin. One of these cases was that of a young farmer, aged twenty-three years, the cause of whose

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death was pulmonary and laryngeal tuberculosis. He died April 11th, 1897. His clinical history presents nothing of interest in this connection until March 1st, 1897, when he complained of pain in the left leg. On examination the left leg and foot were found swollen, soft, and œdematous. The thigh was also swollen, although less than the leg. On March 8th, 1897, examination showed the left leg only slightly œdematous and it was no longer painful. No tumor was detected, however, and a marasmic thrombus was believed to have caused the œdema. The autopsy showed a very general tuberculous process. Both lungs were infiltrated with tubercles and contained large cavities. Small tubercles were found in the spleen, liver, adrenals, and kidneys, and a tuberculous ulcer in the lower portion of the ileum. The bronchial glands contained many areas of caseation, the mesenteric glands were enlarged, many of them caseated, and all the lymph glands of the body were enlarged. In the left saphenous vein was found an old obturating thrombus, which extended through the femoral, the left external iliac, and into the left common iliac and the abdominal vena cava. Around the wall of the femoral vein there was an area of hyperæmia and infiltration, originating apparently from an enlarged lymph gland near by. This gland on section showed infiltration and caseation. The microscopical appearance was as follows: Both femoral vessels were nearly or quite filled by thrombi in various stages of organization. The entire section showed marked hyperæmia, all the smaller vessels and even the capillaries being distended and packed full of blood corpuscles. The connective tissue surrounding the large blood-vessels, as well as that around the smaller ones, was infiltrated with leucocytes, which were especially numerous in the tissue around the capillaries. This leucocytic infiltration was especially marked in the intermuscular connective tissue and around the capillaries of the endomysium. Many of the leucocytes showed degeneration and in some portions of the sections larger or smaller necrotic, abscess like areas were found. Surrounding these necrotic areas, and indeed in many portions of all the sections, attempts at repair were noticeable. The inflammatory tissue had been replaced by a new granulation tissue, rich in small, thin-walled blood vessels and in large plate-like cells with little fibrous tissue. The most marked changes, however, were in the muscular tissue. In addition to the alterations in the intermuscular connective tissue already noted, various degenerative changes in the muscle were observed.

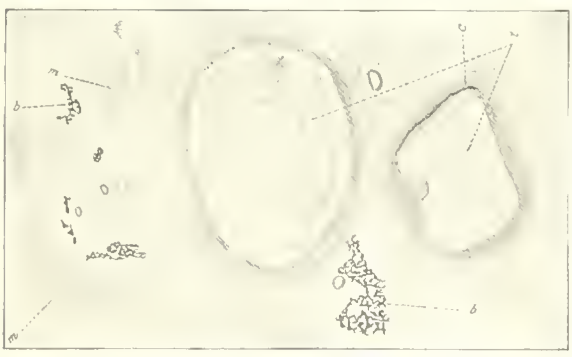

FIG. 3125. Section Through Both Thrombosed Femoral Vessels, Muscles, Fat, Connective Tissue, and Granulation Tissue Containing Plates of Bone. *m*, Muscle; *b*, bone; *c*, calcification; *t*, thrombus. Drawn under the dissecting microscope, with aid of camera lucida. Magnified about eight times. Reduced to one-half size of drawing. (DeWitt.)

In some portions of the sections, especially at a distance from the centre of the inflammatory area, the muscle appeared fairly normal, both in size and in the finer structure. Near the centre of the inflammatory area, however, the muscle fibres were much smaller, of very irregular contour, and either tapered to a point or divided into numerous bundles of finely fibrillar tissue resembling fibrous connective tissue. The cross striation was lost and in some even the longitudinal striation seemed lost or very indistinct, so that the fibre appeared finely granular or entirely homogeneous. In some places a muscle nucleus, with a fusiform fragment of sarcoplasm, was separated off from the rest of the cell. The nuclei may be absent from a considerable portion of the fibre and crowded together at one end or at one side, and often a small fragment of muscle containing many nuclei, or even a mass of nuclear substance in which the nuclear outlines were very indistinct was seen. Small, isolated, fragments of muscle could be seen in the granulation tissue and even in and near the inflammatory, necrotic areas, containing numerous nuclei embedded in homogeneous-appearing protoplasm, producing the appearance of giant cells. These may be interpreted as attempts at regeneration of the degenerated muscle fibre, although probably many of the forms, especially those in the necrotic areas, were degenerating sarcolytes. In addition to the simple atrophy, fatty degeneration and Zenker's waxy necrosis were noted.

In the granulation tissue, which seemed to have replaced the larger inflammatory areas, were irregularly branching and anastomosing trabeculæ of osteoid tissue consisting of a dense matrix, enclosing rather large cells usually not surrounded by a capsule. The spaces between the trabeculæ were filled with very vascular granulation tissue, somewhat resembling bone marrow. Many of the large cells of these areas were arranged on the trabeculæ, like the layer of osteoblasts on the trabeculæ of developing bone. Most of the osteoid tissue had undergone calcification, at least in the central portion, so that, according to Ziegler's definition, it represented a true ossification process. It may be added that some of the sections were stained by Schmorl's bone stain, and, while, as might be expected from the short duration of the process and the thinness of the trabeculæ, no structure of compact bone was to be seen and the cells did not show the processes so characteristic for adult bone cells, yet in each case a layer of greater or less width surrounding the trabeculæ gave the typical color reaction given by bone to that stain. In some of the sections these plates of bone formed a nearly continuous ring around the large blood-vessels. In others they were scattered throughout the section in smaller masses, always found in the granulation tissue, never in the old connective tissue, nor in the inflammatory tissue which was still undergoing retrograde changes. These ossified masses were found, not only immediately around the femoral vessels, but also extending out in all directions between the degenerating and regenerating muscle fibres, wherever a sufficiently large area of granulation tissue was found. The relation of the plates of bone to the other tissues in the section is represented in Fig. 3125. In the marrow spaces were often seen bits of degenerated muscle, atrophied, non nucleated, and appearing homogeneous.

By Unna's orcein differential stain and also by Weigert's stain for elastic tissue it was shown that a regeneration of the yellow elastic-tissue fibres was taking place in the granulation tissue. Although the patient was tuberculous, no tubercle bacilli were found in the enlarged lymph glands in the neighborhood of this inflammatory process, nor was the structure that of a tubercle, but rather that of a simple, necrotic abscess. The changes in the tissue indicate that the intermuscular inflammation, the changes in the muscle, and the bone formation antedated by a considerable period the thrombosis, which was probably secondary to the other changes.

In the second case, the clinical history presented nothing of interest except the fact that the femur was broken about five weeks before the death of the patient, but the fracture was not in the immediate neighborhood of the point of ossification of the muscle. The microscopical appearance of the two cases was identical and an obturating thrombus was found in the femoral vein in both. The fact that in these two cases the ossification was not discovered until the autopsy had been made and the

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tissues examined microscopically is of interest as suggesting the possibility that pathological ossification of muscle after injury or inflammation may occur much more frequently than is generally supposed or than can be gathered from the literature, since such an ossification, if limited in extent, may not cause any symptoms that would lead to the diagnosis of myositis ossificans. When the diagnosis is made and the disturbance is sufficient to warrant it, operation seems to offer great hope of recovery. In the cases reported by Cahen, Lehmann, Munro, and others, entire extirpation of the tumor, with the periosteum in cases in which the bone had become adherent to the periosteum, resulted in perfect recovery. Much difference of opinion has arisen as to the true character of the bone formation. Virchow places the disease on the border line between inflammation and new growth and is supported by Lexer, Bollinger, and many others. Mays asserts that it is a true tumor and is supported by Kümmel, Pinter, Helferich, Pincus, Partsch, Cahen, and others. Cahen bases his assumption on the microscopical appearance, especially on the fact that new connective tissue, cartilage, osteoid tissue, and bone are found in the same section, thus showing the characteristics of an atypical growth. They consider the inflammatory phenomena and muscle degeneration to be secondary to the tumor formation. Pincus, after a most exhaustive study of the literature and of his own cases, arrives at the conclusion that myositis ossificans progressiva is not a disease, but undoubtedly a tumor belonging to the multiple osteomata and exostoses of Virchow. He states that the process begins in the periosteum, the muscle degenerating secondarily, and that an inborn, not hereditary, constitutional anomaly lies at the foundation, the constitutional anomaly consisting of an excessive productivity of the periosteum and connective tissue of the locomotor apparatus. The disease needs for its development an external cause, which may be trauma or rheumatism. The apparently spontaneous cases arising in early life are really of traumatic origin and due to intrapartum injuries. Nicoladoni advances the hypothesis that it is a trophoneurosis, comparable to progressive muscular atrophy and pseudohypertrophy of muscle. Electrical tests, however, indicate the absence of any neuropathic factor and the disease is probably myopathic, and either primarily inflammatory in character or having the primary characteristics of a neoplasm. In the progressive form of the disease many of the tumors are probably neoplasms, while others, as would seem to be indicated by Lexer's description, are developed on an inflammatory basis. In consequence of the diffuse interstitial myositis, an indifferent granulation tissue arises, which may change either into scar tissue or into cartilage and bone. In the myositis ossificans limited to single muscles or groups of muscles, the primary condition is an inflammatory process in the intermuscular connective tissue resulting in the degeneration of the muscle fibres, either from simple pressure atrophy or from fatty degeneration, so that the name myositis interstitialis ossificans seems not inappropriate. Processes of repair are then established, granulation tissue rich in fibroblasts and small blood-vessels, in which white fibrous and yellow elastic fibres are sparingly developed, is formed. Instead of changing to mature connective tissue, however, a portion of this granulation tissue changes to trabeculæ of osteoid tissue, and the rest into bone marrow which fills the spaces between the trabeculæ. This is not unusual since, as is well known, the different members of the connective-tissue group change with great readiness to other forms of connective tissue. Cold, unsanitary surroundings, trauma, either single or repeated, irritation, as in the exercise bones, or chronic pathological processes may act as the direct causes of the development of the disease. This might be satisfactory on the etiology of the affection, were it not that the exciting cause is often so slight and trivial that we cannot believe it sufficient to produce the disease in a normal individual.

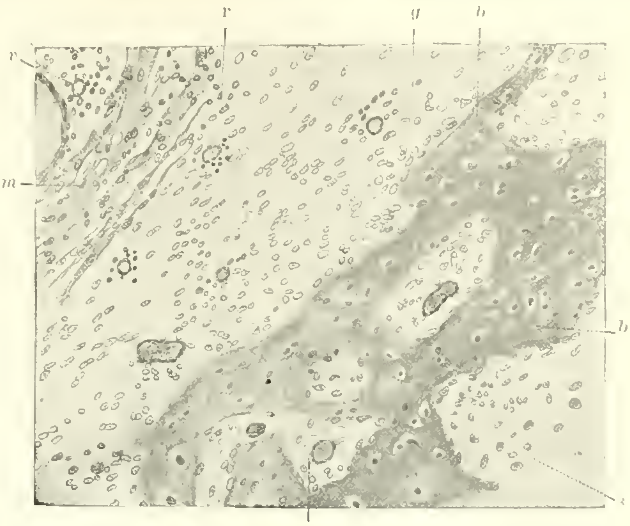

FIG. 3426.—Section Through a Few Trabeculæ of Pathological Bone Formation, with Marrow Spaces, Surrounding Granulation Tissue, and, at the Periphery, Degenerating Muscle Fibres. *b*, Bone; *m*, degenerating muscle; *g*, granulation tissue; *s*, marrow spaces; *r*, capillaries surrounded by connective tissue infiltrated with leucocytes. Drawn with the aid of the camera lucida. No. 2 eyepiece; one-sixth inch objective. Reduced to one-fourth. (DeWitt.)

This is especially true of the progressive type, while in the stationary form of the disease the irritant cause which has operated on hundreds of cases has produced ossification in very few. The explanation of these facts has opened a large field for conjecture and speculation. Virchow believes that in these individuals there is an ossifying predisposition, either hereditary or congenital, which he calls diathesis ossificata sive ossea. Mannz suggests as a predisposing causative factor a disturbance of embryonic development. He says: "In the 'Anlagen' of musculature, where in later life pathological bone formations occur, osteoblastic nuclei enter. These nuclei remain dormant so long as they are held in check by the physiological resistance of the neighboring tissues. If, however, this be weakened, the bone Anlagen develop into the pathological bone formation." He explains in a similar way the occurrence of exostoses and osteophytes which are so frequently found in conjunction with the muscular ossification. Those who favor the view of embryonic disturbance cite the frequent occurrence of microdactylie in this disease as an evidence in favor of their hypothesis. Atavistic influence, misplaced periosteal buds and osteoblasts, etc., have been suggested. Direct heredity, however, seems from the history of the cases reported to have very little influence. Atavistic influence seems to be contraindicated by the fact that in the hand and foot, where splint bones are most common in the lower animals, these osseous growths rarely occur. In the progressive myositis ossificans, beginning in early life, it may be necessary to admit the hypothesis of a congenital condition consisting of an abnormal activity of the osteoblastic, or, if we accept the Weismann theory of embryonic development, the persistence of indifferent, undifferentiated mesenchymal cells, which, under the requisite conditions of nutrition, develop abnormally into nodules of fibrous connective tissue, cartilage and bone, sometimes in connection with the skeletal bones, sometimes in fascia, tendons, ligaments, or intermuscular connective tissue. In the localized form of the disease, however, no such hypothesis seems to be necessary. In these cases granulation tissue is formed, a new connec-

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tive tissue, whose cells may therefore revert to the undifferentiated, indifferent, embryonal cell type, mesenchymal cells, which may develop into fibrous tissue, cartilage, or bone according to the prevalent nutritive conditions.

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WOUNDS AND INJURIES OF MUSCLE.—Injuries of muscle may be of the most varied degree of severity, from a slight strain or sprain, twisting, or laceration of a few fibres of the muscle, which results in the so-called myalgia, to complete severance of all the fibres of the muscle.

Myalgia is a temporary condition of pain in the muscle, which is usually neuralgic, and which is caused by a slight traumatism, with possibly an inflammation of the muscle, or may arise from an acute infectious disease, from syphilis, or from some toxic agent, as mercury, alcohol, or lead. The affection is usually but trivial, and is cured spontaneously, especially if the affected part is put at rest by the use of splints or strapping. Local applications of heat and anodyne solutions are useful, and the pain may at times be so severe that hypodermic injections of morphine may be necessary. If the muscle fibres are weakened by disease or degeneration, or if the strain upon the muscle is too great, either from an external force or from too violent and sudden contraction, the muscle may be fractured, either completely or partially. Fractures and lacerations of healthy muscle are rare except in cases of sudden, unexpected, or unusual contractions. Such accidents are more common among soldiers. Certain diseases, however, such as typhoid fever, yellow fever, scarlet fever, and other severe fevers weaken the resistant power of the muscle, which may undergo various degenerative changes which make it more brittle. The rectus abdominis, the rectus femoris, the adductors of the thigh, the calf muscles, the psoas, and the flexors of the forearm are the muscles most frequently fractured. The symptoms of fracture of muscle are quite characteristic, consisting of sudden sharp pain, with a sensation of giving way and powerlessness of the muscle. In case of complete rupture, a gap is immediately formed between the broken ends of the muscle by the contraction of the parts, and this gap, which can easily be palpated, is a characteristic feature of the affection. It is soon filled, however, by an extravasation of blood, which may form a hæmatoma of greater or less extent and hence a prominence in place of the depression. The skin becomes discolored usually from the extravasation of blood. Wherever muscle is lacerated, whether the tear is large or small, blood extravasates into the tissues, except in those cases in which the injury is very near the tendinous extremity of the muscle, where the vascular supply is poor. The interference with the function of the muscle depends upon the extent of the laceration, the use of the muscle being lost in cases of complete rupture. If only a few fibres of the muscle are broken, recovery is usually rapid and complete and the function of the muscle may be quite well restored even when the injury is quite extensive. In these milder cases the only treatment usually necessary is perfect rest of the affected part. If, however, the muscles are completely torn across, it is usually necessary to suture their ends; and where there is a considerable gap between the ends, it may be well to fill in the interval with the muscle from an animal (muscle grafting), or with sutures of chromicized catgut or kangaroo tendon to act as a framework for the reparative material. The interval is at first filled with granulation tissue, even the engrafted muscle undergoing degenerative changes, later a scar tissue is formed, penetrated in places by the regenerated muscle fibres. In spite of the experimental work on muscle grafting previously mentioned, the consensus of opinion among surgeons and pathologists seems to show that, while the function of the muscle may be fairly well restored, muscle fibres are not regenerated in sufficient numbers to fill the intervening space. At times the injury results in the formation of bone in the granulation tissue following the law of the metaplastic tendencies of the connective tissues. In some cases the muscle remains intact, while the overlying fascia is torn, generally as the result of the imperfect healing of some former wound. In these cases the muscle may protrude through the opening in the fascia, forming a muscle hernia. Féré collected thirty-one cases of muscle hernia in epileptics, fifteen of which were symmetrical, a finding which would seem to indicate a certain nervous influence as a possible etiological factor in these cases. The hernia is distinguished from a neoplasm in the muscle, from an aneurism, etc., by the fact that it disappears entirely or diminishes in size when the muscle is at rest, becoming prominent during the contraction of the muscle. Generally the opening in the fascia can be felt through the skin. The condition may often be attended by considerable inconvenience, pain and loss of function of the affected muscle. Rest and bandaging are usually sufficient to effect a cure in recent cases. In cases of long standing it may be necessary to freshen the edges of the rent and unite them by stitches. It is distinguished from fracture of muscle by the fact that the symptoms usually develop more gradually than those of fracture. It affects the adductor muscles by preference. Muscle may also be more or less completely crushed by external violence. The results of this as well as of other injuries of muscle depend upon several factors. Apparently identical injuries may in one case cause only temporary disturbance of function, in another ossification, and in another paralysis. Young tissues tend to heal more readily than old. The condition of the muscle at the time of the injury, whether at rest or contracted, has a marked influence on the effect of any traumatism. The nerve fibres which may be cut, injured, or compressed may have a vital bearing on the permanency and severity of the functional disturbance. Single or repeated injuries of muscle may have a real or fancied relation to the development of malignant tumors, a fact which may be explained by the assumption that embryonic tumor-tissue germs are latent in the muscle, which are either excited to activity by the irritation produced by the traumatism or permitted to grow because the normal resistance of the tissues is removed or diminished as an effect of the injury.

II. INVOLUNTARY MUSCLE.

Involuntary muscle has a wide distribution, occurring in the walls of the digestive tract, blood-vessels, skin, in the capsules of many organs, and making up the greater part of the structure of the uterus, bladder, and other organs. Its structure is far simpler than that of voluntary, striated muscle, and its pathological changes are therefore less complicated and have received less attention and research. It consists of mononuclear, fusiform cells, cemented together to form bundles or membranes, which are separated by a larger or smaller amount of connective tissue. The pathological processes in nonstriated, as in striated muscle, consist of inflammations, degenerations, and tumors. Certain abnormalities may be noted occasionally, such as the presence of striated muscle fibres among the involuntary muscle fibres of the uterus. These may be due to the metaplasia of nonstriated into striated muscle or to the misplacement of embryonal cells.

The pathological processes occurring in involuntary muscle have not attracted the attention of investigators as have those of voluntary muscle. This may be explained, in part at least, by the fact that any disturbance in the function of voluntary muscle causes unmistakable symptoms, while in most cases the symptoms of change in involuntary muscle are masked and indefinite and the pathological processes in it are often not recognized until after the death of the patient. In most cases of muscular atrophy, whether neuropathic or myopathic, and in other muscular degenerations the statement is made either that the involuntary muscle was normal or that it was not examined. Certain regressive changes, analogous to those which occur in striated muscle, are, however, observed, having been described especially in connection with inflammations and tumors of the myomatous type. Œdema of non-striped muscle is frequently

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noted. Kenntmann described a case of myometritis œdematosa, in which the muscle fibres of the uterus became so soft and œdematous that the uterine wall was perforated by a sound. Microscopical examination of the myometrium in this case showed the muscle bundles separated by large clear spaces, equal in size to the muscle bundles themselves. This condition was especially marked in the vascular middle layer, in which the blood-vessels presented thickened walls, the connective tissue of the intima being especially thickened. The muscle cells appeared cloudy and in places atrophied. Near the vessels the muscle fibres appeared especially narrowed, even the nuclei being atrophied. Large areas were found in which the muscle had undergone pathological degeneration. No solid strands or bundles were found, and the single fibres were so small that they gave the impression of being reduced to fine fibrils, whose single thicker part, we might almost say whose single dimensional part, consisted of the degenerated and poorly stained nucleus. The connective tissue was probably somewhat increased, but not markedly so; still in places where the muscle was most degenerated, some increase of connective tissue could be observed. Similar degenerative changes are frequently observed and described in myomata of the uterus, which have undergone myxomatous or œdematous degenerative changes.

Atrophy of involuntary muscle occurs under conditions similar to those of atrophy of voluntary muscle. A neuropathic form of atrophy of involuntary muscle—although a form which may be considered neuropathic has been mentioned in connection with vitiligo and other skin diseases—has not so far as I have been able to find, been described. The atrophies are largely due to circulatory disturbances, as in the case above described, or to pressure of a fluid or cellular exudate, as in inflammations. No better picture of atrophy of involuntary muscle has been given than that by Kenntmann. Similar atrophy of the involuntary muscles of the skin in skin diseases has been described by Unna, Pospelow, and Lelois and Vidal.

Hypertrophy of non-striated muscle frequently occurs and may be physiological or pathological. The best example of the physiological hypertrophy is that found in the pregnant uterus. Pathological hypertrophy occurs as a result of stenosis or obstruction of the intestinal canal and other ducts. This is regarded by Herczel as a true hypertrophy, without increase of the number of cells, although many authors regard it rather as a hyperplasia accompanying the hypertrophy. Hypertrophy of the skin muscles was also described by Unna in keratosis suprafollicularis and in pityriasis rubra and other skin diseases. In elephantiasis streptogenes he found the non-striated muscles enlarged, but not increased in number. Calcification of involuntary muscle was noted by Meslay and Hyeme and others, and Brunings reports a case of fatty degeneration of a myoma, the process corresponding to that in progressive muscular atrophy. True ossification of uterine myomata has also been noted. Liquefaction necrosis of the dermal muscles was noted by Unna in abscesses and a collaginous degeneration of these muscles in erysipelas. Gangrene and other forms of necrosis have also been observed in myomatous tumors, as well as cystic degeneration. Nuclear degenerative changes have also been noted, such as atrophy, vacuolation, granulation, and karyolytic changes. The question of the *regeneration* of involuntary muscle is one which has been considerably discussed, and upon which authors are still at variance. Vignolo-Lutati, in his experimental study of the pathological conditions in the skin muscles, was never able to find karyokinetic division figures, but frequently, especially after the less severe injuries, he found appearances which he interpreted as direct nuclear division. Ziegler states that "there is a new formation of smooth muscle fibres and also a regeneration after traumatic, toxic and chemic injuries, as well as in the hypertrophic new formations of muscle, as in tumors; that this process begins with the karyokinetic division of the nucleus of the muscle cell. However, it is shown by experiment as well as by observation of men that there is very little reproduction of the non-striated muscle fibres, as in the healing of wounds and areas of degeneration, the regeneration soon ceases and the loss of substance in the muscular coats of stomach, intestine and bladder is replaced mostly by connective tissue. The new muscle tissue is formed probably entirely from preexisting muscle tissue." Moleschott and Piso Borne and Busachi support these conclusions, while Arnold, Aeby, Frey, Neumann, and Virchow favor the view that it may originate from connective-tissue cells, and Kölliker and Förster believe that it develops from embryonal germ cells or formative cells. Tizzoni also found a zone of proliferation near the diseased area in typhoid ulcer of the small intestine; and Baumgartner in cases of tuberculosis found mitoses in the muscle tissue of the arteries, veins, and bronchi near the affected area. Herczel and Baumgartner were unable to find signs of proliferation after their experiments, while Vignolo-Lutati found only direct nuclear division in the skin muscles in his experiments. From all this work we may conclude that regenerative changes occur in non-striped muscle as in striated muscle, both by mitotic and by amitotic nuclear division; but that the result is only a partial replacement of the destroyed muscle tissue, the main portion being replaced by scar tissue.

Inflammatory processes in smooth muscle are exceedingly common, although generally secondary to similar processes in the neighboring tissues. Vignolo-Lutati reports the development of inflammatory changes in the involuntary muscle of the skin as the result of the injection of bacria and also of chemical, thermic, and mechanical irritants. With some variations in degree, the pathological picture in all these experiments was essentially the same. The intermuscular connective tissue was infiltrated with leucocytes, which were either diffusely scattered through the tissue or formed small nodes. The blood-vessels were distended and filled with blood, while the whole tissue appeared œdematous. The muscle fibres were swollen, vacuolated and hydropic, and crowded apart by the exudate. The muscle nuclei were either granular or vacuolated and karyolytic figures were noted in some of the experiments. After the simpler mechanical injuries the nuclei showed direct division, which the authors regarded as preliminary to regeneration of the muscle fibres. Purulent inflammation of the non-striated muscle of the uterus is a very frequent occurrence, while Aristoff notes a case of syphilitic inflammation of the muscle coats of the stomach, extending from the mucosa. Tuberculous nodes have been noted in the non-striped muscle of myomas of the uterus, as well as in involuntary muscle in other localities.

Muscle Tumors.—Certain tumors composed largely of muscle are known as myomas, one class of which consists of striated muscle and are called rhabdomyomas, while the other and more common class of myomas consist of non-striated muscle and are called leiomyomas. The rhabdomyomas have a stroma of connective tissue in which cells and fibres are found which resemble striated muscle cells in various stages of development, degeneration, and regeneration. None of the cells appear as normal, mature striated muscle cells. Many of the cells are small, spindle-shaped cells with a single nucleus or with a few nuclei and with a very faint striation or even showing no transverse striation at all. Others are larger and the striation more distinct, but irregularly arranged, while the nuclei appear at the periphery of the fibre. Some appear granular, with undifferentiated hyperchromatic nuclear substance collected in the centre or near the periphery. Drops of glycogen may be seen in the protoplasm. Sarcomatous, myxomatous, fatty, cartilaginous, or osseous tissue may be mixed with the muscle tissue of these tumors, giving rise to the rhabdomyosarcomas, rhabdomyomyxomas, rhabdomyochondromas, etc. The teratomas also consist in part of muscle tissue closely resembling the atypical striated muscle tissue of the rhabdomyomas. The rhabdomyomas may occur in regions in which striated muscle is normally present, but

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are far more common in the kidney, testes, uterus, and other organs in which striated muscle is not normally found. They occur in childhood and even in the newborn, and it is generally conceded that they arise from misplaced embryonic muscle tissue. Fujinami, however, reports an interesting case of a so-called cylindroma and rhabdomyoma in a man of fifty, in the voluntary, skeletal muscle, the tumor showing a distinct endotheliomatous arrangement. There was a hyaline degeneration of certain tumor cells, as well as of the vessel walls and connective-tissue fibres, but especially of the fusiform sarcoma cells. Fujinami believes that the crosss-triped muscle cells arise from the fusiform sarcoma cells.

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Leiomyomas are far more common and occur usually in adult life and in the organs consisting of non striated muscle tissue, as the uterus, prostate and the muscular walls of the stomach and intestine. The tumors consist of strands of fibrous connective tissue, between which are found bundles of non-striated muscle, running in different directions. Although often hypertrophied, the muscle cells are fairly normal and yet sharply separated from the surrounding muscle tissue, either by a connective-tissue capsule or by a different arrangement of the muscle fibres. Blood-vessels run through the tumor mass, the arrangement of the muscle cells of the tumor having often a direct relation to the axis of the blood-vessel. These tumors are regarded as benign tumors, the seriousness of which depends upon the size which they may attain and the organs and tissues upon which they may press. When they occur in the intestine, however, especially in the internal coat, they cause an obstruction which is often fatal. They may also cause hemorrhage in the intestine, although this is not often seen in myoma of the stomach. If situated in the outer coat of the intestine, they may develop for a considerable time before causing any obstruction. Although the leiomyomas are generally regarded as purely benign tumors, Brodowski, Hansemann, and Schmorl describe multiple metastases in tumors which were regarded as pure myomas. Such observations are, however, so rare that the question naturally suggests itself whether some, possibly small, areas of the original muscle tumor may not have been sarcomatous. The occurrence of epithelial or glandular tissue within the muscular tissue of the myoma is noted by Schroeder and Ruge, Recklinghausen, and many

FIG. 3427. Degeneration of Muscle Fibre (a), and Penetration of Fibre by Carcinoma Cells (b). (Fujinami.)

others. This may give the tumor an adenomatous or even a carcinomatous character. These adenomatous appearances are found especially in the digestive tract, as in the case reported by Lubarsch, which he regarded as aberrant pancreatic tissue, which had excited the surrounding muscle to new growth. The muscle may undergo also all kinds of degenerative changes, such as calcification, gangrene, necrosis, œdema, inflammation, which may be tuberculous or simply purulent. It may also be so richly vascularized as to give it a telangiectatic or cavernous character. The sarcomatous and the rarer carcinomatous malignant degenerative changes in these tumors have already been mentioned. Steiner has collected from the literature and reported fifty-two cases of

FIG. 3428.—Muscle Forms Found in the Neighborhood of Malignant Tumors. (Fujinami.) a, b, c, h, Ampullar degeneration; d, e, f, g, giant-cell formation.

myoma of the stomach and intestine, while those of the uterus and prostate are much more numerous. The multiple dermatomyomas form a most interesting class of cases, in which numerous painful swellings arise in the dermis developed from the non-striated muscle of the blood-vessels, from the arrectores pilorum, or even from the involuntary muscle of the sweat glands. The etiology of the leiomyomas is still in dispute. Although they usually develop late in life, the theory is advanced by some that they are of embryonal origin, the tumor germs remaining latent, until they are excited to activity by some irritation. Others claim that they originate by a metaplasia of the connective tissue. Some claim that

FIG. 3429. Showing Twisting of Fibrils within the Sarcolemma. (Fujinami.)

the tumor tissue arises from the non-striated muscle of the blood-vessels and others say that the muscle tissue of the organ in which it develops is responsible for its growth. While all these theories have strong supporters, it seems reasonable to conclude that the muscle tissue of

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these tumors usually originates from pre-existing muscle tissue, either of blood-vessels or of the organ involved, or from embryonal germs of such tissue which have re-

FIG. 3430.—Showing Irregular Contour of Muscle Fibres and Irregular Arrangement of Striation. (Fujinami.)

mained latent until some cause excited them to growth or removed the inhibition which was preventing their development.

Among the less important, because less frequent tumors arising in muscle are lipomas, angiomas, fibromas, chondromas, osteomas and myxomas. The structure of these tumors when found in muscle does not differ materially from their structure in other localities.

Carcinoma in muscle is a result of lymphogenous metastasis or of the infiltration of the muscle by the carcinomatous nodules in the neighborhood. The muscle fibres take no part in the formation of the tumor, although they undergo various degenerative changes, and the tumor cells may even penetrate the broken sarcolemma and fill the muscle fibre, as shown in Fig. 3427. From this fact it has been said that the carcinoma cells arise from the muscle cells, but although we recognize the atypical character of origin and growth of tumors, yet it seems unnecessary to assume in this case a mode of origin so remote from the normal type. Inflammatory processes may also be seen in the neighborhood of these tumors. *Sarcoma* is, however, the most common malignant tumor occurring in non-striated muscle. These may be very large and either consist of round cells or of spindle-shaped cells. The sarcoma may be mixed with fat, fibrous tissue, mucoid tissue, etc., forming the liposarcomas, fibro-sarcomas, and myxosarcomas. As in carcinoma, sarcoma cells may penetrate the broken sarcolemma, giving the impression of being formed from the muscle cells. The structure of these tumors does not differ materially from that of analogous tumors in other regions. We are therefore far more concerned at this place with the pathological changes produced in the muscle by the ingrowth of the tumors than with the structure of the tumors themselves, which will be fully treated in another place. Schaeffer, Fujinami, Anzinger, and others have investigated the changes which occur in voluntary striated muscle in the neighborhood of malignant tumors, and have found nearly every possible form of degenerative change. Fujinami asserts that the alterations in the muscle are essentially the same in sarcoma as in carcinoma, while Anzinger believes that degenerative changes are more marked in the neighborhood of carcinomas, while the so-called regenerative changes are seen in greater abundance near sarcomas. All agree that the distinctness of the striation may be greater or less than normal, varying much in different portions of the same preparation. Atrophy is the most frequent and constant change, due probably, at least in part, to a disturbance in the nutrition of the muscle, but partly also to the diminished functional activity of the muscle, and possibly also to nervous and trophic influences. Peculiar depressions, containing large numbers of muscle nuclei, are often found at the sides and ends of the fibres, giving an irregular contour to the fibre; this is known as lacunar erosion. The muscle fibres may also break up, either longitudinally into slender fibrils containing rows of nuclei, or transversely into segments containing groups of nuclei. Fujinami also notes a peculiar twisting of the muscle fibrils within the sarcolemma. Zenker's necrosis, cloudy swelling, vacuolation, proliferation of nuclei, both by mitotic and by amitotic processes, with marked alterations in the nuclear form, are frequently observed in the neighborhood of these tumors. Fujinami regards all these changes as essentially degenerative in character, in spite of the fact that certain multinuclear forms resembling the myoblasts of regenerating muscle are frequently seen. Anzinger and others regard these giant-cell forms as abortive attempts at regeneration. While more work is needed on this point, there seems little doubt that at certain stages of the process degenerative forms occur which closely resemble the regenerative forms of voluntary muscle, although the conditions are such that no attempt at regeneration is to be expected.

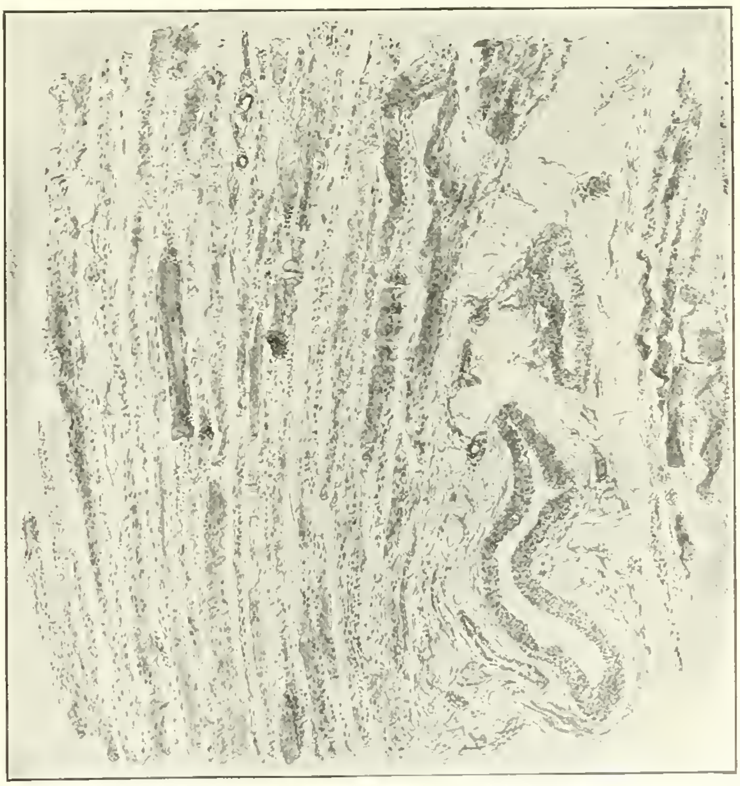

FIG. 3431.—This Figure Shows the Atrophy, Irregular Contour, Faint Striation, and other Degenerative Changes in the Muscle and the Inflammatory Process in the Intermuscular Connective Tissue in the Neighborhood of a Malignant Tumor. (Anzinger.)

The perimysium of the voluntary muscle in the neighborhood of these malignant growths is often hyperplastic and shows leucocytic infiltration, hemorrhage, œdema, fat infiltration. Endarteritis and periarteritis are frequent occurrences.

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The penetration of mast cells and leucocytes and even of tumor cells into the muscle cells is one of the most interesting points mentioned in the study of these cases. Fujinami has figured a number of muscle cells containing a larger or smaller number of tumor cells and states that the tumor cells may be derived from the degenerating muscle cells. This idea is refuted by Schaeffer, although supported by Schroeder, Neumann, Bardeleben, and others. Schaeffer states that there may be a great similarity between the tumor tissue and the muscle tissue, which makes confusion possible, and that the tumor cells may penetrate the muscle fibres. The origin and etiology of these tumors in muscle, as in other tissues, are still obscure; but it seems more reasonable to regard the appearance of the tumor cells within the sarcolemma as a result of the passage of these cells through a broken sarcolemma, especially as they are accompanied in this position by leucocytes and mast cells, than to believe that the tumor cells are formed from the contractile substance of the muscle fibre by its degeneration.

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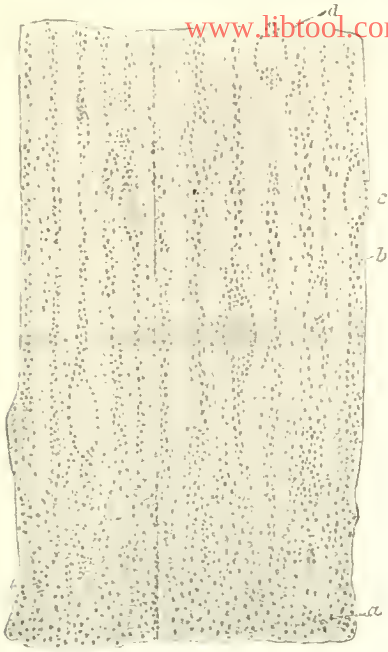

FIG. 3432.—Atrophied Muscle with Circumscribed Dilatations and Nuclear Proliferation in the Neighborhood of the Tumor Mass. (Fujinami.) *a*, Carcinoma cells; *b*, atrophic muscle; *c*, ampullar portion, beginning of giant cell formation; *d*, giant cells.

Lydia M. De Witt.

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MUSCLES, ANOMALIES OF.—The muscular system of man is subject to many variations, all of which are interesting from a morphological point of view, and many are important surgically. Not only do muscles vary as to form and attachment, but supernumerary and rudimentary muscles are not infrequent. Again, some may be absent in a certain number of individuals, *e.g.*, the pyramidalis, palmaris longus, etc.

Many muscles are mere rudiments of those which exist in a well-developed condition in the lower animals, and there is, in fact, no muscular variation in man which has not a corresponding normal condition in some animal lower in the scale.

In the present article space forbids the giving of any extended account of muscular variations, for it is a subject on which volumes have been written. It is intended to describe only the commoner and more important anomalies, especially mentioning those whose relation to arteries renders them of surgical interest. The reader who wishes to obtain a fuller knowledge of the subject is referred to Wood, Turner, and others, in the *Journal of Anatomy and Physiology*; J. Wood, "Proceedings of the Royal Society," 1864–69; "Guy's Hospital Reports"; "St. Thomas' Hospital Reports"; Macalister's "Catalogue of Muscular Anomalies," in Trans. Royal Irish Academy, 1872; W. Gruber, in the *Mém. of Acad.*, St. Petersburg, and Virchow's *Archiv f. klin. Med.*; Henle, "Handbuch, Muskellehre"; Hallett, *Edin. Med. Jour.*, 1845; Krause, "Handbuch," 1880; Testut, "Les Anomalies Musculaires chez l'Homme," Paris, 1884; also various papers in the *Journal of Anatomy and Physiology*.

MUSCLES OF THE HEAD AND NECK.—*Occipito-Frontalis* varies much as to size and position. The *occipitalis* occasionally approaches the median line, and may be divided into several portions. Some of its fibres may be continuous with the posterior auricular muscle.

The *Frontalis* may send slips to the nasal and superior maxillary bones. Theile says that it generally sends a bundle of fibres to the external angular process of the frontal bone. Its fibres have been described as normally continuous with the levator labii superioris alæque nasi.

Auricular Muscles.—Very various as to their development. The retrahens is very often of large size, and its tendon frequently arises from the neighborhood of the external occipital protuberance: in such cases its belly is

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very fleshy, and may be divided into two portions. It is sometimes connected with the transversus nuchæ. Cruveilhier has described a deep *musculus auricularis anticus*, which goes beneath the superior from the zygoma to the outer surface of the tragus. The anterior auricular muscle is often very much diminished in size, and its fibres may be very indistinct.

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Muscles of the Nose.—Absence of the pyramidalis has been observed. The compressors and dilators are often so feebly developed as to be seen only with a magnifying glass.

The *Musculus Anomalus* (Albinus) is a slip described as being frequently present. Lying beneath the levator labii superioris alæque nasi, and arising with it from the nasal process of the superior maxillary bone, it is inserted into the same bone near the origin of the compressor naris.

Muscles of the Face.—*Zygomaticus Major.* Frequently double. The second head may arise in the neighborhood of the infra-orbital foramen or from the masseteric fascia below the zygoma. It is sometimes absent.

Zygomaticus Minor. Frequently absent. It may be inserted into the fascia of the cheek. It may be fused with the levator labii superioris proprius, zygomaticus major, or frontalis. It is not infrequently double; the second head may arise in common with the levator labii superioris proprius. Sometimes it arises from the orbicularis palpebrarum, and it may be inserted into the levator labii superioris proprius or levator labii superioris alæque nasi, or both.

Levator Labii Superioris Proprius occasionally sends a slip to the zygomaticus minor. The writer has twice seen this muscle arise by two heads, the extra head arising from the malar bone. In both these cases the zygomaticus minor was present.

Risorius (Santorini). Often absent. Santorini describes it as double, and even triple. It has been seen to arise from the zygoma, external ear, fascia over the mastoid process, and the skin over the upper portion of the sterno-mastoid.

Depressor Anguli Oris (triangularis menti). Santorini described a muscle, the *transversus menti*, which is sometimes found arising from the inner border of the depressor, and passing downward and inward across the mesial line below the chin to the corresponding part of the opposite side.

Muscles of the Orbit.—*Levator Palpebræ.* Sometimes absent or fused with the superior rectus. Budge describes the *tensor trochleæ*, which is a muscular slip given off from the levator to the trochlea.

The muscles of the eyeball are very constant. The two heads of the *rectus externus* have been seen separate to their insertion, forming a double muscle. Absence of the outer head has been noted by Macalister, and Curnow describes it as giving slips to the outer wall of the orbit and lower eyelid.

Transversus Orbita (Bochdalek). This is an arched slip of muscular fibres passing from the orbital plate of the ethmoid across the upper surface of the eyeball to the outer wall of the orbit (Quain). Macalister suggests that it is a deep, displaced slip of the palpebral fibres of the orbicularis.

Obliquus Inferior Accessorius is a slip going from the inferior rectus to the inferior oblique. The writer has seen a slip going from the inferior oblique to the superior rectus.

Muscles of Mastication.—*Masseter.* Monro has described a bursa as occasionally occurring between the two portions of this muscle, and Hyrtl has once seen a bursa between the masseter and the capsule of the inferior maxillary articulation.

Temporal. Henke says that sometimes the temporal muscle, and sometimes the deep portion of the masseter, is attached to the fore and back part of the interarticular fibro-cartilages of the lower jaw, or from the borders muscular fibres arise which are inserted into one or other of the afore-mentioned muscles. In many cases these fibres form a well-developed muscular belly, the *musculus temporalis minor*, which is inserted into the bottom of the sigmoid notch of the lower jaw (Henle). The writer has occasionally seen a deep slip from the temporal muscle attached to the pterygo-maxillary ligament. This slip is sometimes pierced by the internal maxillary artery.

Pterygoideus Externus. A considerable portion may be inserted into the capsule of the inferior maxillary articulation. When the pterygoideus proprius is present the upper head is of small size.

Pterygoideus Proprius. This is a muscle which is not infrequently seen arising from the infratemporal crest of the sphenoid and part of the great wing itself; it then passes over the external pterygoid to the lower part of the external pterygoid plate, or to the tuberosity of the palate and superior maxillary bones. It sometimes receives a slip from the upper head of the external pterygoid, and a portion of the upper head of the muscle may arise from it. The writer has occasionally seen the pterygoideus proprius inserted into the pterygo-maxillary ligament and alveolar process of the upper jaw (see Fig. 3433). In one case it sent a slip over the internal pterygoid to be inserted into the inferior maxilla near its angle. Externally this muscle is tendinous, and deep down, muscular; sometimes it is tendinous along the inner border only. When the pterygoideus proprius is present, the upper head of the external pterygoid is generally much diminished.

Pterygospinosus (Thane). This name is given to a muscular slip occasionally seen springing from the spine of the sphenoid and inserted into the hinder margin of the outer pterygoid plate, between the external and internal pterygoid muscles; the parts are frequently connected by fibrous tissue, and sometimes by bone.

MUSCLES OF THE NECK.—*Platysma Myoides.* This muscle varies considerably in its development. It is sometimes well developed, thick and red, and at other times its fibres are pale, thin, and hardly to be seen. It has been reported absent by Macalister. The platysma may reach over the clavicle as far as the fourth rib. It sometimes fails to reach as far as the clavicle; in such cases it is reduced in extent at other parts as well. It may have an insertion into the thyroid cartilage or the sternum. When well developed it has been seen attached to the lower jaw above and to the clavicle below. The upper part of the platysma is occasionally joined by a slip from the mastoid process, or from the occipital bone. The two muscles not infrequently cross each other in

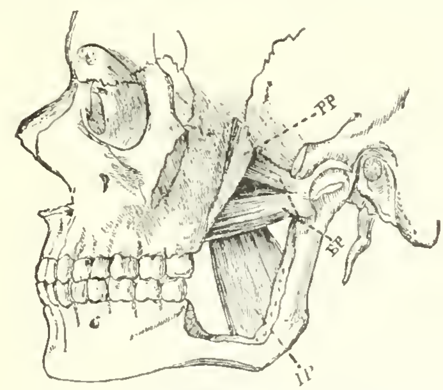

FIG. 3433.—*PP*, Pterygoideus proprius; *EP*, external, and *IP*, internal pterygoid muscle. (Shepherd.)

the median line. The writer has seen the lower fibres continuous with some fibres of the musculus sternalis. Fasciculi in connection with this muscle have been traced to the axilla. The platysma is the principal representative in man of the skin muscle (*panniculus carnosus*) of the lower animals. In most mammals with loose skins these tegumentary muscles are well developed; *e.g.*, in the hedgehog, porcupine, porpoise, etc.

Occipitalis Minor. This is the name given to a bundle of muscular fibres arising from the fascia over the upper

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end of the trapezius and ending in the fascia over the upper end of the sterno mastoid. It is probably a modification of the slip which occasionally joins the platysma from the mastoid process or occipital bone.

Sternocleidomastoideus. This muscle is usually considered to be made up of two muscles, the sterno-mastoid

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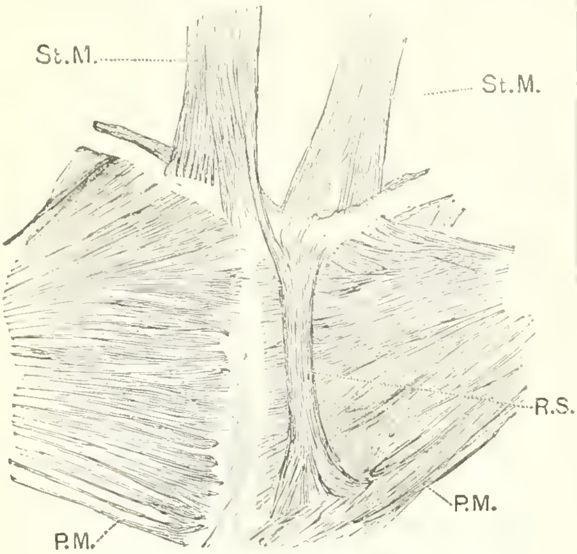

FIG. 3434.—*R.S.*, Rectus sternalis continuous with (*St M.*) sterno-mastoid of the opposite side. (Shepherd.)

and cleido mastoid. Krause, however, regards it as consisting of four muscles, viz.: (1) Sterno-mastoid, (2) sterno occipital, (3) cleido occipital, (4) cleido-mastoid. The spinal accessory nerve pierces the cleido-mastoid, or runs between the cleido-occipital and cleido-mastoid. Krause suggests the name *sternocleidomastoideooccipitalis*, or the *musculus quadrigeminus capitis*. He says that the ordinary varieties in man are readily explained by the isolation or absence of particular parts, or by the extension of the cleidooccipitalis to the occipital protuberance. Both the cleidooccipitalis and sternooccipitalis may be feebly developed, or both may be absent, as, indeed, may be the sterno-mastoid. Again, the cleido occipital or cliedo-mastoid may be developed as separate muscles. The views of Krause are supported both by human and comparative anatomy. However, for ordinary purposes it is sufficient to regard the sterno-mastoid as consisting of two muscles. These two portions may be completely separate, or may join together at a much higher point than usual. This separation of the muscles into two is the normal condition in the greater number of mammals; *e g.*, ruminants, solipeds, the majority of carnivora, and many of the anthropoid apes.

The sterno-mastoid and cleido-mastoid muscles may be completely fused—a condition which is not of great rarity.

Sternal attachment of the muscle may vary; the two sternal tendons may unite on the sternum or cross each other. The writer has seen the sternal tendon of one side continuous with a musculus sternalis of the opposite side (see Fig. 3434).

The sternal tendon may in rare cases be divided into two portions, inserted separately into the sternum. The sternal portion has been noted absent by Macalister. A sesamoid bone is sometimes seen in the tendon of the sterno-mastoid; this is looked upon as a rudiment of the episternal bone of monotremes and lizards.

The clavicular portion varies considerably as to the extent of its attachment to the clavicle; it not infrequently covers the space called the subclavian triangle, and this should be borne in mind when performing the operation of ligature of the subclavian artery in its third part. The writer once, when operating on the neck, found the clavicular portion absent. In animals without clavicles the cleido-mastoid forms part of the cephalo-humeral muscle, being continuous with the outer portion of the pectoralis major or deltoid.

Cleido-occipital (Cephalo-humeral of Flower). This is a muscle described by Wood and others as arising from the clavicle outside the cleido-mastoid and inserted into the superior curved line of the occipital bone close to the origin of the trapezius. It is usually separated by a distinct areolar interval from both the sternal and clavicular fibres of the sterno-cleido-mastoid (see Fig. 3435).

This muscle corresponds to the cleidooccipitalis of Krause. It exists as a separate muscle in the guinea-pig, hedgehog, etc. In apes and monkeys it is always present, but is in them continuous with the hinder border of the true sterno-cleido-mastoid. In many of the carnivora, as the dog and cat, it forms part of the cephalo-humeral muscle. Wood found this muscle thirty-seven times in one hundred and two subjects.

The sterno-mastoid has been described as sending slips to the angle of the lower jaw and hyoid bone (Gruber). The sterno-hyoid and omo-hyoid, and in rare cases the trapezius, may unite with the sterno-mastoid.

A tendinous intersection is sometimes seen near the lower end of the muscle; the same intersection is seen in the sterno-hyoid and sterno-thyroid muscles; it is probably the remains of one of the transverse septa of the primitive ventral muscle plate. These intersections are seen normally in the rectus abdominis.

Levator Claviculæ arises from the clavicle, and is inserted into the cervical vertebræ. A fuller description of this muscle will be given farther on, under Muscles of the Upper Limb.

Supraclavicularis is a small muscle behind the sterno-mastoid, which arises by a slender tendon from the first piece of the sternum, crosses above the sterno-clavicular articulation, and is inserted into the upper surface of the clavicle. When present on both sides the muscles may be continuous in the middle line.

Transversus Nuchæ. This is described by many anatomists as a normal muscle, which is always represented when absent by tendinous fibres. It arises from the external occipital protuberance, and is inserted into the aponeurosis of the sterno-mastoid (see Fig. 3436).

Sternohyoideus occasionally arises only from the clavicle. In such cases there is a wide interspace at the root of the neck devoid of muscle. The writer in one case saw, on both sides, the sterno-thyroid and sterno-hyoid arise altogether from the clavicle an inch outside the sterno clavicular articulation. On removing the skin and fascia the trachea and thyroid gland immediately came into view.

This muscle is occasionally double. There is sometimes an accessory muscle seen going from the clavicle to the hyoid bone (cleido hyoid). The sterno-hyoid has been described as occasionally arising from the sterno - clavicular ligament and first costal cartilage. It is sometimes fused with the muscle of the opposite side, as in the horse. The muscular fibres are not infrequently interrupted by a tendinous intersection, which is generally on a line with the tendon separating the two bellies of the omo hyoid. This intersection is seen

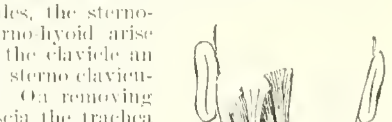

FIG. 3435. *C.h.*, Cephalo-humeral muscle; *Sp. Cap.*, splenius capitis; *D*, deltoid; *T*, trapezius. (After Flower, from the dissection of a Bushwoman, *Jour. of Anat. and Phys.*, vol. i.)

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normally in some animals, as the chimpanzee, horse, etc. The muscle has been noted as absent on one side. It may be united by slips with the omo-hyoid, mylo-hyoid, or sterno-thyroid. All the anomalies above mentioned have their corresponding normal condition in the lower animals.

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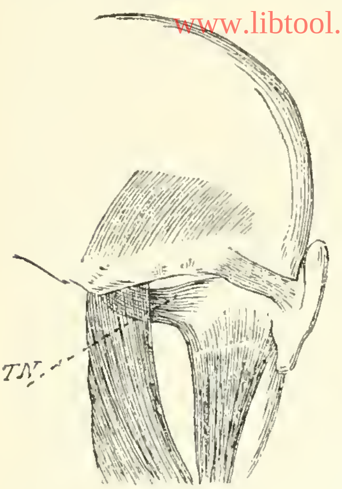

FIG. 3436. – *TN*, Transversus nuchæ. (After Henle.)

Sternothyroideus. Occasionally some of the fibres of this muscle continue on upward and are inserted into hyoid bone with the omo-hyoid, or are continuous with the hyo-glossus muscle. A few fibres may be continued into the thyro-hyoid or inferior constrictor of the pharynx. In one case the writer saw it, on both sides, arise, with the sterno-hyoid, entirely from the clavicle. Walsham reports a case ("St. Barth. Hosp. Rep.," 1880) in which the right sterno-thyroid arose from the left as well as the right side of the sternum and crossed the trachea. The left muscle was rudimentary. This muscle would be a source of embarrassment in performing tracheotomy.

In the gorilla and chimpanzee some fibres usually arise from the clavicle. The two sterno-thyroid muscles are often united at their origins across the middle line. Doubling of the muscle, as well as absence, has been observed. A tendinous intersection is sometimes seen opposite the tendon of the omo-hyoid. It may exist in both the sterno-hyoid and sterno-thyroid in the same line.

Costofascialis. Wood describes a slip arising with the sterno-thyroid from the hinder part of the first rib, which crosses the carotid vessels to be inserted into the cervical fascia as high as the thyroid cartilage.

Sternofascialis. This is a slip described by Gruber as arising from the first piece of the sternum behind the sterno-mastoid and passing upward to be inserted into the fascia of the subclavian triangle. It might be called the tensor fasciæ colli.

Thyrohyoideus. This muscle is often fused with the sterno-thyroid, and in such cases the sterno-thyroid is inserted into the hyoid bone. Absence of this muscle has been reported; this is generally due to a fusion of the sterno-thyroid and thyro-hyoid, so that they form one muscle, which is inserted into the hyoid bone. The muscle may be divided into two distinct slips.

Cricohyoid. Walsham first described this muscle as arising from the lower border of one side of the cricoid cartilage and inserted into the lower border of the hyoid bone. Gruber also mentions its occurrence.

Depressor Thyroideæ. A small muscle described by Bradley as arising from the first tracheal ring, passing over the cricoid cartilage and inserted into the lower border of the thyroid cartilage.

Omohyoideus. This muscle is frequently abnormal. In 250 subjects examined the writer found anomalies of the omo-hyoid in 39, or about 1 in 6. The muscle may be completely absent, and in rare cases it has been noted double. Again, one or other of its bellies may be wanting. When the anterior is absent, the posterior belly ends in the cervical fascia beneath the sterno-mastoid. In 250 subjects the writer has seen this arrangement twice. Sometimes the anterior belly arises from the clavicle and ascends the neck directly to its insertion into the hyoid bone without having any intermediate tendon or intersection. This has been regarded by some as absence of the posterior belly. The writer has only in one subject seen this anomaly; it occurred on both sides. This muscle has been called the *cleido hyoid.* In some rare cases, however, the posterior belly is altogether absent, the anterior arising from the fascia covering the subclavian triangle (*hyofascialis*).

The posterior belly not infrequently arises from the clavicle solely. In 120 subjects examined, the writer has seen this arrangement 8 times (1 in 15). The posterior belly may be double, the supernumerary portion arising from the clavicle. The writer has seen this occur 9 times in 120 subjects. In these cases the origin from the clavicle is generally extensive, and is from the middle third of the posterior border for a distance of two and sometimes three inches. In rare cases it may arise from the sternal end. The posterior belly of the omo hyoid may be so bound down by fascia to the clavicle that the subclavian triangle is obliterated. In ligaturing the subclavian, it would be well for surgeons to bear in mind this occasional arrangement. This condition is present more frequently when the posterior belly arises from the clavicle.

The omo-hyoid being originally fused with the sterno-hyoid, it would be natural to see the lower portion occasionally displaced and have its origin from any of the osseous points between the scapula and sternum, or to receive supernumerary heads from the various points.

The scapular head of the omo-hyoid, besides having an accession from the clavicle, may receive one from the coracoid process, the acromio-clavicular joint, the acromion process, and even the first rib.

The anterior belly of the omo-hyoid is occasionally double. The writer has seen this anomaly three times. In the first case the supernumerary belly was inserted into the superior cornu of the thyroid cartilage; in the second, into the great cornu of the hyoid; and in the third it blended with the sterno-hyoid.

The anterior belly not infrequently blends with the sterno-hyoid so as to form one broad muscle, which is occasionally bounded below by an arched tendon, as in the seal. This fusion is due to the non-differentiation of the primitive brachiocephalic sheet from which these two muscles are developed.

The writer has twice seen a portion of the omo-hyoid muscle pass over the hyoid bone and go up between the anterior bellies of the digastrics to be inserted into the lower jaw near the symphysis (see Fig. 3437).

The omo-hyoid may send slips to muscles in the neighborhood; *e.g.*, sterno-mastoid, sterno-hyoid, and the various muscles of the submaxillary region. A slip has been seen going from the posterior belly to the transverse process of the sixth cervical vertebra.

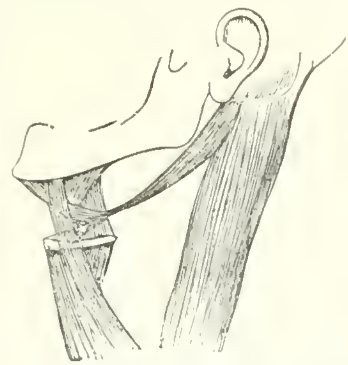

FIG. 3437. Shows the Omo-Hyoid Muscle Continuing up Over the Hyoid Bone to be Inserted into the Inferior Maxilla; also, the Muscular Belly going from the Tendon of the Digastric to be Inserted into the Body of the Hyoid Bone. (Shepherd.)

The intermediate tendon of the omo-hyoid may be absent or represented by a tendinous intersection.

Comparative Anatomy. The omo-hyoid is completely wanting in many animals, as the cat, dog, peccary, mole, and also in rodents without clavicles. The anterior belly is absent in the orang outang. The muscle arises from the clavicle in the scink and in some of the bats and the iguana. The intermediate tendon is absent in many mammals as the echidna, ornithorhynchus, the American black bear, and some of the quadrumana. In the seal

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the anterior belly is fused with the sterno-hyoid and is bounded below by an arched tendon.

Levator Glandulæ Thyroideæ. This is a fibrous or muscular band which goes from the body of the hyoid bone to the isthmus or one of the lateral lobes of the thyroid gland. There may be two or three slips. The writer, in one subject, on both sides, saw this slip proceed from the oblique line of the thyroid cartilage and go to each lateral lobe of the gland. The levator thyroideæ is looked upon as an aberrant portion of the muscles between the sternum and hyoid bone (see Fig. 3438).

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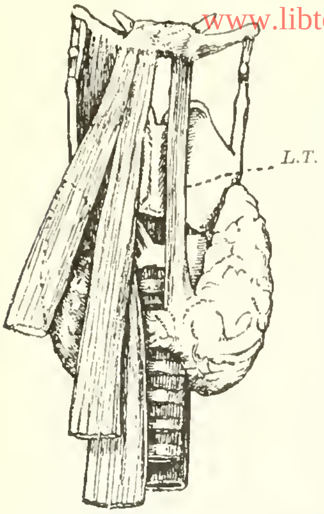

FIG. 3438.—*L.T.*, Levator thyroideæ, going from Hyoid Bone to Left Lateral Lobe of Thyroid Body. (Quain.)

Digastricus. The digastric muscle is subject to many variations. Occasionally its tendon fails to pierce the stylo-hyoid. The *anterior belly* is very often abnormal; not infrequently the two anterior bellies unite in the median line and completely shut out from view the mylo-hyoid muscles. The two bellies often decussate, as in the Norway rat and ruminants. It is not uncommon to find the anterior belly divided into two or more parts, one of which may cross the middle line of the neck and join the anterior belly of the opposite side. A slip from the anterior belly may join the mylo-hyoid, or decussate in the middle line with a similar slip from the opposite muscle. These slips may be looked upon as varieties of the mento-hyoid muscle, described below. In one subject the writer saw a well-marked muscular slip given off from the intermediate tendon and inserted into the body of the hyoid bone (see Fig. 3437). Also, in another subject there was complete absence of the anterior belly on the left side; the posterior belly ended in the deep cervical fascia attached between the hyoid bone and angle of the jaw. This might be regarded as a form of the monogastric muscle, which is well seen in the lower animals, as the carnivora. MacWinnie describes a case in which the muscle was monogastric and was inserted into the middle of the body of the lower jaw. In rare cases a muscular slip from the angle of the jaw joins the anterior or posterior belly. The writer once saw a well-marked tendinous slip going from the angle of the jaw to the posterior belly.

The *posterior belly* occasionally receives accessory slips from the styloid process. It has been seen arising entirely from the styloid process. It is sometimes connected by a muscular slip with one of the constrictors of the pharynx. Walsham describes a tendinous intersection, and in one case a distinct tendon, occurring in the posterior belly. The posterior belly has been seen to pass behind instead of in front of the carotid artery.

Occipito-hyoid. Perrin (*Jour. Anat. and Phys.*, vol. v.) first described this muscle as an additional digastric; he regarded it as homologous with the stylo hyoid of birds. The muscle is double bellied; its posterior belly arises from fascia covering the occipital bone, and its anterior belly is inserted into the hyoid bone beneath the hyoglossus. Humphry looks upon it as a superficial appendage to the stylo-hyoid and digastric muscles. There is a similar muscle in the seal.

Mento-hyoid (Macalister). This is the name given to a slip of muscle of variable size, and sometimes double, which is not infrequently seen passing, superficial to the mylo-hyoid, from the lower jaw near the symphysis to the body of the hyoid bone. Occasionally the muscle does not reach the hyoid bone, but ends in a fascia which covers the mylo-hyoid and is attached to the bone. It is sometimes triangular in shape. Macalister looks upon the mento-hyoid as a differentiated portion of platysma; but it is probably more closely related to the anterior belly of the digastric and the sterno-hyoid group, which are formed from the superficial brachiocephalic stratum of muscle (see Fig. 3439). The mento-hyoid exists normally in many animals, as the bat, hippopotamus, etc.

Stylohyoideus. Occasionally absent. Testut suggests that in cases of supposed absence of this muscle it is fused with the posterior belly of the digastric. A division of the muscle into three has been noticed. It may sometimes pass behind the carotid artery. It is occasionally inserted into the tendon of the digastric or lesser cornu of the hyoid bone. Its fibres may be continuous with the mylo-hyoid, thyro-hyoid, omo-hyoid, or, as in the ant-eater, with the muscles of the tongue. It sometimes arises from the lower jaw and goes to the hyoid bone (hyomaxillaris); again, it may not reach the hyoid bone, but go from the styloid process to the angle of the lower jaw, as in birds (stylomaxillaris). The writer has seen this muscle absent in two subjects, once on both sides.

Stylochondrohyoideus (Douglass); *Stylohyoideus alter* (Albinus). This is an additional muscle which occasionally replaces the normal stylo-hyoid and has the course of the stylo-hyoid ligament; in other words, it is the stylo-hyoid ligament become muscular. It is inserted into the lesser cornu of the hyoid bone and passes behind the carotid artery. In one case, noted by the writer, in which this muscle existed the normal muscle was represented by a thin tendinous slip. The normal stylo-hyoid and this muscle frequently are present together. The

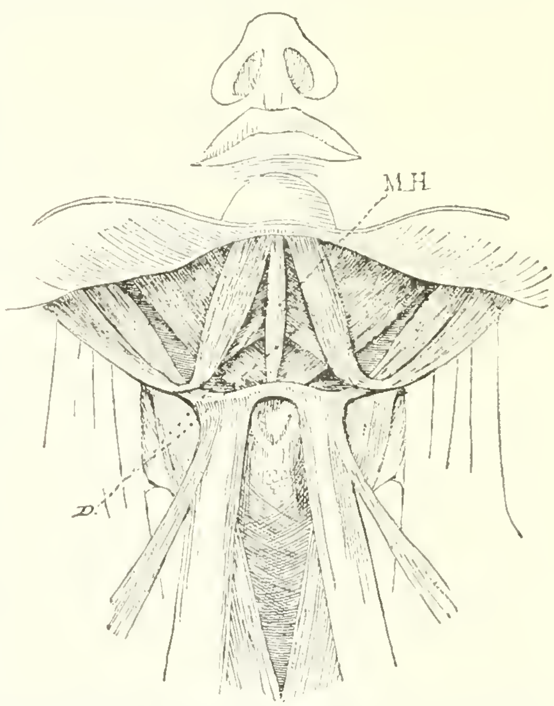

FIG. 3439.—Showing Mento-Hyoid Muscle (*MH*); also, the Anterior Bellies of the Digastric Muscles United in the Middle Line by Muscular Fibres (*D*). (Shepherd.)

stylohyoideus alter may receive a slip from the lower jaw. In one hundred and twenty subjects the writer has seen this muscle nine times; three times it occurred on both sides of the same subject.

Stylohyothyroideus. This is the name given by the

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writer to a muscle seen by him in a female subject in the anatomical rooms of McGill University during the winter session 1885–86. On both sides of a thin female subject, in addition to the usual stylo-hyoid, a stylo-chondro-hyoid was present. On the left side this muscle gave off a slip to the middle constrictor of the pharynx. On the same side, arising in common with the stylo-chondro-hyoid, was another muscle of the same size, this had a well-developed belly, and passed down posterior but parallel to the above-mentioned muscle to a little above the hyoid bone; here it left its companion and developed a well-formed round tendon, which passed under the middle constrictor and was inserted into the tip of the superior cornu of the thyroid cartilage. The stylopharyngeus was of normal size and insertion.

Mylo-hyoid. The median raphe between the two muscles is sometimes absent. The mylo-hyoid is often closely united to the anterior belly of the digastric, and may be partially replaced by it. The sterno-hyoid, omo-hyoid, or stylo-hyoid may send slips to it. The muscle may be divided into two portions, an anterior and a posterior, separated by a considerable interval. This is the arrangement in some of the rodents. A deficiency of the fore part is of common occurrence, the origin not reaching farther than the canine tooth (Quain).

Geniohyoideus. The two muscles may be fused in the middle line. It occasionally receives a slip from the great cornu of the hyoid bone. It may be closely united with the geniohyoglossus or hyoglossus.

Geniohyoglossus. This muscle has been found united with the genio-hyoid. The two muscles may be fused together, no cellular interval separating them. Slips have been seen going from the geniohyoglossus to the epiglottis, stylo-hyoid ligament, and lesser cornu of the hyoid bone. An accessory muscle has been described by Henle, Luschka, and Bochdalek, going from the mental spine to the hyoid bone between the two geniohyoglossi muscles.

Hyoglossus. Sometimes pierced by the lingual artery. The middle portion of the muscle is occasionally absent, leaving a larger or smaller interval between the outer and inner portions, and exposing the lingual artery (see Fig. 3440). The lingual artery may lie on the muscle instead of beneath it.

Triticoglossus (Bochdalek). This is a small muscular slip which arises from a cartilaginous nodule in the thyro-hyoid ligament, and passes upward and outward to join the posterior part of the hyoglossus.

Chondroglossus. This has been described as a distinct muscle, occurring normally, separated from the hyoglossus by the pharyngeal fibres of the genioglossus. It arises from the base of the lesser cornu and, spreading out, is inserted into the dorsum of the tongue near the middle line.

Styloglossus. The styloglossus is occasionally absent. The writer once saw it absent on both sides of the same subject. There is sometimes an additional origin, from the angle of the lower jaw or the stylo-maxillary ligament. The whole muscle may arise from these points, the styloid origin being absent. When it arises from the angle of the jaw it is called the *myloglossus.* Gruber has described a rare origin of this muscle, from the external auditory meatus (*styloauricularis*). The muscle may be divided into two portions; one of which is inserted normally, the other into the pharynx (Sandifort). Macalister has reported this muscle as double. Henle has described a slip going from the styloglossus to the genioglossus near its origin.

Muscles of the Pharynx.—Constrictor Superior. The second portion may be distinct. Meckel describes an accessory slip, arising from the pharyngeal spine and becoming lost in the middle line of the posterior wall of the pharynx. The writer once, on both sides of the same subject, saw this muscle receive a slip from the Eustachian cartilage.

Constrictor Medius occasionally receives fibres from the stylo-hyoid ligament or hyoid bone; also from the tongue and hinder part of the mylo-hyoidean ridge. It is common to see a slip from the thyro-hyoid ligament (*syndesmopharyngeus*, Douglass). The upper fibres of the muscle may reach the occipital bone.

Constrictor Inferior. A few fibres of origin may come from the trachea. It is occasionally connected by muscular slips with the crico-thyroid, sterno-hyoid, or sterno-thyroid muscles.

Stylopharyngeus. Cleavage of this muscle into two or even three parts has been noted. Gruber has described a double-headed stylopharyngeus. The accessory head in his case arose from the mastoid process.

Supernumerary Muscles of the Pharynx are not infrequently present, proceeding from the lower part of the base of the skull and going to one of the constrictors or passing between these muscles and the fibrous layer of the pharynx. They may arise from the petrous portion of the temporal (*petropharyngeus*), spine of the sphenoid (*sphenopharyngeus*), hamular process (*pterygopharyngeus*), basilar process (*occipitopharyngeus*), or from the pharyngeal tubercle of the occipital bone (*azygopharyngeus*).

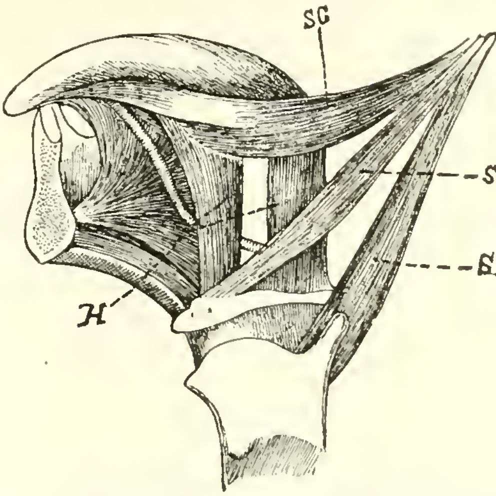

FIG. 3440.—*H*, Hyoglossus muscle deficient in its central portion; *SG*, styloglossus; *SH*, stylo-hyoid; *SP*, stylopharyngeus. (Walsham.)

PREVERTEBRAL MUSCLES.—*Scalenus Anticus.* Absence of the muscle has been reported by Macalister. In this case the subclavian vein was in direct contact with the artery. The attachment to the cervical vertebræ may vary in extent. The muscle may be divided into several distinct portions. It is sometimes pierced by the subclavian artery, and in rare cases lies behind the artery, or, more properly speaking, the artery passes in front of it.

Scalenus Medius and Posticus. These two muscles are so intimately united that French anatomists regard them as one muscle. They vary considerably as to the extent of their attachments to the transverse processes of the cervical vertebra; frequently the slips from the upper cervical are absent. In rare cases the posterior scalenus may be attached as far down as the third and even the fourth rib, as in many of the lower animals. In some animals, as the bear, it reaches as far as the seventh and eighth ribs. In man it is not infrequently absent. The scalenus medius is perforated by branches of the brachial plexus and frequently by the posterior scapular artery.

Scalenus Minimus (Albinus). This is a small slip of muscle, normal in apes, which is seen in man occasionally. It passes from the transverse processes of the lower cervical vertebræ to the first rib, behind the subclavian artery, and in front of the brachial plexus.

Transversalis Cervicis Medius (Törnblom). Under this name a muscle has been described as arising from the transverse processes of the second, third, and fourth cervical vertebræ, and inserted into the sixth and seventh cervical transverse processes.

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Rectus Capitis Anticus Major. Varies occasionally in the extent of its attachment to the cervical vertebræ. It is sometimes strengthened by a fasciculus from the transverse process of the axis, and has been noted as having

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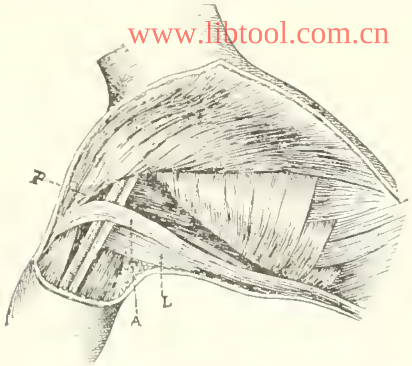

FIG. 3441.—*A*, Axillary band, between the latissimus dorsi (*L*) and the great pectoral (*P*).

no origin from the sixth cervical. It is frequently united with neighboring muscles, as the anterior scalenus, transversalis cervicis, etc.

Rectus Capitis Anticus Minor. Occasionally has a slip from the axis. Macalister has described a supernumerary muscle attached to the anterior portion of the atlas (M. rectus anterior medius of Gruber).

Longus Colli. The longus colli is subject to some variations in the number of its attachments and in the degree of separation of its constituent parts.

The lower oblique portion may send a slip to the head of the first rib. It is also sometimes prolonged to the rectus capitis anticus major, and has been seen sending a slip of insertion to the basilar portion of the occipital bone. A supernumerary longus colli (*M. transversalis cervicis anterior* Luschka) may arise by thin, tendinous slips from the anterior tubercles of the transverse processes of the lower four cervical vertebræ and be inserted by two tendons into the base of the transverse process of the atlas and the body of the axis (Henle).

MUSCLES OF THE UPPER LIMB.—*Trapezius* (Cucullaris). The attachments of this muscle are subject to considerable variation. The muscle may be much smaller than usual, and have no occipital origin or be attached to as few as six instead of twelve dorsal spines; it may be divided into a cervical and a dorsal portion. Again, its spinal attachments may be confined to the upper three or four dorsal, or lower three or four cervical spines, the other portions being absent. It is sometimes inserted into more of the clavicle than normal, being continuous with the insertion of the sterno-mastoid. Occasionally there is a slip passing forward across the subclavian triangle to reach the sterno-mastoid; this would be in front of the third part of the subclavian artery, and interferes somewhat with the operation of ligature of that artery. Again, it may be continuous with the deltoid, as is the case in animals without clavicles. In rare cases the portion attached to the clavicle is absent or very small. This arrangement is seen in some of the lower animals. A slip has been described going from the anterior border of the muscle near the clavicle to the sternum; this is a variety of the sterno-scapular muscle. Not infrequently slips of attachment unite the trapezius to the levator anguli scapulæ.

Latissimus Dorsi. The number of dorsal vertebræ to which this muscle is attached may vary considerably. It may be attached to as many as nine, and as few as four. The writer has seen it attached to all the dorsal vertebræ. Its attachments to the ribs also vary, the number being sometimes increased, sometimes diminished. It is occasionally attached to the lower angle of the scapula: the writer has twice seen it send slips to the spine of the scapula.

Axillary Band (Achselbogen). This is a muscular band which crosses the lower part of the axilla from the latissimus dorsi to the great pectoral muscle near its insertion (see Fig. 3441).

It may, instead of uniting with the great pectoral, be inserted into the coracobrachialis or fascia covering the biceps. In its course it usually crosses the axillary vessels, and hence it is well to bear this in mind in ligaturing the axillary artery in its third part. It is sometimes of large size, being as broad as 6.2 cm., and so may cover a considerable extent of the axillary vessels. More frequently it is a small slip, from 1 to 3 cm. broad. It occurs in about five per cent. of all subjects, and is frequently on both sides of the same subject. The writer has seen it in eleven subjects out of two hundred and fifty noted. This muscular band exists normally in many animals, as deer, etc., and is the remains of the continuity which previously existed between the latissimus dorsi and the pectoralis major.

Dorsoepitrochlearis. This is a muscle which is occasionally seen in man in a rudimentary form, but in many of the lower animals, as apes, lemurs, seals, bears, etc., is a well-developed muscle, and is the normal arrangement. It is a muscular slip which is given off from the lower border of the tendon of the latissimus dorsi, and is attached to various points in the arm. It may end in the long head of the triceps, some portion of the internal intermuscular septum, the epitrochlear process of the internal condyle, or the olecranon process (see Fig. 3442). In man the muscle is occasionally represented merely by a fibrous band, sometimes by a small, muscular slip ending in a fibrous cord, which is inserted into the internal condyle, or is continuous with the internal intermuscular septum.

Rhomboideus Minor and Major. Both these muscles are subject to variation as to extent of origin and insertion. They may be divided into two fasciculi, as in some animals.

Rhombo-occipital (occipito-scapular of Wood). This is a slip not infrequently seen in man, and occurs normally in many of the lower animals, *e.g.*, the deer, cat, tiger, etc., as a well-developed muscle immediately beneath the trapezius, and reaching from the occiput to the base of the spine of the scapula. In man it generally exists in an incomplete form, and varies considerably as to its upper and lower attachments. Instead of reaching the scapula it may be connected with either of the rhomboid muscles, serratus posticus superior, or levator anguli scapulæ. Its superior attachment may not reach the occiput, but be connected with the spines of the upper cervical vertebræ. Again, in man, this muscle may be represented by a slip from the aponeurosis covering the splenius capitis to the spine of the scapula, or by a slip from the levator anguli scapulæ to one of the rhomboids. In one case recorded by the writer it consisted of a well-developed muscular slip reaching from the transverse process of the atlas to the aponeurosis over the greater rhomboid (*rhombo-atloid* of Macalister). The many varieties of this muscle in man have been carefully described by Prof. J. Wood (Proceed. Roy. Soc., 1870—see Fig. 3443).

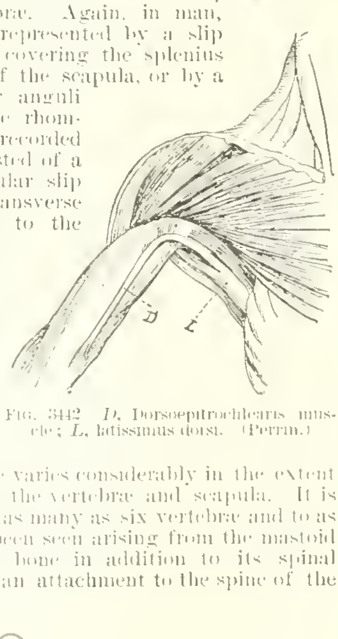

FIG. 3442.—*D*, Dorsoepitrochlearis muscle; *L*, latissimus dorsi. (Perrin.)

Levator Anguli Scapulæ. This muscle varies considerably in the extent of its attachments to the vertebræ and scapula. It is often seen attached to as many as six vertebræ and to as few as two. It has been seen arising from the mastoid process and occipital bone in addition to its spinal origin. It may have an attachment to the spine of the

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scapula, and it sometimes sends slips of insertion to the first or second rib. Occasionally it is seen divided into two or more slips, the portions connected with the different vertebræ remaining separate. It is often connected with neighboring muscles by muscular slips. The writer has seen it thus connected with the serratus posticus superior, serratus magnus, deep surface of the trapezius, complexus, splenius capitis, rhomboideus minor, and scalenus posticus. These slips are regarded by Wood as varieties and modifications of the occipito-scapular muscle of the lower animals. In many of the lower animals the levator anguli scapulæ is merely the upper portion of the serratus magnus, forming with it a single muscle.

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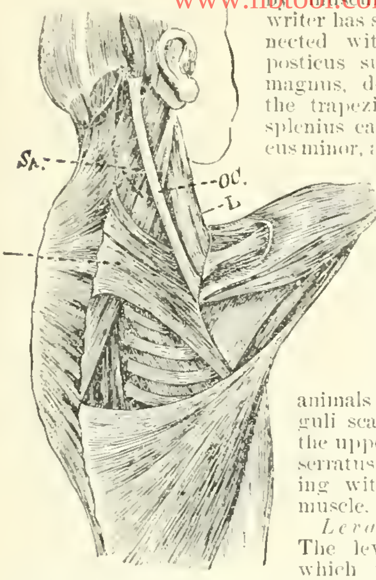

FIG. 3443.—*OC*, Occipito-scapular muscle; *L*, levator anguli scapulæ; *R*, rhomboid muscles; *Sp*, splenius. (Wood.)

Levator Claviculæ. The levator claviculæ, which normally exists in all mammals with the exception of man, is occasionally seen in him. It appears as a separate muscular slip arising from the transverse processes of one or two upper cervical vertebræ, and inserted into the outer end of the clavicle. Slips of muscle from the levator anguli scapulæ, or from the upper cervical spines, to the scalene muscles, serratus magnus, and ribs, are regarded as modifications of the levator claviculæ.

Cleidocervicalis (Gruber). This is a form of the above muscle arising from the transverse process of the sixth cervical and inserted into the outer end of the clavicle. Gruber looks upon it as a supernumerary scalene muscle attached to the clavicle.

Pectoralis Major. Many variations of this muscle have been observed. The more common varieties consist of a greater or less extent of attachment to ribs and sternum, and the separation of its clavicular from its costal attachment.

M. Testut divides the anomalies of this muscle into eight groups, viz.:

1. Fusion of the clavicular portion with the deltoid.
2. Fusion with the great pectoral of the opposite side.
3. Union with the rectus abdominis.
4. Union with the biceps brachii (see Fig. 3450).
5. Separation of the clavicular and sterno-costal portions by an interspace.
6. Division of the costo-sternal portion into two strata or layers.
7. Anomalies in the mode of insertion into the arm.
8. Complete or partial absence of the muscle.

Testut divides the anomalies of the brachial insertion into: (*a*) Insertion into the coracoid process and aponeurosis of the coracobrachialis. (*b*) Insertion into the capsule of the shoulder-joint. (*c*) Prolongation of the tendon of insertion into the capsule of the shoulder-joint. (*d*) Supernumerary insertion into the humerus. (*e*) Insertion into the brachial aponeurosis. (*f*) Insertion into the two lips of the bicipital groove.

Chondroepitrochlearis (Duvernoy). This is the name given by Duvernoy to a muscular slip which is sometimes seen arising from the cartilage of one or two ribs, the aponeurosis of the external abdominal oblique, the lower border of the great pectoral itself, or its tendon; from one of these origins it passes down and out, and is inserted in a variable way into the arm. It is often inserted into the internal intermuscular septum and occasionally reaches as far as the internal condyle of the humerus.

Mr. J. B. Perrin (*Jour. Anat. and Phys.*, vol. v.) has described under the name of epigastric slips a number of muscles connected with the lower border of the pectoralis major, or arising separately from the sixth or seventh rib and inserted into the tendon of the great pectoral, or into the fascia covering the coracobrachialis muscle (see Fig. 3444). They may also be connected with the latissimus dorsi. These muscles are developed to a high degree in many mammals, and are well seen in pigeons and fowls.

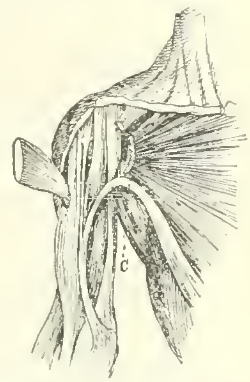

FIG. 3444.—Example of the Chondroepitrochlearis Muscle (*C*). (Perrin.)

Musculus sternalis. Syn.: Rectus sternalis, sternalis brutorum (Albinus), présternal (Testut). The musculus sternalis is a supernumerary muscle which has always excited a great deal of interest among anatomists; even yet its proper morphological significance is not fully determined. It is seen in about three or four per cent. of ordinary individuals, but in anencephalous monsters is nearly always present. Its fibres are generally at right angles, and superficial, to the great pectoral; it is often bilateral, but more frequently unilateral, and is subject to many variations. Frequently it has no attachment to bone but rests on the great pectoral, attached above and below to fascia (see Fig. 3445). It is often attached to the sternum and costal cartilages of one side or both, and is occasionally continuous above with the sternal origin of the sterno-mastoid, and below, with the external abdominal oblique (see Fig. 3433).

It usually arises from the first piece of the sternum, and is inserted into some of the ribs and costal cartilages, generally the fifth and sixth. It may be continuous in

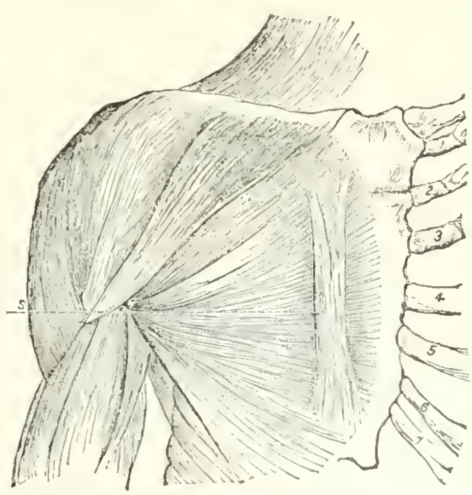

FIG. 3445.—*S*, Musculus sternalis, attached above and below to fascia. (Shepherd.)

part with the great pectoral itself and be associated with deficiency of that muscle. Sometimes it is of small size, but occasionally it is quite a large muscle, 8 to 10 cm. long, and 3 to 5 cm. broad. It has been recognized under the skin in the living. It derives its nerve supply from the same source as the pectoral muscles,

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viz., the anterior thoracic. The muscle is regarded by Sir William Turner, Dr. Dobson, and others as a remnant of a skin muscle. Henle, Theile, Bourrienne, and others look upon it as a prolongation downward of the sterno-mastoid. Halbertsma thought it a muscle *sui generis* peculiar to man, having no animal representative. D. J. Cunningham thinks it a new inspiratory muscle appearing in man, and is of opinion that

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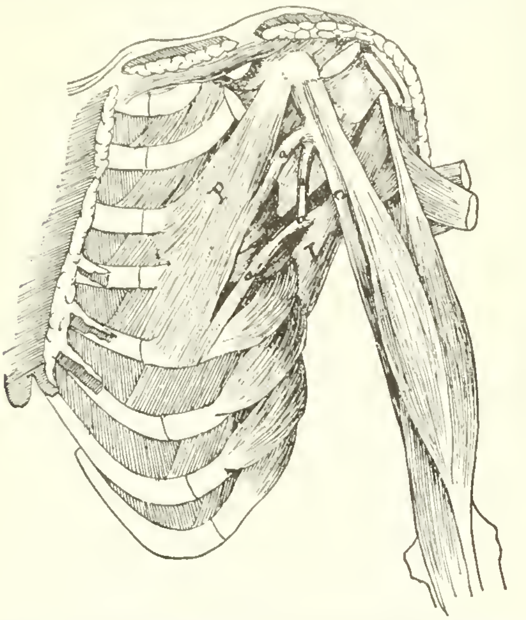

FIG. 3446.—*a, a, a,* Muscular slips connecting the pectoralis minor (*P*) with the coracobrachialis (*C*) and the latissimus dorsi (*L*). (Shepherd.)

it occurs more commonly in females, costal inspiration being more pronounced in them. In dissections of anencephalous monsters made by the writer the nerve supply was traced, in nearly all the specimens examined, to the anterior thoracic. These dissections convinced him that this muscle belongs to the pectoral and not the panniculus group (see *Jour. Anat. and Phys.*, vol. xix.).

Pectoralis Minor. The origin of this muscle varies considerably. It may arise from the second, third, and fourth ribs, instead of the third, fourth, and fifth. Not infrequently it arises from four ribs, and the writer has occasionally seen it arise by five digitations from the five upper ribs. It has been described as attached to only two ribs, and Testut, in his work on "Muscular Anomalies," describes a case in which it arose by a single digitation from the fourth rib, in this case the subclavius muscle was of large size. Sometimes the pectoralis minor is divided into a number of slips corresponding with the ribs from which it arises. It is occasionally connected with the great pectoral. In one case the writer saw it connected by muscular slips with the latissimus dorsi and coracobrachialis, and these two slips were connected together by a third (see Fig. 3446).

The variations of insertion of the pectoralis minor are numerous. The muscle not infrequently passes over the coracoid process and is inserted into the capsule of the shoulder-joint and great tuberosity of the humerus. It very frequently is united at its insertion to the coracobrachialis. In one case the writer saw it inserted into the coracobrachialis by a tendinous expansion, 5 cm. broad; in this case the coracoid process received no fibres of insertion. In many of the carnivora and quadrumana this muscle is normally inserted into the humerus. In rare cases the pectoralis minor is divided into two layers which have distinct insertions, and sometimes it is absent.

Pectoralis Minimus. Gruber has described a slip, to which he gives the above name, arising from the first piece of the sternum and cartilage of the first rib; from this origin it passes outward between the subclavius and lesser pectoral to be inserted into the coracoid process. Some regard it as a variety of the chondro-scapular muscle of Wood.

Subclavius. The subclavius is not infrequently inserted into the coracoid process as well as the clavicle; occasionally it has no clavicular attachment, but is wholly inserted into the root of the coracoid process. It has been described as double by some anatomists, but the supernumerary muscle will be described below as the sterno-scapular. Walsham describes a case in which the subclavius had an insertion into the humerus, as is normally seen in birds. The subclavius is sometimes absent, its place being taken by the sterno-scapular.

Sterno-chondro-scapular (Wood). Syn.: Scapulocostalis minor (Macalister), subclavius posticus (Rosenmüller). This is a supernumerary muscle of a somewhat cylindrical shape, which is attached externally to the root of the coracoid process or upper border of the scapula, passes inward over the subclavian artery and brachial plexus of nerves, beneath the clavicle and subclavius muscle, to be attached by a round tendon to the costal cartilage of the first rib, first piece of the sternum, or both (see Fig. 3447).

Sometimes this muscle passes over the clavicle in place of beneath it, and occasionally it does not reach as far as the coracoid, but may be inserted into the anterior

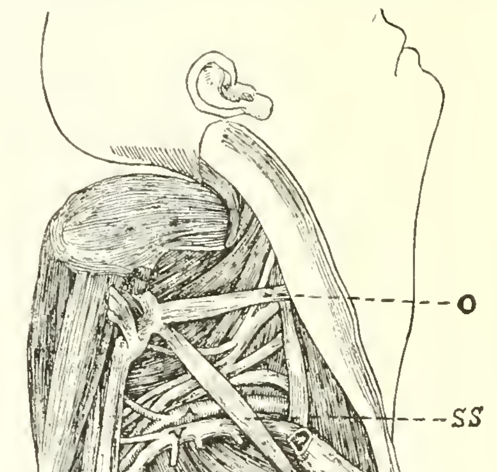

FIG. 3447.—*SS*, sterno-scapular muscle; *O*, omo-hyoid. (Wood.)

border of the clavicle (sterno-clavicular anterior). A variety of the sterno-clavicular muscle which the writer has seen is one which reaches from the sterno-clavicular articulation to the anterior border of the trapezius. In its course it passes over the clavicle and across the subclavian triangle, covering the third portion of the subclavian artery (see Trapezius). In ligature of the subclavian it is

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well to bear this anomaly in mind. When the sterno-scapular muscle exists there is sometimes absence of the subclavius muscle; the writer has seen this occur once only out of seven cases; in three cases, however, the subclavius was much reduced in size. W. Gruber saw absence of the subclavius in seven out of eleven cases of sterno-scapular muscle.

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Comparative anatomy: In the Norway rat, guinea-pig, wombat, etc., the sterno-scapular muscle is normally present. In the horse it is a well-developed muscle. In animals without clavicles having a sterno-scapular muscle it is regarded as the homologue of the subclavius.

Chondro-coracoid is a small muscle described by Wood as arising from the first costal cartilage by a round tendon, and, passing outward below the subclavius, is inserted into the coracoid process superficial to the coracobrachialis.

Many other supernumerary clavicular muscles have been described, such as the scapulo-clavicular, coracoclavicular, supraclavicular, infraclavicular, etc., but they are so rare that it is only necessary to mention them and refer readers wishing to learn more about them to the special works on muscular anomalies mentioned in the introduction to this article.

Serratus Magnus. The serratus magnus may arise from nine ribs instead of eight, and occasionally it receives a slip from the tenth. Again, some of the highest or lowest digitations may be wanting, the muscle thus being attached to only six or seven ribs. Occasionally some of the central digitations are absent, and the muscle is then divided into two portions. Wood has described two large muscular bands, distinct from the serratus, arising from the ninth and tenth ribs, and inserted into the inferior angle of the scapula. He regards these bands as homologues of the depressor scapulæ of birds. Sometimes there is more or less complete fusion of the serratus with the levator anguli scapulæ. In many mammals it forms one muscle with the levator.

MUSCLES OF THE SHOULDER.—*Deltoid.* This muscle is not subject to many variations. It is sometimes divided into several distinct portions, viz., the clavicular, acromial, and spinal, as in carnivora. The clavicular and acromial portions are often separated by an interspace; not infrequently the clavicular portion is intimately connected with the contiguous part of the great pectoral, the division between them being determined only by the cephalic vein. The clavicular portion may also, in some cases, be continuous with the fibres of the trapezius, as in animals without clavicles.

The insertion of the deltoid varies in position and extent; in some cases it is inserted much lower than usual. Macalister has described a rare anomaly of this muscle, viz., the prolongation of its tendon as far as the lower end of the radius; he considers this to be the homologue of the extensor plicæ alaris of birds.

Testut has described a slip going from the clavicular portion of the deltoid to the internal condyle, crossing in its course the brachial vessels; he calls it the *cleido-epitrochlearis.* The deltoid not infrequently receives accessory slips from the axillary or vertebral borders of the scapula, and also from the spine and subspinous aponeurosis.

Supraspinatus. Variations of this muscle are extremely rare. It is very constant both as to its size and attachments. Occasionally fibres of the great pectoral are inserted into it. The writer once saw its tendon pass over the capsule of the shoulder-joint in a pulley-like depression, and become continuous with the deep portion of the insertion of the pectoralis major (see Fig. 3448).

Infraspinatus is occasionally fused with the teres minor. It may be connected with the deltoid by a strong fasciculus, and, again, it may be divided into several slips.

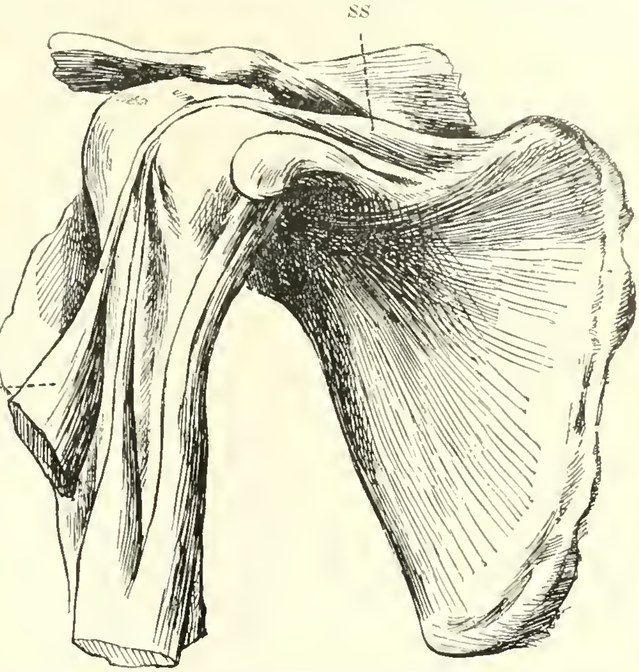

FIG. 3448.—*SS*, Tendon of the supraspinatus, continuous with the deep portion of the tendon of the pectoralis major (*PM*). (Shepherd.)

Teres minor is occasionally divided into two portions, the lower being called the teres minimus.

Teres major may be reduced to the size of the teres minor. It is sometimes inseparably connected with the latissimus dorsi, as in some of the lower animals. A fasciculus has been described descending on the fascia of the arm externally. It is analogous to the tensor fasciæ of the leg.

Subscapularis. Varies but little. A small accessory muscle (subscapulocapsularis, subscapularis minor) has been described by W. Gruber, Macalister, and others, which goes from the axillary border of the scapula to the capsule of the shoulder-joint or humerus. Knott describes some fibres given off from the lower border of the subscapularis and inserted into the aponeurosis and skin of the axilla. These are regarded as remnants of the panniculus carnosus muscle of the lower animals.

Curnow, Walsham, and others have described a muscle arising from the inner bicipital ridge, or the groove itself, and passing up to be inserted into the capsule of the shoulder-joint near the insertion of the coracobrachialis. Testut describes this muscle under the name of *brachiocapsularis.*

Coraco-brachialis. Professor Wood (*Jour. of Anat.*, vol. i.) considers that this muscle consists typically of three portions—superior, middle, and inferior. In man the middle and part of the inferior portion exist most constantly, the two portions being separated by the musculo-cutaneous nerve. Both the superior and inferior divisions are, however, occasionally seen in addition to the middle division (*coracobrachialis proprius*. The superior (*coracobrachialis superior vel brevis*), when it exists in man, arises from the coracoid process, passes over the subscapularis muscle, and is inserted below the lesser tuberosity, or more rarely into the capsule of the shoulder-joint (*coracocapsularis*). This is the normal arrangement in many animals, as the dog, cat, etc.

The inferior division (*coracobrachialis longus*) is also occasionally seen. It may be of large size and be in-

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serted into the internal condyle or into a supracondyloid process when that anomaly exists. It is sometimes represented at its lower portion by a fibrous band; this is the internal brachial ligament of Struthers. As a rule, the inferior portion, when present, passes over the axillary artery, and must be kept in mind when ligaturing that vessel (see Fig. 3449).

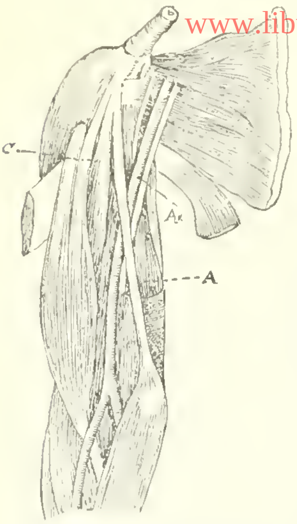

Fig. 3449. *A*, Coracobrachialis longus passing over the brachial vessels (*A c*) to reach the internal condyle; *C*, normal coracobrachialis. (After Wood.)

The coracobrachialis occasionally is not pierced by the musculo-cutaneous nerve.

Comparative Anatomy: In animals which swim or climb, as the beaver, bear, etc., the *coracobrachialis longus* is well developed. In most of the quadrumana there is a double insertion of the coracobrachialis, and, in the guinea-pig, the median variety only is present, as in man. In some animals, as the kangaroo, the muscle is absent altogether. It has once been found absent in a human monster. The coracocapsularis is present normally in many animals, *e.g.*, the dog, cat, etc.

Biceps Brachii. This muscle is rich in varieties. The most common is the presence of a third head, which arises near the insertion of the coracobrachialis, and in close connection with the brachialis anticus. The proportion of subjects having a third head is, in the writer's experience, one in seven; Theile makes it one in nine; Hallett, one in fifteen; Wood and Macalister, one in ten. In two hundred and fifty subjects examined the writer found it five times on both sides of the same subject. The third head generally soon joins the coracoid head about its middle, but it is occasionally seen quite separate as far as the bicipital fascia, into which it is inserted. The third head usually lies outside the vessels, but sometimes is seen covering them. It may arise from the bicipital groove, one of the ridges, or even from the great tuberosity. The writer has seen it arise from the lower edge of the great pectoral near its insertion (see Fig. 3450).

The third head is regarded by some as an offshoot from the brachialis anticus. Struthers has described a muscular slip which comes off from the inner border of the biceps, passes over the brachial vessels, and is inserted into the internal intermuscular septum or internal condyle.

The biceps has been seen with as many as four and even five heads. The supernumerary heads, as a rule, have their origin from the bicipital groove, body of humerus, coracoid process, capsule of shoulder joint, or tendon of the pectoralis major. The coracoid and glenoid portions of the biceps muscle may fail to unite, being completely separate to their insertion. The long head is occasionally absent, the muscle being uniceps instead of biceps, as in some animals. The *long* or *glenoid head* may not pierce the capsule, but arise from the capsule itself, the humerus, or the great pectoral tendon. The tendon of the biceps sometimes pierces the tendon of the pectoral (see Fig. 3450). This is a very rare anomaly. It is not uncommon in old joints that have become dry from rheumatic disease to find the long tendon worn through, and perhaps attached to the groove outside the capsule, or to the head of the humerus, or absent altogether. This pathological condition must not be confounded with the anomaly above described.

The *short* or *coracoid head* may also in rare cases be absent.

The biceps may send a slip of insertion to the coronoid process, capsule of the elbow-joint, or fascia of the forearm. It is sometimes connected with the pronator teres, supinator longus, brachialis anticus, and palmaris longus, by muscular slips. In one case, in which the muscular slip crossed the artery and went to the pronator teres, the bicipital fascia was given off from it.

The semilunar fascia is often of larger extent than usual, and may have a high origin. It may be developed into an almost true tendon. It not infrequently sends offshoots to neighboring parts.

Brachioradialis (Wood). The writer once saw this muscle. It arose from the supracondyloid ridge above the supinator longus, and between it and the deltoid; it coursed down the arm between the long supinator and biceps, and was inserted into the oblique line of the radius immediately above the insertion of the teres. Wood looks upon this muscle as a variety of a fourth head to the biceps.

Comparative Anatomy: A third head is the normal arrangement in many animals, *e.g.*, bat, seal, rhinoceros, etc. The long or glenoid head is absent in many animals, especially birds. The short or coracoid head is not present in many animals, as the seal, porcupine, paca, and the carnivora, as the dog, cat, bear, hyena, etc. The glenoid head in these comprises the whole muscle. In some, as the American bear, the coracoid head is represented by a very thin tendinous strand.

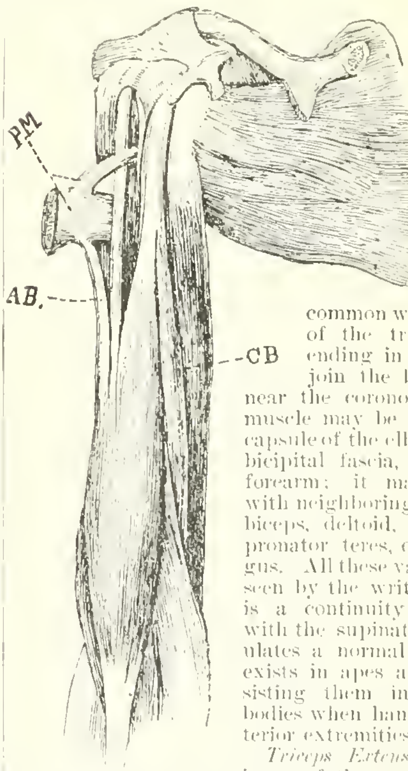

Fig. 3450. *AB*, Third head of biceps, arising from the pectoralis major (*PM*), which is perforated by the long tendon of the biceps; *CB*, coracobrachialis. (Shepherd.)

Brachialis Anticus. Subject to frequent variations. It may be divided into two or three portions. On one occasion the writer saw a slip arise in common with the outer head of the triceps, and after ending in a round tendon, join the brachialis anticus near the coronoid process. The muscle may be inserted into the capsule of the elbow-joint, radius, bicipital fascia, or fascia of the forearm; it may be connected with neighboring muscles, as the biceps, deltoid, coracobrachialis, pronator teres, or supinator longus. All these varieties have been seen by the writer. When there is a continuity of this muscle with the supinator longus it simulates a normal condition which exists in apes and monkeys, assisting them in twisting their bodies when hanging by their anterior extremities.

Triceps Extensor Cubiti. This is one of the most constant muscles in the body as to its insertion. One of the most common varieties is a fourth head arising from the inner side of the humerus. This fourth head may come from the axillary border of the scapula. The scapular head may have a more extensive origin than usual. The writer once saw a strong muscular slip, continuous with the deltoid and separated by a bursa from the teres minor, have a tendinous insertion into the scapular head near its origin.

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In some animals, as the American black bear, the scapular head is of huge size, and arises from the whole axillary border of the scapula.

Gruber, Macalister, and Testut each report a case of a slip going from the coracoid process and capsule of the shoulder-joint to the triceps. In one instance the writer saw a fleshy slip between the triceps and teres major.

Dorsoepitrochlearis (accessorius tricipitis). Occasionally the muscle to which the above name is given, and which is common in quadrumana and other animals, is seen in man. It has already been described with the latissimus dorsi.

Epitrochleoanconeus. Exists frequently in man. Gruber found it in one in three; Macalister, one in four; and Wood, one in seventeen. It is triangular in shape, the apex being attached to the back of the internal condyle and the base to the olecranon process. The ulnar nerve passes beneath it and supplies it (see Fig. 3451). This muscle is exceedingly common in mammals. According to Galton, it is universally present in the edentata, less frequent among the primates, disappears among the anthropoid apes, and emerges again occasionally in man as an anomaly. Mr. Galton considers that it, like the supracondyloid process, is now "an almost functionally useless heirloom, which has descended to us from remote ancestors." Mr. J. B. Sutton (*Jour. of Anat. and Phys.*, April, 1885) says that when the epitrochleoanconeus is not represented as a muscle, its place is occupied by a collection of fibrous tissue having the exact shape and attachments of the muscle, and forming a bridge under which goes the ulnar nerve.

Subanconeus. This consists of a few muscular fibres, which are seen on removing the triceps from the lower part of the humerus; they extend from the lower end of the humerus to the capsule of the elbow-joint. It is homologous with the subcrureus muscle found in the lower limb beneath the quadriceps extensor. It is looked upon by many anatomists as a dependent of the triceps.

Anconeus. May vary as to the closeness of its connection with the triceps or extensor carpi ulnaris.

Pronator Radii Teres. The coronoid head is sometimes wanting, in most animals it does not exist. Occasionally there is a third head which arises from the internal intermuscular septum, or from a supracondyloid process when that variation is present; in such cases the direction of the brachial artery is often changed.

Sometimes the third, or supernumerary, head arises from the tendon of the biceps or brachialis anticus. The pronator teres may have its insertion lower down the radius than usual. It may also be divided into two portions, as in birds. The coronoid portion may be separated entirely from the condyloid, or there may be a doubling of each of these portions.

The pronator teres may be connected with the palmaris longus, carpi radialis flexor, or sublimis digitorum in the forearm and the biceps, brachialis anticus, and coracobrachialis in the arm.

Flexor Carpi Radialis. It may receive an additional slip of origin from the biceps tendon and fascia, the coronoid process, or the radius. It may have an insertion partly into the annular ligament, trapezium, scaphoid, or fourth metacarpal bone.

Palmaris Longus. This is one of the most variable muscles in the body. It is absent in about ten per cent. of individuals, and in rare cases is represented only by a tendinous band. It does not exist in the solipeds, ruminants, or pachyderms. The form varies considerably. There may be a central fleshy portion, with a long, slender tendon at each end; the muscular portion may be at the distal end. It has been seen muscular throughout, and again has been seen to consist of two bellies united by tendon. The palmaris longus is occasionally double; when a second muscle exists it generally arises by tendon, or is connected with the carpi ulnaris, or sublimis digitorum muscle. It may arise from the intermuscular septum between the two last-mentioned muscles, by a tendinous origin, and continue as part of the ulnaris as far as the middle of the forearm, then form a large belly which ends in a tendon near the wrist. The writer has seen it furnish the origin of the flexor brevis minimi digiti; a somewhat similar arrangement exists in the cebus and magot. Occasionally it receives an additional slip of origin from the coronoid process or radius. It sometimes terminates variously in the fascia of the forearm, muscles of the little finger, annular ligament, scaphoid, and pisiform bones, and tendon of the flexor carpi ulnaris. The writer once saw the tendon of this muscle near the wrist give off a broad muscular slip, which was inserted into the base of the first phalanx of the little finger. Most of the anomalies of this muscle correspond to the normal arrangement in some of the lower animals.

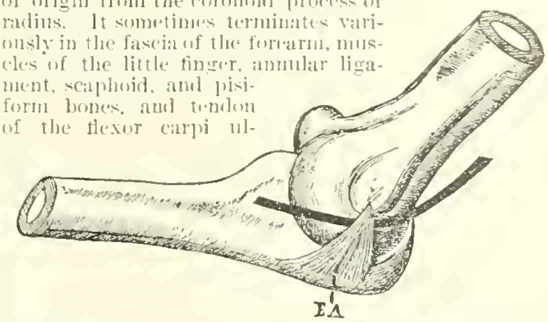

FIG. 3451.—*E.A*, Epitrochleoanconeus covering the ulnar nerve. (Sutton.)

Flexor Carpi Ulnaris. Is frequently inserted into the fifth metacarpal bone. It has been seen sending a slip of insertion to the fourth metacarpal. It sometimes gives off a slip to the annular ligament, but this is regarded as a supernumerary palmaris longus, as are also those cases in which a separate portion from the epicondyle passes down to be inserted into the pisiform bone. It is in rare cases double. I have once seen this muscle absent on the left side of a female subject.

Flexor Sublimis Digitorum. The radial origin of this muscle is sometimes wanting. The muscle is occasionally subdivided, each of the tendons being connected with a separate fleshy belly. This is more common with the index and little fingers, and may be classed among the anomalies called progressive. The tendon to the little finger may be absent, or the superficial flexor may be connected by slips with the deep flexor and the long flexor of the thumb. This is the arrangement in most mammals, and in man, and his order only, is seen the marked differentiation of the flexors. One of the lumbrical muscles occasionally arises from the sublimis digitorum. This muscle may send a muscular slip to the annular ligament and palmar fascia; this is the arrangement in the bear, and is supposed to represent the palmaris longus.

Flexor Profundus Digitorum. In many animals this muscle is intimately blended with the foregoing, but in man is generally quite distinct; not infrequently, however, it is connected with the sublimis digitorum and also with the flexor pollicis. It occasionally has an additional origin from the internal condyle and coronoid process (the *accessorius ad flexorem profundum* of Gantzer), which may join any one of the perforating tendons, commonly those going to the index and middle fingers (Wood). This is the normal arrangement in many mammals. The writer saw this coronoid slip very well developed on both sides of a negro subject. He also, some years ago, found a strange variety of the *accessorius* muscle occurring on both sides of the same subject. The muscle arose from both the internal condyle and inner side of the coronoid by fleshy fibres, developed into a large muscular belly which divided into two portions, each ending in a tendon, the innermost going to the terminal phalanx of the little finger, and the outermost to the terminal phalanx of the index, superficial to the tendon of the sublimis. On both sides, near the origin of this accessory muscle, a large slip went to the profundus digitorum.

The profundus digitorum may have an origin from the radius; when this occurs it joins the indicial portion of the muscle.

Flexor Indicis. The indicial portion of the profundus

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may be quite distinct from the rest of the muscle. In one case the writer saw it connected with the flexor longus pollicis by a tendinous intersection. A flexor indicis is found in the gorilla and chimpanzee.

The tendon to the little and middle fingers may also be quite separate and distinct from the rest of the profundus. Accessory slips are not infrequently found going to join the various tendons of the muscle.

FIG. 3452. The Pronator Quadratus, *PQ*, consisting of two triangular portions with bases reversed. (Fenwick.)

Lumbricales. Varieties of these muscles are common; they may be diminished in number to three, or increased to five or six. Two may be inserted into one finger, or one into two by the bifurcation of a muscle. Occasionally the perforating tendons of the fourth and fifth fingers are furnished by lumbrical muscles. The third muscle is more frequently abnormal than the others. The writer has seen the lumbrical muscle of the little finger arise in the middle of the forearm from the sublimis digitorum by a round tendon, this, after passing under the annular ligament, developed a large fleshy belly which was inserted into the fifth finger. This might be regarded as a case of absence of the fourth lumbrical muscle, its place being taken by a slip from the sublimis.

Flexor Longus Pollicis. Has frequently a slip of origin from the coronoid process and internal condyle. This slip has been seen to pierce the radial nerve. The muscle may be connected by a slip with the superficial and deep flexors, and also with the pronator teres. It is sometimes fused with the profundus digitorum so as to form a single muscle, as is the case in nearly all mammals. It is sometimes fused with the indicial portion of the profundus, when that part forms a distinct flexor indicis, as in the gorilla. It has been observed sending a slip to the index finger and also to the first lumbricalis.

Pronator Quadratus. The pronator quadratus is sometimes entirely wanting; it may consist of two, three, and even four layers crossing each other. The attachment to the bones of the forearm may be greater than usual. It occasionally sends a muscular slip from its ulnar or radial attachment to the carpus. It may consist of two distinct triangular portions with the bases reversed; the anterior arising from the ulna by aponeurotic fibres and inserted into the radius by fleshy fibres, the deeper and inferior portion inserted into the ulna by fleshy fibres, and arising by aponeurosis from the radius (Fenwick, Sappey, and Macalister). (See Fig. 3452.)

The muscle may consist of a single triangle, as in some animals, *e. g.*, the macaque, seal, etc.

Flexor Carpi Radialis Brevis (Wood) (Radio-carpus of Fano). This is a small muscle occasionally seen. It arises from the anterior surface of the radius below the oblique line, and is inserted into the annular ligament, trapezium, os magnum, or other part of the carpus. It may also be inserted into one of the metacarpal bones. A variety of this muscle is, in rare cases, seen arising from the ulna (ulno carpus).

Supinator Longus. The varieties of this muscle are few in number. It sometimes has a higher attachment to the humerus than usual, and its insertion into the styloid process may be extended upward along the radius. It may have no attachment directly to the external condyle of the humerus, and in such a case it is closely connected with brachialis anticus. The writer once saw a slip from the supinator attached to the middle of the outer border of the shaft of the radius.

The tendon of the supinator may be divided into two or three slips. In cases of absence of the radius this muscle is wanting.

Occasionally it is double, the accessory portion (*brachio-radialis*) arising with it and being inserted into the radius in the neighborhood of the oblique line. It not infrequently is connected with neighboring muscles, viz., the deltoid, brachialis anticus (as in monkeys), flexor carpi radialis longior, and the abductor pollicis. The tendon may be pierced by the radial nerve.

Extensor Carpi Radialis Longior et Brevior. These muscles are sometimes completely fused. In many mammals (horse, pig, etc.) they form a single muscle, which ends in two tendons. In man the fusion may be only partial. The tendons of one or other of the muscles may be subdivided. The *radialis longior* may have an additional insertion into the second or third metacarpal bone. Wood has described a muscle which he calls the *extensor carpi radialis accessorius.* It arises from the humerus below the *radialis longior*, and is inserted into the first metacarpal bone, first dorsal interosseous muscle, abductor, or short flexor of the thumb. The writer has seen a digastric slip given off from the extensor carpi radialis longior, which joined the abductor pollicis. Testut has described an *abducteur huméral du pouce*, arising from the external condyle, and inserted into the first phalanx of the thumb. The long extensor is occasionally united with the supinator longus. Macalister has recorded absence of the short extensor.

Extensor Communis Digitorum. The varieties of this muscle relate chiefly to the increase or diminution of the tendons of insertion. The tendon going to the little finger may be absent, and also that going to the index finger. It is more common to have an increase than a diminution of tendons. Any one of the tendons may be subdivided, and as many as eleven have been observed by Perrin and Rüdinger, due to doubling of some tendons and tripling of others. Curnow in one case saw twelve tendons go to the inner four digits and five to the thumb, making seventeen in all. Five and six are commonly seen, the tendons of the little and index fingers being most often duplicated. The extensor communis occasionally sends a slip to the thumb.

The indicial portion of the muscle may be completely separated from the rest, and the extensor minimi digiti may be inseparably connected with the larger muscle.

Extensor Minimi Digiti. Sometimes fused with the common extensor or carpi ulnaris. It may be double, the additional tendon being inserted into the ring finger. It may have an ulnar attachment, and may be inserted into the annular ligament. Complete absence of the muscle has been observed.

Extensor Carpi Ulnaris. An accessory or short extensor, going from the lower end of the fourth and fifth metacarpal bone, has been described. The tendon is not unfrequently prolonged downward to the first phalanx of the little finger (*ulnaris quinti*). It is also frequently connected with the abductor minimi digiti. Sir William Turner has lately reported a case of absence of this muscle; its place was taken by a slender band of fibrous tissue. Curnow has also recorded absence of this muscle.

Supinator Brevis. An accessory supinator brevis has been observed going from the external condyle of the humerus to the radius or ulna. The extent of attachment to the radius may be much greater than usual. A sesamoid bone is sometimes found in the tendon of the muscle. This occurs normally in some animals, and is also seen in the popliteus, of which the short supinator is supposed to be the homologue.

Extensor Ossis Metacarpi Pollicis. The tendon of this muscle is frequently double, and sometimes is triple. When double, usually both are inserted into the meta-

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carpal bone, or one into this bone and the other into the trapezium, as is the normal arrangement in apes. The supernumerary tendon may be inserted into one of the short muscles of the thumb. The muscle may be double throughout, and Curnow has in one case seen it triple.

Extensor Primi Internodii Pollicis. Is sometimes absent, or is not differentiated from the extensor ossis metacarpi. Curnow describes a case of doubling of this muscle. It is found only in man.

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Extensor Secundi Internodii Pollicis. Doubling of the muscles is not uncommon. Additional muscles are occasionally present, and have been described by Curnow (*Jour. Anat. and Phys.*, vol. x., p. 596).

Extensor Primi Internodii Pollicis et Indicis. In some rare cases there is an accessory extensor present, which arises between the extensor indicis and the extensor secundi internodii pollicis; it divides into two tendons, one of which goes to the first phalanx of the thumb, and the other to the index finger. This muscle exists normally in the dog and many other carnivora.

Extensor Indicis. The tendon of this muscle is frequently divided into two portions, one going to each side of the index finger; sometimes one of the tendons goes to the middle finger. This latter is occasionally seen as a distinct muscle (*extensor proprius digiti medii*). It arises from the lower part of the ulna or posterior ligament of the wrist-joint, and is inserted into the base of the first phalanx of the middle finger. It exists normally in apes.

A short *extensor indicis* is occasionally seen taking its origin below the long extensor, from the back of the wrist or a carpal bone; it is inserted with the long extensor into the index finger. The writer has seen this accessory muscle arise from the radius, and pass through a separate compartment in the annular ligament to be inserted into the index finger. The extensor indicis may have a more extensive attachment to the radius than usual. The writer has seen it connected by a tendinous slip with the extensor secundi pollicis. Curnow describes one case in which the muscle divided into three tendons—one inserted normally, one with the secundi internodii, and one with the aponeurosis over the middle finger. A somewhat similar arrangement is seen in the hedgehog, kangaroo, and manis. It is rarely absent.

Extensor Pollicis and Indicis (see above).

Extensor Brevis Digitorum. Very rarely met with. It arises from the back of the wrist, post-annular ligament, from the carpus itself, or the bases of some of the metacarpal bones by fleshy fibres; it sends tendinous slips to one, two, or three fingers. The writer has seen them going to the ring and index fingers and to the middle finger. It is probable that the extensor brevis indicis and extensor medii digiti are varieties of this muscle. (See Fig. 3453.)

This muscle is common in reptiles, and survives only in a few anomalous mammals of the order Edentata (Curnow).

Muscles of the Hand.—*Palmaris Brevis.* Varies considerably as to its degree of development. It is occasionally altogether wanting.

Abductor Pollicis. Some anatomists describe the muscle as normally consisting of two portions—an outer and inner. It may receive a third belly from the opponens pollicis, or be connected with it by a muscular slip. It may also receive an accessory slip from the extensor carpi radialis longior, ossis metacarpi pollicis, palmaris longus, or from the radius. Not infrequently a thin, muscular slip is seen going from the skin of the ball of the thumb opposite the tuberosity of the trapezium to the abductor pollicis. Some regard this latter as a skin-muscle.

Flexor Brevis Pollicis. The deeper belly of the muscle is often with difficulty differentiated from the adductor pollicis.

Adductor Pollicis. This muscle is frequently blended with the deep portion of the short flexor of the thumb.

Abductor Minimi Digiti. Sometimes divided into two or even three slips. It is often united with the flexor brevis minimi digiti. It may have an accessory slip, arising from the tendon of the ulnar flexor, the annular ligament, fascia of the forearm, and tendon of the palmaris longus. The writer has seen an accessory head arise from the intermuscular fascia beneath the flexor radialis and ulnaris. The accessory slip may pass down and cover the ulnar artery.

Flexor Brevis Minimi Digiti. May be absent or replaced by a slip from the abductor minimi digiti or opponens. An accessory head may spring from the lower third of the inner border of the ulna, from the carpi ulnaris, or fascia of the forearm. A doubling of the muscle has been observed.

Opponens Minimi Digiti. May be closely connected with neighboring muscles, or receive a second head from the fascia of the forearm (Henle.)

M. Pisiuncinatus. This is a muscle described by Calori, and stretches between the pisiform bone and unciform process of the unciform bone.

Interosseous. These muscles do not vary to any great extent. They may be double in one or two interosseous spaces. Henle describes a *palmar interosseous* muscle of the thumb as normal. It arises from the metacarpal bone of the thumb, and joins the inner head of the flexor brevis pollicis. The arrangement of the interosseous muscles of the hand has been observed, in rare cases, to be similar to that of the foot.

Accessory Palmar Abductor Indicis. The writer once saw a small muscle arising from the third metacarpal bone, beneath the adductor pollicis and inner head of the flexor brevis pollicis. After ending in a round tendon, it was inserted into the base of the first phalanx of the index finger.

Muscles of the Lower Limb.—*Gluteus Maximus.* The great size of this muscle is peculiar to man, principally on account of his erect position. In the human species the muscle always covers the ischial tuberosity; in apes, this is uncovered. The variations are important. The muscle may be considerably reduced in size. Macalister reports a case in which the muscle was attached above to the last two sacral vertebræ only. The superficial portion of the muscle is often separated from the deep by a layer of cellular tissue. The lower edge of the muscle is sometimes quite distinct, and represents the *agitator caudæ* of the lower animals; it may be inserted into the femur or the femoral aponeurosis. The gluteus maximus is occasionally blended with the tensor fasciæ, as in the elephant and some monkeys.

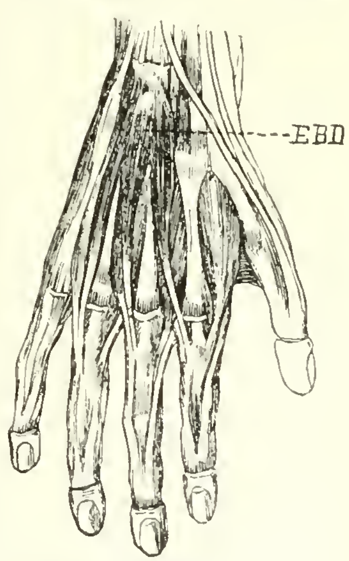

Fig. 3453.—*EBD*, Extensor brevis digitorum. (After Wood.)

Ischio-femoral. The writer has only once seen this muscle. It arose from the inner edge of the great tuberosity by a round tendon, which soon developed into a triangular-shaped muscle of considerable size; it was separated from the gluteus maximus by the great tuberosity, and joined it near the femur. It was inserted into the lower end of the gluteal ridge of the femur. The *ischio-femoral* muscle exists normally in the gorilla, certain apes, and other animals.

Gluteus Medius. The deeper fibres of this muscle may

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end in a separate tendon, which is attached to the upper border of the great trochanter. Its upper or lower border may be separated from the rest of the muscle. Occasionally a bursa is interposed between the tendon of the gluteus medius and the pyriformis. Some of its fibres may be inserted into the pyriformis, or its posterior border may be completely fused with that muscle.

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Gluteus Minimus. Occasionally divided into anterior and posterior portions; may send slips to the hip-joint, to the pyriformis, gemelli, or vastus externus muscles.

Accessory Gluteus Minimus (fourth gluteal; scansorius). The fibres of the anterior border are in some cases separated from the muscle, and inserted variously into the anterior border of the great trochanter, into the capsule, or near the lesser trochanter, where it is connected with the iliacus tendon. It represents the scansorius muscle of apes. Testut looks upon it as representing the extrapelvic portion of the iliacus muscle.

Tensor Vaginæ Femoris (tensor fasciæ). Varies but little. May have a supernumerary origin from the abdominal fascia, iliac crest, and Poupart's ligament. It

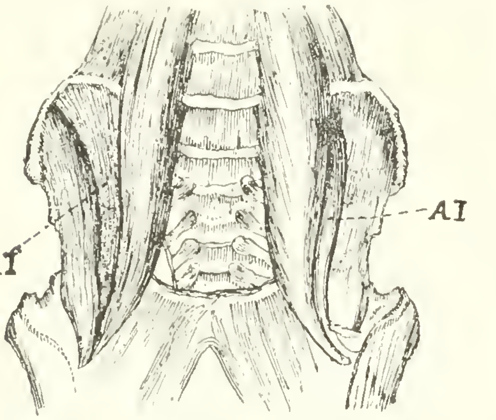

FIG. 3454.—*AI, AI.* Examples of double superficial iliacus muscles.

is sometimes fused with the gluteus maximus. A duplication of the muscle has been observed by Macalister and Testut.

Pyriformis. The most common variation of this muscle is its division into two portions by the great sciatic nerve or its external popliteal branch. It is occasionally fused with the gluteus medius more or less completely. It may be connected with the gluteus minimus by a few fibres. Its tendon is sometimes united with that of the obturator internus, or receives the gemellus superior. It may have its origin from as many as five sacral vertebræ, or as few as one. It frequently has no attachment to the first sacral vertebra. It may be inserted into the capsule of the hip-joint. Its complete absence has been noted by several observers.

Obturator Internus. The variations of this muscle are unimportant. It may receive supernumerary fasciculi from various parts in the pelvis, as the psoas minor muscle, ischial tuberosity, sacro-sciatic ligaments, third sacral vertebra, pubes, etc. A pubic portion is sometimes separated by the obturator nerve.

Obturator Externus. Wood has described a large fleshy slip going from the adductor brevis to join the tendon of this muscle, and Macalister has noted a separation of a pubic fasciculus by the obturator nerve.

Gemelli. The *superior gemellus* is not infrequently absent, or very small in size. The *inferior gemellus* has also been observed absent, but more rarely. Doubling of the *superior* has been noticed; it has also been seen fused with the pyriformis and gluteus minimus. The gemellus inferior and quadratus femoris are frequently inseparably united to the obturator internus.

Quadratus Femoris. This muscle may be much reduced in size, or absent altogether; in such a case, the inferior gemellus is larger. It has been described as sometimes double. It may be united above with the gemellus inferior, and below with the adductor magnus.

Biceps Flexor Cruris. The two heads may be quite separate, as in the orang and chimpanzee. The short head may be divided into several fasciculi, or, in rare cases, absent altogether. This latter arrangement is the usual one in a large number of mammals. There is sometimes a third head, which may arise from the femur, from the ischial tuberosity, coccyx, sacrum, fascia lata, or gluteal fascia. The third head generally joins the long head, though when it arises from the linea aspera, or inner condyloid ridge, it joins the short head. The third head has been looked upon as homologous with the caudal origin of the biceps in the lower animals. In rare cases a slip (*ischiocalcaneus*) has been seen going from the long head to the gastrocnemius, external tuberosity of the tibia, femoral aponeurosis, and even to the tendo Achillis. This arrangement is a modification of that seen in the lower animals, especially the bear.

I have seen a muscular slip arising from the biceps near its insertion and inserted by a tendinous expansion into the fascia covering the lower third of leg.

Semitendinosus and *Semimembranosus.* These two muscles may be fused into one. The *semimembranosus* may be absent altogether. It has been seen double. Occasionally, it derives its origin for the most part from the great sacro-sciatic ligament.

The *semitendinosus* may have a supernumerary origin from the coccyx, and sometimes gives off a muscular slip about its middle, which is inserted into the fascia of the leg. This arrangement is normal in some of the lower animals.

Psoas Magnus. Varies somewhat in volume, according as its origin is more or less extensive. It occasionally forms a muscle quite distinct from the iliacus. It may be divided into two portions, between which passes the anterior crural nerve. This is merely an exaggeration of the normal condition. An accessory psoas is sometimes seen arising from the transverse processes of some of the lumbar vertebræ. The writer, in a male subject, saw this accessory psoas of considerable size; it arose from the transverse process of the fourth lumbar, and as it descended widened out into a broad muscle, which joined the magnus in the middle of the iliac fossa.

Psoas Parvus. Frequently absent and occasionally fused with the magnus. It usually arises from the bodies of the last dorsal and first lumbar vertebræ, and soon becomes tendinous; it then passes down to the inner side of the magnus, and ends by being inserted into the ilio-pectineal line and pectineal eminence. It has been noted as having an insertion into the lesser trochanter, as in the seal, guinea-pig, etc.

Although inconstant in man, it is a large, well developed, and constant muscle in the lower animals. Gruber in 450 subjects found absence of this muscle on both sides in 183, and on one side in 69; Perrin in 112 subjects found it present in only 32; Theile found it in only 1 out of 20 subjects examined; and Testut, 6 out of 32.

It is occasionally double.

Iliacus. May be divided into several distinct portions. The deep portion is not infrequently separated from the superficial by a well-marked cellular interval, and thus constitutes a separate muscle.

Superficial Iliacus. Sometimes seen arising from the crest of the ilium, last lumbar vertebra, or upper border of the sacrum. In one subject, the writer saw this muscle on both sides: on the right side it was a broad, flat muscle, arising from the posterior third of the crest of the ilium, and on the left a fusiform muscle, which arose from the body of the last lumbar vertebra and upper border of the sacrum. Both muscles ended in strong tendons, which were pierced by the anterior crural nerve, and joined the iliacus below Poupart's ligament (Fig. 3454).

Iliocapsularis vel Iliacus Minor. Arises from the anterior inferior spine of the ilium and capsule of the hip-joint; it may be inserted into the lower part of the

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anterior intertrochanteric line, lesser trochanter, or iliofemoral ligament. In one subject the writer saw a well-marked bursa separating it from the iliacus.

Sartorius. A case of absence of this muscle has been reported by Meckel. It is occasionally double in its whole course. An accessory portion has been seen having an insertion into the femur, patella, or tendon of the normal muscle.

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The sartorius, in addition to its tibial attachment, may have an insertion into the femoral aponeurosis, the capsule of the knee-joint, or the femur itself in the neighborhood of the internal condyle. All these various insertions are seen normally in mammalia. A tendinous inscription in rare cases is seen in this muscle. The writer has only once met with this anomaly.

Quadriceps Extensor Cruris. Not subject to many variations. Occasionally the acetabular origin of the *rectus* is wanting, or it may be reinforced by an additional origin from the anterior superior spine. The *vasti* muscles may be divided into two portions, superficial and deep; this bilaminar arrangement is the normal one in many birds. The two vasti muscles are often closely united.

The *Subcrureus* is a muscle which is very variable in volume. It is often divided into two or more separate muscular bundles.

Accessory Head to Quadriceps. The writer once saw, on the left side of a male subject, a supernumerary muscle which arose by a double tendinous origin from the anterior portion of the capsule of the hip-joint and the anterior border of the great trochanter. The two tendons soon united to form one strong tendon, which passed down the thigh between the iliacus and tensor fasciæ, lying on the vastus externus; about the middle of the thigh it developed into a strong muscular belly three inches long. After passing beneath the rectus it joined the common tendon of the quadriceps.

Gracilis. The variations are unimportant and consist chiefly of a greater or less extent of origin and insertion. An accessory head is sometimes seen.

Pectineus. May be occasionally divided into two portions, as in some of the lower animals, each portion supplied by a different nerve—the inner by the obturator, and the outer by the anterior crural. In one case the writer saw it divided into a superficial and a deep portion; the superficial arose from the pectineal line, two inches outside the pubic spine, and was inserted into the linea aspera, with the adductor magnus. The deep portion was the normal muscle.

The pectineus is not infrequently united with the adductor longus; this occurs normally among the Rodentia, Carnivora, and Quadrumana. It may be sometimes inserted into the capsule of the hip-joint.

Adductor Longus. May be divided into two portions by the passage of blood-vessels. It is often inserted low down on the femur, and its tendon is inseparable from the magnus. It is sometimes fused with the pectineus.

Adductor Brevis. Occasionally divided into two or three portions—may be continuous with the magnus. It has been reported as united to the tendon of the obturator externus.

Adductor Magnus. The upper part of this muscle is so often separated from the main portion that Henle, Macalister, and other anatomists describe it under the name *adductor minimus* or *quadratus.* Its upper border is occasionally completely united with the quadratus femoris. The different parts of the muscle are not infrequently separated; the portion inserted into the internal condyle is frequently quite distinct (*ischio-condyloid*).

Tibialis Anticus. This muscle has been seen arising from the femur, as occurs so generally in the higher mammals. In the case reported the leg was congenitally deformed. The tendon is occasionally double, the extra tendon being inserted into the astragalus or base of the first metatarsal, as in apes. The tendon has been seen divided into three portions, and occasionally a sesamoid bone is formed in it.

I have seen a muscular slip from the tibialis anticus end in a tendon which was inserted into the proximal phalanx of the fourth toe. I have also seen this slip inserted into the first phalanx of the great toe.

Tibiofascialis Anticus. A small muscle described by Wood, Macalister, and Humphry, which arises from the lower third of the anterior edge of the tibia, over the tibialis anticus, and is inserted into the annular ligament and deep fascia. It is sometimes represented by a tendinous slip from the tibialis anticus, which is inserted into the fascia of the dorsum of the foot. Gruber describes a *tibio-astragulus anticus* arising from the tibia and interosseous ligament behind the tibialis anticus, and inserted in the neck of the astragalus.

Extensor Proprius Hallucis. Is occasionally united with the extensor communis digitorum, or short extensor of the toes. The muscle or its tendons may be double, and have a supernumerary insertion into the metatarsal bone or first phalanx of great toe. It is sometimes inserted into the second toe. Its tendon may be divided into three portions (*extensor hallucis longus tricaudatus*).

Extensor Ossis Metatarsi Hallucis is a small muscle arising from the extensor hallucis, tibialis anticus, extensor communis digitorum, or as a separate muscle close to the extensor hallucis, going through the same compartment in the annular ligament as the hallucis; it is inserted into the metatarsal bone of the great toe.

Extensor Primi Internodii Hallucis. In one-half the subjects examined Professor Wood found this muscle; it is generally an offshoot from the extensor hallucis, but sometimes arises separately.

Extensor Longus Digitorum Pedis. Varies considerably in the mode of origin and the arrangement of its tendons. The number of tendons may be increased by the doubling of any one. It is not uncommon for the tendon going to one toe to give slips to adjacent toes. It may have an additional insertion into the metatarsus. Occasionally a supernumerary tendon is seen going to the great toe. The tendons may be united on the dorsum by slips, as in the hand. It may be united to a greater or less extent with the extensor proprius hallucis, or extensor brevis digitorum. Each of the tendons may have a separate muscular belly in connection with it. Wood reports a case in which the four tendons had each a separate muscular belly. All these abnormal arrangements have their corresponding normal conditions in the lower animals.

Peroneus Tertius. Sometimes of large size, and occasionally inserted entirely into the fourth metatarsal bone. Its tendon may unite with that of the extensor going to the fourth or fifth toe, or it may unite with the fourth dorsal interosseous. The muscle may be absent altogether or be double.

Peroneus Longus. Occasionally fused with the brevis. In one case it has been noted as arising from the femur, as in many lower animals, *e.g.* the bear, hyæna, etc. It may have a supernumerary insertion into one of the metatarsal or cuneiform bones, as occurs in some animals. The tendon sometimes gives origin to the flexor brevis minimi digiti and outermost plantar interosseous (Wood).

Peroneus Accessorius. This is a small muscle which arises from the fibula between the peroneus longus and peroneus brevis, and ends in a tendon which joins the long peroneal.

Peroneus Brevis. The tendon of this muscle is occasionally divided into two portions, the supernumerary one going to the fourth metatarsal or cuboid bone, or to the proximal phalanx of the fifth toe, joining the extensor tendon of that toe. It may also be inserted into the abductor minimi digiti.

Peroneus Quinti Digiti. It arises from the fibula beneath the peroneus brevis, and is inserted into the extensor aponeurosis of the little toe. It is seldom seen as a distinct muscle, being generally united with the peroneus brevis. It is seen normally in some animals, as the bear and the cat.

Peroneus Quartus. A muscle which is not infrequently seen arising from the back of the fibula, between the peroneus brevis and flexor hallucis, or from the fascia of the deep muscles of the calf; it is inserted into the external malleolus, peroneal tubercle of the os calcis, or the

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ridges of the cuboid groove. This is looked upon by Testut as a variety of the peroneus quinti digiti.

In a male subject the writer saw, on both sides, the peroneus longus divided into two portions: the outer and larger passed down in the usual course of the long muscle, but the inner and smaller portion, which arose principally from the intermuscular septum, ended in a tendon which passed through the same compartment in the annular ligament as the outer portion, and immediately before it reached the peroneal tubercle it divided into two parts, one of which spread out and was inserted into the tubercle; the other crossed over the tendon of the peroneus brevis and was lost in the fascia covering the dorsum of the foot; between these two tendons passed the tendon of the peroneus brevis. This was probably a variety of the peroneus quinti digiti and peroneus quartus muscles.

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FIG. 3455. A. Example of a third head to the gastrocnemius. (Wood.)

Extensor Brevis Digitorum. The number and arrangement of the tendons vary considerably. Very frequently one or more of the tendons are doubled. A slip not infrequently goes to the little toe. The number of tendons may be reduced to two; occasionally a single tendon may have two muscular heads in connection with it. The innermost portion going to the great toe is often separated from the rest of the muscles, and is called the *extensor brevis hallucis.* Wood describes cases in which slips from the tendons of the extensor brevis joined the dorsal interosseous. There may be a special slip going to the second metatarsal bone or long extensor tendon of the second toe. This would be the homologue of the extensor indicis of the hand.

Gastrocnemius. The two bellies are sometimes more or less completely separated from each other, as in the marmot, unau, coati, etc. The most common anomaly is the existence of a third head (see Fig. 3455). This consists of a band of muscular fibres, which may arise from either condyloid ridge, the popliteal surface of the femur, or the posterior ligament of the knee-joint; passing down, it most frequently joins on the united muscle. This third head may pass between the popliteal artery and vein, or over both vessels and nerves. It is sometimes divided into two portions.

The writer has seen a third head arising from the inner side of the tendon of the biceps femoris, about three inches above the condyles. It passed down, and joined the external head about one inch above its junction with the internal one. This is the normal arrangement in the lion and some other animals.

FIG. 3456. Absence of the external head of gastrocnemius. (Shepherd.)

A slip may be given off from the biceps, semitendinosus, or adductor magnus to the gastrocnemius. The writer, in one female subject, saw complete absence of the external head. On removing the skin and fat, the first structure which came into view was the plantaris muscle (see Fig. 3456). Absence of the whole muscle has been observed.

Occasionally a sesamoid bone is developed in the tendon of the external head. A similar arrangement exists in many animals.

Soleus. An accessory soleus is occasionally seen which arises from the oblique line of the tibia and joins the inner side of the soleus; it covers the posterior tibial artery, and is often of large size.

The soleus has been observed of very small size, the fibular portion alone existing.

It is sometimes inserted into the os calcis separately from the gastrocnemius, an arrangement which is common in many animals. A muscular slip going from the tibia to the tendinous arch over the popliteal vessels has been occasionally seen.

Plantaris. The plantaris, which is rudimentary in man and gradually disappearing, is of large size in some animals, and in them is continuous with the plantar fascia or flexor brevis digitorum. In man it is frequently absent. It sometimes arises by two heads, the supernumerary one coming from the posterior ligament of the knee-joint or from one of the condyles. The writer has seen this supernumerary head arise from the outer head of the gastrocnemius and the middle of the outer surface of the soleus by a tendinous origin.

The plantaris has been seen to arise from the popliteal fascia and fibula. The writer on one occasion saw it arise solely from the posterior ligament of the knee-joint. The mode of its insertion varies, its tendon sometimes joins the tendo Achillis or internal annular ligament, or ends in the deep fascia of the leg. It may send a slip to the plantar fascia (*tensor fasciæ plantaris*). Its tendon may be enclosed in the lower part of the tendo Achillis.

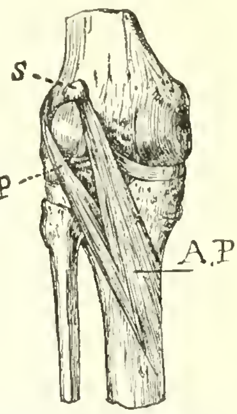

FIG. 3457.—AP, Accessory popliteus arising from a sesamoid bone (S); P, normal popliteus. (Wagstaffe.)

Popliteus. A sesamoid bone is sometimes developed in its tendon of origin. The muscle in rare cases is absent altogether.

Popliteus Minor. Is a small muscle, rarely seen, which arises from the femur internal to the plantaris and is inserted into the posterior ligament of the knee-joint. Wagstaffe has described an accessory popliteus which arose from a sesamoid bone developed in the external head of the gastrocnemius, and was inserted into the oblique line of the tibia superficial to the normal muscle (see Fig. 3457).

Peroneotibialis. This is a muscle described by Gruber, who met with it in one in seven subjects. It arises from the inner side of the head of the fibula, and is inserted into the upper end of the oblique line of the tibia. It is placed beneath the popliteus, and is looked upon as the homologue of the pronator teres in the arm. It is seen in many of the lower animals.

Flexor Longus Digitorum Pedis. This muscle varies somewhat as to its origin. It frequently receives extra slips of origin from the deep fascia and aponeurosis of the leg, the tibia, fibula, or flexor hallucis. The writer has several times seen muscular fibres originating extensively from the deep aponeurosis and flexor hallucis, and crossing the tibialis posticus to reach the flexor digitorum. In some cases the tibialis posticus was completely hidden from view by muscular fibres. A similar arrangement is seen in a great many of the apes. The tendon going to the second toe is sometimes absent; in these cases the second toe receives a slip from the flexor hallucis.

Flexor Accessorius Longus Digitorum Pedis. This muscle and its varieties have been described under various names, as *tibioaccessorius, accessorius ad accessorium* (Turner); *peroneocalcaneus internus* (Macalister); *pronator pedis* (Humphry). It may arise from the tibia or

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fibula by a fleshy belly and in a well-marked tendon, which passes through a separate compartment in the annular ligament, either in front of or behind the flexor hallucis, and finally ending by joining the flexor accessorius or the tendon of the long flexor before it divides. It has been seen to replace the proper accessorius. In its course down to the foot, its fleshy fibres generally cover over the posterior tibial vessels and nerves. When it arises from the fibula and is inserted into the tubercle of the os calcis, it is called the *peroneocalcaneus internus*, and is looked upon as the homologue of the pronator quadratus of the forearm. The writer has several times seen this muscle arising from the tibia, and only once from the fibula. In one case it arose by two fleshy heads, one from the flexor hallucis, and the other for two inches from the inner border of the tibia immediately below the soleus; the two heads united to form a single belly which, after covering the posterior tibial vessels, ended in a tendon. This tendon passed beneath the annular ligament posterior to the vessels, and in the sole of the foot joined the tendon of the long flexor; the normal accessorius was inserted into this tendon instead of into that of the flexor.

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A *flexor proprius digiti secundi*, arising from the tibia and going to the second toe, has been described by Bahnsen.

Flexor Accessorius. The outer head is not infrequently absent. The muscle is sometimes much reduced in size and may even be absent. Its accessory long head has already been described under the name flexor accessorius longus digitorum pedis.

The number of digital tendons to which this muscle can be traced varies considerably. Offsets may be sent to the second, third, and fourth toes, and sometimes to the fifth. In rare cases it can be traced to only two tendons. The muscle has been observed going to the flexor hallucis tendon instead of the digitorum. It sometimes gives off a slip to the fifth toe (as in monkeys), when the slip to that toe from the brevis digitorum is absent.

Lumbricales. Absence of one or more of these muscles occasionally occurs. The writer once saw, on both sides of the same subject, the two outer ones absent. Two are sometimes seen going to one toe. The tendons are frequently inserted into the first phalanges of the toes.

Flexor Hallucis Longus. Seldom varies. The tendons of the digitorum longus and hallucis are seldom completely separated; they are generally united by a slip from the hallucis to the digitorum, and sometimes by one from the digitorum to the hallucis. The slip from the hallucis may generally be traced to the second or third toes, sometimes to all, and sometimes to the second only. In a subject dissected in 1879 by the writer, the tendon of this muscle divided into three tendons, which went to the great, second, and third toes. The longus digitorum divided into four tendons as usual; but those going to the second and third toes were of small size, and joined the ones from the hallucis. The lumbrical muscles were in connection with the digitorum tendons. In this case there was no connection between the tendons of the muscles before division. A slip may be given off from the flexor hallucis in the leg, and after passing under the annular ligament, may join the accessorius. This is a variety of the muscle described above—*flexor accessorius longus digitorum pedis.* In rare cases the tendons of the two long flexors are fused into one, as is seen in the lower animals. The writer once saw a sesamoid bone developed in the tendon of this muscle as it passed over the astragalus and os calcis.

Tibialis Posticus. Very seldom varies. Is occasionally blended more or less intimately with the flexor hallucis. A sesamoid bone is frequently developed in its tendon. It has been described as being inserted into the peroneus longus tendon, second, third, and fourth metatarsal bones, and cuboid. Wood has seen it combine with the flexor brevis hallucis muscles. It has been reported absent by Budge.

Tibialis Secundus. This is a muscle described by Bahnsen, Henle, and Linhart. Henle calls it the tensor of the capsule of the ankle-joint. It arises from the back of the tibia below the flexor digitorum longus, and is inserted into the posterior part of the capsule of the ankle-joint or annular ligament. A similar muscle has been described as being inserted into the anterior part of the capsule of the ankle-joint.

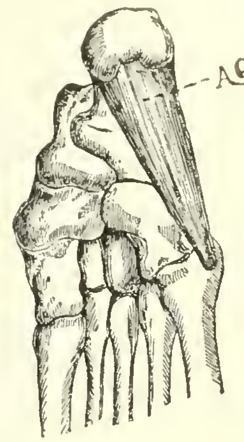

FIG. 3458.—*AQ.* Example of the abductor ossis metatarsi quinti arising from os calcis. (Bradley.)

Flexor Brevis Digitorum. The slip going to the fifth toe, which is usually of small size, and very often not perforated by the deep flexor, is sometimes absent altogether. Five tendons have been observed, two going to the second toe. The slip to the little toe, when absent, is occasionally replaced by a small muscle arising from the outer side of the long flexor tendon or flexor accessorius. This arrangement is seen in many of the apes.

The tendons of the short flexor may be united to those of the long flexor, and have a common insertion. Some portion of the short flexor may arise from the long flexor tendon. The writer, a few years ago, saw a very good example of this, an arrangement which is like that which exists in apes. The muscle consisted of two portions, superficial and deep; the superficial arose from the inner tuberosity of the os calcis, and divided into two tendons which went to the second and third toes; the deep portion, however, arose by a fleshy origin from the deep flexor tendon before it was joined by the accessorius; its tendons were distributed to the fourth and fifth toes.

Wood mentions a case in which the slip to the fifth toe was augmented by another from the long flexor tendon; they formed a single tendon, which was not perforated but blended with the tendon of the long flexor going to that toe.

Abductor Hallucis. Its tendon is sometimes joined by a muscular slip which comes from the skin in front of the inner ankle. Wood describes a muscular slip from the abductor to the base of the first phalanx of the second toe.

Abductor Minimi Digiti. The tendon is sometimes double.

Abductor Ossis Metatarsi Quinti. A portion of the above has been described, by Wood and Bradley, as a separate muscle arising from the outer tubercle of the os calcis, and inserted into the base of the fifth metatarsal bone; it occurs in about every other subject. Most anatomists look upon this as merely an insertion of the abductor minimi digiti, which fails to exist in about half the subjects examined. Occasionally it exists as quite a separate muscle (see Fig. 3458), having an extensive origin from under the surface of the os calcis. The interest attaching to this muscle lies in the fact that it is the true homologue of a muscle always present in the anthropoid apes.

Flexor Brevis Hallucis. A slip may be sent to the base of the first phalanx of the second toe (Wood). It sometimes receives fibres of origin from the os calcis or long plantar ligament. Occasionally it fails to be attached to the cuboid.

Adductor Hallucis. Occasionally a slip is seen going to the base of the first phalanx of the second toe; this may arise from the second metatarsal bone, or sheath of the tendon of the peroneus longus. Henle thinks it represents the *interosseus volaris primus* of the hand.

Opponens Hallucis (Macalister). Given off from the preceding muscle and inserted into the base of the metatarsal bone of the great toe, as in apes.

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Adductor Indicis. The writer once saw a large muscle arise from the cuboid and sheath of the peroneus longus tendon, outside the adductor hallucis, and go to be inserted into the base of the first phalanx of the second toe. This, no doubt, is the homologue of the adductor indicis of quadrumana and other animals, as the sloth, elephant, etc.

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Transversus Pedis. The slip from the fifth toe is often wanting, and others may also be absent. The whole muscle is occasionally absent.

Superficial Transversus Pedis. In 1879 the writer saw, in the right foot of a male subject, immediately beneath the skin, a muscle which arose from the bases of the first phalanges of the second, third, and fifth toes, and was inserted into the base of the first phalanx of the great toe; deeper down the normal transversus pedis existed and was of the usual size.

Flexor Brevis Minimi Digiti. A slip of muscle is very frequently seen given off from the inner border of this muscle, and inserted separately into the anterior half of the lateral border of the fifth metatarsal bone. In some cases it is almost a distinct muscle. Henle calls it the *opponens minimi digiti*, and looks upon it as the normal arrangement. It is well developed in the orang-outang.

Interosseous. Seldom abnormal. May vary sometimes in size, according to the size and use of corresponding digit (Wood). A slip is occasionally seen arising from the base of the second metatarsal bone and sheath of the peroneus longus, and inserted into the base of the first phalanx of the second toe. Henle regards this as the homologue of the interosseus volaris primus of the hand.

MUSCLES OF THE TRUNK.—*Rectus Capitis Posticus Minor.* The writer has once seen this muscle absent on the right side. The left was of large size.

Serratus Posticus Inferior. Macalister has observed absence of this muscle. It may consist of only three slips, or in rare cases there may be as many as five or six from the first to the sixth rib. Slips may be received from the levator anguli scapulæ. I have, in two cases, seen a well-developed muscular slip arising from the mastoid process, beneath the sterno-mastoid, and inserted into the upper border of the serratus posticus superior. Once I noted a slip passing from the fifth cervical transverse process to this muscle.

Serratus Posticus Superior. In rare cases the whole muscle has been absent. Absence of one or more digitations is not infrequent. It is occasionally of larger size than normal. The writer once saw it arise from the four lower dorsal spines, and two upper lumbar, and go to be inserted into the five lower ribs.

Splenius. The extent of origin of the splenius varies. It not infrequently reaches as high as the middle of the ligamentum nuchæ; it may even be attached to the occipital protuberance (as in the bear). In one subject, on both sides, the writer saw the splenii attached to the whole length of the ligamentum nuchæ, the occipital protuberance, the superior curved line of the occipital bone, and the mastoid process. The two muscles presented the appearance of an inverted triangle.

The splenius colli may have a slip of attachment to the third cervical transverse process. The writer has seen it send slips to the second and third cervical, and in one case to the cervicalis ascendens. The splenius capitis may be quite distinct from the splenius colli, or these two portions may be fused together. The colli portion has been reported absent.

Rhombo-atloid (Macalister). Splenius accessorius, adjutor splenii (Walther). This muscle has already been described with the rhomboid. It is a muscular slip going from the transverse process of the atlas to the serratus magnus, rhomboid or serratus posticus superior, and is looked on by Wood as indicating the first degree of differentiation in man toward the formation of the occipito-scapular muscle of the lower animals.

Ligamentum Nuchæ Replaced by Muscle. The writer, in one case, saw the upper part of this ligament replaced by strong muscular fibres, which were attached to the external occipital protuberance, the whole length of the occipital crest, and the posterior tubercle of the atlas and axis. The external border of this muscle consisted of a thick, round tendon, continuous below with the ligamentum nuchæ, which was normal from the spine of the third cervical vertebra.

Sacrolumbalis. The inferior and superior accessory origins of the sacrolumbalis are infrequently absent. The *cervicalis ascendens* may arise as low as the tenth rib, and be inserted as high as the third cervical.

Spinalis Cervicis. This is described by Henle as a normal muscle. It is very inconstant, and arises from the spines of the fifth, sixth, and seventh cervical and upper two dorsal vertebræ, and is inserted into the spine of the axis, and sometimes the spines of the third and fourth cervical vertebræ.

Extensor Coccygis (sacrococcygeus posticus). This is the name given to some slender muscular fibres occasionally seen going from the lower end of the sacrum or the posterior inferior iliac spine to the coccyx. It is the homologue of the great caudal extensor of the lower animals.

Longissimus Dorsi. May vary somewhat as to the number and extent of its attachments. The writer once saw it receive accessory fibres from the spines of the third, fourth, fifth, and sixth dorsal vertebræ.

Spinalis Dorsi. The number of tendons of insertion may be reduced to three; one spine may receive two tendons.

Complexus. The biventer cervicis may be completely fused with this muscle. It may be fused with the trachelo-mastoid or longissimus dorsi. The number of vertebræ to which it is attached may vary from two to seven. A supernumerary fascia sometimes arises from the transverse process of the second dorsal vertebra, and is inserted into the occipital bone beneath the normal muscle. The biventer frequently receives accessory slips from some of the lower cervical or upper dorsal vertebral spines, or from the ligamentum nuchæ. Slips have been seen going to join it from the seventh cervical transverse process.

Multifidus Spinæ. The origin from the seventh cervical vertebra may fail. Muscular slips may run from the necks of the first and second ribs to the fifth and sixth cervical vertebræ, as well as between other ribs and vertebræ.

Interspinales. Longer interspinous bundles are sometimes found passing over one or two vertebræ. In the neck the bundles are broader.

The short *Rotatory* muscles of the neck may be occasionally doubled.

External Intercostals. The last ones are sometimes wanting. Not infrequently they extend as far as the sternum between the costal cartilages. The lower intercostals occasionally are continuous with the external abdominal oblique.

Internal Intercostals. These frequently extend to the vertebral column. The last two are sometimes absent, or so small that it requires a very careful dissection to discover them.

Supracostalis (Wood); *Rectus Thoracis* (Turner). This is a muscle which lies on the upper ribs in the antero-lateral part of the thorax, and generally extends from the first to the fourth rib.

It has been looked upon: (1) as the homologue of the thoracic extension of the rectus abdominis to the first rib, as is seen so often in mammalia, *e.g.*, cat, otter, beaver; (2) as a reproduction in man of the sterno-costal muscles of the lower animals, *e.g.*, dog, badger, etc.; (3) as belonging essentially to the scalene system of muscles, and corresponding to the condition seen in many animals. In the bear the scalene muscles extend back as far as the seventh or eighth ribs. The last view is probably the correct one.

Triangularis Sterni. This muscle varies much as to its extent and points of attachment. Absence of one or both muscles has been noticed. Theile reports a case

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in which it extended to the clavicle. It is sometimes continuous with the transversalis abdominis, of which it is supposed to be a remnant or appendage.

Diaphragm. The sternal portion of the muscle is not infrequently wanting (Quain). Carruthers (*Lancet*, 1879) reports a case of absence of the left half of the diaphragm in a child which lived two days. In this case there was hernia of the small and part of the large intestine into the thorax. Absence of portions of the diaphragm is occasionally seen, and in these cases there is nearly always hernia of some of the contents of the abdomen into the thorax. At a post-mortem held at the Montreal General Hospital in 1885 on a man aged forty, a portion of the left half of the diaphragm was absent, and through the opening the greater portion of the stomach protruded into the thorax.

A fleshy fasciculus has been seen passing from the border of the œsophageal opening to the œsophagus. Knox has described a *musculus hepaticodiaphragmaticus* arising from the left side of the central tendon and passing over the œsophagus to the right, dividing into two slips, one of which went to the under surface of the liver and, becoming tendinous, joined the obliterated ductus venosus and umbilical vein; the other crossed the right crus and was lost in the peritoneum.

Henle and Bourgery describe a muscular slip going from the costal cartilage of the seventh rib partly to the costal cartilage of the ninth, and partly across the middle line of the diaphragm to the opposite border of the sternal portion.

Anomalous Muscle of the Thorax, Connected with the Diaphragm (Subvertebral Rectus of Humphry?) In a well-developed male subject in removing the lung and pleura the writer found a long, flat, ribbon-shaped muscle running down the left side of the bodies of the dorsal vertebræ. It arose from the anterior surface of the head of the sixth and seventh ribs. Becoming broader as it descended, it ended in two slips, one blending with the left arcuate ligament, and the other, which remained muscular with a tendinous intersection, united, by a blending of the two muscles, with the left crus of the diaphragm (*Jour. of Anat. and Phys.*, vol. xxx.).

External Abdominal Oblique (obliquus externus abdominis). According to Macalister, the number of attachments to the ribs varies from six to nine, and one or more slips may be doubled, generally those arising from the eighth and ninth ribs. It is not uncommon to see absence of the highest and lowest digitations. The two lowest may be rudimentary, and an additional fasciculus may come from the lumbar aponeurosis. This muscle may be connected with the serratus magnus, as well as with the pectoralis major, by continuous fibres. The musculus sternalis, when present, may be intimately associated with the external oblique.

A fasciculus has been described going from the ninth rib to the skin over that region (Flesch). This is no doubt a remnant of the dorso-abdominal skin muscle of mammals. Poland ("Guy's Hospital Reports," 1841) reports a case in which the external abdominal oblique became tendinous at a horizontal line on a level with the umbilicus. It was inserted as usual into the ilium and pubis, but had no connection with the linea alba or linea semilunaris; the internal edge of the muscle being external to the semilunar line, and leaving exposed the internal oblique. In this case the external oblique received a special fleshy fasciculus from the eighth rib, near its cartilage.

Internal Abdominal Oblique (obliquus internus abdominis). This muscle, like the preceding, is subject to variations in the extent of its attachments. Its upper or lower attachments may be reduced; it may have an additional slip of insertion into the ninth costal cartilage. A tendinous inscription in the upper part of this muscle has been described as not uncommon; it generally proceeds from the tenth or eleventh rib. Henle describes once finding in the anterior portion of this inscription a short, thin cartilage.

Accessory Abdominal Oblique (M. lateralis abdominis). This is a muscle situated between the two oblique muscles, which arises from the ninth, tenth, or eleventh rib, and passes down to be inserted into the crest of the ilium. The writer once saw this muscle on both sides of the same subject; on the right it arose from the tip of the twelfth, and on the left from the lower border of the eleventh, rib; this latter muscle was not inserted into the iliac crest directly, but blended with the aponeurosis of the external oblique behind and above the anterior superior spine of the ilium. Both muscles became broader as they reached their iliac attachment.

In some cases this muscle is attached to Poupart's ligament or to the sheath of the rectus.

Transversalis Abdominis. The extent of its attachments may vary. Cases are reported in which it was attached to the whole length of Poupart's ligament. The spermatic cord may sometimes pierce its lower border,

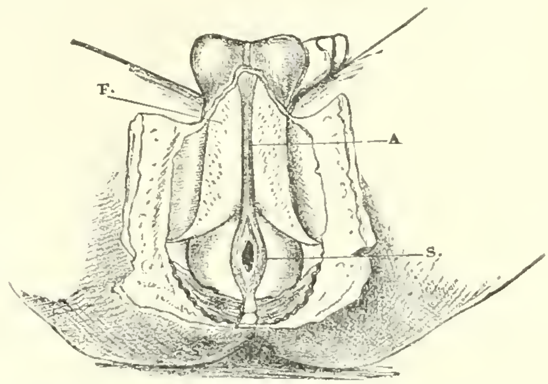

FIG. 3459.—*A*, Sphincter ani continued upward in the middle line and blending with the dartos of the scrotum; *F*, perinæal fascia; *S*, sphincter ani. (Shepherd.)

especially in those cases in which the attachment to Poupart's ligament is more extensive than usual. Fusion of the muscle with the internal oblique has been observed, and total absence has been noticed by Macalister. A tendinous intersection has also been seen.

Rectus Abdominis. In some cases this muscle has been seen extending as high as the third, and even the second, rib. It is not uncommon to see a supernumerary slip going to the fourth rib. In most animals the rectus abdominis extends higher than it does in man; in many it reaches as far as the first rib, *e.g.*, in the bear, otter, beaver, cat, porcupine, etc. The writer once saw a slip go from the upper part of the rectus to the middle of the lower border of the pectoralis major. The number of tendinous intersections may vary; as many as six have been noticed in the negro.

Pyramidalis. This muscle varies much as to size. It is very frequently absent, and is occasionally double. When absent the lower part of the rectus is increased in size. It is a muscle which is of no use in man, and is a mere rudiment of the larger muscle which exists in marsupials. It is absent in many of the lower animals, *e.g.*, solipeds, ruminants, and many of the carnivora, as the dog, cat, bear, etc.

Quadratus Lumborum. Is sometimes attached to the eleventh rib, and to the bodies and transverse processes of the tenth and eleventh dorsal vertebræ. Lange ("*Annals of Surgery*," vol. ii., p. 289) figures a quadratus muscle sending a slip to the fascia covering the pleura between the twelfth dorsal and first lumbar rib.

Muscles of the Perineum and Pelvis.—Sphincter Ani. The writer once saw the superficial fibres of this muscle continued up past the tendinous point of the perineum, as a flat muscular slip 6 mm. broad and 5 cm. long. This slip blended above in the middle line with the dartos of the scrotum (see Fig. 3459). Occasionally fibres of the transversus perinæi are inserted into this muscle.

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Coccygeus. Is sometimes inserted wholly into the side of the sacrum (Quain).

Sacrococcygeus Anticus (curvator coccygis). This is the name given to a few fleshy and tendinous fibres passing from the lower part of the anterior portion of the sacrum and coccyx. It is well developed in animals with tails.

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Transversus Perinæi. This muscle is a very variable one. It is occasionally absent, or so small as to be with difficulty dissected out. It is sometimes inserted either partly or wholly into the accelerator urinæ (bulbocavernosus) muscle or sphincter ani. This muscle is not infrequently fan-shaped, covering the triangular space formed by the three perineal muscles. In these cases the ischiocavernosus forms one edge of the fan. The fibres are inserted into the accelerator urinæ, central tendinous point, and sphincter ani. The muscle is occasionally double, the extra slip joining the accelerator urinæ or levator ani. Henle describes a muscular slip springing from the fascia at the lower border of the gluteus maximus, and inserted into the lower surface of the triangular ligament. In one case of absence of this muscle, the writer found the deep transverse muscle of large size.

Ischiocavernosus (erector penis). Houston has described a variety of this muscle under the name *compressor venæ dorsalis penis.* It is a slip arising in front of the ischiocavernosus and crus penis, which passes upward and forward, and is inserted with its fellow into an aponeurosis above the dorsal vein. The writer once saw this extremely well developed. In the dog and some other animals it is quite a strong muscle.

Bulbocavernosus (accelerator urinæ). This muscle is occasionally joined by the transversus perinæi. Kobelt describes the fibres which cover the most prominent part of the bulb, and which are separated from the others by a more or less distinct interspace, as the *compressor hemisphericum bulbi.* *Francis J. Shepherd.*

MUSCULAR ATROPHIES, PROGRESSIVE.—The presence of muscular atrophy at once suggests to the clinician one of two possibilities, namely:

1. The atrophy is a *symptom.* As such it may indicate injury, hemorrhage, inflammation, or new growth, affecting more or less acutely the oblongata, the spinal cord, or a peripheral nerve; or it may be one expression of joint disease and then due to reflex trophic disturbance in the cord.

2. The atrophy is a *disease.* In other words, it is sufficiently regular in its evolution and constant in its associated symptoms to merit a definite place of its own in our nosology. The scope of the present article is limited to this second group of muscular atrophies, those of the first group being treated under appropriate headings elsewhere in this work.

Our knowledge of muscular atrophy as a clinical entity dates from 1850, when Aran [1] published the first account of what we now recognize as progressive spinal muscular atrophy, although he considered it a disease of the muscles primarily. The disease was elaborated upon by Duchenne a few years later, whence the name "Aran-Duchenne Disease." [10]

The muscular atrophies which are classed as distinct diseases are divisible pathologically into two types, namely:

1. The myopathies or progressive muscular dystrophies; also known as "idiopathic" muscular atrophies, which are characterized by slow premature dissolution of muscle fibres from inherent vital defect. This is a long-recognized tissue condition for which Gowers has recently given us the convenient and expressive term "abiotrophy." [2]

Abiotrophy of the myon would be a concise statement of the pathologico-anatomic status of this group.

2. The myelopathies or "spinal muscular atrophies," characterized pathologically by the same process (premature dissolution) in the spinal motor nerve elements (anterior horn cells or lower motor neurons). Since, however, these same changes often occur also in the cerebral motor neurons (pyramidal motor cells) or in other cases are apparently limited to the peripheral nerves, a more comprehensive designation would be *neuronic muscular atrophy. Abiotrophy of the motor neurons,* therefore, would express the pathologico-anatomic nature of this group.

While this classification serves to define the great majority of cases, a series of mixed forms or so-called "connecting links" between the two main groups is becoming numerous in the literature as experience in their recognition increases, *e.g.*, cases which present symptoms of myopathy and myelopathy combined. These serve to illustrate the anatomical and physiological fact now well recognized, that the entire motor tract from the cortex cerebri to cord and from cord to muscle fibre constitutes a continuous functionating unit, and cannot suffer long in one part without in some degree impairing others.

There seems no good reason, however, to the writer for the use of the term "connecting link" for these cases. The coincident or consecutive involvement of one more segment of the motor tract is all that is necessary to the evolution of these mixed forms, and this may be reasonably postulated in any given case.

Accepting the pathological grouping into myopathic and neuronic, therefore, as the best at present available, we proceed in the order mentioned to consider the individual diseases in each group. The accompanying diagram shows at a glance the anatomical location of the pathological process in the several clinical types (Fig. 3460).

The myopathies or primary atrophies are divided clinically into several "types," somewhat arbitrarily perhaps, since there are good reasons for the view held by many that they are all due to the same pathological processes, differing mainly in location. An exception to this statement, however, must be made in the case of the "pseudo-hypertrophy," which is a prominent feature in one form.

They are all characterized, moreover, by certain clinical features in common, of which the chief are:

1. Hereditary or familial tendency.
2. Onset before puberty.
3. Preponderance in the male sex.
4. Loss of myotatic irritability, and in consequence loss of "tendon reflexes."
5. Electrical changes of reaction of *quantitative* character (diminished response to galvanism and faradism), and absence of typical R. D.

The recognized types of myopathy are:

A. PSEUDO-HYPERTROPHIC MUSCULAR ATROPHY.—*Causation.* The disease begins in childhood; in two-thirds of the cases before the sixth year (Gowers). Heredity is traceable in three-fifths of the cases (Dana). The hereditary influence is strongest through the mother's side, though the *male members* of the family are more frequently affected. Church explains the transmission by the female members of affected families by the fact that the disease renders the males impotent.

The disease is frequently preceded by some acute infection—diphtheria for instance, which probably favors its onset in those already predisposed.

Symptoms.—Weakness in the legs of gradual onset, accompanied by a "waddling" gait and frequent stumbling without evident cause are the earliest symptoms. These are usually noticed about the fifth year and are often attributed to carelessness or stupidity on the part of the child. Later, a noticeable enlargement (pseudo-hypertrophy) of the leg muscles, especially of those of the calves, appears. This may extend to the thighs and gluteal muscles; and the infraspinati are also frequently enlarged. The enlargement of muscles may be slight in some cases, but even in these an undue firmness with lack of elasticity is noticeable on palpation. The shoulder girdle muscles are affected later, while those of the face, forearms, hands, and feet escape for a long time, but are probably affected eventually in most cases that survive a sufficient length of time. Thus in two cases, brothers, aged four-

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EXPLANATION OF
PLATE D.

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EXPLANATION OF PLATE D.

Serial kinetographs illustrating the characteristic method of arising from the recumbent position in progressive muscular dystrophy, the patient "climbing up his own legs." (From Curschmann.)

Beginning at the top of left-hand column the figures are to be read downward; then begin at top of right-hand column. The successive utilization of the muscles of the upper extremities to assist the more atrophied ones of the legs and back is evident.

The weakness of the back muscles is also well indicated by the drooping head, counterbalanced by the lordosis. The figures represent a case of myopathy with little if any pseudo-hypertrophy.

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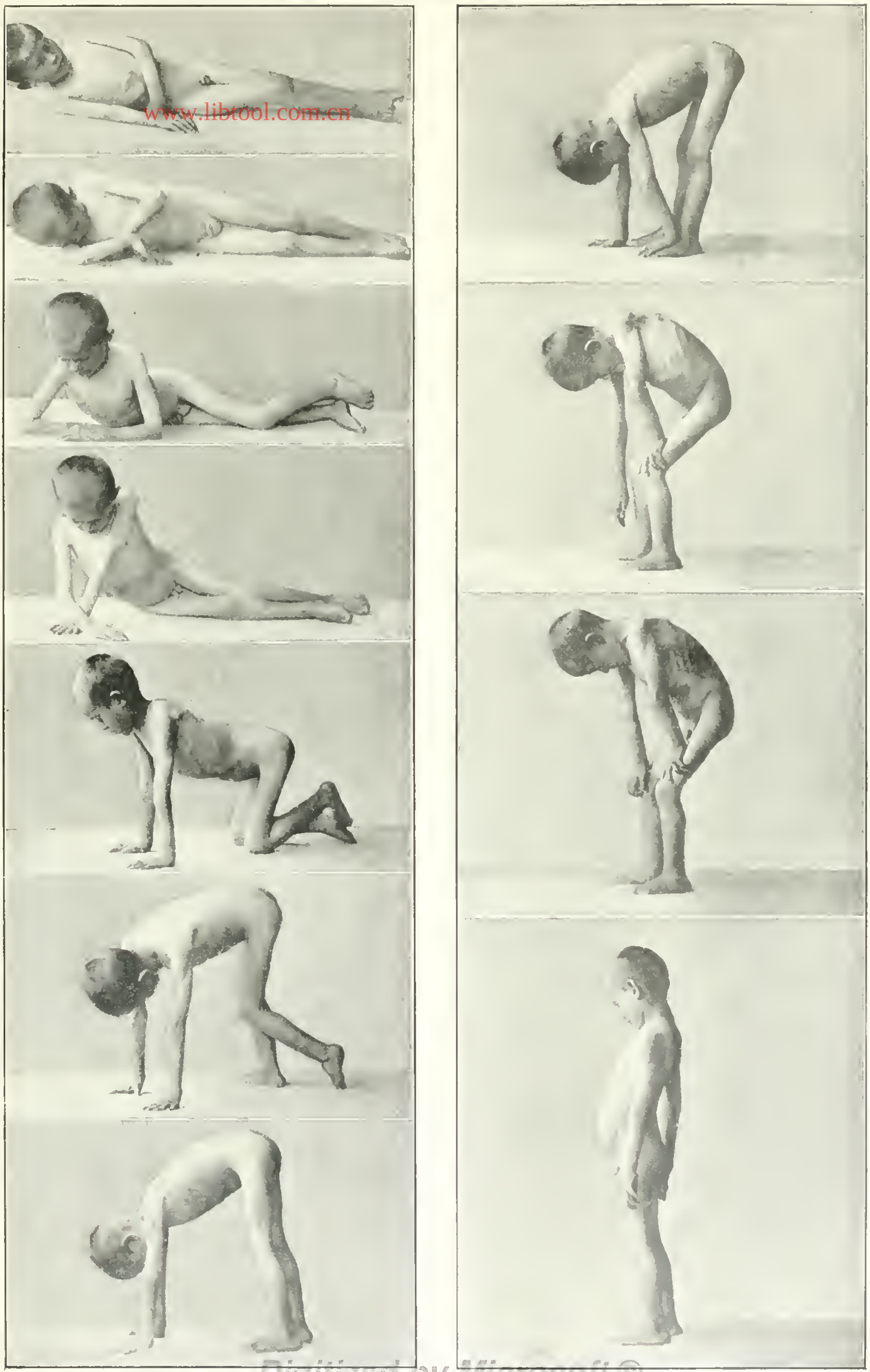

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PROGRESSIVE MUSCULAR DYSTROPHY
(CURSCHMANN)

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teen and nineteen, seen recently by the writer, through the kindness of Dr. W. E. Lewis of Cincinnati, one presented marked weakness of facial muscles, and the occipitofrontalis could not be made to act at all, though the patient could frown at command. In this same patient as well as his brother, aged nineteen, the hands were markedly involved, the grasp registering by the dynamometer only nine (right hand) and ten (left) in the younger; and nineteen (right) and fifteen (left) in the elder, both showing a reduction in power estimated by me at seventy-five per cent. or more. Moreover, in the elder of these brothers there was marked wasting of the thenar group of right hand, as well as *fibrillary twitching*, though both cases were typical myopathies in their development and most other respects.

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Peculiarities of posture and gait due to the muscular weakness are developed in time. Lordosis is commonly present when the patient stands. The gait is waddling and clumsy. Frequent falls result from the lack of muscular power and irregular control of movements, so that contusions and abrasions are frequent accompaniments of the disease. Ascending stairs is particularly difficult, and the patient arises from the prone or supine position in a characteristic manner by pushing with his hands upon the front of each thigh, to steady the legs. Thus he is said to "climb up his own legs." (See Plate D.)

While the statement is commonly made that the face is unaffected, nevertheless the facies of most of these patients, according to the writer's observation, is characteristic in some degree of defective muscular action. A blank, expressionless countenance is the rule, or again a marked senile aspect is present after the disease has progressed for a few years. In one case this facial involvement notably affected the smile, the mouth extending horizontally in a straight line, without the usual curves, a pathological "*risus sardonicus.*"

In addition to lordosis, which is common, other forms of spinal curvature appear late in the disease. Contractures are also a feature in the extremities, talipes equinus often resulting therefrom.

Apparent lengthening of the neck, due to the drooping of the shoulders consequent upon weakening of the trapezii (Brissaud) is noted.

Fibrillary twitching in the affected muscles is commonly absent, but there are numerous exceptions to this rule. Notably in the two brothers just cited, the elder presents marked fibrillation in the lower portions of the pectoralis major, as well as in the thenar muscles of the right hand.

Sensation is usually unaffected. The writer has noted one case in which a constant "prickly" sensation was complained of throughout the trunk and limbs, but most accentuated on the anterior chest wall.

The tendon reflexes are progressively diminished and finally lost, as the muscular structure disappears.

The cases without pseudo-hypertrophy are separated from the preceding form by that circumstance and from each other mainly by differences in distribution of the atrophy. Two forms appear to require recognition, clinically speaking.

B. The Scapulo-humeral Form, Erb's "Juvenile Type" (Fig. 3462).—This begins as a rule between the ages of fifteen and thirty-five, though a range of from two to sixty years in ages of patients is recorded (Gowers).

The shoulder, scapular, and upper-arm muscles are first affected, though the deltoid often escapes (Gowers). The pectoralis and latissimus dorsi commonly waste in their lower portions. The supinator longus is commonly involved. As the disease progresses, the muscles generally are invaded.

Fibrillary contractions and R. D. are said to be absent.

C. The Facio-scapulo-humeral Form, or Landouzy-Dejerine Type.—Also called the "infantile variety." In this the face is the part first attacked, but the ocular muscles and those of mastication escape. The shoulder and upper arm are invaded later.

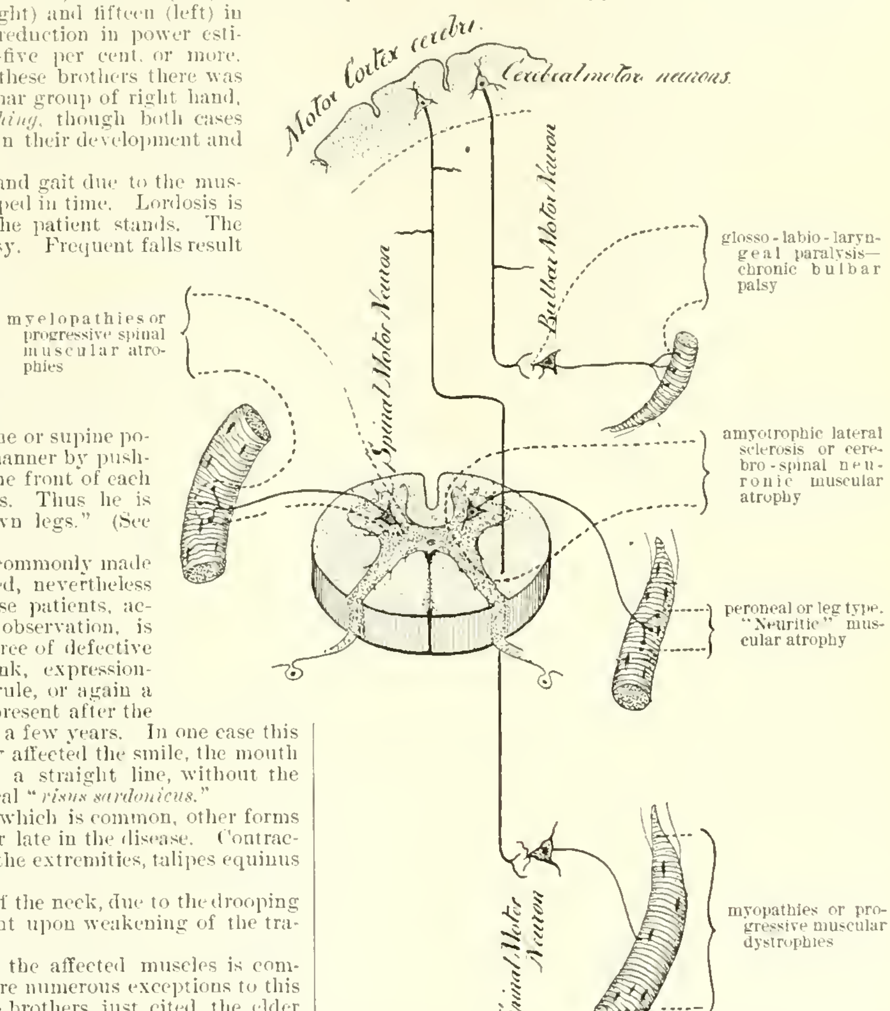

Fig. 3460.—Diagram of Motor Tract from Cortex Cerebri to Muscles, Showing Sites of Initial Degenerations in the Progressive Muscular Atrophies and Dystrophies.

The disease begins earlier as a rule than the two preceding forms, though marked exceptions to this statement are recorded.

For instance, in two cases reported by Hoppe,[3] one began at twenty-three, and was alive at fifty-five. In the other, a daughter of the first patient, the disease began at about the twenty-eighth year. These cases are also anomalous in the fact of R. D. being present as follows: In the mother's case, in the thenar and hypothenar muscles of both hands. In the daughter, in the *opponens pollicis and flexor brevis pollicis* only.

Fibrillation was not present in either case, and the mode of onset and distribution were regular in all respects.

D. Distal Form of Myopathy.—Gowers[7] applies this term to a case recently described by him, which dif-

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fers from the other myopathies chiefly in the fact of the atrophy beginning in the hands and feet, although the sterno-mastoids and tongue were also involved.

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FIG. 3461. Pseudo-Hypertrophic Muscular Atrophy. (C. L. Dana.)

The disease began at ten or twelve, and at eighteen the patient still had good power in the peroneal groups and calf muscles as well as in the thighs.

The trunk muscles apparently escaped; of the shoulder-girdle muscles the trapezius only was affected, and that slightly.

Electrical response was diminished to both currents.

Another case referred to at the same time combined the features of this type with those of the scapulo humeral (form B).

As that author remarks, this is only another link in the chain of evidence which favors the essential unity of all types of myopathy.

Pathology and Morbid Anatomy.—These are practically the same in all forms of myopathy.

The process is a degenerative atrophy, with irritation and swelling of muscle fibres and proliferation of nuclei in the early stages. Later, there is atrophy of the muscle fibres with disappearance of their transverse striæ. Increase of connective-tissue elements follows the disappearance of muscle fibres, causing a "myosclerosis" with, in the pseudo-hypertrophic forms, a lipomatosis in addition. Along with the atrophy and pseudo-hypertrophy a number of observers have noted an apparent *true* hypertrophy in some fibres.

The spinal cord and nerves are normal with rare exceptions, which are found in the "irregular forms" of the disease.

The *diagnosis* of the myopathies in general is simple. The age of onset (usually under puberty), the slowly increasing weakness, the waddling, stumbling gait, the muscular atrophy without R. D., and the absence of fibrillary twitching sufficiently separate the myopathies from the neuronic or "spinal muscular atrophies." The diagnosis of the different "*types*" of myopathy from each other is mainly a question of the place of beginning and order of distribution of the muscular atrophy, as already noted. (See Fig. 3461.)

Prognosis and Treatment.—The disease being dependent on inherent defect in tissue vitality, the most that can be hoped for from treatment is to retard its progress and promote the comfort and general well-being of the patient. As already seen from some of the cases cited, the disease is not always incompatible with a moderately prolonged life. From ten to twenty-five years, however, expresses the usual range of duration in ordinary cases.

The usual treatment recommended consists of nutritional and tonic measures. Strychnine is spoken highly of by Gowers.

The glycerino phosphates of lime and soda and other phosphorous compounds would seem indicated in young and developing patients.

Exercise, massage, and electricity have been recommended by most authors. Overuse of these agents may do harm. Orthopedic measures, such as division of tendons, are useful in the contractural disabilities.

THE SPINAL PROGRESSIVE MUSCULAR ATROPHIES OR MYELOPATHIES.

These are the atrophies of neuronic origin, and imply primary degenerative disease of motor neurons of the cord, or cord and brain combined.

A. PROGRESSIVE MUSCULAR ATROPHY PROPER, OR ARAN-DUCHENNE DISEASE, "WASTING PALSY."—*Definition.*—A chronic progressive disease of the spinal motor neurons (ventral horn cells), characterized by fibrillary contractions, slow atrophy, and gradually increasing weakness of voluntary muscles, with R. D.

Causation.—Direct heredity is rare. The neuropathic diathesis is presumably the chief predisposing factor. Adult age (twenty-five to forty-five), the male sex, exposure and fatigue, typhoid fever, rheumatism, gout, syphilis, and lead poisoning are credited as additional causes. The actual exciting cause, if such exists, is unknown. Why certain "systems" of neurons should die in some persons and not in others, after the operation of the preceding causes, is a problem which can be solved at present only by assuming a "potential insufficiency" in the nerve elements, an "abiotrophy" (Gowers), only fully developed by the action of some profound and persistent nutritional drain.

FIG. 3462.—Juvenile Type of Scapulo-Humeral Muscular Atrophy. (C. L. Dana.)

Pathology and Morbid Anatomy.— Degenerative atrophy of peripheral motor neurons (ventral horn cells) is the essential lesion. As a result of this, sections of the cord in affected areas show shrinkage and disappearance of cell bodies, with corresponding degeneration and diminution in their processes (dendrites and anterior root fibres). These changes are naturally most marked in the cervical enlargement, since the disease begins in the upper extremity in typical cases.

The posterior horns, together with the columns of Goll and Burdach, as well as the direct cerebellar tracts are normal, excepting in the rare cases of muscular atrophy supervening upon tabes dorsalis, of which the writer has seen two well-marked instances. In this case two dis-

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Muscular Atrophies.

eases are present, according to our present nosology. It is probable that the first actual destructive changes occur in the neuron endings (muscle plates) of the affected

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FIG. 3463.—Pathological Histology of Pseudo-Hypertrophic Muscular Dystrophy. (Partly diagrammatic; after Erb.) *A*, Hypertrophied fibres; *B*, mixture of hypertrophy and atrophy; *C*, *D*, atrophy and fatty deposit; *v*, vacuolization; *s*, splitting of fibres; *h*, hypertrophy of fibres; *g*, thickened blood-vessel.

muscles (see diagram, Fig. 3460). Following closely upon this impairment of their neurotrophic organs the muscles degenerate, fibre by fibre, into granular and fatty material, the transverse striæ disappear, while the adjacent connective tissue at first proliferates and later undergoes fibroid changes and contraction. Distention of blood-vessels is also described.

The pyramidal tracts of the cord are usually affected in some degree. In fact, so experienced an observer as Gowers[4] remarks that he has not seen a single case in which they were unaffected.

This, as the same writer aptly puts it, is "the visible expression of a tendency to decay of the whole motor path from the cortex of the brain to the muscles."

Clinical History.—The disease begins with weakness and wasting of the thenar and hypothenar muscles of one hand, usually the right. This may be preceded by dull aching pains in the corresponding limb and cervical region. Otherwise sensory changes are absent. The nutrition of the bones and skin is not affected. The wasting advances slowly to other muscle groups, notably the interossei and lumbricales, producing the characteristic longitudinal furrows between the metacarpals, especially noticeable on the back of the hand. The wrist flexors and extensors may go next, or the deltoid and biceps may be affected before the forearm. In this case, as the writer has seen, the patient may present the anomaly of a powerful grasp, with inability to abduct the arm to a right angle.

The spinal extensors are commonly affected early, producing lordosis and allowing the head to droop forward in extreme cases.

The upper portion of the trapezius escapes, which may be a diagnostic sign of importance, as between this disease and the myopathies.

The disease extending downward involves the hips and thighs, impairing locomotion. Marked weakness of the legs proper also exists, often without atrophy, but with more or less spasm and heightened muscle jerks. The explanation of this is the involvement of the upper neuron for the legs, with escape of the lower. In those cases in which the lower leg is atrophied, however, the peroneal group suffers most, thus corresponding to the same process in the "peroneal" type (to be considered later); and also to the atrophy in multiple neuritis.

This distribution contrasts with the myopathies, which affect more markedly the calf muscles.

If the disease extends upward, the upper cervical segments and the oblongata may be invaded, giving rise to respiratory and bulbar symptoms of grave import, such as dyspnœa, dysphagia, dysphonia, dysarthria, irregular heart action, glycosuria, etc. The facial muscles usually escape, but not always.

Fibrillary tremor is a characteristic symptom and is almost continuous in the affected muscles so long as any contractile substance remains. The mechanical irritability of the muscles is increased, light taps producing marked contractions.

The deep reflexes diminish gradually and finally disappear.

Electrical changes in the affected muscles are marked and constant. Early a quantitative reduction (diminished response) to both faradism and galvanism may be noted. Later, reaction of degeneration in varying degrees from simple sluggish response to complete polar reversal, *i.e.*, the muscle contracts more readily (or to a weaker current) with the anodal (positive) closure than with the cathodal (negative) closure.

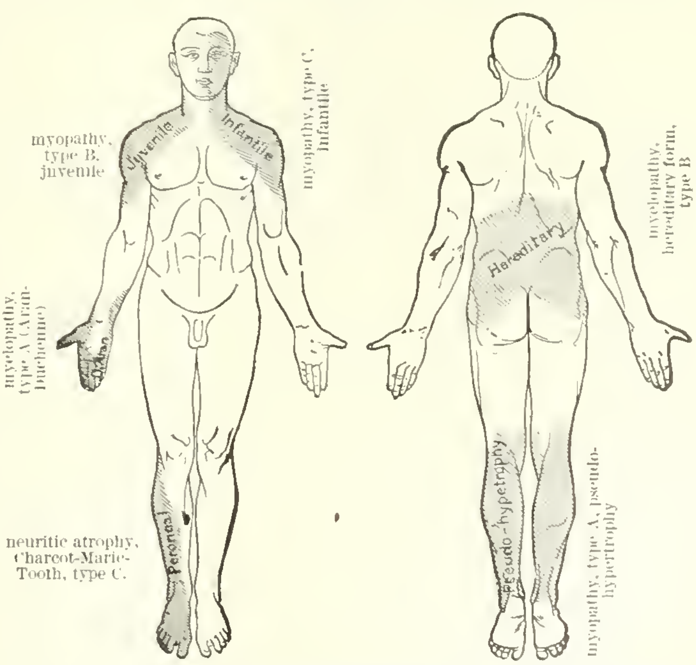

FIG. 3464.—Clinical Chart of Distribution of Muscular Atrophies. The shaded portions indicate the initial locations of muscular wasting in the different forms. (From C. L. Dana.)

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The presence of this R. D. is an important diagnostic sign in excluding the myopathies or "idiopathic" atrophies.

Contractions and deformities due to unequal wasting of opposing muscles are common. The "claw-hand" or "main en griffe," lordosis, and talipes equinus are examples.

The sphincters www.libtool.com.cn

Sexual power is commonly lost.

Eventually the patient presents an extreme degree of generalized emaciation, the "living skeleton" type.

Pulmonary complications, bulbar palsies, bedsores, and septic infection are of serious import.

Diagnosis.—The myopathies, the age (adult) at time of onset, the initial affection of the hands, the presence of

FIG. 3465.—Case of Spinal Progressive Muscular Atrophy of the Aran-Duchenne Type. (From the Neurological Department of the Cincinnati Hospital.)

fibrillary tremor and the R. D. are sufficiently distinctive. The onset in one hand and the extremely slow progress separate this from other neuron diseases, such as multiple neuritis, lead neuritis, and poliomyelitis, acute or chronic. The absence of pains and cervical deformity distinguish the affection from pachymeningitis cervicalis hypertrophica. Syringomyelia is excluded by absence of the "dissociation" sensory symptoms and of cutaneous trophic lesions.

Prognosis.—Arrest is said to be possible in rare cases. Remissions are more likely to occur. To retard the progress of the disease and improve the "compensation" in the remaining muscle tissue is as much as can be reasonably expected from treatment.

The duration is commonly prolonged, varying from two to thirty years (Dana). The fatal outcome is due to complications, pulmonary or laryngeal, resulting from involvement of the respiratory muscles.

Treatment.—Strychnine nitrate, administered hypodermically in doses gradually increased from gr. $\frac{1}{80}$ to gr. $\frac{1}{15}$, is highly commended by Gowers, who has seen the disease apparently arrested by its use.

General hygienic measures, careful diet, avoidance of fatigue are important. The phosphorus compounds should be tried.

Electricity, massage, and gymnastics should be used with caution, and any excess or fatigue should be avoided.

Mercurials and iodides are *never* indicated and may do harm.

B. HEREDITARY OR FAMILIAL TYPE OF PROGRESSIVE SPINAL MUSCULAR ATROPHY.—This is a rare form of neuronic atrophy described by Werding[5] and Hoffman.[6] It is characterized by heredity, by early onset (under two years), beginning in the hips and back; by rapid progress to complete helplessness and a fatal termination at or before the sixth year. R. D. is present, and wasting of the ventral horn cells has been found. Beevor[7] records one case which began in utero.

Diagnosis.—This is distinguished from the ordinary spinal atrophies (Aran-Duchenne type) by the hereditary element, early age, rapid progress, and absence of fibrillary twitching; from the myopathies, by the absence of hypertrophy, the presence of R. D. and the early termination.

Treatment has not influenced these cases appreciably.

C. AMYOTROPHIC LATERAL SCLEROSIS.—This is practically a progressive spinal muscular atrophy (type A) plus involvement of the upper neuron (pyramidal tracts of cord) to a marked degree (see Fig. 3460). The clinical difference consists in the marked spasticity, causing a stiff-legged gait, with toes tending to dig into the ground. There is also a rather more marked tendency to bulbar involvement, and the lower half of the face may be affected. The affection does not differ materially from type A as regards the prognosis and treatment.

D. GLOSSO-LABIO-LARYNGEAL PARALYSIS. — *Chronic Progressive Bulbar Palsy.*—This may occur primarily, or may indicate an extension upward of ordinary spinal muscular atrophy (type A). As a primary affection the degenerative process is limited to the bulbar neurons.

Patients are usually at the degenerative period of life. In many respects the disease appears to indicate a localized presenile change.

The chief *symptoms* are hoarseness, aphonia, dysarthria, dysphagia, sialorrhœa, atrophy, and fibrillation of the tongue, glycosuria, cardiac arrhythmia, and dyspnœa.

Pseudo-emotional symptoms, as causeless weeping or laughter, are frequent accompaniments. The palate reflex is absent in advanced cases.

The *diagnosis* must be made from bulbar apoplexy (small hemorrhage, thrombosis) by the sudden onset of the latter, with sensory defects of face frequently present; from cerebral lesions in the bulbar motor path (pseudobulbar palsy) by the sudden onset of the latter, with absence of sensory defects, of atrophy of the tongue, and also of accompanying hemiplegic symptoms; from asthenic bulbar palsy (bulbar palsy without anatomical findings) by the absence in the latter of muscular atrophy and twitching and by the frequent remissions which occur.

The progress is toward a fatal termination from inanition or respiratory complications in from one to seven years. Treatment is similar to that of other neuronic muscular atrophies—viz., rest and attention to hygiene and nutrition. Electrical treatment may add to the comfort of the patient and prolong life.

E. NEURITIC OR LEG TYPE OF PROGRESSIVE MUSCULAR ATROPHY, CHARCOT-MARIE-TOOTH DISEASE.—This variety of the "neuronic atrophies" differs from the typical (spinal) form (type A):

(1) In its hereditary character.

(2) In its onset in the legs and feet (peroneal group of muscles).

(3) In its slower course.

(4) In the circumstance that the prospects of prolonged life are better.

It is a rare disease in this country, Burr[8] recording but

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five known cases up to 1897, including one reported by himself.

Pathologically a degenerative neuritis has been found. The disease therefore affects the distal extremities of the lower motor neurons.

Treatment is similar to that of the other neuronic forms.

F. W. Langdon.

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[10] Charcot, J. B.: Contribution à l'étude de l'atrophie musculaire Progressive—Type Duchenne-Aran. Paris, 1895.

This work contains a digest of the French literature on the subject, with especial reference to the clinical and pathological distinctness of the Duchenne-Aran form (type A), and the amyotrophic lateral sclerosis form (type C), which Charcot (the younger) considers well established. The work is beautifully illustrated.

MUSK.—MOSCHUS. "The dried secretion from the preputial follicles of *Moschus moschiferus* L.; Order, *Ruminantia*," U. S. P. This little animal, the so-called musk-deer, is a slender-limbed, active, and very timid inhabitant of the mountain regions of Central and Northern Asia. In its general shape it resembles a young deer. It is 60 or 80 cm. long (from two to three feet), from 40 to 60 cm. in height, with the rump higher than the shoulders, of a grayish or blackish-brown color, with long, slender ears, large dark eyes, and two long, curved tusks projecting downward from the upper jaw. The secreting organ containing musk is a large, simple sac, situated in the median line just beneath the skin of the abdomen, in front of the preputial canal (of the male; it does not exist in the female), with which its posterior wall is connected. It is of a round or oval, plano-convex shape, 6 or 7 cm. in its longest diameter, and 1 or 2 cm. or more thick. Internally, it is incompletely divided by folds and partial partitions reflected from the wall. The orifice, often double, is situated over the middle portion of the sac, and is 1 or 2 mm. in diameter. Its position is easily determined from the outside, because the hairs converge toward it and fairly grow within it. In the living animal the secretion contained in the gland is a soft solid, not much thicker than honey, of a brownish-red color, and of a most intense, offensive smell. As it dries it darkens, becomes greasily brittle, and less odorous.

The musk-deer is laboriously hunted in the central and northern provinces of China, in the countries to the north of India, and in Siberia,—in short, over a very extensive portion of Central Asia,—for its skin and musk glands. These "pods," as they are called, are cut out as soon as the animal is killed, and dried, often with the aid of artificial heat, when they are ready for the market. In this condition they are flattish, shrivelled pouches, covered on one side with hairy skin, in the centre of which is the orifice; the other side has the black appearance of dried meat. As now usually marketed, they are prepared so as quite closely to resemble a large fowl's gizzard. The contents are dryish, crumbly, breaking as they are turned out into coarse fragments (called grains), of an almost black color and penetrating odor. The very high cost of musk has led to numerous ingenious methods of adulteration. Thus, stones and other heavy minerals, hair, dried blood, fæces, etc., are sometimes introduced through the natural opening; occasionally, also, the sac is split and emptied, and then filled and dextrously sewed up again, with a mixture containing but little musk, or that of an inferior quality—Siberian musk, for example, instead of that from Tonquin. Or the musk itself, when sold in grains, may be tampered with in similar ways. Sometimes artificial pods are made and filled—the scrotum of some animal is used, or a bag is made entirely *de novo* from skin, with a bladder, or some other membrane, for the back. The geographical source is important in determining the quality of musk; that of China and its tributaries is the most fragrant and best. Its pods are rounder, of more uniform shape, and its grains more odorous and larger. That from the north of India comes in irregular sacs, and that from Siberia in larger and longer ones. The following are the characters of musk as given by the Pharmacopœia: "In irregular, crumbly, somewhat unctuous grains, dark reddish-brown, of a peculiar, penetrating, and persistent odor, and bitterish taste. It is contained in oval or roundish sacs, about one and a half to two inches (4 to 5 cm.) in diameter, on one side invested with a smoothish membrane, on the other side covered with stiff, appressed, grayish hairs, concentrically arranged around two orifices near the centre. About ten per cent. of musk is soluble in alcohol, the tincture being light brownish-yellow, and on the addition of water becoming slightly turbid. About fifty per cent. of musk is soluble in water, the solution being deep brown, faintly acid, and strongly odorous.

"When ignited with free access of air, musk gives off a peculiar, somewhat urinous odor, and leaves behind not more than eight per cent. of a grayish ash."

COMPOSITION.—Musk is a very complex substance, and consists chiefly of common animal tissues and secretions. The following synopsis is from Hager's "Pharmaceutische Praxis": *Fats, cholesterin, wax, biliary matters, mucus, albumin*; besides traces of *lactic, butyric, phosphatic, sulphuric*, etc., *acids*; traces also of *ammonia* and a *volatile oil*. The odorous principle has never been separated. It is supposed to be formed by the gradual decomposition of some of the other constituents.

ACTION AND USE.—This substance was for centuries the leading antispasmodic, and was, during most of this time, much more highly esteemed in medicine than it is at present, and it was given for numerous diseases involving disturbance of the nervous or mental faculties—*e.g.*, hysteria, epilepsy, mania, etc. In a similar manner several other odorous animal secretions—civet, castor, etc.—have been employed, but of them all musk is by far the least disgusting. Its high cost and impressive odor made it well adapted to hysterical outbreaks, for the relief of which it undoubtedly has some real value. As it is, however, it acts in these cases merely as a palliative, and as there are now a dozen or more remedies which are more certain and far cheaper (a single dose of musk, which might be repeated several times a day, costs two dollars or more), musk as a medicine may be considered as fairly out of use. It can, however, be given, if desired, in doses of about 1 gm. (gr. xv.) in pill or emulsion. A tincture (*Tinctura Moschi*, U. S. P., strength one-tenth) is official and may be used, but is mostly employed as a basis of perfumery, where the persistent or "staying" qualities of musk make it of the greatest value.

The odor of musk is considerably diminished by fennel, ergot, tannin, sour fruit juices, and some other things. Mixed with sugar it keeps very well.

W. P. Bolles.

MUSTARD.—BLACK MUSTARD, or SINAPIS NIGRA, "the seed of *Brassica nigra* (L.) Koch," and WHITE MUSTARD, or SINAPIS ALBA, "the seed of *Brassica alba* (L.) Hooker fil. (fam. *Cruciferæ*)," are thus separately official in our Pharmacopœia. Since they agree in most respects, they may be discussed together, and their differences pointed out in passing. Both are natives of Europe and Western Asia, cultivated and naturalized in most countries. Both are slender, tall, and widely spreading, weedy-looking herbs, with coarsely pinnatifid or pinnate leaves, the upper entire, and yellow flowers. The two are best distinguishable by the habit of their pods. In the black mustard these are erect on spreading

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pedicels; in the white, both the pedicel and the pods are spreading. White mustard is also a rougher and smaller plant. The herbage of both is reputed antiscorbutic, and is used as a salad, also for poultices. The relationship of these plants to some of the forms of turnip, rape, cabbage, and colza is close and confusing, so that in India, where mustard is largely cultivated, a number of ill-defined forms exist. This condition—partly the result of natural causes and partly effected by design—results in much admixture in some lots of seeds. The following are the descriptions of the Pharmacopœia:

White Mustard.—"About 2 mm. in diameter, almost globular, with a circular hilum; testa yellowish, finely pitted, hard; embryo oily, with a curved radicle, and two cotyledons, one folded over the other; free from starch; inodorous; taste pungent and acrid."

Black Mustard.—"About 1 mm. in diameter, almost globular, with a circular hilum; testa blackish-brown or grayish-brown, finely pitted, hard; embryo oily, with a curved radicle, and two cotyledons, one folded over the other; free from starch; inodorous when dry, but when triturated with water, of a pungent, penetrating, irritating odor; taste pungent and acrid."

The principal adulterant of whole black mustard is rape seed, which can readily be distinguished by its slightly larger size and its peculiar bluish tinge. In the ground condition, white mustard is often mixed with it. This addition, if kept within moderate limits, only adds value to the product, for reasons stated below. Most other adulterants either contain starch—which may be determined by the iodine test—or, like curcuma, the most common of these, they contain resins, which may readily be indicated by the use of sulphuric acid.

Pure ground black mustard is almost too strong for safe use upon the table, and curcuma is usually added to dilute it. Advantage is taken of this to use excessive quantities of the substance selected for admixture. Hence the importance of the preparation of black mustard for medicinal purposes by purely pharmaceutical agencies.

Composition.—The constituents of the two varieties of mustard, although presenting close relationships, are not exactly identical. They both agree, however, in containing a considerable amount of a bland, light-colored non-drying *fixed oil*—a mixture of the glycerin combinations of *oleic, stearic*, and *erucic acids*; in white mustard oil *benic acid* is also found. This oil amounts to about twenty-two or twenty-three per cent. of the seeds. The most remarkable constituent of black mustard is the crystalline, bitter-tasting, inodorous glucoside, *myronate of potassium*, or *sinigrin*; soluble in water, but not in alcohol or ether, and in its watery solution decomposing, in the presence of various ferments, especially of one to be mentioned below, into glucose, bisulphate of potassium, and the horribly acrid, sulphureted, *essential oil of mustard* (isosulphocyanate of allyl, etc.), to which mustard is indebted in part for its medicinal value, and which is described below. This oil is not present in the dry seeds or their powder, but is produced only when they are moistened. The development of the odor upon wetting mustard flour is very evident, and distinguishes this from that of white mustard. The albuminous ferment which assists in this decomposition is called *myrosin*, and is common to both kinds of mustard.

The glucoside in white mustard, resembling the sinigrin of the black, has been correspondingly named *sinalbin*, a neutral crystalline substance, soluble in cold water, and decomposed in a similar way as sinigrin into *sugar*, *sulphate of sinapin*, and *sulphocyanate of acrinyl*, the latter corresponding to the essential oil of the black mustard. It is an acrid and vesicating substance, but much milder than the glucoside of the black variety, and not volatile.

To bring out the full percentage of the black mustard oil, a certain amount of myrosin, additional to that contained in this drug, is desirable, and is obtained by judiciously adding a certain quantity of the white mustard. The flour from this mixture is the strongest and best that can be made. That obtainable in our market is often the flour of white mustard only, and is generally more or less adulterated besides.

An oil exactly resembling that of black mustard has been made synthetically and is in the market.

Action and Use.—Both sorts of mustard seeds possess the same qualities; they vary only as regards the degree of pungency, the black being the stronger. Swallowed whole they do not disintegrate much, but pass through the digestive tract. In this way white mustard seed, particularly, is now and then given, in doses of a teaspoonful (3 or 4 gm.), for dyspepsia, constipation, etc.; like nearly everything else, it has also been employed in chronic cases of bronchitis, rheumatism, and some skin diseases, without any rational indication for such employment. Its rare use at present for these purposes shows its slight value.

Ground mustard, white, black, or mixed, is an active local irritant as soon as wet with water so as to produce the acrid decomposition products of the drug. Applied to the skin, it is quickly and painfully rubefacient; and if allowed to remain in contact with it for a long time, it is vesicant—producing a crop of fine, deep, eczematous blisters, easily ruptured, very painful, and rather slow to heal after rupture takes place. Internally, mustard, in small doses of 2 or 3 dgm., is an aromatic stimulant, and as such is in every-day use at the table. In larger quantities, 10 or 15 gm., it is a prompt and valuable emetic, usually coming up in from two to five minutes after being swallowed. On this account, and because it is almost always at hand in the house, it is the most valuable emergency emetic at our command. For poisoning by opium or by other narcotics it is a remedy almost without an equal.

Administration.—The employment of whole mustard has been noticed sufficiently above. The ground mustard in use in this country is that sold by grocers for family use, and is seldom, if ever, a plain mixture of the two sorts of seeds and nothing else, which gives the most perfect product. It is oftener ground white mustard alone, and oftener still mustard diluted with a varying amount (generally considerable) of inert yellow powder. It is therefore subject to considerable variation in strength. This is used both internally and externally—internally, as a stimulant (condiment) and emetic; externally, always as a rubefacient. For an emetic, from a dessert- to a tablespoonful should be given, as a less amount may fail to produce vomiting but still cause considerable gastric distress. Externally, it is chiefly employed in foot-baths and sinapisms—for the former, from one to two tablespoonfuls may be added to a small tubful or bucketful of warm water; for the latter, the mustard meal is simply mixed with a little water and spread upon a cloth, or it may be diluted with meal or flour to reduce its strength. In this way mustard is the most widely used local remedy for the sudden and intense pain or distress of pleurisy, colic, some neuralgias, etc. It is also used as a derivative in nervous vomiting, cerebral and spinal inflammations, etc., and in many other conditions when acute attacks of pain are present. Both kinds of mustard are greatly damaged, or even spoiled, if mixed with hot water, as this destroys the ferment which brings out the active decomposition principles. The following preparations are official: *Charta Sinapis*, U. S. P., made by taking ground black mustard, exhausting it of its fatty oil by percolation with benzin, then mixing it with enough solution of india rubber to make a paste, and spreading it upon paper. This mustard paper is almost never made by the dispensing apothecaries, since several manufacturers here and in France make excellent substitutes for it that can be easily obtained and carried everywhere. The activity of the mustard paper is not developed until it is moistened in cold or merely warm water.

Oleum Sinapis Volatile, U. S. P. The oil of black mustard is also official. It is obtained by grinding and macerating black mustard, or a mixture of both kinds, in water and distilling. It is "a colorless or pale yellow

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liquid, having a very pungent and acrid odor and taste, and a neutral reaction. Sp. gr., 1.017 to 1.021. It boils at 148° C. (298.4° F.). It is freely soluble in alcohol and in ether." Its vapor when concentrated is intensely disagreeable, causing lachrymation and severe pain in the nose. Applied to the skin, it blisters severely. Diluted with nine parts of alcohol, or three parts of olive oil, it causes, when rubbed upon the temples or forehead, a sharp temporary tingling that occasionally relieves mild headache. The compound liniment of mustard (*Linimentum Sinapis Compositum*, U. S. P.) contains:

Volatile oil of mustard	3	parts.
Fluid extract of mezereum	20	"
Camphor	6	"
Castor oil	15	"
Alcohol q. s. to make	100	"

It is a good stimulating liniment. *Henry H. Rusby.*

MYCOSIS FUNGOIDES.—Mycosis fungoides, while one of the rare diseases of the skin, its real nature being still in dispute, has been sufficiently observed since 1860 to establish for it a sharply defined clinical evolution. Alibert first described it in 1814. The symptoms, for convenience of description, have been grouped in three stages, which, however, do not always occur in regular succession. The third or fungoid stage, for example, appears at times without antecedent lesions, this giving rise to the erroneous belief that two forms of the disease exist. There is but one form. The earliest phenomena vary greatly in the first or so-called premycotic stage, the only characteristic and constant symptom being intense itching. Eczema, urticaria, pityriasis rubra, erythema exudativum, or psoriasis may be simulated in this stage, the eczematous form being, however, the most common. Kaposi says that nearly every case of mycosis fungoides starts with the characteristics of an eczema. The lesions manifest themselves upon the trunk, folds of the articulations, the face, more particularly the forehead, or, indeed, any part of the body, by more or less sharply defined erythematous patches, varying from the size of a silver dollar to that of the palm of the hand and even larger. Upon these patches the epidermis presents a fine desquamation, and it is but rarely and only in places here and there that a slight exudation occurs with the formation of thin crusts. The alteration in the skin corresponds perfectly to the well-known picture of squamous eczema which occurs in patches of a pale red color with but slight tendency to become moist. The itching is intense at this stage, and insomnia is often a troublesome feature of the disease. This "eczema" may persist for several months or for one or two years (French authors denominate this the eczematous stage of mycosis fungoides), and while certain areas fade out and disappear, others make their appearance. Some of the lesions persist, extending peripherally over quite large areas of the body to unite with neighboring lesions. Hence, in some cases, although rarely, almost a completely generalized eczema, with interspersed areas of normal skin, will be established. Some of the lesions fade in the centre while they extend peripherally, giving rise to circinate lesions. Besides the desquamation and the slight occasional moisture, no lesions except those secondary to scratching supervene.

After a more or less extended period the second stage, or stage of infiltration, sets in. This is marked by a thickening of the skin consequent upon an inflammatory œdematous infiltration of the chorion, more particularly appreciable at the periphery of the eczematous areas, the borders of which appear tense, smooth, and shining. From this time on appear various circinate, sharply defined, more or less elevated plaques and nodules of a brownish-red or bright pink color, situated at the centre or upon the irregular borders of the eczematous parts of the skin. These nodules, plaques, and elevations vary in size and may appear upon regions of the skin which are free from eczema, which are located at the most diverse points, and which manifest no particular regularity in their disposition. A certain number of these lesions disappear completely after an existence of several days or weeks, leaving no trace other than a slight pigmentation, while others start up at new points. This spontaneous disappearance is quite as characteristic as is that of the lesions of the first stage. The two periods together may last many years (fourteen in one case) before the appearance of tumors.

In the so-called third or fungoid stage, which in some instances is the first and only stage, the characteristic tumors of the disease appear upon different portions of the body. They vary in size from a bean to an orange or even a larger object, and their coloring likewise varies from a pink to a dull red hue. As regards their shape they are either sessile or pedunculated, well rounded or lobulated, and distinctly circumscribed. When developing from the plaques they may be quite flat. They may develop from previously existing lesions or from the sound skin. They are usually painful. Like the other lesions of this disorder, the tumors may disappear spontaneously, while at the same time others make their appearance; or they may all disappear to return after uncertain intervals without known cause. As a rule, they leave no trace behind them of their previous existence, though they may be followed by pigmentation or slight atrophy of the skin. Sooner or later some of the tumors degenerate and lead to superficial ulceration, usually followed by papillary excrescences and mushroom-like growths of varying sizes, from which the disease obtains its name. At times they may be the seat of much more destructive ulceration, though with but few exceptions this destruction is limited to the new growths; and even large fungoid and apparently deeply ulcerated tumors may completely disappear and leave no trace of their previous existence, further than pigmentation and possibly a small atrophic scar.

The general condition of the patient at first seems unaltered; later, when the tumors ulcerate, exhaustion occurs and the victim usually dies as the result of febrile processes, of intercurrent disorders, of cachexia, or of pyæmia. Extirpation of the tumors is usually followed by recurrence, frequently with added malignancy. The duration of the tumor stage is brief compared with the others, death frequently occurring within a few months, though it may be postponed for two or three years.

Although the cause of the disease is not definitely known, there can be little question to-day as to its infectious character. It is probably produced by specific micro-organisms, but direct evidence of contagion and successful culture and inoculation experiments are wanting. The disease is more frequent in men than in women, and usually occurs after the fortieth year, though in a few recorded instances it began earlier.

Diagnosis.—At the beginning, when apparently simple eruptions precede the formation of the tumors, the diagnosis may be very difficult, even Hebra having once diagnosed a case as eczema; and it may also be mistaken for an exudative erythema, a psoriasis, or a pityriasis rubra. The irregularity of distribution, the sharply defined border, and the greater thickening than in any of those diseases might excite suspicion. There is generally not so much discharge as in eczema with the same amount of hyperæmia; the heaping of silvery scales is decidedly less than it is in psoriasis; and, finally, there is too much scaliness and it persists for too long a time for exudative erythema. The itching, also, is generally more severe than it would be in any skin affection except eczema. Besnier says: "In all cases of ambiguous pruritic dermatoses which are prolonged and rebellious to ordinary methods of treatment, the possibility of the affection being the premycotic period of mycosis fungoides should be borne in mind." When the bright red gives way to a deeper or more coppery red, and the infiltration increases, a suspicion of tubercular leprosy may be aroused, but there would be no anæsthesia and the scaliness would be much greater than that which leprous infiltrations present; moreover, the characteristic bacilli of that disease would be absent. When the fungating tumor

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stage is reached there can be no difficulty in making diagnosis. In the more localized forms in which there is no preceding eruption, the disease may be mistaken for sarcoma or carcinoma cutis. Against this diagnosis, however, there would be the absence of early implication of the lymphatic glands (although tumors in the groin may simulate them), and the comparative painlessness; and besides, as a rule, the course would be slower than in cancer and the internal organs would never be implicated.

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With possibly two recorded exceptions, the disease has invariably terminated fatally, the extremes of duration being nine weeks (a case of Gaillard's) and fifteen years. The widespread cases, which commence as apparently simple inflammations, are much less malignant in their course than those which begin at once as tumors.

PATHOLOGY.—While the main facts as to the morbid anatomy of mycosis fungoides are generally agreed upon, much difference of opinion exists as to the interpretation to be placed upon these facts. Anatomically, the tumors consist of round cells supported by a scanty, delicate reticulum, which replace the normal tissue of the cutis. The new growth is somewhat scantily provided with vessels, and as it spreads it destroys the cutaneous capillaries. The boundary between the healthy and diseased tissues is ill defined. Ranvier and most French observers have classed it with lymphadenoma, but Sireday thought it was lymphosarcoma, and until recently all German authors have considered it to be a sarcoma. There is a growing tendency among observers at the present time to class the disease with the infectious granulomata. Various micro-organisms have been seen in the tissues by different observers and some have been cultivated, but none have as yet been demonstrated to have any pathogenic relation to the disease.

TREATMENT, so far as a cure is concerned, seems to be of little avail. Arsenic has been used hypodermically with apparent temporary benefit. Large doses of quinine are recommended. Resorcin subcutaneously has failed. The *x*-ray has of late been tried, but not with sufficient thoroughness to determine its value. Pyrogallic acid, aristol, iodoform, ichthyol have been used for the relief of local symptoms. It should, of course, be the physician's endeavor to make the patient as comfortable as possible by treating the various distressing symptoms as they arise. *Charles Townshend Dade.*

MYCOSIS INTESTINALIS. See *Anthrax*.

MYDRIATICS AND MYOTICS.—The opposing forces which maintain the iris in a state of equilibrium are controlled by two sets of nerves; the contracting muscle, the *sphincter pupillæ*, and the ciliary muscle being supplied by the third, while the dilating muscles are under the influence of the sympathetic nerve. The action of the third nerve has been very clearly demonstrated, but that of the sympathetic is not so evident, as the presence of radiating muscle fibres in the iris is a matter of dispute. Paralysis, or section of the third nerve, is followed by a relaxation of the sphincter muscle and dilatation of the pupil, and stimulation of the nerve produces contraction of the muscle and myosis. If the sympathetic nerve is stimulated there follows a dilatation of the pupil, and that the nerve exercises a positive dilating influence is shown by the greater degree of dilatation that takes place when a mydriatic is placed in an eye in which the third nerve has been paralyzed. This action of the sympathetic has generally been explained by the direct effect of the nerve upon the dilating muscles; but, since the presence of these latter has been called in question, a further explanation is necessary, and it has been suggested that the dilating nerve acts through the muscular tissue in the walls of the blood vessels of the iris (see article on *Cocaine*).

Alterations in the size of the pupil may be due to ordinary physiological action, to some pathological change, or to the effect of certain drugs. Exposure to a strong light or to darkness, efforts at accommodation, the influence of fear or of shock, will produce an enlargement or a narrowing of the pupil, according as one or other set of muscles is reflexly irritated. So also diseases of the central nervous system, which interfere with the integrity of the third nerve, cause dilatation, as is seen in meningitis, hydrocephalus, brain tumors, etc., while any profound effect upon the basal ganglia or depression of the sympathetic will be followed by contraction of the pupil.

MYDRIATICS.—Mydriatic drugs produce their effect either by paralyzing the motor oculi or by stimulating the sympathetic nerve. Belladonna and its allies are examples of the first group, and cocaine belongs to the second.

In the first group are belladonna, hyoscyamus, stramonium, and duboisia, the alkaloids of which—atropine, hyoscyamine, daturine, and duboisine—are active mydriatics and are almost identical chemically. Many other plants, not employed therapeutically, are members of the order Solanaceæ and possess the same physiological action. Hyoscine and scopolamine are closely allied to atropine, yet differ from it to some extent and form another group.

Belladonna is the best-known mydriatic and has been longest employed. Whether administered internally or applied directly to the eye, one of its earliest and most marked symptoms is the dilatation of the pupil. This persists for several days, the length of time depending upon the dosage. In some cases of poisoning the pupil has remained under the influence of the drug for three or four weeks. When it is employed as a mydriatic, a solution of the alkaloid is applied directly to the eye in order to obtain a purely local action. Formerly the extract was painted around the eye or upon the temple, or an infusion of the leaves was applied as a poultice over the eye. The pupil is extremely sensitive to the effects of atropine. It will be influenced by gr. $\frac{1}{130000}$, and a solution of the strength of 1 to 80,000 will enlarge the pupil within an hour. Accommodation is not affected by solutions below a strength of from one-thirtieth to one-tenth per cent. Generally a one-per-cent. solution is selected, which, instilled into the eye, begins to act in fifteen minutes and fully dilates the pupil in half an hour, accommodation being lost in one hour. The paralysis lasts for three or four days and is accompanied by annoying disturbance of vision caused by the enlarged pupil and loss of accommodation. Minor disturbances may persist for several days. For convenience of use gelatin discs are prepared which contain gr. $\frac{1}{5000}$, and which are easily inserted beneath the lid. If paralysis of accommodation is required, discs containing gr. $\frac{1}{500}$ must be used. A solution of salicylate of atropine is to be preferred to the sulphate, as it forms an antiseptic solution which remains free from any fungoid growth such as forms in solutions of the sulphate.

Homatropine is replacing atropine when dilatation is required for the purpose of examination. The advantage is a more rapid and less prolonged action. The pupil begins to dilate in the course of a few minutes and accommodation fails in thirty or forty minutes. Its effect begins to subside in three or four hours, and the eyesight is quite recovered within twenty-four hours. The drug is also less irritating to the conjunctiva and is devoid of constitutional effects when used with ordinary care. For the purpose of simply dilating the pupil, a one-per-cent. solution is employed; when accommodation is to be paralyzed, a two-per cent. solution is to be preferred. If mydriasis is required for a prolonged period, atropine is selected in preference to homatropine.

Hyoscyamine and *daturine* are rarely or never employed for their mydriatic action. Their action is the same as that of atropine, but they are less to be depended upon and offer no advantages.

Hyoscine exercises a much less marked influence upon the pupil, and is never used.

Duboisine.—This alkaloid has recently been extolled as possessing a more powerful action than atropine and as producing effects which are of shorter duration. As it is chemically identical with atropine, it will probably be found to have the same mydriatic action. The solu-

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tion employed has a strength of one per cent., and produces dilatation within an hour.

Cocaine.—As a mydriatic cocaine differs from atropine and possesses many advantages. It is much less intense in its action, the pupil is not dilated to so great an extent, and a certain degree of reaction to light or other stimulus may be retained. Its effect is accomplished in half an hour and passes off in a few hours. There is little or no influence exerted on the power of accommodation. As before stated, it acts through the sympathetic nerves, either by stimulating the dilating muscle of the iris (if these exist) or by contracting the arteries of the iris.

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When it is combined with atropine a very powerful mydriatic is obtained, as both a paralysis of the sphincter and a stimulation of the dilators are obtained. Koller uses a mixture of equal parts of a one-per-cent. solution of atropine sulphate and a five-per-cent. solution of cocaine hydrochlorate. This is applied every ten minutes until dilatation is secured, and if a prolonged action is required it is maintained by applying the solution three times a day. In inflammatory conditions much benefit is also obtained from the anæmia and blanching of the parts which the cocaine produces.

Mydriatics are employed to dilate the pupil for the purpose of an efficient intraocular examination and to facilitate cataract operations; also to remove the iris from the danger of adhesions in many inflammatory conditions. The dilatation of the pupil will also lessen the probability of prolapse of the iris in wounds of the eye.

For ophthalmic examinations and for simple dilatation of the pupil, homatropine and cocaine are now employed almost to the exclusion of atropine on account of their transient action. In examinations in which it is necessary to paralyze accommodation homatropine must be employed, as the action of cocaine upon the ciliary muscle is insufficient. In inflammatory states where a prolonged effect is required, atropine, with or without cocaine, is to be preferred. It is also indicated in all forms of iritis and in wounds or injuries accompanied by inflammatory action. When there is much ciliary spasm, it lessens the pain and photophobia by paralyzing the muscle.

The employment of mydriatics is not unaccompanied by dangers. For example, the alkaloid may be absorbed to such an extent as to cause severe constitutional disturbances, or some of the solution may pass into the nasopharynx and its local action be extended into the throat. Mydriatics may also, by continued use, prove so irritating as to produce a conjunctivitis. The most serious danger is the possibility of aggravating an incipient glaucoma—a result which has frequently followed their careless employment. This is due to the increased intraocular tension which accompanies the paralysis of the ciliary muscle, and, although cocaine is thought to have but little effect in increasing this tension, many cases are reported in which it has aggravated a glaucomatous condition of the eye. Certain signs of glaucoma, which readily distinguish it from iritis, are very marked and should never be overlooked. In iritis the iris is contracted and fixed, while in glaucoma it is dilated and also fixed; in iritis the eye is hypersensitive, in glaucoma it is almost insensitive. In glaucoma there are also the early symptoms of vomiting, with inflammation of the eye, and the prodromal disturbances of vision, with haziness of the cornea, color rings, etc.

MYOTICS.—The action of myotics is quite the opposite to that of mydriatics, the contracting muscles being stimulated and the dilating muscles depressed. With the contraction of the sphincter pupillæ there is also a contraction of the ciliary muscle which lessens intraocular tension. The action of myotic drugs is not well understood. It is probable that they act upon both sets of muscles, but even in the case of physostigmine, the best known of these drugs, many authorities consider that its action as a stimulant of the motor oculi is the most important, while others claim that its influence is directed chiefly as a depressor of the sympathetic. Myotics are of less therapeutic value than are mydriatics, and were it not for the lessened intraocular tension that accompanies the narrowing of the pupil, they would very rarely be employed. They are recommended in cases of paralysis of the third nerve, but are rarely of any service, except in the paralysis following diphtheria. In glaucoma they are of undoubted value. The great tension is overcome and the eye is relieved, and in many instances their employment has apparently rendered an operation unnecessary. In wounds of the surface of the eye and in corneal ulcers the tendency to rupture of the coat is lessened by their use.

Physostigmine or *Eserine* is the drug always selected. Pilocarpine exercises the same effect, but it is mild and uncertain. A solution of the sulphate or salicylate of eserine is employed, of the strength of one-quarter grain to the ounce. This will begin to act in fifteen minutes, its full effect will be reached in an hour and will continue for two or three hours, and in twenty-four hours the myosis will have disappeared. In glaucoma myosis is more difficult to obtain, and a solution of two per cent. may be required. The condition of myosis is not so intense as is that of mydriasis, and if atropine has been applied to the eye eserine will have no effect until the action of the atropine has begun to pass off. On the other hand, atropine rapidly dilates a pupil under the influence of eserine.

Beaumont Small.

MYDRIN is a colorless powder composed of ephedrine hydrochloride, 100 parts, and homatropine hydrochloride, 1 part. It is used in ten per-cent. solution as an evanescent mydriatic.

W. A. Bastedo.

MYELOMA.—Under the greatest variety of names there have been described in recent years cases of an affection of the bones which have in common certain features so distinctive as to justify their union under one name. Briefly stated, these cases show as a rule evidence of the presence of multiple new growths developing simultaneously in the most widely separated bones. Pain is often felt in these tumor-like masses, and from the destructive influence which they exert upon the bony structure fractures with dislocation and deformity soon appear as the result of the most trifling traumatism. A cachectic condition supervenes in the later stages and is associated with the occurrence of a peculiar urinary condition, — one in which the urine contains albumoses. Various paræsthesias and pareses may occur, and with the great increase in the deformities produced by the tumor masses the patient finally dies of exhaustion or succumbs to some intercurrent affection.

As early as 1847 a case of this sort was observed by Bence Jones[1] and Macintyre. Their attention was particularly attracted to the condition of the urine, in which a peculiar proteid could be demonstrated. The patient after a long and very painful illness died, and at the autopsy there were found red gelatinous masses replacing in large part the vertebræ, sternum, ribs, etc. They designated the condition "osteomalacia fragilis rubra."

Rustizky[2] first gave the name multiple myeloma to the condition in a paper published in 1873. He considered it a simple hypertrophy of the bone marrow, because, although the tumors were multiple, they were present only in the bones and did not give rise to metastases.

Since then a number of cases have been described under this name, while many others obviously of the same nature have been designated "osteomalacia," medullary pseudoleukæmia, sarcomatous osteitis, malignant osteomyelitis, lymphosarcoma, etc. Good summaries of the literature with descriptions of cases have recently been given by Hammer,[3] Winkler,[4] Wieland,[5] and Paltauf,[6] from which it appears that there is really a well-defined condition, easily distinguishable from the endotheliomata and sarcomata of bone, and for which the name myeloma is most fitting,—a condition which Virchow prophesied, although at that time no case had been published.

The disease may perhaps be made clear most easily by the description of a case which occurred recently at the

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Johns Hopkins Hospital and which has been reported in its clinical and pathological aspects by Dr. Hamburger and myself. For the clinical description I quote from his paper in the *Johns Hopkins Hospital Bulletin* (vol. xii., 1901, p. 38).

The patient was a colored woman, fifty years of age, who entered the hospital complaining of "rheumatism" and a "sprained wrist." Her personal and family history were unimportant, but for about a year she had had pain in the region of the right groin and hip. One night about six months ago, while picking up a bucket of coal, she experienced a remarkable sense of lengthening in the left arm, and next morning found that she could not raise it to her head because of pain and a feeling of weight. A week later the right arm became affected. She had pains in the shoulders, neck, and chest. About this time she noticed a swelling the size of a hen's egg on the back of her head. Pain and stiffness in the arms continued, so that after two months she could not feed herself. Six days before admission to the hospital, while walking, the right leg "gave way" without apparent cause. She fell to the ground and since then had not been able to stand or walk. She suffered great pain in the right hip.

She became much emaciated and very weak and anæmic. On admission to the hospital, any movement of the body was found to produce great pain. Over the occipital region there was a round, soft, fluctuating mass about 10 cm. in diameter, not adherent to the skin, not movable on the deeper tissues, not tender. A nodule, 3 to 4 cm. in diameter, was visible on either clavicle over its inner third, the one on the left being a little larger and evidently eroding the bone, for manipulation caused pain and crepitus. There was another tumor in the left supraspinous region, about 4 cm. in diameter, connected with the acromion process of the scapula. The right leg was rotated outward and abducted, the upper third of the thigh being markedly enlarged and deformed by the presence of a tumor about the size of a child's head, projecting from its postero-external aspect. It was firm and tender on pressure and any attempt to move the limb caused intense pain.

Physical examination was otherwise negative. There was no glandular enlargement and examination of the blood showed only a diminution in the number of red corpuscles with a corresponding diminution in the percentage of hæmoglobin. The urine was turbid, light yellow, and usually alkaline; from 600 to 800 c.c. were voided daily, of a specific gravity varying from 1.012 to 1.030. Heller's reaction was positive. When the urine was acidified and heated to a temperature of 56° C., a heavy white precipitate appeared. It redissolved in part on boiling and returned on cooling. The nitric-acid precipitate disappeared on boiling, to reappear on cooling. The mixture assumed a darker color and particles of the precipitate adhering to the tube became pink. The biuret reaction was marked. The proteid content measured by the Esbach albuminometer varied from 0.3 to 0.6 per cent.

This case illustrates well the symptoms which have been spoken of as fairly constant, viz., the emaciation and anæmia, the simultaneous occurrence, over the bones, of soft, almost fluctuant masses, and the erosion of these bones with fracture and deformity associated with great pain. Particularly well, however, is the albumosuria illustrated. Acute transitory or slight albumosuria has been observed in many acute febrile diseases, and similarly slight peptonuria has been described in the greatest variety of conditions. The work of Kühne and Chittenden renders it probable that all of these are instances of albumosuria, the proteid substance found in the urine being very closely related to, but not exactly identical with, the products of partial digestion described by those authors. These cases, however, are without difficulty distinguished from those in which the quantity of albumoses is large and its occurrence persistent throughout a long time. It has been found (Hamburger) that in the great majority of cases of definite albumosuria multiple myelomata have been found at autopsy, although as yet the evidence is not sufficient to prove that in all cases of myeloma albumosuria is found.

The origin and exact nature of this proteid substance are as yet quite obscure, but when it is present in considerable quantities it is easily recognized by the reactions described above, and especially by its property of redissolving at boiling temperature in acidified solution, from which it was precipitated by a temperature of 56° C.

The pathological anatomy of the multiple myeloma may be made clear by a further reference to the case above mentioned.[7] The patient died after a stay of some months in the hospital, and at the autopsy multiple tumor masses were found involving various bones. The right leg was shorter than the left by about 3 cm., and in the trochanteric region, where there was a large tumor mass, there was excessive mobility of the femur. The organs in general showed only the evidences of senile atrophy and in the lungs a few old tuberculous scars. On removal of the sternum it was found to contain, at the points of insertion of the second and third costal cartilages, a tumor mass, which, being very soft, allowed free movement of the two parts of the sternum upon each other. The left clavicle was much enlarged at its sternal end, the bone being apparently distended by the tumor mass within, for the cortical portion was very thin and could be compressed by the fingers. On sawing through the bone lengthwise the cancellous bone was found to be much rarefied and the cortical portion very much thinned; the marrow was almost entirely replaced by the tumor mass, which extended quite to the acromial end.

The right clavicle showed evidences of a healed fracture, the portions having united in a somewhat abnormal position, so that a slight angular deformity existed. The marrow of this bone also showed tumor masses, which did not, however, cause any extensive erosion of the bone.

From the spinous process of the left scapula there arose a soft tumor mass which on section was found to have eroded and replaced a considerable portion of the bony process. None of the cortex or cancellous bone tissue was to be discovered in this one. The ribs were not involved. Unfortunately, the vertebral column was not sawn through, but there were no evident tumor masses visible from without. The right ilium was completely eroded through in its median portion by a large soft mass, which had destroyed the whole thickness of the bone and which projected both ways—inward into the pelvis under the iliacus muscle, and outward under the muscles covering the outer surface of the ilium. The hip-joint on this side showed no abnormality, but in the intertrochanteric region a large tumor mass sprang from the marrow of the femur. At the upper end of the shaft of the femur there was a fracture, the shaft being displaced upward. On sawing through the bone at this point the intertrochanteric region was found to be extensively involved in the new growth, which extended into the adjacent tissues. The cancellous bone was almost entirely destroyed and the cortex much atrophied and roughened internally. For a distance of about 5 cm. the cavity of the shaft of the femur was invaded, the yellow marrow being pushed ahead and fairly sharply limited from the dark purple new growth. The bone marrow was atrophic and œdematous, grayish-pink and moist in appearance, and sunken below the level of the cut surface of the invading tumor. The left femur showed no evidence of tumor formation.

Removal of the large mass at the vertex of the skull revealed a large aperture in the skull, the edges of which were very ragged, as if gnawed away, with here and there loose spicules of bone lying in the soft tumor mass which evidently sprang from the marrow cavity. This tumor mass spread itself between the cranium and the dura for a short distance, and, completely filling the aperture in the skull, projected outward to form the large soft mass felt under the scalp.

No other tumor nodules were to be found so far as it was possible to examine the bones.

These growths presented everywhere the same appear-

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ance. Everywhere they evidently sprang from the marrow of the bone, from which they were not by any means sharply demarcated. Only where the tumor seemed to invade the yellow marrow of the shaft of the femur was the outline sharp, but even there the microscopical examination showed evidences of the presence of tumor elements far past this outline. Where the red marrow of the short bones formed the point of origin, the outline was not nearly so sharp. The well-defined tumor masses were perhaps somewhat firmer than such a mass of bone marrow would be. They varied somewhat in consistency, however. In general they were soft; some of the larger ones were almost diffluent, and they flattened out when they were cut and laid out on a pan. Others were less soft, and in some parts the gelatinous pulpy consistency gave way to a fair degree of firmness. In color there was also considerable variation. The greater part of the masses was of a deep red color, perhaps even darker than that of the normal red bone marrow, but showing everywhere a grayish tint. Usually lines and streaks of gray were to be seen throughout this deep red, and in nearly all the masses definite nodules of firmer consistency and of grayish-white color were found. At some points there was a slight yellow opacity.

Microscopically, the various authors have emphasized the regularity in form and size of the cells, and Wieland has adduced this as a distinction from the myelocytes. Nearly all writers have thought the tumor cells to be derived from some cell or other of the bone marrow. Wright alone considers them to be plasma cells or closely related cells at least, to explain which he states that plasma cells are present in the bone marrow. The results of attempts to determine the histogenesis of the cells in this case will appear from the following description of the microscopical appearances:

The tumor masses present in sections a remarkably homogeneous appearance. There is, as described in practically all of the other cases, a delicate stroma with rather wide meshes in which lie innumerable rather large round cells. These are not in intimate connection with one another, but lie singly and loose; sometimes, where their number is very great, they are somewhat compressed into a polygonal form, but in general they are quite regularly rounded; they vary slightly and may be elongated or pear-shaped or even notched. The nucleus is large, round, and vesicular, sometimes lying eccentrically. The protoplasm presents a rather ragged granular appearance. Blood-vessels exist throughout the tumor and are indeed rather numerous. The smaller ones lie in very intimate contact with the tumor cells, their walls being merely a single layer of endothelium. Connected with these and the coarser strands of the stroma are exceedingly fine filaments of connective tissue which run in between the cells. Everywhere, scattered quite without order through the tumor mass and among the tumor cells, are numerous red blood corpuscles, which are quite well preserved. These evidently give the dark red color to the tumor masses, being absent or present in only very small quantity in the translucent grayish-white nodules described above.

More careful examination of the characteristic cells of the tumor shows them to be distinctly of one type, although certain variations in size occur. They measure from 13 to 21 μ in diameter, and thus approach very closely the myelocytes, while they exceed considerably the plasma cells in size. The nucleus is provided with a definite nucleolus, which shows especial avidity for certain aniline dyes. In smears from the tumor the nuclear structure is shown clearly. The nuclei appear large and flattened out, and in the general pale blue stain there appear irregular spaces which do not stain or take only the tint of the cell protoplasm. In this respect they resemble closely the myelocytes as described by H. F. Müller. The protoplasm is rather ragged and granular-looking, but the granules are not sharply outlined and with specific stains they take on no different coloration from the rest of the protoplasm. These are, therefore, not specific granulations. In sections as well as on smears stained with the polychrome methylene blue of Unna or the alkaline methylene blue, the protoplasm takes on only the palest greenish-gray coloration; there is nothing of the specific staining described by Unna and others for the plasma cells. With polychrome methylene blue and eosin the protoplasm stains with eosin.

The relation of these cells to the other normal cells from which they might possibly arise is therefore about as follows: In size they greatly exceed the plasma cells, but agree fairly well with the myelocytes and non-granular cells resembling myelocytes found in the bone marrow. With polychrome methylene blue, etc., they do not show the reaction typical of the plasma cells; on the other hand, their protoplasm, although in its raggedness it does resemble the "granoplasma" described by Unna for the plasma cells, shows none of the specific granulations characteristic of the myelocytes. The presence of a nucleolus must be admitted for all these various types of cells, so that it is of no help in determining such relations. The cells of the myeloma and the myelocytes and non-granular cells of the bone marrow have in common, however, the peculiar lacunar structure of the nucleus, as seen in dried smears, which H. F. Müller[8] describes as follows: "With adequate magnification one sees in the myelocytes a remarkable nuclear structure; one finds often nuclei in which definite clear fields are visible. These may be in part nuclear substance, but in many such nuclei these fields seem to represent the cell substance which stretches itself into pre-existent holes or pores in the nucleus." And then again: "There is a large round or oval nucleus limited by a thin chromatin wall which shows frequently more or less numerous larger and smaller clear areas, which are often plainly seen to be definite apertures in the nucleus through which the cell substance extends into the interior of the nuclear body."

This structure seems so peculiar that its occurrence in these various cells at least indicates their close relation to one another. The descriptions and figures of plasma cells in the papers of Unna,[9] Jadassohn,[10] Marschalko,[11] Justi,[12] Krompecher,[13] and Councilman[14] give no hint of such a structure in the nuclei of these cells.

The myeloma cells are apparently separated from the myelocytes by the absence of the characteristic neutrophile granulations. An examination of a bone-marrow smear, and more especially of a smear from actively proliferating bone marrow, will convince one of the great variations in the abundance of the granules which occur in these cells. In a recent paper on the relation of the myelocytes to leucocytosis, Rubinstein[15] describes the transitions which take place in the development of myelocytes from smaller cells whose protoplasm is quite free from granules. These young myelocytes reach quite the size of the adult myelocytes before the granules appear, which they do gradually a few at a time. The resemblance then between these non-granular myelocytes, as they may perhaps be called, and the myeloma cells is most striking, and suggests most strongly the origin of the myeloma from these characteristic cells of the bone marrow in one or other stage of their development.

Further evidence of this close relation is given in the abundant presence of the tumor cells in the marrow adjacent to the tumor masses, where they take on exactly the arrangement of the myelocytes among the fat cells and are intermingled with the occasional eosinophile cells. Indeed, if, in a large section, we pass gradually from the relatively normal marrow toward the tumor, we find a gradual and insensible transition, the myelocytes being replaced entirely in time by the tumor cells, which become more and more densely arranged, forming finally definite nodules. Among the trabeculæ of the cancellous bone this consolidation of the cells which have the position and form of myelocytes into solid strands in direct continuity with the tumor mass is very convincing evidence of the direct relation between the tumor and bone-marrow cells.

Various alterations in the appearance of the tumor cells, such as fragmentation and partial division of the

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nucleus, occur. Indeed, one sometimes finds large cells containing numerous nuclei and a vacuolated protoplasm in which irregular or rounded cellular inclusions are present. These are perhaps best interpreted as evidences of degeneration.

The tumor mass as described above contains in the interstices between the cells very numerous red blood corpuscles in a very well-preserved condition. There is very little evidence of any breaking down of the red corpuscles,—hardly any deposit of hæmatoidin in the tissues, which would certainly be present if the presence of the blood were due to actual hemorrhage. Red corpuscles are found scattered in considerable numbers among the myelocytes and other cells in the normal bone marrow, however, and it seems probable that the condition here is analogous. The walls of the blood-vessels in the tumor are nevertheless of extreme thinness and extravasations might readily occur. So also tumor cells are quite frequently found inside these blood-vessels lying among the red corpuscles, although an examination of the circulating blood a few days before the death of the woman showed only one or two doubtful myelocyte-like cells among a great number of leucocytes, the varieties of which were those of the blood in practically normal relations.

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From this description, then, it is seen that in this condition we have multiple new growths from the bone marrow, not very sharply delimited from the marrow and showing very gradual transitions into it. The cells have the form and general characters of the bone-marrow cells, lacking the specific granules of the myelocytes, but possessing the peculiar nuclear structure found in the myelocytes and their formative antecedents. They differ in essential particulars from the plasma cells, and in view of these facts and of the fact that they largely replace the myelocytes in the marrow in the neighborhood of the tumor, there being no sharp boundary between the myeloma-like marrow and the myelocyte marrow, we may consider them directly related to these cells and probably derived from the large non-granular forerunners of the myelocytes.

The exact relations of this condition to others with which we are familiar are difficult to determine. On the one hand, there are none of the anatomical features of the ordinary forms of chronic inflammation, while on the other hand the process differs from that which characterizes the majority of tumors in its simultaneous origin in many bones and in its mode of growth, which while destructive is not of such a nature as to give rise to metastases. We are quite ignorant of any etiological factors, but on the whole the condition seems most analogous to those forms of lymphosarcoma which, arising often simultaneously from many lymphoid structures, invade and destroy the adjacent tissues.

William G. MacCallum.

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[2] Deutsch. Zeitschr. f. Chir., 1873, Bd. iii., S. 162.
[3] Virchow's Archiv, 1894, cxxxvii., p. 280.
[4] Virchow's Archiv, 1900, clxi., p. 252.
[5] Primäre multiple Sarcome der Knochen. Inaug.-Diss., Basel, 1893.
[6] Ergebnisse der allgemeinen Pathologie u. pathologischen Anatomie. Herausgegeben von Lubarsch u. Ostertag, 1896, iii., 1, p. 676.
[7] W. G. MacCallum: Case of Multiple Myeloma. Journal of Experimental Medicine, vol. vi., No. 1, 1901.
[8] Deutsches Archiv f. klin. Med., 1891, xlviii., p. 57.
[9] Monatshefte f. prakt. Dermatologie, 1891, xii., p. 296.
[10] Berliner klin. Wochenschrift, 1893, xxx., p. 222.
[11] Archiv f. Dermatologie u. Syphilis, 1895, xxx., p. 3.
[12] Virchow's Archiv, 1897, cl., H. 197.
[13] Ziegler's Beiträge z. path. Anat., 1898, xxiv., p. 163.
[14] Journal of Experimental Medicine, 1898, iii., p. 401.
[15] Zeitsch. f. klin. Med., 1901, xlii., p. 161.

MYOMA.—The myoma is a tumor composed chiefly of muscle tissue, therefore of mesoblastic origin, and belonging in the connective-tissue group. According to the type of muscle tissue of which myomata are composed, they are divided into leiomyoma (Zenker) or myoma lævicellulare (Virchow), containing smooth muscle fibres, and rhabdomyoma or myoma striocellulare, containing striated muscle fibres.

In general, the term myoma, without further distinction, is used for leiomyoma.

Leiomyoma.—Of the two varieties, the tumor composed of smooth muscular fibres is by far the most frequent and of the most importance clinically.

HISTOLOGY.—The physiological type of the tissue, the smooth muscular fibre, is widely distributed over the body, and is best seen in the intestinal canal and in the uterus. The smooth muscular fibres are long, fusiform cells, which are connected by a small amount of cement substance. The nucleus is a long rod-shaped body situated in the middle of the cell. The tumor is composed for the most part of such muscular fibre cells, which are arranged in bundles, closely packed together, frequently interlacing, and separated from one another by a small amount of connective tissue which carries the blood-vessels. On section of the tumor these bundles are cut at various angles, and when the nuclei are brightly stained the section often appears peculiar. When a bundle of fibes is cut exactly across, the section of the muscular fibres, with the brightly stained nuclei in the centre, may be mistaken for round cells with a central nucleus, or, still more readily, for a section of a nerve. The nuclei may be mistaken for connective-tissue nuclei and the tumor for a fibroma. In the myoma the nuclei are longer, narrower, and more refractive than connective-tissue nuclei, and in the fibroma the arrangement of the fibres in bands is never so characteristic as in the myoma. In cross-section of the fibres the muscle substance around the nucleus is seen to be denser, more homogeneous, and more refractive than the protoplasm of other cells. When fresh unstained sections are examined the tumor may be mistaken for a sarcoma, in which the cells are often arranged in bundles in the same way, but a careful study of the nuclei will reveal its true character. The separate cells which compose the tumor may be isolated by macerating small portions in a twenty-per-cent. nitric-acid solution or in a thirty-per-cent. solution of caustic potash. This dissolves the cement substance between the muscular fibres, and they can then readily be teased apart. There is often a considerable difference in size between the tumor cells and the cells of the analogous physiological tissue. The cells may be very much larger or very much smaller than these. Sometimes cells as large as the muscle cells in the rapidly growing pregnant uterus are found. There is always with the muscular tissue a variable amount of connective tissue which is principally found between the larger muscle bundles. From this, smaller septa are given off which run between the smaller bundles of cells. White (*Johns Hopkins Hospital Bulletin*, xi., 111, 1900) has demonstrated that this connective tissue is of the white fibrous and reticular types, and that each muscle cell is surrounded by a connective-tissue capsule. He could demonstrate no elastic fibres. In this connective tissue run the blood-vessels. In some cases the connective tissue is so abundant that it forms a considerable part of the tumor, and in others there is scarcely any present, except around the larger vessels. The amount seems to vary with the age of the growth, being always less in small tumors of recent for-

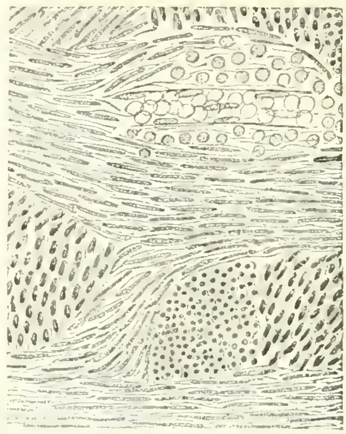

FIG. 3466.—Section of a very Small Myoma of the Uterus, Hardened in Müller's Fluid and Stained with Hæmatoxylin. Bands of muscular fibres are seen cut in various directions. (× 175.) (After W. T. Councilman.)

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mation. When there is much connective tissue present the tumor is generally firm and fibrous, but in some places it may have more the character of loose areolar tissue and contain numerous lymphoid cells. In some of the very large myomata of the uterus the development of connective tissue is so great that the tumor appears to be principally composed of this, and it is only after considerable search that the muscular tissue is found. To this form the term *fibro-myoma* is given. In almost every tumor some places will be found where neither muscular tissue nor connective tissue can be made out. There are larger or smaller areas of firm, highly refractive, homogeneous tissue, in which a few rod-shaped nuclei are scattered. Such areas are most abundant in the larger tumors, and represent a hyaline transformation of the tissue. As a rule the myomas have a very poor vascular supply, but cases are sometimes seen in which the blood supply is so abundant that the tumor almost resembles a cavernous tissue. This variety of tumor will be considered more fully in speaking of myoma of the uterus.

Gross Appearance.—Macroscopically the myoma resembles most the hard fibroma or one of the sarcomas. It is always sharply circumscribed, and generally surrounded by a firm capsule of connective tissue. On section of the tumor it can always be easily separated from the tissue surrounding it. The cut surface has a whitish or yellowish color and glistens. It is not homogeneous, but marked by fissures and lines which represent the spaces between the muscular bundles, and which often have a concentric or spiral direction. Whiter and darker patches are sometimes seen on the surface; these generally depend on degenerative processes in the tumor.

Origin.—The tumor always develops from non-striated muscular tissue. Unlike the rhabdomyoma, it never develops in any locality where this tissue is not found; it is never heterologous. Although its origin from smooth fibres has long been generally accepted, it is interesting to note that Kölliker and his followers believed its origin to be from the connective tissue. The exact histogenesis, however, is not always clear. Keifer (*La Presse médicale*, 1899, No. 10, p. 49) has demonstrated by injection methods small islands of non-vascular tissue in the uterus, which increase peripherally by the addition of smooth muscle tibres. In the centres of these masses was frequently seen an arrangement of cells suggesting obliterated vessels. From these masses about obliterated vascular trunks he believes myomata take their origin. Cohen (Virchow's *Archiv*, 1899, clviii., 524), in a study of the histogenesis of myomata of the uterus and stomach, concludes that in many cases it is impossible to determine the origin. He examined by serial section small tumors, and in many but not in all he found a central blood-vessel without an adventitia, whose muscular coat could not be differentiated from the newly formed muscular fibres.

In myomata of the skin the origin of the new growth is supposed to be the muscular coat of the blood-vessels and the erector muscles of the hair shaft (Jadassohn).

Nature.—The leiomyoma is a benign tumor, distinctly encapsulated and of slow growth. Although not in itself a dangerous tumor, it may, mechanically, cause serious complications; thus submucous myomata of the uterus may become eroded and be the source of a serious hemorrhage. Pedunculated tumors may be forced into the cervix uteri, causing a spurious labor; or if of large size they may perhaps produce prolapse of the uterus. Similar tumors beneath the peritoneum may exert pressure on the rectum or bladder, or by their weight bring about displacement of the uterus and other pelvic organs. They may form adhesions to other organs and thus induce strangulation; or they may themselves, if pedunculated, become strangulated and form free masses in the peritoneal cavity. Myomata of the digestive tract may cause occlusion or serious results may follow the traction superinduced by their mere weight.

Etiology.—Little is known in regard to the etiology of the myomata. In the uterus they are found most frequently after middle life and are much more frequent in blacks than in whites. On the other hand, the analogous tumor of the prostate in man is much more common in the white race than in the black. It cannot be shown that irritation exerts any influence. Some uterine tumors containing glandular acini suggest a congenital origin, the result of misplaced uterine fragments, thus supporting Cohnheim's theory.

Seats.—The more common situations are the uterus, gastro-intestinal tract, and prostate; the less common are the bladder, skin, nipple, and walls of blood-vessels.

Uterus.—The most frequent place of the formation of the tumor is the uterus. Every variety of the tumor is found, and it can be studied best here. The new growth may spring from any part of the uterine wall, but usually from the portion above the cervix; and it may vary in size from a microscopic nodule to a mass or masses weighing over a hundred pounds and entirely filling the abdominal cavity. The chief mass of these tumors is composed of muscle fibres, which are generally much larger than those of the normal uterus. The increase in size affects principally the width of the cell and the nucleus. Cells are often seen which are wider than the diameter of a red blood corpuscle. The muscle fibres are arranged in bundles, which are surrounded by wide capillary vessels. The walls of these vessels consist of a single layer of endothelial cells with large nuclei, supported by a thin layer of connective tissue. Both between the muscle bundles, and between these and the connective tissue of the vessels, are small spaces which contain white corpuscles and are surrounded by a fine tissue in which here and there nuclei are enclosed. In this way a cavernous structure is formed, which is not present in the normal uterus. Klebs supposed that these spaces represent lymphatic cavities, in which the whole tissue, muscular fibres, and blood-vessels are suspended by the small bands of connective tissue. Larger blood-vessels, with thick walls and a wide adventitia, are but seldom found, and then in the broad partitions between the larger bundles of muscular fibres.

The tumors may increase in size by the joining together of the neighboring growths, but this mode of increase is rare. Generally it appears that the same process of new formation, in consequence of which the smallest and most simple myoma was formed, repeats itself. Every single vessel, with the muscular and connective tissue belonging to it, proliferates again and forms a second generation of nodules, which are situated in the original tumor. These different centres of growth can, as a rule, be easily made out, and sometimes the arrangement is such that the tumor appears to be composed of triangular masses, the apices of which point to the centre and the base is along the periphery of the tumors. In other cases, the formation of secondary nodules takes place only in certain parts of the tumor, and in this way very irregular, uneven masses arise. This peculiar process of growth leads to the displacement of the tumor, which originally is enclosed in the walls of the uterus. If the growth takes place most rapidly in the part of the tumor nearest the mucous or the serous membrane, that part escapes from the muscular tissue and projects into the uterine cavity or on the surface of the organ, and finally the whole tumor becomes separated from the uterine walls. In this way the submucous and subserous varieties of the tumors arise, which are either connected with the uterus by a narrow pedicle or have a wider attachment. This attachment often contains dilated venous vessels in the loose connective tissue. The tumors which remain within the muscular coat are termed interstitial or intramural. When the connective tissue is much developed the tumor is denser and harder, and on section the lines and fissures are not so evident. The lymph spaces and blood vessels become narrower and partly obliterated. The smooth muscular fibres remain preserved, but the single fibre cells can no longer be recognized, and in place of them small, long, rod-shaped nuclei are found embedded in a substance which appears more or less fibrillar (fibromyoma). The

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best conditions of nutrition are found in the small tumors of the uterus, which sometimes are composed entirely of muscle fibres and blood-vessels. Such tumors have the grayish-red, dull appearance which the uterus shows on section, and microscopically they cannot be distinguished from the uterine tissue. The small lymph spaces which were spoken of may become widened to form large cysts filled with a clear fluid analogous to serum and coagulating spontaneously on exposure to air. Often these do not seem to have a special lining membrane. Small processes of connective tissue sometimes grow from the walls of these cysts, which penetrate between the adjoining bands of muscular tissue, and in this way a series of smaller cysts may arise. These *cystomyomata* of the uterus may attain a large size, especially when, as often happens, heterologous formations of a myxomatous or sarcomatous character arise in them. Single cysts of large size, entirely surrounded by muscular tissue, are sometimes found. Their contents are fluid, generally more or less colored with blood pigment from numerous hemorrhages which have taken place into them. The contents of all of these cysts will usually coagulate spontaneously. The walls often contain a layer of fibrin of variable thickness, and the cysts may be traversed by bundles of muscle tissue. Dilated blood-vessels are often found in the neighborhood of the tumor, and in the extramural forms they run in the loose connective tissue of the attachment. These are the most frequent source of the hemorrhages which so often accompany this form of tumor, they being often torn across by the traction of the tumor. The dilatation of these vessels is nothing but a passive process, but in some cases there is a very abundant formation of vessels in the tumor itself. Virchow distinguishes this variety under the name *telangiectatic myoma* or *cavernous myoma*. There is little or no development of connective tissue, and the vessels are immediately in contact with the muscular bundles. It is in such tumors that marked variations in size are seen, the tumor appearing sometimes double its usual size. It is probable that this variability in size may be due both to changes in the amount of blood in the dilated vessels and to different degrees of contraction of the muscle cells.

There may be mixed forms of myomata. The most frequent combinations are with myxomatous and sarcomatous tissue. The myxomatous degeneration occurs when much fibrous tissue is present. Sarcomatous change is much less frequent. Such tissue develops around the vessels in the septa between the bundles of muscles. The myxomatous tissue in the tumor can be recognized as patches of grayish, gelatinous material, while the sarcomatous portions are whiter and less refractive than other parts. Combinations with other forms of tumors do not take place. In the uterus carcinoma may coexist with myoma, and the carcinoma may erode and grow into the myoma in the same way that it grows into the muscle tissue of the uterus itself.

Of the degenerative processes the most frequent is calcification, which may affect the whole tumor or only parts of it. When the calcification is complete the whole tumor may be changed into a hard, stony substance, in which no tissue or blood-vessels can be made out. Generally the process is not so complete as this, and a network of calcified tissue traverses the tumor, in the meshes of which small bands of muscle tissue and vessels are seen. In some cases a true formation of osseous tissue has been made out in the tumor, and in one tumor the writer has observed areas of adipose or true fat-bearing connective tissue. Occasionally complete gangrene may result from interference with the blood supply of large areas. Suppuration is rare but may occur. After the menopause these growths are said to undergo atrophy.

An interesting form which occasionally occurs is one which contains glandular structure of the type of the uterine mucosa and is known as adenomyoma. It is distinctly a benign tumor, though its growth may be diffuse. It is usually situated in the inner layers of the muscular wall. Opinions vary as to the origin of this growth. Von Recklinghausen believes that it develops from remnants of the Wolffian body, but admits the possibility of its origin from the uterine mucosa. Cullen (Johns Hopkins Hospital Reports, vol. vi., 1897), who has studied carefully two cases, believes the latter to be the only possible origin.

The presence of a myoma usually produces more or less hypertrophy of the muscular coat. This is especially true of the mucous form. Distortion of the uterus is common. The mucosa is usually atrophied over submucous myomata, but elsewhere is unaltered (Cullen).

Broad Ligament.—It is very doubtful if myomata ever arise in the broad ligament. Tumors found there are in reality subserous forms which have developed in the lateral wall of the uterus, and have finally become separated from it.

Prostate.—The myomata of the prostate come next in importance to those of the uterus, and are most frequently found in advanced age. Some of these enlargements of the prostate depend on an actual hypertrophy, in which all parts of the gland participate. In others, the enlargement is principally due to hyperplasia of the glandular elements, and this form passes most readily into adenoma. In the third class Virchow has shown that the enlargement is principally due to a hyperplasia of the smooth muscle fibres, which make up a large part of the gland.

This new formation is sometimes diffuse, but more often is in the form of distinct nodules. The favorite seat for their formation is on the posterior upper portion of the gland, and this distinct tumor formation is generally spoken of as hypertrophy of the third lobe of the prostate. The lateral halves of the gland are the next most frequent seat of this formation. It is rather rare that the anterior part of the gland is affected, although Thompson has described a tumor here as large as a walnut.

Digestive Tract.—The myomata of the digestive tract are, next in order, most frequent. Their microscopic characters do not present any differences from those of the uterine myomata. Cyst-formation and degenerative processes are not commonly found. They occur in the œsophagus, generally near the cardiac end, in the stomach, and in the intestine. Myoma of the appendix has also been reported. They are comparatively rare in all these localities, they seldom attain a large size, and usually do not give rise to symptoms, unless of sufficient size to produce obstruction or invagination. In the duodenum such tumors may obstruct the common bile duct (Delafield and Prudden). These tumors develop from the muscular coats of the canal, soon project into the lumen, are covered only by the mucous membrane, and may become pedunculated. Less frequently they project outward beneath the peritoneum.

Skin.—Myomata in this location are divided by Besnier (Hyde) into two groups: simple and dartoic. The former are rare, less than a dozen cases having been reported. They are generally multiple, occurring chiefly on the upper extremities and in old people, especially men. They are supposed to arise from the erector pili muscles.

The dartoic type is more common, generally occurs singly, and is found most frequently in the skin of the mammæ, scrotum, and labia majora. They may be sessile or pedunculated, and vary from the size of a nut to that of an orange. Mixed forms may occur, as fibromyoma, angiomyoma, and lymphangiomyoma.

Bladder.—Myoma of this organ is rare. It was first described by Virchow, who supposed it to be an outgrowth of the prostate; but a myoma of the bladder pure and simple, arising from the muscularis and extending beneath the peritoneum, has since been described by Belfield (*Wien. klin. Woch.*, 1881, 329), and a somewhat similar one by Verhoogen (Kelly, "Operative Gynæcology"). These tumors may be sessile, but are usually pedunculated. They may be submucous or subserous, and vary greatly in size. In Verhoogen's case it was the size of a child's head. They are usually quite vascular.

Urethra.—Myoma in this location is rare. Büttner

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(quoted by Kelly) found an ulcerated myoma the size of a hen's egg in a woman of forty years of age.

Veins.—Small leiomyomata have been found in the saphenous and ulnar veins. A large myosarcoma of the inferior vena cava has been reported.

Kidney.—Minute myomata, usually multiple, are occasionally found in the kidney. They are generally found in the cortex, close beneath the capsule, and may arise either from the capsule or from blood-vessels (Lartigau and Larkin, *Journal of Medical Research*, N. S., vol. l., No. 1, 1901). They give rise to no symptoms during life.

Other locations in which leiomyoma is occasionally found are the spermatic cord (the growth occurring here sometimes as a myolipoma), the liver (where these growths are of slight significance), the Fallopian tubes, ovaries, vagina, and vulva; in all of which locations the type is generally that of a fibromyoma. In mixed tumors of the mammary gland small masses of both smooth and striated fibres are occasionally seen.

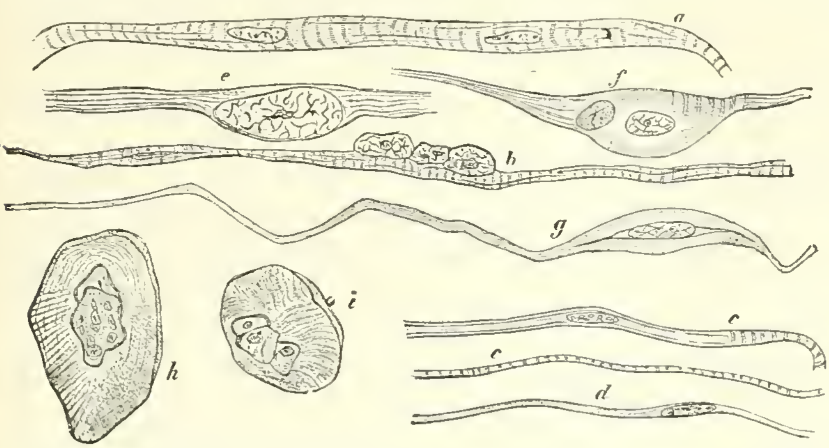

FIG. 3467.—Cells from a Rhabdomyoma. (From Ribbert and Wolfensberger.) *a, b, c,* Fibres of various sizes with transverse striation; *d,* small nucleated fibre without striæ; *e,* spindle cell with longitudinal striæ; *f,* spindle cell with longitudinal and transverse striæ; *g,* spindle cells, non-striated, with elongated processes; *h, i,* round cells with concentric and radial striation.

Rhabdomyoma.—This form of myoma, into whose structure striated muscle fibres enter, must be considered one of the rarest of tumors. The first of these tumors was described by Rokitansky, and since then not more than thirty or forty cases have been reported. Von Recklinghausen found in the hearts of newly born children, in a few instances, small tumor masses which contained striated muscle fibres. Generally the tumors are not pure forms, but are mixed with sarcoma. The muscle fibres are, as a rule, not straight and arranged in masses, but are separated from one another and irregularly distributed in the tumor. The character of the fibres varies. The well-developed fibres appear as nuclear bands of varying width and may have both longitudinal and transverse striations. The poorly developed forms are narrow bands without transverse striations, or spindle cells with long processes and imperfect or no striations; also there may be seen irregular round or oval cells, varying in size, with radial or concentric striation. Associated with these are numerous cells of indefinite origin. (See Fig. 3467.) A sarcolemma is not always demonstrable, but has been described.

The most frequent place of formation of these tumors is in the genito-urinary system, especially in the kidney or testicle, and frequently in the uterus, vagina, bladder, or ovaries. They occur occasionally, however, in other locations, as in the skeletal muscles, parotid gland (Prudden), subcutaneous tissues, mediastinum, and œsophagus. They are found almost exclusively in children, and may reach a very large size; as in the case described by Marchand, in which such a tumor of the left kidney extended from the diaphragm to the pelvis and weighed 2,770 gm. Most probably the explanation given by Cohnheim of their origin, which refers them to unused embryonic material, is the correct one. Their presence in such parts where complications in the embryonic formations take place, and where there is a mingling of the germinal layers, speaks in favor of this. *Richard Mills Pearce.*

MYOPIA—**M**—(μυωπία, μυωπίασις, also μυωπός, μύωψ—from μύω and ὤψ, signifying winking or contracting the eyelids—German, *Kurzsichtigkeit;* French, *vue courte;* English, short- or near-sightedness)—is mentioned by Aristotle, in the Galenical writings, and by the Byzantine medical authors—Oribasius, Aëtius, Paulus Ægineta, and Actuarius. It is described as a congenital condition, in which small near objects are seen distinctly, but distant objects imperfectly or not at all; also as the opposite condition to that occurring in old persons who distinguish small near objects, such as written characters, imperfectly, but see well at a distance. It is further recognized as incurable.

These brief statements, which comprehend practically the sum of the teaching of the earlier writers on medicine, and which were not seriously questioned until after the middle of the last century, include, nevertheless, two fundamental errors: (*a*) M, although very common in children, and dependent in many cases on inherited tendencies or conditions, is very rarely congenital; and (*b*) M is not the opposite condition to presbyopia—which is a disability resulting from impairment of the function of accommodation incident to advancing age—but is really the opposite of hypermetropia—H—(see *Hypermetropia*), which is a congenital condition, and which, like M, consists essentially in a faulty proportion between the radii of curvature of the refracting surfaces of the eye and the length of the antero-posterior axis of the eyeball.

As in H the axis of the eyeball is, as a rule, actually shorter than in the normally proportioned (emmetropic) eye, so in M the axis of the eye is, as a rule, longer than in the emmetropic eye. These two opposite anatomical conditions constitute, in fact, the essential variations from the normal in typical H and M respectively, namely, *axial* H and *axial* M.

Fig. 3468 represents, in section, a myopic eye, the dotted outline indicating the section of the emmetropic eye (*cf.* Fig. 2758, vol. iv., p. 796). It has been explained (see *Accommodation and Refraction*, vol. i., p. 56) that the sum of the successive refractions at the cornea and the two surfaces of the crystalline lens is just sufficient to focus pencils of parallel rays upon the retina at its normal position *E*, and that, through the exercise of its accommodation, the emmetropic eye is able to focus, upon its retina, pencils of divergent rays, such as are received from near objects (*cf.* Fig. 2762, vol. iv., p. 797). In the myopic eye the principal focus—*i.e.*, the focus for pencils of parallel rays—is in front of the actual position of the retina, so that the retinal image of any distant object is made up of overlapping circles of confusion and is, therefore, imperfectly defined.

The unaccommodated myopic eye is, however, adapted for the correct focussing of pencils of divergent rays emanating from an object at some particular short distance, as shown in Fig. 3469, in which a pencil of rays

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diverging from r is represented as refracted to a focus on the retina of the myopic eye at M. The distance of this *far-point* of distinct vision (*punctum remotissimum*—r), measured from the eye in metres or fractional parts of a metre, is the reciprocal of the grade of the myopia expressed in dioptries. Representing this distance by R, and the grade of the myopia by M, we have:

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$$R = \frac{1}{M} \text{ metre} \quad . \quad . \quad . \quad . \quad [1]$$

By the exercise of its accommodation the myopic eye is able to adjust itself for distinct vision at any distance

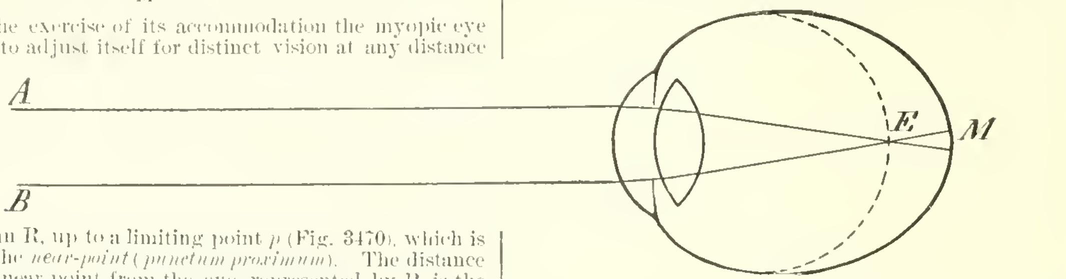

FIG. 3468.

less than R, up to a limiting point p (Fig. 3470), which is called the *near-point* (*punctum proximum*). The distance of the near-point from the eye, represented by P, is the reciprocal of the grade of the myopia plus the range of accommodation, both expressed in dioptries. Representing the range of accommodation by A, we have:

$$P = \frac{1}{M + A} \text{ metre} \quad . \quad . \quad . \quad . \quad [2]$$

From the form of equations [1] and [2], it is evident that, for increasing values of M, both R and P decrease, but that R decreases at a greater rate than P. It follows that for higher grades of myopia, both r and p fall nearer

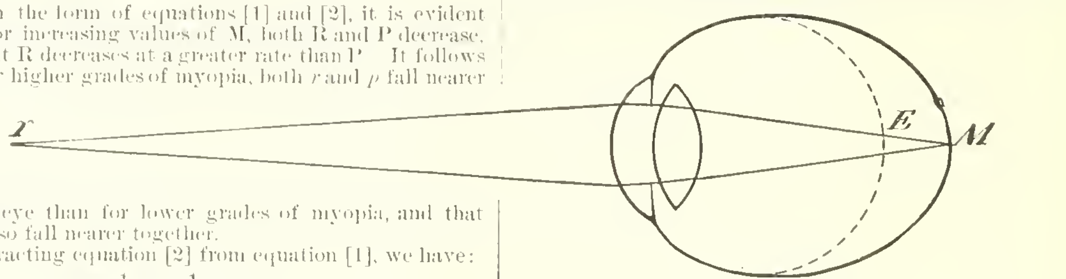

FIG. 3469.

to the eye than for lower grades of myopia, and that they also fall nearer together.

Subtracting equation [2] from equation [1], we have:

$$R - P = \frac{1}{M} - \frac{1}{M + A} \text{ metre} \quad . \quad . \quad . \quad . \quad [3]$$

The linear measure R — P, which represents the difference in the distance of the far-point (r) and the near-point (p) from the eye, and which represents, therefore, the linear distance through which the myopic eye is able to adjust itself for distinct vision by the full exercise of its accommodation (A), is its *region of accommodation*. As R is the reciprocal of M, the region of accommodation, R — P, is at its maximum (infinity) when M = zero (emmetropia). Table I. shows the measure of R, of P, and

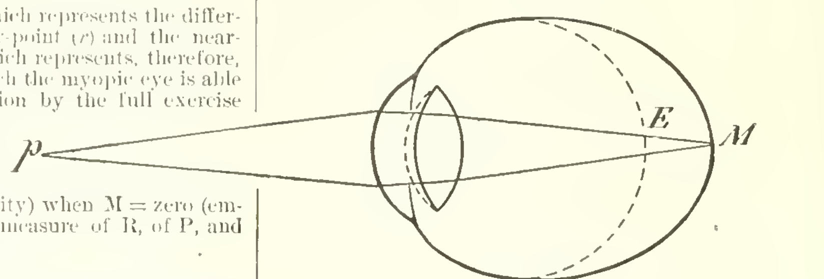

FIG. 3470.

TABLE I.

M =.	$R = \frac{1}{M} =.$	$P = \frac{1}{M + A} =.$	$R - P = \frac{1}{M} - \frac{1}{M + A} =.$
1. D.........	1 = 1.000 m.	$\frac{1}{11}$ = 0.091 m.	$\frac{10}{11}$ = 0.909 m.
2. D.........	$\frac{1}{2}$ = 0.500 m.	$\frac{1}{12}$ = 0.083 m.	$\frac{10}{24}$ = 0.417 m.
3. D.........	$\frac{1}{3}$ = 0.333 m.	$\frac{1}{13}$ = 0.077 m.	$\frac{10}{39}$ = 0.256 m.
4. D.........	$\frac{1}{4}$ = 0.250 m.	$\frac{1}{14}$ = 0.071 m.	$\frac{10}{56}$ = 0.179 m.
5. D.........	$\frac{1}{5}$ = 0.200 m.	$\frac{1}{15}$ = 0.067 m.	$\frac{10}{75}$ = 0.133 m.
6. D.........	$\frac{1}{6}$ = 0.167 m.	$\frac{1}{16}$ = 0.063 m.	$\frac{10}{96}$ = 0.104 m.
7. D.........	$\frac{1}{7}$ = 0.143 m.	$\frac{1}{17}$ = 0.059 m.	$\frac{10}{119}$ = 0.084 m.
8. D.........	$\frac{1}{8}$ = 0.125 m.	$\frac{1}{18}$ = 0.056 m.	$\frac{10}{144}$ = 0.069 m.
9. D.........	$\frac{1}{9}$ = 0.111 m.	$\frac{1}{19}$ = 0.053 m.	$\frac{10}{171}$ = 0.058 m.
10. D.........	$\frac{1}{10}$ = 0.100 m.	$\frac{1}{20}$ = 0.050 m.	$\frac{10}{200}$ = 0.050 m.

of R — P, respectively, for progressively increasing grades of myopia, from 1. D to 10. D, in a young person with an unimpaired range of accommodation of 10. D.

Inspecting Table I., it will be observed that in high grades of myopia both the near-point (p) and the far-point (r) are very near to the eye, and that the region of accommodation (R — P), although extended, by a few centimetres, in the direction toward the eye, is so greatly contracted, as a whole, as practically to annul the part played by the accommodation in seeing at short range; only in the lower grades of myopia, in which r lies farther from the eye than the reading distance, is there a limited field for a partial exercise of the accommodation to meet the restricted requirements of near vision.

As a consequence of the displacement and contraction of the region of accommodation in myopia, the interrelation of accommodation and convergence, as it exists in emmetropia (see *Accommodation and Refraction*, vol. i., pp. 55–58), is materially altered. Thus, in myopia of M dioptries, the farthest point of distinct vision—r—(under full relaxation of the accommodation) is at a distance of $\frac{1}{M}$ metre from the eye; but, in order to see an object at this distance with the two eyes, the axes of the two eyes must converge to an amount represented by M metre-angles (see vol. i., p. 583, note). It follows that for perfect binocular vision, at or within the distance of the far-point, a normal exercise of the convergence, corresponding to the distance of the (near) object, must be associated either with full relaxation or with less than the normal exercise (relative relaxation) of the accommodation; in other words, there is an essential change in the relation between accommodation and convergence from that which obtains in emmetropia, in which (normal) condition an exercise of the convergence measured by any number of metre-angles goes hand-in-hand with the

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exercise of an equal number of dioptries of accommodation.

As a fact, a notable readjustment of the physiological bond by which the two functions of accommodation and convergence are linked together follows closely upon the progressive change in the refraction in most cases of myopia; and this readjustment is often so nearly perfect as to admit of the easy and sustained use of the two eyes together in near work. Thus in most cases of stationary or slowly progressive myopia, up to a grade of about 3. D, no difficulty is experienced in reading ordinary print, with the two eyes, at approximately the normal reading distance of about ⅓ metre; also, in notably higher grades of myopia, very fine print may be read, easily and without fatigue, at some shorter distance corresponding to the distance of the point of intersection of the visual axes. Hence the very old and widely disseminated belief that myopes, as a class, enjoy a substantial advantage in respect of strong and fine vision in near work, and that this advantage, together with the further advantage of partial or complete exemption from the ordinary disabilities incident to presbyopia, may be held to outweigh the single recognized disadvantage of imperfect vision at a distance. That this old belief is, in the main, erroneous, and founded in ignorance or imperfect appreciation of the pathology of myopia as the visual expression of distention of the eyeball from disease, is proved by the anatomical demonstration of extensive and characteristic lesions in the fundus and coats of the eye in high grades of myopia; by the study of these lesions in the living eye in their successive stages of development, as revealed by the ophthalmoscope; by extended statistical researches on the refractive conditions existing in the eyes of school children in the lower and higher classes and grades; and by clinical experience based on successive examinations of the eyes of individual myopes, extending often over many years.

Two fundamental facts, based on exhaustive studies of myopia during the past half-century, are definitively established:

(*a*) Myopia is ordinarily the optical expression of an elongation of the antero-posterior axis of the eyeball, dependent on a pathological distention of the globe. Furthermore, this distention is in many cases rapidly progressive, and not infrequently attains to so high a grade as to become a grave menace to the integrity of the eye as an organ of vision.

(*b*) In many cases of myopia, especially when it is of high grade or of rapid development, the compensatory readjustment of the convergence to the displaced region of accommodation is in so far incomplete as to give rise to a state of persistent conflict between accommodation and convergence. As alternative issues of this conflict there may result either an habitual exercise of the accommodation in excess of that which is required for perfect vision at the distance of the point of intersection of the visual axes, or accurate accommodation for the actual reading distance accompanied by fatigue or insufficiency of the recti interni muscles—muscular asthenopia, or relative or actual strabismus divergens (see *Asthenopia* and *Strabismus*).

A myopic eye looking through a concave lens of any (negative) power up to the measure of its myopia is rendered virtually less myopic. With a concave lens of N dioptries, taking N < M, the uncorrected part of the myopia is M — N dioptries.

If we take N = M (Fig. 3471), we have M — N = zero, in which case the myopia is completely corrected (neutralized) by the concave lens, and the eye is rendered virtually emmetropic, *i.e.*, the far-point (*r*) is carried off to an infinite distance. At the same time the near-point (*p*) is removed farther from the eye, to a distance, $\frac{1}{A}$, determined by the magnitude of the range of accommodation (see *Accommodation and Refraction*, vol. i., p. 57).

The effect of a concave lens added to a myopic eye is, then, to remove both the far-point (*r*) and the near-point (*p*) to a greater distance from the eye; but the recession of *r* is greater than that of *p*. The region of accommodation (R — P) is therefore enlarged, attaining its maximum (infinity) when the (negative) power of the lens is numerically equal, in dioptries, to the grade of the myopia.*

As a result of this re-establishment of a normal region of accommodation, with the far-point (*r*) at infinity, the requirements for the conjoined exercise of the accommodation and the convergence in binocular vision become identical with those which obtain in emmetropia—the distance of the near-point, as determined by the exercise of a certain number of dioptries of accommodation, now coinciding with that of the point of intersection of the visual axes, as determined by an exercise of the convergence measured by the same number of metre-angles. As a rule, in uncomplicated myopia of low or medium grade, with unimpaired range of accommodation and normal acuity of visual perception, little or no inconvenience is experienced in utilizing fully the enlarged region of accommodation and, at the same time, re-adjusting the convergence to the changed optical conditions imposed by the wearing of neutralizing concave glasses. In the higher grades of myopia, especially if concave glasses are to be given for the first time, only a partial optical correction may be accepted in the beginning, and the full correction may have to be reached by a later change, or perhaps through one or more changes, to glasses of greater power.

With advancing years, as the crystalline lens becomes progressively harder and less capable of undergoing changes in form (see *Accommodation and Refraction*, vol. i., p. 59), the range of accommodation (A) diminishes in myopia just as in emmetropia and in hypermetropia. With decreasing A, approaching zero in old age, $P = \frac{1}{M + A}$ . . [2] increases, approaching $R = \frac{1}{M}$ . . [1] as a limit; the region of accommodation (R — P) being then reduced to zero through the recession of *p* to *r*. At the practically unchanged distance of *r*, the vision of the myopic eye is still perfect, and whenever *r* lies within a convenient reading distance from the eyes, as in myopia of not less than 3. D or 4. D, convex glasses are not needed for reading. In myopia of less than 3. D the need of convex reading glasses is first experienced later in life than in emmetropia, and relatively weak glasses then suffice. Similarly, in the higher grades of myopia, concave glasses weaker than those which completely correct the eyes for distant vision must be given for reading at the best distance from the eyes.

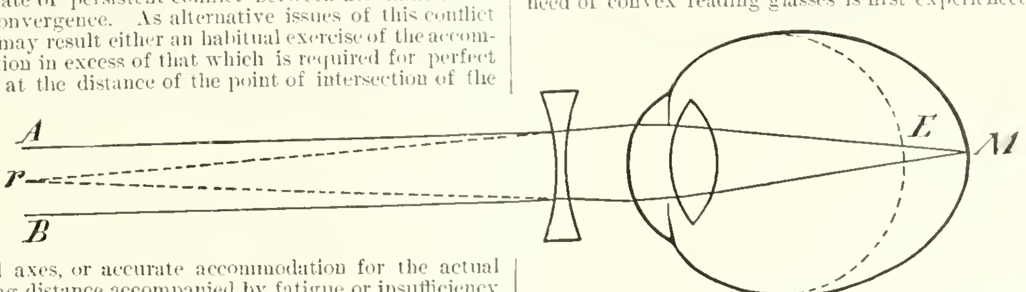

FIG. 3471.

*If we take N > M, the effect of the concave lens will be to overcorrect the myopia, and the eye will be rendered virtually hypermetropic (see *Hypermetropia*.)

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Although the tendency in axial myopia is, as a rule, in the direction of a progressive increase in grade as a result of progressively increasing distention of the eyeball, in a notably large proportion of all cases of myopia this tendency becomes arrested sooner or later, and the length of the axis of the eye may then continue stationary for many years or during the remainder of life. In such cases a small decrease in the grade of the myopia, amounting to a dioptrie or two, or perhaps a little more, may generally be detected in old age, as a result of a physiological decrease in the refractive power of the crystalline lens (see *Hypermetropia Acquisita*, vol. iv., p. 800). On the other hand, an increase of a few dioptries in the refractive power of the crystalline lens is not infrequently observed as an incident of beginning senile cataract, and from this cause a true lenticular myopia may make its appearance in old age, or a pre-existing myopia may develop a considerable increase. Thus certain elderly persons, who have used convex glasses in reading for perhaps many years, discover that they can read as well or better without glasses (so-called second sight), and in certain cases of myopia it is found that the concave glasses which have been habitually worn are no longer perfectly satisfactory in distant vision. A revision of the glasses worn by myopes, whether for distance or in reading, is therefore generally indicated in advanced life, changing oftenest to somewhat weaker concave glasses, but occasionally to stronger, according as the lenticular refraction is found to have diminished or to have undergone a pathological increase.

The size of the retinal image of any object situated at or within the distance of the far-point of the myopic eye is greater than in the case of the same object focussed by an emmetropic eye through the exercise of its accommodation, in the ratio of the respective distances of the second nodal point of the eye (k'') from the retina. The size of the retinal image increases, therefore, for every increase in the length of the eyeball, so that a young person, with uncomplicated myopia of high grade, may enjoy, for a time at least, exquisitely fine sight for small near objects. With the correction of the myopia by concave spectacles, the nodal point is moved nearer to the retina, and, in the case of a neutralizing concave glass worn at the anterior principal focus of the eye (about 13 mm. in front of the cornea), the distance of the nodal point from the retina, consequently the size of the retinal image, becomes the same as in emmetropia. Owing to this diminution in the apparent size of small near objects, it not infrequently happens that a myope of high grade, although accepting neutralizing concave glasses for distance, is disinclined, or, in the case of subnormal visual acuity, is unable to use them in reading. This may become a source of grave embarrassment to the ophthalmic practitioner, who recognizes the dangers attendant upon the habitual use of the uncorrected eyes in fine near work, but may find it difficult to persuade a young patient to abandon such work as a means to the conservation of his sight.

Origin and Development of Myopia.—In young children hypermetropia is the typical refractive condition. Of 100 eyes of infants from one to four weeks old, measured, under atropine, with the ophthalmoscope, by Horstmann,[1] 88 (aggregating 244. D) were hypermetropic, 10 were emmetropic, and 2 (aggregating 4. D) were myopic. Of 100 eyes of children between one and two years of age, similarly examined under atropine, 84 (aggregating 188. D) were hypermetropic, 10 were emmetropic, and 6 (aggregating 8. D) were myopic. Of 100 eyes of children between four and five years of age, 74 (aggregating 188. D) were hypermetropic, 13 were emmetropic, and 13 (aggregating 22. D.) were myopic.

Of 10,060 pupils of public schools in Breslau (including 1,486 children in five village schools) examined subjectively by H. Cohn,[2] the percentage of cases of myopia increased progressively from an average of 6.7 per cent. in twenty elementary schools, to an average of 26.2 per cent in two gymnasia (colleges). The grade of myopia also increased from an average of 1.8 D. in the elementary schools, to 2. D in the gymnasia.

Erismann[3] measured the refraction in 4,338 pupils of schools in St. Petersburg; he found: Of hypermetropes, 43.54 per cent.; of emmetropes, 26.10 per cent.; of myopes, 30.36 per cent. Tabulated in percentages for successive years of school life, Erismann's statistics show, for seven consecutive school grades, a progressive decrease in hypermetropia from 55.6 per cent. in the lowest to 36.2 per cent. in the highest grade, and an increase in myopia from 15.8 per cent. in the lowest grade to 42.8 per cent. in the highest. The percentage of emmetropic is given as 28 per cent. in the lowest grade, 25.1 per cent. in the sixth grade, and 21 per cent. in the seventh (highest) grade; in grades I. to VI. it fluctuates between 28 per cent. and 25.1 per cent., averaging 26.1 per cent. Studied as a whole, the numbers show (*a*) a progressive increase in the percentage of cases of myopia, (*b*) a concomitant progressive decrease in the percentage of cases of hypermetropia, and (*c*) a nearly constant percentage of cases of emmetropia. They thus emphasize the fact, previously suspected, but denied by Donders, that the ranks of myopia are recruited, through emmetropia as a transient condition, from eyes originally hypermetropic. It follows that a condition of emmetropic or even of hypermetropic refraction may be present in an eye which has already undergone notable distention, and that the beginning of the pathological process typical of myopia must be dated back, in many cases, to a period possibly long antecedent to the development of myopic refraction. In this fact is found an explanation of the cases in which pathological conditions characteristic of myopia of high grade are seen in eyes of relatively low myopic refraction, or, more rarely and less highly developed, in eyes which are optically emmetropic or hypermetropic.

An enormous mass of statistical material gathered by many observers in many lands shows conclusively that with moderate and easily explicable variations in the percentages, the conclusions based on the original researches of Cohn and Erismann are essentially true for all highly civilized communities.

Distribution of Myopia.—Myopia is pre-eminently a disease of the higher ranks of society, and of highly cultured peoples. It is widely prevalent in Germany, where its causes may be referred, in part, to the national "studious habit"; partly to long hours of school work, supplemented by protracted study hours at home, by artificial light; partly to the general use of the old German text, in which the differentiation of certain letters is especially difficult; and possibly to racial predisposition.

In a relatively small proportion of cases, myopia of high grade and of malignantly progressive type is observed in laborers or other persons who have never been subjected to the conditions generally recognized as especially causative of myopia; in these cases an inherited predisposition to myopia may be suspected. Myopia often occurs in certain families, appearing in several children of a myopic parent or parents, and sparing others. Soldiers and sailors are, as a rule, exempt; but this is mainly a result of selection. Savage races are largely exempt from myopia; Furnari[4] found no cases among the Kabyles. "Survival of the fittest" and the absence of exciting causes of myopia afford an obvious explanation.

Myopia as Related to Age.—The statistics of myopia show that it is essentially an acquired condition; also that, in school or college, myopia of high grade occurs almost exclusively in the more advanced classes. Every case of myopia must, therefore, be regarded as having passed through a progressive change from a lower to a higher grade, and, especially in the case of a young person, as, possibly or probably, still in a stage of continuous or remittent progression. The study of the refraction of individual young moypes, examined from year to year, enforces the same conclusion. The age at which a more rapid increase is ordinarily first noticed follows very closely upon that at which considerably increased

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demands are made upon the eyes in study, namely, about fourteen years. From about the fifteenth to about the twenty-fifth year the increase is generally most rapid. This corresponds, in a general way, to the years of advanced preparatory and collegiate study, with some added years in the university or in a professional school. It also includes the ordinary period of apprenticeship to trades which may demand close and continuous application. Furthermore, a somewhat rapid rate of increase may be expected to go on, for a time, after the special determining conditions have been mitigated or have ceased to be actively operative.

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In considering the influence of age in its relation to the development of myopia, the greater extensibility of the scleral tissue in children may be assumed to play an important part. Also, in older subjects, the stretched and thinned sclera of the highly myopic eye may oppose inadequate resistance to continuing distending forces to which it has already yielded. As a fact, myopia is seldom developed, in a previously healthy emmetropic eye, after the term of youth has been passed; the apparent exceptions are almost always instances of increase in the grade of pre-existent, but unrecognized or unacknowledged, short-sightedness.

Myopia of high grade (10. D or more) is occasionally observed in a child of eight or nine years, and should then be contemplated with great solicitude in view both of the disability incident to the high grade to which it may be expected to attain and the fear that, later in life, the integrity of the eyes may be endangered.

It has been erroneously assumed that myopia tends to diminish with advancing age. On the contrary, it is always either progressive or, at the best, stationary. An apparent exception, based on certain cases in which a myopia of low grade disappears as a result of a decrease in the refractive power of the crystalline lens in old age, also the occasional late occurrence of a lenticular type of myopia dependent on a pathological increase in the refractive power of the crystalline, have been already mentioned.

Classification of Myopia.—Donders[5] has divided myopia into three categories, basing them on the course and progress of the disease, namely: (1) stationary M; (2) temporarily progressive M; (3) permanently progressive M.

(1) The type of the stationary class is represented mainly by cases of myopia of low grade, which increase slowly up to a limit not much exceeding 2.5 D to 3. D at the age of twenty-five years; after the twenty-fifth year the increase is insignificant. In this category are included certain cases of myopia of higher grade, which follow a similar course of slow and limited progression. After the age of about fifty years, distant vision often improves, owing in part to the smaller pupils, in elderly people, lessening the diameter of the circles of confusion in the retinal image, and in part to the slight physiological decrease in the refractive power of the crystalline lens.

(2) The temporarily progressive class includes those cases which increase rapidly up to about the twenty-fifth year, and become stationary, generally before the thirtieth year, after having attained a grade averaging about 8. D. At this grade the myopia remains practically stationary during the remainder of life, but with a tendency, in certain cases, to recrudescence, which may bring the case under the category of—

(3) Permanently progressive myopia. In this class a myopia of 6. D or more, at the age of twelve years, develops continuously, but generally at a decreasing rate, up to a limit which may reach or exceed 20. D at the age of sixty years. "The worst is then to be feared. It is rare at sixty years of age to find a tolerably useful eye with myopia of 16. D or even of 13. D" (Donders).

Ophthalmoscopic Appearances.—The region of the fundus about the entrance of the optic nerve (optic disc) is the seat of certain very characteristic changes which, although occasionally seen in eyes of emmetropic or even of hypermetropic refraction, are so constant in myopia that they are justly regarded as typical of this disease.

Especially characteristic is an alteration in the choroid which, from its general configuration, is known as the "crescent" or "sickle" (Figs. 3472, 3473, and 3474).

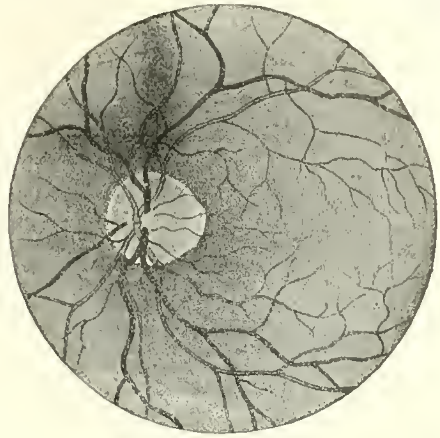

Fig. 3472.—Left Eye.

Fig. 3473.—Left Eye.

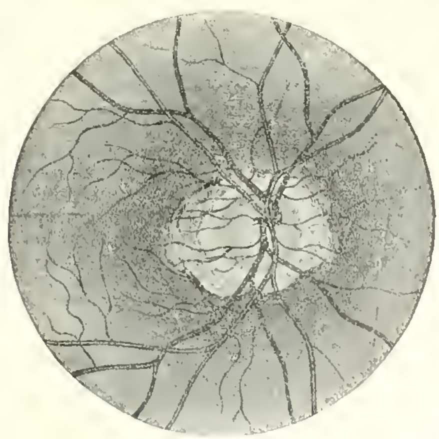

Fig. 3474.—Right Eye.

Figs. 3472, 3473, and 3474.—Represent Different Types of Crescents as seen in the erect image. (From Jaeger.)

This appears, ordinarily, as a whitish or grayish-white area, crescentic in outline, the concavity of the crescent closely hugging the outer margin of the disc, the con-

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vexity either sharply outlined by a more or less conspicuously pigmented border or shading gradually into the normal choroidal tissue in the general direction of the fovea. Traversing this area the finer retinal vessels, which supply the region about the macula, are seen somewhat straightened in their course, as if stretched longitudinally. The crescent may vary in width from a thin sickle shaped band at the disc-margin, from which it is with difficulty to be distinguished, to a large area, approximately parabolic in outline, which, from its resemblance to a conic section, has been named "conus." In other cases, especially in myopia of high grade, the approximately regular curvilinear outline is lost, the altered area taking on irregular and often bizarre shapes.

The myopic crescent is essentially the expression of a localized atrophy of the choroid, accompanied in many cases by a stretching and thinning of the sclera adjacent to and mainly at the temporal side of the optic disc. It then becomes an area of least resistance which may be the seat of a gradually increasing protuberance or, in extreme cases, of a deforming boss, at the posterior pole of the eye (*staphyloma posticum*).

The pathological processes leading to the development of the crescent are still imperfectly understood. In general, the ophthalmoscopic appearances are such as to suggest a sliding of the choroid on the sclera, with attendant stretching of the choroidal tissue at the temporal side of the disc. As a result of this stretching, a localized choroidal inflammation of low grade, passing into atrophy, may be invoked as offering the best explanation of the origin and subsequent enlargement of the crescentic area. The irregular extension of the conus in advanced stages of the disease is clearly the expression of atrophy following choroiditis. Atrophic spots in different parts of the fundus, indicating areas of previous circumscribed inflammation of the choroid, are of not infrequent occurrence in high grades of myopia.

The optic disc in myopic eyes often presents an oval contour, as if shortened in its horizontal diameter. This appearance may be simply the effect of foreshortening due to an oblique position of the disc with reference to the direction from which it is viewed. In many cases, however, there is almost certainly an actual variation from the typical circular form.

Capillary hyperæmia of the disc is a frequent condition, especially in young myopes whose myopia is in the progressive stage; it may be regarded as the local expression of general ocular hyperæmia. At a later period, after the congestion has disappeared, the disc often assumes a pallid tint indicative of anæmia, and may even present the appearance of a shallow excavation.

Liquefaction of the vitreous, with the presence of finer or coarser floating specks or shreds, is very common in myopia of high grade and long standing. Myopic eyes are also especially subject to detachment of the retina,

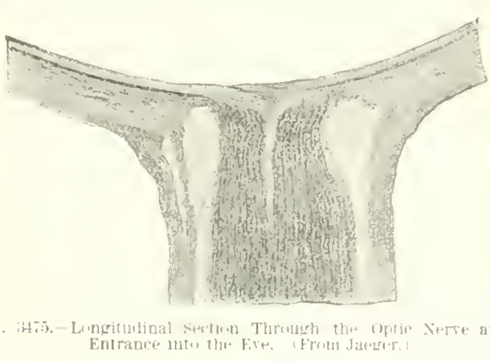

FIG. 3475.—Longitudinal Section Through the Optic Nerve at its Entrance into the Eye. (From Jaeger.)

a disaster which has been attributed to a dragging of the vitreous upon the retina. A bow shaped reflex concentric with the disc (best seen through a concave lens, a little weaker than the measure of the myopia, behind the hole in the mirror of the ophthalmoscope) has been described by Weiss[6] as a sign of posterior separation of the vitreous from the retina.

Pathological Anatomy.—A meridional section through the fovea and the distal end of the optic nerve (Fig. 3475) shows, in cases of highly developed conus, a wide separation of the inner and outer nerve sheaths where the nerve joins the globe. Beyond the limits of the conus the outer sheath becomes continuous with and reinforces the sclera, but within the area corresponding to the conus, where the reinforcing fibres of the outer sheath are absent, the outer coat of the eye appears very much thinner than in its normal condition or than at the posterior region of the globe generally.

A general thinning of the sclera, the decrease in thickness becoming gradually more marked posteriorly, is characteristic of the higher grades of myopia.

A typical change in the form of the ciliary body, as shown in a meridional section of the anterior segment of the eyeball, conjoined with an appearance as of an increased development of the radiating fibres and a decrease in the number of the circular fibres of the ciliary muscle, as first described by Iwanoff,[7] may be regarded as an expression of the general stretching of the choroid.

Causes of Myopia.—The causes leading to the typical pathological changes in myopia are but imperfectly understood. Donders[8] laid much stress on the hypothesis of an inherited predisposition, and this opinion is supported by many clinical facts. Certain families show a very large proportion of myopes, others comparatively few. The inheritance of a special anatomical condition of the sclera or optic nerve, implying less than normal resistance to the operation of distending forces, is not more improbable than the inheritance of a hypermetropic configuration of the eyes. Corneal asymmetry, the ordinary cause of astigmatism, is distinctly transmissible from parent to offspring, and astigmatic refraction is too frequently associated with myopia to admit of reasonable doubt that the former stands in a causal relation to the latter. The general distention of the globe, mainly in its posterior half and especially about the posterior pole, corresponds to the thinner and presumably less resistant scleral region posterior to the insertions of the recti muscles. The immediate causes of the distention, whether they are to be sought in original structural weakness of the tissues or in increased intraocular pressure, or both, are matters of dispute. Continuous close application to fine near work, in which strong accommodation and convergence go hand-in-hand, is a most important etiological factor. After elongation of the globe has begun, convergence for the ordinary reading or working distance tends to evoke accommodation for some shorter distance; but reading or working at this shorter distance implies an increase in convergence, which in turn incites to increased exercise of the accommodation. As a result of this inter-action of convergence and accommodation, the tendency is to a progressive shortening of the reading distance, and, *pari passu*, to an increase in the grade of the myopia.

Weiss[9] has suggested that a short optic nerve, dragging on the sclera in inward rotation of the eyes, may be a factor in the development of posterior staphyloma. Stilling[10] has called attention to a particular conformation of the orbit, giving rise to an alteration in the direction of the pull of the reflected tendon of the superior oblique muscle, as a supposed cause of injurious traction upon the globe.

Treatment of Myopia.—"The cure of myopia belongs to the *pia vota*" (Donders). Erroneous assumptions regarding the causes of short-sightedness have led in the past to the proposal of a variety of futile or harmful plans of treatment. Thus attempts have been made to diminish the convexity of the cornea by the prolonged application of pressure, or by corneal paracentesis repeated at short intervals. Practice in reading at progressively increasing distances from the eye has been strongly advocated, in the belief that a supposed excessive lenticular refraction might thus be gradually lessened. Division of one or more of the recti, or of the

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oblique, muscles, in order to diminish a supposedly injurious muscular pressure on the globe, has also been advised and practised.

Therapeutic measures directed to the removal of conditions of irritation which not infrequently appear in connection with rapidly progressive myopia, belong to the realm of rational therapeutics. Rest of the eyes from near work, protection from exposure to excessive light, regulation of the general physical condition, and, in some cases, the local abstraction of blood from the temples—preferably by means of the artificial leech of Heurteloup—are all of value. The so-called atropine cure is also employed, with good effect, in certain cases of rapidly increasing myopia; the eyes are kept under the full influence of atropine for about two weeks, in a moderately darkened room, after which the patient is permitted to go about with the eyes well protected by dark glasses; the use of the eyes in near work is forbidden for another fortnight.

Use of Concave Glasses.—The wearing of concave glasses to improve the distant vision of myopes is first mentioned by writers of the latter half of the sixteenth century; but the intelligent prescribing of such glasses, with a view to their effect upon myopia considered as a disease, belongs exclusively to modern ophthalmology; and even now there is notable divergence of opinion on certain points. In general, it may be accepted as a well-established principle that in uncomplicated myopia of low or medium grade, with normal acuity of visual perception and unimpaired range of accommodation, concave glasses should be chosen of such strength as to correct the vision accurately for distance, and that the same glasses should be worn for near work. Furthermore, it should be the aim to raise the vision, as controlled by tests made at a distance, to the highest point of acuity of which the eyes are capable; and to this end even low grades of astigmatism should be carefully investigated and corrected. The distance at which the glasses are worn, their proper centration before the two eyes, and the direction of the plane of the glasses with reference to the line of sight should all be definitely prescribed and controlled. Inasmuch as the same glasses are worn both for distance and in reading, they should be tilted so that the angle made by the visual axes to the plane of the lenses shall be as nearly equal as practicable in looking forward at distant objects and downward on the book ("pantoscopic" position). The effect of the tilting of the glasses in increasing their effective refractive power in the vertical meridian, and to a less degree in the horizontal meridian, should, in every case in which glasses of high power are required, be considered and allowed for in deciding upon the formula for the lens. The eyes should, further, be reexamined, at first at short intervals and later at intervals of a few months, in order that any change in the grade of the myopia may be promptly discovered and corrected. Explicit instruction should be given as to the kind and amount of work which may be permitted; reading or sewing without glasses, and especially the use of the eyes in near work by failing daylight or by insufficient artificial illumination, should be absolutely forbidden. The glasses (ordinarily spectacles made with elastic sides curved to fit accurately behind the ears*) should be worn continuously during the waking hours.

The wearing of neutralizing concave spectacles is ordinarily attended with great comfort to the patient, and the progress of the disease is, as a rule, either greatly retarded or wholly checked. Every renewal or change of glasses should be rigorously controlled, and it should be fully explained to the patient or, in the case of a child, to the parents, that the condition is one that must be kept under continuous observation for years.

Cases of myopia complicated by low acuity of vision, whether dependent on impaired perceptive power of the retina or on irregularity or imperfect transparency of the cornea or crystalline lens, present especial difficulties which militate against the best results from wearing glasses. In general, such patients cannot see small objects unless they are brought very near to the eye, a condition unfavorable to binocular vision. Accordingly, they often form the habit of using only one eye in reading. By this, perhaps unconscious, neglect of the retinal image in one of the eyes, the conditions which ordinarily give rise to a state of conflict between accommodation and convergence are eliminated, so that reading to a limited extent without glasses may be practically innocuous. Concave glasses may, however, be accepted in distant vision, although not in all cases.

Operation for the Removal of the Transparent Crystalline Lens.—The proposal to lower the grade of myopia in extreme cases, or to render a strongly myopic eye either moderately hypermetropic or possibly emmetropic, by the removal of the transparent crystalline lens, has been frequently discussed, although generally rejected by ophthalmic surgeons, to be revived and somewhat extensively practised in recent years.[11] Simple discission of the lens capsule, discission followed by removal of the swollen lens through a small corneal incision, and, in older subjects, extraction combined with iridectomy are the methods which have been recommended and employed. Apart from the immediate risks incident to the operation, and the uncertainty as regards its possible effect in arresting or retarding the progressive distention of the globe, the possibility of later adverse complications, such as not infrequently occur in patients upon whom an apparently ideal operation has been performed for cataract, would seem to forbid resort to an operation on the transparent lens except in extreme cases, and even then only after an exhaustive study of the particular case in all its aspects. In addition to the ordinary chances of disaster following operations for cataract, it is probable that the removal of the lens increases the tendency to retinal detachment, which is always to be feared in the higher grades of myopia. On the other hand, the fact that in the highest grades of myopia the ordinarily beneficial effect of concave glasses, in sharpening the definition of the retinal images, is largely neutralized by the diminution in the size of the images may afford an argument in favor of the operation. The incidental sacrifice of the accommodation should not be accorded undue weight in the exceptional cases in which alone the operation may be regarded as permissible.

Effect of the Removal of the Lens on the Refraction of Highly Myopic Eyes.—The average focal length of the crystalline lens, *in situ*, is estimated at 43.707 mm., which represents a power equal to 22.877 D. But the removal of the crystalline lens changes the eye from a compound dioptric system, of three refracting surfaces, to one in which the entire refraction is effected at the surface of the cornea, and in which a single principal point at the vertex of the cornea and a single nodal point at the centre of curvature of the cornea replace the two principal points and the two nodal points of the complete eye.

In the case of a previously emmetropic eye of average dimensions, the refractive insufficiency caused by the removal of the crystalline lens is exactly corrected by an addition of 13.428 D at the cornea, which may be represented by an effectively equivalent meniscus, of negligible thickness, assumed to be worn in contact with the cornea. But a convex spectacle lens, of a thickness such as is ordinarily required after an operation for cataract, is necessarily worn at a distance of approximately 15 mm. in front of the cornea, in which position it becomes a part of a new compound system in which a convex lens of 11.177 D suffices to correct the aphakial eye for distant vision.

A myopic eye whose length of axis is equal to the posterior focal length of the cornea (31.692 mm.) has a focal length (measured from the second principal point, h'') of 29.336 mm., and the distance of the concave spectacle lens which is worn to correct the myopia, measured from the first principal point, h', is about 2 mm. greater than its distance from the cornea. In the case which we have assumed, the myopia is measured by a thin concave lens

* So much of a concession to fashion may often be made as to permit the occasional use of a carefully adjusted *pince-nez*, instead of the spectacles, in distant vision.

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of −16.326 D, supposed to be placed at the position of the second principal point of the eye, but a stronger concave lens, of no less than −21.234 D, is required for distinct distant vision when worn 15 mm. in front of the first principal point, or 13 mm. in front of the cornea.* It follows that in a case of axial myopia measured by a spectacle lens of −21.234 D, the eye, after the removal of its crystalline lens, will be adapted for distinct distant vision without a glass; and a spectacle lens of + 3. D or + 4. D will then suffice for reading.

K. Bjerke[12] has collected, from different sources, 93 reported cases of myopia in which emmetropic refraction is said to have followed the removal of the crystalline lens by operation. In 29 of these cases (31 per cent.) the pre-existent myopia, as measured by a concave spectacle lens, is given as 20. D. In 44 cases (47.3 per cent.) it is given as between 20. D and 26. D, and in 44 cases (47.3 per cent.) it is given as between 14. D and 19. D. The tabulated figures would seem to point to about 19.5 D as the mean grade of myopia in which emmetropic refraction may be expected to follow the removal of the crystalline lens from the eye. The difference of about −1.7 D, between the mean of the observed results and that calculated from the dimensions and corneal curvature of the schematic (average) eye, may be explained, in part at least, by errors of observation incident to the employment of collections of trial lenses of insufficient range and with too great intervals between the higher numbers. The very large number of cases (thirty-one per cent.) given as of 20. D, which corresponds to the strongest concave lens in the trial cases in ordinary use, points to a probable higher grade of myopia than that reported for these especially typical cases.† If we could assume a slightly greater radius of corneal curvature in the average highly myopic eye as compared with the emmetropic eye, the discrepancy between the mean observed grade and the calculated grade of myopia corresponding to emmetropic aphakial refraction would practically disappear. The assumption of an exceptionally short radius of corneal curvature in the higher grades of observed myopia, and of a curvature of exceptionally long radius in the lower grades, as tabulated, would similarly explain the comparatively few aberrant cases in which a very wide departure from the mean has been observed. As regards possible or probable differences in the focal length of the crystalline lens or differences in its effective power due to variations in its distance from the cornea, in individual eyes or as related to ametropia, trustworthy data are as yet almost wholly wanting.

Prevention and Control of Myopia.—In the evolution of the race the eyes have become admirably adapted to the requirements of binocular vision both at long and at short range. But the demands upon the eyes, incident to higher civilization, have doubtless been always in excess of the ability of certain eyes to withstand assiduous and prolonged application to near work. Certain myopes must always have had a notable advantage over emmetropes in many kinds of exceptionally fine work, such as engraving gems, embroidery, writing and illuminating manuscripts, etc.; and even now it is said that only myopes are successful in the production of the finest needle-wrought lace. In view of the fact that the gravest disabilities of the myope appear somewhat late in life, it is hardly conceivable that the predisposing causes, of myopia can ever be appreciably lessened through the operation of natural or artificial selection. It remains to consider some of the more common exciting causes, incident to the lives of children, with reference to the possible amelioration of existing harmful conditions.

In civilized communities the school is an all-important factor in the life of the child, and it is during school life that myopia ordinarily develops and attains to a notably high grade. So striking is the observed relation of myopia to the grade of the pupil in school, that the designation *Schulmyopie* (school myopia) has been widely adopted by German writers. As regards ocular hygiene, the prevalent methods in teaching and the conditions under which they are carried out are radically faulty. As a rule, there is an excessive amount of book-work, required of all pupils alike and relegated in great part to hours of study at home by uncontrolled and often badly arranged or insufficient light; many of the best hours of daylight, during the school sessions, being too often given up to exercises or occupations unrelated or remotely related to the curriculum of studies. School-rooms, especially in large school-buildings, are often inadequately or unequally lighted, and the desks are not always so placed with reference to the windows as to afford the best illumination to the greatest number of pupils. Preliminary investigation of the vision of children entering upon school life, and periodical examination of the eyes from year to year, with a view to the early detection of possible visual defects, are scarcely thought of. Indifference, on the part of teachers, to recognized symptoms of beginning myopia; inciting children with known ocular defects to perform tasks which are necessarily attended with danger to the eyes; and, in general, sacrificing individual pupils to inflexible arrangements of class work are some of the besetting faults of routine wherever children are brought together in large classes.

A general recognition, on the part of physicians, that myopia is essentially a progressive and often a dangerous disease; that it may be prevented in certain cases and arrested in its progress in other cases, but never cured; that prompt attention and careful and continuous hygienic control, together with the exercise of the highest professional skill in the adaptation and renewal of glasses, are necessary in order to check its progress and guard against possibly grave pathological changes later in life; and that the haphazard resort for glasses to venders who offer advice gratuitously, and make their profit by selling a possibly badly selected *pince-nez* or pair of spectacles, is an unintelligent evasion of a serious problem in therapeutics, will go far toward creating and disseminating juster views than now prevail.

The not uncommon habit, with children, of reading an interesting book by failing daylight or by insufficient or badly arranged artificial illumination, is especially harmful in the early stages, as indeed in any stage, of myopia; fine sewing or embroidery, as an habitual occupation for leisure hours, and long-continued application to fine work of whatever kind are also to be deprecated.

Imperfect vision at a distance, as demonstrated by easily available visual tests such as the test-letters of Snellen or as revealed by inability to follow blackboard exercises at school, should be promptly reported by the teacher, and the child excluded from school until an investigation of the condition of the eyes has been made by

* The assumption of a shorter distance from the cornea, in the case of a strong concave as compared with a strong convex spectacle lens, is justified by the fact that a concave lens, however strong, is very thin at its centre. But a double-convex spectacle lens of 11. D has a thickness of about 4 mm. at its centre; a plano-convex lens, and still more a meniscus, is even thicker.

As the optical distance of a spectacle lens from the eye is measured to the second principal (= nodal) point of the lens, which in the case of a double-convex lens lies nearly half the thickness of the lens within its substance, the optical distance of a double-convex lens from the eye is greater, by nearly half its thickness, than its distance, or that of a double-concave lens, as measured from the surface of the cornea to the back of the lens. In the case of a plano-convex lens, worn with its plane surface toward the eye, the optical distance exceeds the measured distance by about the thickness of the lens, and in the case of a meniscus, worn as a periscopic lens, the difference is still greater. Conversely, a concavo-convex lens, worn with its concave surface toward the eye, has its principal (= nodal) points outside of, and behind the lens, so that the optical distance of such a lens is less than its measured distance, and still less than the measured distance of any convex spectacle lens.

In all cases in which lenses of high power are worn, and especially when a thick convex lens is given in aphakia, or a very strong concave lens in myopia of high grade, the form of the lens becomes a factor of too great importance to be neglected.

† The appearance, in the table, of 11 cases of M = 16. D and 14 cases of M = 18. D, with only a single case of M = 17. D and 5 cases of M = 19. D, has been explained by Bjerke as resulting probably from the general omission of the numbers − 17. D and − 19. D from the series of trial-lenses in common use. The occurrence of 29 cases of M = 20. D, with only 2 cases of M = 21. D and 5 cases of M = 22. D, may be interpreted as indicating a similar source of error growing out of the general omission, from the series, of trial-lenses of higher power than − 20. D.

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an ophthalmic practitioner of recognized competency and any necessary treatment, by glasses or otherwise, has been prescribed and adopted. In this way astigmatism will often be detected and corrected, and other abnormal conditions which militate against the easy and safe use of the eyes may be ameliorated. *John Green.*
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John Green, Jr.

[List of abbreviations used in this article: M = myopia; H = hypermetropia; A = range of accommodation; r = far-point (*punctum remotissimum*) of distinct vision; p = near-point (*punctum proximum*) of distinct vision; R = distance of r from the first principal point of the eye; P = distance of p from the first principal point of the eye; R − P = region of accommodation; D = dioptrie or dioptries; h = principal point; h' = first principal point; h'' = second principal point; k = nodal point; k' = first nodal point; k'' = second nodal point.]

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MYOTICS. See *Mydriatics and Myotics.*

MYRONIN is a mixture of potash soap, carnauba wax, and doegling oil (chenocoeti), and is employed as a very stable ointment base. *W. A. Bastedo.*

MYRRH.—*Myrrha.* *Gum Myrrh.* "A gum resin obtained from *Commifera Myrrha* (Nees) Engler (*Balsamodendron M.* Nees.—fam., *Burseraceæ*)." The variety of myrrh thus defined is that known in commerce as Somali or Herabol myrrh. It is official in all pharmacopœias, though these are much at variance as to the species named as its source. There appears no good reason to believe that it is derived from any other than the species named in our definition, though the inferior varieties (Arabian and Yemen) and various spurious substances often sold for it are—some of them certainly, others probably—obtained from other species of *Commifera.* This plant is a spiny, large shrub or small tree of northeastern Africa. The myrrh exudes as a thick milky juice from natural and artificial fissures, and slowly hardens to a red-brown mass, which is then collected by the Somali natives, either from the plant or from the ground where it has fallen. "Drossy myrrh," containing a large amount of earthy matter, may result from the accidental entrance of dirt into these fallen masses or from its intentional admixture. The substance is chiefly carried to Aden, whence it is exported to Europe and America, either directly or, as was formerly usual, viâ Bombay. The "Turkish myrrh," which a generation ago was a favorite brand, was simply a carefully selected quality exported viâ Turkey. Either at Aden or in Bombay the myrrh is picked and assorted, yet when it leaves those places it commonly contains a considerable percentage of spurious or inferior fragments.

Description.—In irregular, more or less rounded nodules or tears, from 2.5 to 10 cm. (1 to 4 in.) in diameter, the surface more or less roughened by nodules and small cavities, as though eroded, red-brown, dull, and more or less gray from adhering powder; heavy, hard, and rather tough-splintery in fracture, the freshly fractured surface of a waxy lustre and oily feel, red-brown, usually variegated by gray crescent-shaped spots and intersecting lines; thin fragments translucent, usually strongly so; strongly and agreeably aromatic, the odor characteristic; the taste bitter and somewhat acrid, and producing a hardening and slight wrinkling of the mucous membrane of the mouth, though different from the astringency of tannin; readily powdered when cold and dry, but with difficulty when warm and damp; the freshly fractured surface, moistened with alcohol, colored purplish, as is the brownish-yellow alcoholic tincture, by nitric acid (distinction from bdellium); yielding a brownish-yellow emulsion with water; the ten-per-cent. ethereal extract acquiring a violet color in the presence of bromine vapor; if six drops of a seven-per-cent. petroleum ether extract be mixed with 3 c.c. of acetic acid, and 3 c.c. of sulphuric acid be then added, forming a heavy lower layer, the latter takes only a light rose color, which does not deepen (*distinction from Bissabol myrrh*); not more than seventy per cent. should be insoluble in alcohol, and the ash should not exceed six per cent.

Constituents.—Good myrrh consists of from two to five per cent., or occasionally more, of the volatile oil *myrrhol*, and from twenty-five to forty per cent., rarely nearly fifty per cent., of resin, the remainder being mostly gum, with a very small amount of a bitter principle, and from two to six per cent. of ash. In "drossy myrrh," the earthy matter increases the ash, frequently to fifteen per cent. or more. In the poorer grades of myrrh the amount of gum is larger, at the expense of the resin. Myrrh resin is a complex substance, the composition of which is not fully understood. Myrrh oil, which is sold for use in perfumery, is yellow or greenish-yellow, thick and viscid, and almost as heavy as, rarely appreciably heavier than, water.

Action and Uses.—Myrrh is essentially an aromatic stimulant, with slightly bitter properties, and a mild disinfectant. Its stimulant properties are especially active on mucous or raw cutaneous surfaces with which it comes into contact, so that it is a favorite ingredient of mouth washes, hardening the gums and acting like a mild astringent, and an excellent cleansing and stimulating application to ill-conditioned sores, for which purpose the tincture is diluted to about one-fourth strength. Combined with cathartics, it enhances their activity and is at the same time somewhat carminative. When administered internally it acts as a mild stimulating expectorant and diuretic, through its respiratory and renal excretion. In connection with the latter mode of elimination, it acts as a stimulating emmenagogue. It has from ancient times been credited with specific emmenagogue properties, but these effects have probably been largely imaginary. In all its internal uses it is almost invariably combined with other drugs, as in the pills and the tincture of aloes and myrrh, the pills of iron and myrrh, the compound iron mixture, etc.

The principal preparation of myrrh is the official twenty-per-cent. tincture, the dose of which is 1 to 4 c.c. (fl. ʒ ¼ to i.). The Tinctura aloes et myrrhæ contains ten per cent. each of aloes, myrrh, and liquorice root, and the dose is 4 to 8 c.c. (fl. ʒ i. to ij.). The Pilulæ aloes et myrrhæ each contain 0.13 gm. (gr. ij.) of aloes, about half as much myrrh, and one-third as much aromatic powder, the dose being from two to eight pills. The Mistura ferri composita contains 1.8 per cent. of myrrh, 0.6 per cent. of ferrous sulphate, 0.8 per cent. of potassium carbonate, and 6 per cent. of spirit of lavender, with sugar, etc.

Allied Substances.—*Bdellium* (elsewhere considered) is very similar in composition and properties to myrrh, but is very inferior, being less aromatic and one of its varieties being devoid of bitterness. The myrrh of the Bible is not our myrrh, but the Balm of Gilead or Mecca balsam, from *Commifera* ("*Balsamodendron*") *Opobalsamum* (Kunth.) Engler, now rarely seen in commerce. *Henry H. Rusby.*

MYRRHOLIN—a solution of equal parts of tincture of myrrh and castor oil, is used as a vehicle for creosote in tuberculosis. *W. A. Bastedo.*

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MYRTOL.—A constituent part of the essential oil, derived by distillation, from the leaves of *Myrtus communis* L. It is supposed closely to resemble eucalyptol. It is a clear liquid with a powerful but not unpleasant aromatic odor. It is recommended as a disinfectant and deodorant, but has no bactericidal action. In medicine it is used to replace the balsams in bronchitis, blennorrhagia, and vaginitis. In small doses it improves the digestion and stimulates the appetite, but in larger doses it irritates the stomach. Dr. Solomon Solis-Cohen has reported favorably of its use in subacute and chronic affections of the respiratory tract. It is administered in doses of from two to five minims, in capsules, repeated two or three times a day. *Beaumont Small.*

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MYXŒDEMA.—A chronic disturbance of nutrition characterized by accumulation of mucin in the subcutaneous tissue and caused by loss of function of the thyroid gland. Abundant evidence has proven that myxœdema of adults, cretinism, and the cachectic condition following removal of the thyroid gland for goitre represent the same morbid process occurring under different circumstances. Numerous experiments have demonstrated that similar conditions can be produced in lower animals by removal of the thyroid gland.

Removal of the Thyroid Gland in Lower Animals.—That the thyroid gland is essential to normal metabolism and even to life was shown by Schiff as early as 1859. Its removal is followed either by the acute symptoms known as tetany or by a chronic disturbance of nutrition, myxœdema. Within a few days, often a few hours, after extirpation of the gland in dogs, the animal is seized with tetanic contractions of the voluntary muscles accompanied by active tremor, and death follows, often caused by interference with respiration. In sheep, goats, and monkeys, rarely in dogs, death does not follow these acute symptoms, though this may occur, but a chronic condition supervenes; the animal becomes dull and apathetic, nutrition suffers, and the skin is dry and the hair falls out. The subcutaneous tissue becomes swollen and by chemical examination has been found to contain mucin in greatly increased quantity. Horsley has performed numerous experiments on monkeys; these animals survive the symptoms of tetany which frequently follows the operation, and within a few weeks or months develop in typical form the chronic condition described. The temperature becomes subnormal and exposure to cold hastens the progress of the disease.

Extirpation of the thyroid gland in young animals has a remarkable effect, observed by von Eiselsberg in sheep and goats and by Hofmeister in rabbits. Development is retarded and the animal remains small and stunted in appearance. The growth of the long bones is hindered by interference with the normal transformation of cartilage into bone. The undeveloped animal, like the adult, after extirpation of the gland becomes dull and inert and mucinous material accumulates, particularly in the subcutaneous tissue.

Extirpation of one half of the thyroid gland does not cause the conditions described, but if considerably more than half is destroyed nutrition may suffer, though in some instances little effect has followed when only a sixth of the gland was retained. After partial removal that part which remains, together with accessory thyroid bodies which are not infrequently present, undergoes hypertrophy and replaces the extirpated parenchyma. Schiff first showed that if thyroid tissue were successfully transplanted into the peritoneal cavity of a dog, the thyroid gland of the animal might be removed without fatal effect. Numerous experiments have shown that both tetany and myxœdema may be prevented by transplantation of thyroid tissue. Vessale, moreover, demonstrated that injurious consequences of the operation could be retarded or prevented by the intravenous or subcutaneous injection of an extract made from the gland obtained from other animals, and it was subsequently found that equally beneficial results could be produced by feeding animals with the raw gland or with dried extracts made from it.

Removal of the Thyroid Gland in Man: Operative Myxœdema.—In 1882 Reverdin described certain changes which follow total removal of the thyroid gland for goitre, and the following year, under the name cachexia strumipriva, Kocher described a chronic condition following thyroidectomy. The results which follow loss of thyroid function in man do not differ from those observed in lower animals. Symptoms do not follow partial removal of a goitre if a considerable mass of parenchyma still remains, while in some instances their absence is due to the presence of an accessory thyroid gland which undergoes hypertrophy. In some cases acute symptoms almost immediately follow the operation. The muscles, particularly those of the upper extremity, undergo tonic contractions accompanied by tremor; such attacks may be of mild intensity, but at times are of great severity, causing opisthotonos and death by implication of the diaphragm. More frequently, however, extirpation of the gland is followed by chronic symptoms which sometimes appear shortly after operation, but may not manifest themselves for months. The patient becomes apathetic and indisposed to exert himself, mental actions are slow, and voluntary movements are performed languidly. The temperature is subnormal and the patient feels cold. The subcutaneous tissue of the face and extremities becomes swollen and œdematous in appearance, but does not pit on pressure. The skin is dry, the hair falls out, and the physiognomy assumes the appearance which, as will be pointed out, is observed in cases of myxœdema occurring idiopathically. The symptoms are analogous to those which follow thyroidectomy in lower animals.

In a case described by von Brunn a goitrous thyroid gland had been removed at the age of ten years, eighteen years before death. Development had been arrested and the dwarfed individual, who presented the appearance of a cretin, had the mental characters of an imbecile. Similar cases have been observed.

Myxœdema of Adults.—In 1873 Sir William Gull, in a paper "On a Cretinoid State Supervening in Adult Life in Women," described the symptoms of a disease to which Ord, several years later, gave the name myxœdema, since its most conspicuous feature is an œdema-like swelling of the skin caused by accumulation of mucin in the subcutaneous tissue. The resemblance between myxœdema, cretinism, and the cachectic condition following extirpation of the thyroid gland was soon recognized and was fully elaborated in the exhaustive report upon myxœdema published in 1888 by the Clinical Society of London. Numerous experiments upon animals, already referred to, have been undertaken in order to explain the pathogenesis of this disease, and have been so successful that an efficient therapy has been established within thirty years following its recognition.

Myxœdema of adults may occur at any age, but most frequently affects individuals between the ages of thirty and fifty years. The disease is much more common in women than in men, the ratio being about five to one. Heredity plays a part in its occurrence and several cases have been observed in the same family. Occasionally myxœdema has followed exophthalmic goitre, a disease in many respects the antithesis of myxœdema, while in one instance myxœdema has been observed in a woman whose daughter suffered with exophthalmic goitre.

Pathological investigation has shown the constant occurrence of a destructive lesion of the thyroid gland. The organ is diminished to one-half or even to one-fourth of its normal size; the tissue is pale and tough. By microscopic examination the interstitial tissue is found increased at the expense of the glandular alveoli, which are atrophied and in part destroyed; the gland is the seat of chronic interstitial inflammation comparable to cirrhosis of the liver or to chronic interstitial nephritis. Carcinoma and actinomycosis affecting the gland have in rare instances been associated with the disease. The subcutaneous tissue is distended and spaces occasionally occur

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between the bundles of connective-tissue fibres, while late in the disease there is evidence of proliferation of fibrous tissue associated with atrophy of the sebaceous glands and hair follicles. The amount of mucin present in the subcutaneous tissue varies in different cases, and at a late stage of the disease may diminish in amount. In a case studied by Cranston Charles it exceeded the normal fifty times. The parotid gland and certain other tissues have been found to contain an increased quantity of mucin.

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The symptoms of myxœdema are characteristic and in most cases the condition can be readily diagnosed. The onset of the disease is usually very gradual, but occasionally within a few weeks it is recognizable. There are at first languor and disinclination to exertion, associated with slowness in the performance of voluntary movements. The patient feels cold readily and may suffer much in winter. Myxœdematous swelling of the subcutaneous tissue is observable first in the face, the physiognomy assuming a characteristic appearance which produces a certain likeness among those affected with the disease. The features become coarse and broad, the lines of the face are smoothed out, and the face assumes a stolid expression. The lower eyelids are puffy, the lower lip is thickened and often everted, the nostrils are broadened. Subcutaneous swelling occurs in other parts of the body, the extremities being at times most markedly affected; the hands and feet are broad and clumsy. This œdema-like swelling has a solid character, and, unlike ordinary œdema, does not pit on pressure. The body weight increases in proportion to the gradual swelling. The skin is dry and the nutrition of its appendages suffers; the hair becomes dry and brittle and falls out and the nails are stunted.

The subjective sense of coldness is associated with a subnormal temperature, which not infrequently falls to 95° F. or even lower. The disease is said to progress more rapidly in winter than in summer, and an important factor in its treatment is exposure to a warm temperature. Slowness of mental action is a constant feature of myxœdema and memory becomes defective. The temper is usually remarkably placid, but is occasionally irritable, and dementia is by no means uncommon. Hemorrhages from the gums or nose or from the uterus during menstruation or after pregnancy are not rare. The circulatory, the digestive, and the urinary systems exhibit no characteristic alterations, though albuminuria often occurs. The functions of the sexual organs undergo no constant change, and the greater frequency of myxœdema in women has not been referable to changes in the female organs of generation. Patients with myxœdema seldom become pregnant, but in exceptional instances the myxœdematous condition has been found to improve during pregnancy.

The progress of the disease is very slow and the patient may survive ten, occasionally even thirty years. Death usually occurs with some intercurrent affection, not infrequently tuberculosis or nephritis.

Cretinism or Myxœdema of Childhood.—No essential difference exists between the disease myxœdema and the condition known as cretinism, save that the latter occurring during the early years of life is associated with arrest of development. Endemic cretinism occurs in Switzerland and in certain other countries, particularly in the deep valleys of high mountains where goitre is prevalent. Sporadic cases occur in the United States and elsewhere. The disease, affecting females more frequently than males, usually develops before the fifth year. Lesions of the thyroid gland which cause destruction of its parenchyma and which are analogous to those of myxœdema in adults, occur. In cases of sporadic cretinism the gland is undeveloped or atrophied. In about two-thirds of the cases of endemic cretinism there is a goitre-like enlargement, but doubtless the functional ability of the gland is much diminished; in one-third of the cases the organ has been found absent or atrophic.

The condition of the affected child is analogous to that produced in lower animals and in young children by the operative removal of the thyroid gland. The stature is dwarfed and the limbs are short and thick. There is a corresponding arrest of mental development, so that the intelligence may not be greater than that of a child three years of age, while in many instances there is complete idiocy. The subcutaneous tissue is the seat of solid œdema, giving the features a coarse, repulsive aspect. Not infrequently cretins live to adult age or even to middle life, retaining their dwarfed condition of body and mind.

Treatment.—Experimental pathology and pathological anatomy, having demonstrated the identity of so-called idiopathic myxœdema and cretinism with the disturbance of nutrition which follows operative removal of the thyroid gland, have at the same time furnished an efficient method of treatment. The thyroid gland performs some function essential to normal metabolism. The effects which follow removal or destruction of the gland can be prevented by supplying to the body thyroid tissue or its products derived from another individual not necessarily of the same species. It has been found possible to transplant thyroid tissue, preferably that of the sheep, into the subcutaneous tissue of patients suffering with myxœdema, occurring spontaneously or as the result of operation for goitre, and well-marked improvement lasting for several months has followed. The transplanted tissue undergoes partial vascularization and functions like the normal gland, but atrophy occurs and the improvement is only temporary. Subcutaneous injection of extracts made from the thyroid gland was introduced by Murray, who employed with success a glycerin extract made from the thyroid gland of the sheep. Products of the gland administered by mouth have been found equally efficient, and the effects differ little whether the gland is ingested raw, partially cooked, dried and powdered, or in the form of a glycerin extract. The glycerin extract or the dried powder prepared as tablets is most conveniently used, the dose varying with different preparations. Toxic symptoms may follow the administration of too large quantities.

The effects of treatment in cases both of spontaneous and of operative myxœdema are remarkable. Within a few weeks subcutaneous swelling disappears, the face loses its stolid expression, and there is a rapid diminution of body weight. The mental condition improves and the temperature becomes normal. The treatment of cretinism has proved almost equally successful. With administration of thyroid extract the skin soon becomes normal in appearance and intelligence improves; growth occurs with surprising activity and the height may increase several inches during the first year. When treatment is begun at an advanced age its effects, as might be expected, are less satisfactory. In the treatment of all forms of myxœdema it is necessary to continue the administration of thyroid products after the disappearance of all symptoms, since throughout the remainder of life it is necessary to supply the deficiency caused by the absence or destruction of the thyroid gland.

Eugene L. Opie.

MYXOMA.—The name myxoma, or tumor composed of mucous tissue, was first used by Virchow, who separated from the other connective-tissue tumors a special class of formations to which he gave this name. Before this they had been described under various names, which generally had reference to the soft and jelly-like character of the growth. Laënnec gave them the name colloid, because the soft, trembling, gelatinous character of the tissue reminded him of partially solidified gelatin. Those tumors described by Johannes Müller under the name gelatinous tumor, or collonema, belong in this category, although the latter name seems also to have been used for soft tumors of other sorts, as the soft fibromas, etc. Paget has described them under the name fibrocellular tumors.

Virchow distinguished as a separate variety of the connective tissue, *mucous tissue*, which was characterized by containing in the intercellular substance a quantity of mucin. This tissue was most developed in the fœtus,

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where it formed the jelly of Wharton in the umbilical cord, and was also abundant in the subcutaneous tissue. In the subcutaneous tissue it afterward became converted into fat, and when it was found elsewhere in the body Virchow regarded it generally as an antecedent to fat formation. Its cells either take up fat directly, and so become changed into fat cells, or they proliferate and the young cells so formed become fat cells. In the adult tissues it occupies but a small field, being found only in the vitreous body of the eye and in the subcutaneous tissue in a few places, here principally over the pubes. Histologically the tissue consists of cells embedded in a homogeneous matrix. The cells may be of various shapes, round, spindle-, or star-shaped. Generally they have the latter form, and are abundantly provided with processes which freely anastomose with the processes of neighboring cells, and form a fine meshwork through the tissue. On section of the tissue abundant fluid escapes, which has the same properties as those fluids which contain mucus. The mucin in the ordinary secretions of mucous surfaces is the result of the action of the epithelial cells, and is formed in them; but in the mucous tissue it is not found in the cells, but in the intercellular substance. The mucin contained in the fluid has some of the chemical properties of albumin, but can be distinguished from it in various ways. On the addition of alcohol to fluids containing mucin, there is formed an abundant precipitate, which can be distinguished from the albuminous precipitate, formed in like manner, by the fact that it swells up and dissolves on the addition of water. The albuminous precipitate is not affected by water. Mucin is not dissolved by an excess of the organic acids, but is readily soluble in an excess of mineral acids.

The result of later investigations has been to throw much doubt on the existence of mucous tissue as a distinct type of tissue, such as Virchow has described it. Even in the place where he supposed it to be most typical, *i.e.*, in the umbilical cord, it has been shown that this is only ordinary connective tissue with an abundance of fluid in its meshes. A tissue almost analogous to mucous tissue is found in every subcutaneous œdema, and can be produced artificially by puncturing the skin with a fine hypodermic needle and injecting salt solution. A doughy swelling is so produced, and on section the injected fluid will not flow out again, but is held in the meshes of the tissue and along the fibres. On microscopic examination of sections, made by clipping out a piece of the swollen tissue with a pair of sharp scissors, the cells are found separated from one another, often anastomosing, and the fibres of the connective tissue do not appear so prominent. The fact that the supposed mucous tissue of Virchow contains mucin cannot be held as peculiar to it, and as distinguishing it from other forms of connective tissue. Mucin is found in all the connective tissues, and the gelatinous œdematous tissue does not contain any greater proportion of it than do other tissues of its class. The fatty tissue which Virchow supposed to be developed from the mucous tissue does not stand in any immediate connection with this, but, according to Ranvier, takes its origin from cells which from the beginning are destined to form fat cells

Following this, Rumler and Koster have taken the ground that the myxoma is not to be considered a special type or class of tumors, but that it simply represents conditions which might arise in any of the tumors which contain connective tissue. This myxomatous condition of the connective tissue consists in its saturation with serum in consequence of circulatory disturbances in the tumors, passive congestion, etc. They regard this tissue, wherever found, simply as ordinary connective tissue infiltrated with fluid, or œdematous. In every tumor there can be numerous conditions which might give rise to this. The veins can easily be compressed by the growth of certain parts of the tumor, and we cannot suppose that the vessels of a tumor of any sort are less prone to allow of transudation, in case of passive congestion, than those of any other tissues. On the contrary, it seems probable, from the numerous areas of small-cell infiltration in tumors of every description, and from the frequency with which red corpuscles are found in the tissues, that the vessels are easily traversed by the corpuscular elements of the blood, and where this is the case the fluid elements pass through also. The serum would be most readily taken up in the meshes of the connective tissue, enlarging these, and the connective-tissue fibres would be forced apart and rendered less distinct. The fact that we scarcely ever find a pure myxoma, such as Virchow has described, but almost always this so-called myxomatous tissue in connection with some variety of the tumors which contain connective tissue, as fibroma, sarcoma, carcinoma, etc., speaks much in favor of the correctness of this view of Koster. Still the term myxoma or myxomatous tissue, to denote this swollen and œdematous connective tissue, is a convenient one and will be retained, although the myxoma, in the light of these recent investigations, should occupy no place in the category of tumors. The myxoma was first described by Virchow, and his descriptions of it are in all respects so full that they have undergone but little modification by subsequent writers on the subject. The writer has thought it best after this preface, which sheds a clearer light on what has been a complicated subject in *onkology*, to give, in the main, Virchow's description of the tumor.

The cells in the tumor vary in shape and in numbers, this variation depending chiefly on the stage of development of the tissue. The younger the tissue is, the more the cells are inclined to be round and the more numerous they are. In the older portions the cells are rather star- or spindle-shaped, and have numerous processes which communicate freely with one another, producing a reticular or areolar tissue, in the meshes of which round cells are frequently enclosed. When these cellular elements are fewer in number, the whole tissue has a transparent, gelatinous appearance, and is similar to the vitreous body of the eye. This forms the variety *myxoma hyalinum*. Virchow has described several other varieties, which depend on various, for the most part minor, differences in the structure of the tumor.

Myxoma Medullare.—In this the cells are more abundant, and this gives the tumor a whitish, opaque, medullary appearance.

Myxoma Fibrosum.—In this the tumor contains a considerable amount of fibrous tissue, especially elastic fibres, which often form dense bands which appear on the cut surface.

Myxoma Lipomatodes or Myxo-lipoma.—In this the tumor contains a considerable amount of fat, either in the shape of small drops contained in the cells or as fully formed fat cells. There may be so much fat present that the tumor has most of the characteristics of lipoma.

Myxoma Cartilagineum or Myxo-chondroma.—A large proportion of the myxomata contain islands of cartilage. This is especially the case in the compound tumors of the parotid gland and of the testicle.

Myxoma Cystoides.—In some cases the cells of the tumor enclosed in the mucous tissue undergo mucous or fatty degeneration, and there are formed large cavities filled with viscid fluid.

Myxoma Telangiectodes.—As is the case with most tumors, the vessels here also may be enormously developed, and this name has been given to the condition.

Mucin is found in numerous other tumors, as a result of the physiological activity or of a degeneration of the tumor cells. It is found, for instance, in the cystic tumors of the ovary and in most other epithelial cysts. Virchow excludes these from the myxomata, and has limited this term to those tumors in which the mucin is contained in the interstices of the tissue and forms an integral part of the tumor. Billroth has included with the myxomata all such tumors, among them goitre. Just as the most typical formation of mucous tissue is found in the fœtus, the most typical examples of myxomata are found in tissues belonging to the fœtus. The myxoma of the chorion, forming what has been termed mole pregnancy, is the most typical example of this myxoma. Abortion takes place in this case at an early period, and

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the chorion will be found covered with transparent, gelatinous vesicles, which are connected with the membrane by a narrow pedicle. Sometimes several of these vesicles are connected with the same pedicle, and are strung along it like rows of beads. The vesicles vary in size from a pin's head to a nut. On microscopic examination they are found to be covered with epithelium, and composed of a tissue similar to that of the umbilical cord, *i.e.*, branched cells lying in a homogeneous matrix. Other parts of the fœtal appendages may be the

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FIG. 3476.—Section of a Myxoma of the Subcutaneous Tissue of the Thigh. × 300.

seat of similar formations. Cases have been seen in which the umbilical cord contained along its course a series of such vesicles. Also in the placenta itself there may be an abundant formation of mucous tissue in the form of circumscribed tumor masses. Retained portions of the placenta may form the starting-point of tumors which reach a considerable size.

In the adult the subcutaneous cellular tissue is the most frequent seat of the myxomata. Here they are principally found on the thigh, on the buttocks, on the labia majora, and on the lower lip. The fat in the orbit may be a point of origin for the tumor. Such tumors may reach considerable size; those of the size of a child's head have repeatedly been seen. These large myxomata have a distinctly lobular structure, and when they break through the skin they become ulcerated and often very foul. They may have a deeper origin, as from the intermuscular tissue. In some localities, where the skin covering them is not tense, they become distinctly pedunculated.

The long bones are often the seat of this tumor. In this place it seems to originate in the bone marrow. In these tumors various combinations, as with sarcoma and enchondroma, are seen. The spongy osteomata, with soft cellular marrow, may be confounded with them. The pure myxoma of the bones is a soft, spongy tumor, which ordinarily originates in the bone marrow, and in the course of its growth becomes covered with a thin shell of bone. At a later stage it breaks through this and grows as a soft mass. It is always accompanied by a new growth of bone, is generally lobulated, and here and there portions of the old bone may be enclosed in its substance. The tumor is soft and grayish-white or yellow. Virchow compares its tissue to the flesh of oysters. An abundant formation of blood-vessels may give a reddish tint to the tumor.

The myxomata often have a heteroplastic origin, and in these cases the starting-point is most frequently located in the central nervous system. A considerable proportion of the brain tumors belong in this category, especially those of the cerebral hemispheres. The dura mater of the brain and cord may also be the place of origin.

When seated on the peripheral nerves the tumor does not originate in the neurilemma, but in the interstitial tissue. Such tumors along the nerves are often mistaken for neuromata. They give rise to severe neuralgic pains, and are often multiple. All the nerves of an extremity may be affected, in some cases several being seated on a single nerve trunk. In many cases the nerve does not pass into the substance of the tumor, but over it, and is generally flattened from pressure. It is often possible to dissect out the nerve from such a tumor and remove the tumor, leaving the nerve intact. The consistence of these tumors is so soft that they may be easily mistaken for cysts. They have a tendency to return after removal.

Myxomata may also be found in the glandular organs, where they arise from the interstitial tissue. Such tumors are found in the female breast. The tissue of the tumor grows into the milk ducts in the form of polypoid masses. The duct becomes dilated into a cyst, which is filled with the branching growth. The whole tumor may in this way be enclosed in one large duct, and may be removed from it, leaving a cavity with smooth walls. On microscopic examination the section often appears to be composed of small islands of myxomatous tissue surrounded by epithelium. The islands of tissue are the cross sections of the branching dendrate growth in the duct. This manner of growth is not peculiar to the myxomas of the mamma, but is seen also in fibromas and sarcomas in the same locality. The tumor finds the least resistance to its growth in the milk ducts, and grows into and dilates these. Jungst has recently described one of these tumors in which a great part of the tissue had undergone hyaline degeneration. When the superficial ducts are the seat of this growth, the tumor may project as a nodular mass from the breast. This is particularly apt to take place in the region of the nipple. The skin covering the tumor becomes thin and finally breaks, and a soft, fungous, often gangrenous mass appears. This may have an appearance very similar to that of an ulcerated cancer. If it is closely examined, spaces may be found in which a probe may be pushed deeply down between the single masses of which the tumor is composed.

The mixed forms of the tumor deserve especial attention, for they are much more common than the pure forms. They are most apt to be seen with tumors of the connective-tissue type, as the fibroma and sarcoma, but may be found with any tumors which contain connective tissue. In the spindle-cell sarcoma the tissue may be seen to pass into myxoma. The cells become separated from one another by an increase in the interstitial tissue and lose their spindle shape. In carcinoma the most typical mucous tissue may be found between the masses of epithelial cells. These mixed forms have been given special names, as carcinoma myxomatodes, etc. The fact of the presence of such tissue in a carcinoma or sarcoma does not influence the growth of the tumor, nor its prognosis, but may lead to errors in diagnosis. Wherever this tissue is present the tumor is softer. The mixed tumors of the parotid gland always contain a considerable quantity of myxomatous tissue.

In general the tumors described as myxomata are not malignant. Some, however, are. Those of the central nervous system are malignant from their position, and those of the peripheral nerves have a tendency to multiple formation and to return after extirpation.

The best and most typical pictures of this tissue are to be obtained by examining fresh sections made by the freezing microtome in salt solutions. After the tumor has been hardened in almost any of the hardening agents, the tissue loses its fluid and shrinks very much.

W. T. Councilman.

NÆVUS.[1] — (Greek, *σπίλος*, *σπίλωμα*; French, *næve*, *couenne*, *envie*, *signe*, *tache congenitale*, *ou pigmentaire*, *ou de naissance*; German, *Mal*, *Muttermal*, *Muttermahl*, *Mutterflecken*; Italian, *neo* [*materno*], *nevo*; Spanish, *nevo*, *lunar*.) (Synonyms: Mother's mark, birthmark, etc.)

DEFINITION.—A nævus is a congenital alteration of the skin, confined to a limited area and characterized by an increase in the amount of pigment deposit, and by a certain amount of hypertrophy of one or more of the other elements of the skin, especially the vascular and connective tissues, as well as the hair, fat, nerves, and

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lymphatics. Unna[2] aptly describes nævi as: "Circumscribed, small malformations of the skin, which have a hereditary basis, or have their foundations laid in embryonic life, become evident at different periods of life, develop very slowly, and are distinguishable by their color or the form of their surface."

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The following varieties of nævi may be distinguished: *Nævus fibromatosus; N. lipomatodes; N. pigmentosus; N. pilaris* or *pilosus; N. unius lateris* (*N. linearis*)*; N. vascularis; N. verrucosus.*

Nævus fibromatosus is marked by excessive connective-tissue development; it varies in size and involves the skin in different parts of the body. As subdivisions may be mentioned: N. foliaceus, in which the central portions are fibrous, while the circumference is vascular; N. mollusciformis, a protuberant pedunculated form (Fig. 3477); and N. sarcomatodes, which at first is a simple congenital nævus, but afterward undergoes sarcomatous degeneration.

Nævus lipomatodes is a congenital fatty tumor (lipoma), usually more or less fibromatous.

Nævus pigmentosus, the commonest form of nævus, is characterized by an excessive deposit of pigment in a circumscribed area of the skin. The discoloration thus produced varies from pale yellow to purple or even black. The lesion, which is usually level with the skin, occurs especially on the face, hands, neck, arms, and back. This variety of nævus is often verrucose, or elevated; at times it is more or less covered with hair and is then designated as *Nævus pilosus* or *N. pilaris*.

Fig. 3477.—Case of Angio-Fibroma of Congenital Origin. (Case of Dr. Isadore Dyer.)

Nævus vascularis, N. sanguineus—"mother's mark," includes a large number of forms, among which are now classed varieties of angiomata, which embrace tumors of embryonic rudimentary vessels.

The vascular nævus may involve the capillaries, the smaller veins, or the terminal arterial branches.

The capillary nævus is distinctly cutaneous and in size varies from a pin's head to the palm of the hand or even a larger area; at times it involves whole regions of the body. This is the form of nævus most commonly met with. It is usually only slightly elevated, or it may even be level with the surface of the skin. It is often seen as a tiny red spot with lines (dilated capillaries) radiating from a central point of vascular hypertrophy, and to it are applied the terms "spider nævus," or "spider cancer," or *nævus araneus*.

Vascular nævi often begin indistinctly and spread gradually until they cover large surfaces. On the other hand, nævi, present at birth, may within a few months entirely disappear spontaneously.

The venous nævus is apt to be more elevated than the capillary. It is smooth, stands at a higher level than the surrounding surface of the skin, is soft and compressible, and often is lobulated. The thin-walled veins of which it is composed communicate directly with one another and are bound together by delicate bands of connective tissue, thus constituting a network of intercommunicating venous sinuses. Such a formation should be called a nævus cavernosus or an angioma, for such in reality it is. These tumors are markedly irregular in form, reddish or bluish in color, and at times erectile (in women this is especially noticeable at the time of menstruation).

Although there have been reported many instances of congenital nævi which seem to confirm the belief that prenatal events, through the impressions which they make upon the mother, sometimes play a part in the causation of these tumors, the best modern authorities are opposed to this view.

Nævus Verrucosus.—A warty nævus, often having a hairy growth, and at times highly vascular and erectile.

Nævus unius lateris is excluded, by Unna, from the nævi, but only provisionally. I am disposed to believe that this type of growth may properly be classed among the nævi. It embraces a number of types of nævus, in which the essential feature is the arrangement in a linear way following the distribution of the superficial nerves. Some attempts have been made to show the association of this form of nævus with previous neurotic influence, injury, shock, etc. The terms N. neuroticus, N. linearis, papilloma neuropathicum (neuroticum), etc., have been applied to this type. That the term *unius lateris* is a misnomer is evident from the fact that the author has had two cases of bilateral distribution. To these he has given, by preference, the name "linear nævus."

It is certain that there is a distinct difference in the arrangement of the lesions between this variety and the ordinary nævi. The arrangement is in sprays and clusters of lesions, which vary in character, some of them having a pale yellow pigmentation, while others are black. Then again there are also differences in structure, some of the growths being clearly vascular nævi while others

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are mere papillomatous growths. In some cases there is even involvement of the lymph vessels (lymphangioma) (see Figs. 3479 and 3480).

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FIG. 3478.—Vascular and Verrucose Linear Nævus of the Cheek. (Case of Dr. Isadore Dyer.)

The PATHOLOGY of nævi is of only indirect importance, as the condition is not difficult of diagnosis and the treatment is essentially radical.

Unna (*op. cit.*) quite exhaustively reviews the histological evidence in regard to the different types of nævus, and discursively argues the embryonic origin and course of the several varieties classed by him under the term nævus. Soft nævi, or the warty, epithelial types, are recognized as embryonic deposits in the upper part of the cutis, while the hard nævi are either of prickle-cell layer origin or else are found chiefly in the horny layer. The more complicated nævi are also considered by him in their complex pathology.

TREATMENT.—The necessity for treatment of nævi must depend upon the character, the location, and the size of the lesion or lesions. Simple pigmentary moles are of little serious importance, and, on account of their harmless character, they need not be removed. In exceptional cases the melanotic mole calls for early operative interference. Even the simple moles, when there are several of them, often cause sufficient disfigurement to warrant their removal by surgical interference. Hairy moles are especially disfiguring. In the case of vascular nævi, on the other hand, the danger of accidental hemorrhage must also be taken into consideration.

There are not a few different ways in which nævi may be treated. For the simple pigmentary moles and also for those of a verrucose character the employment of escharotics will often suffice. Of these we might name carbolic acid, chromic acid, glacial acetic acid, picric acid, acid nitrate of mercury, corrosive sublimate, cantharides (in collodion or in ether), pyrozone, sodium ethylate, nitrate of silver, nitric acid, salicylic acid (alcoholic solution or in collodion), chrysarobin, chrysophanic acid, pyrogallic acid, liquor potassæ, etc.

In the case of large lesions, or where the location forbids the use of caustic applications, the actual cautery —the Paquelin or the galvanic—should be used.

In small pigmentary nævi electrolysis is preferable. To the negative pole of a galvanic battery a small needle (steel, platinum, or gold) is attached. The positive pole carries the sponge, which is customarily held in the patient's hand. The needle is introduced beneath the pigmented mole and the current is gradually increased until the lesion blisters. To accomplish this a current of about 8 or 10 milliampères is required, or, if cells with switch-board are used, there should be as many as from twelve to twenty cells. Where the moles are hairy, a blunted broach or needle should be employed. The hairs are removed first by electrolysis, and then the mole itself is removed by the ordinary operative procedures. In removing the hairs the needle should be gently introduced into the hair follicle, the hair shaft serving as a guide and care being taken not to pierce the follicle. The current is gradually applied until there is frothing at the orifice of the follicle, when the hair is ready to come away. If there is resistance on the part of the hair, the operation is not complete. Not more than from 3 to 5 milliampères is needed in this operation; in fact, in some instances a single milliampère will be found sufficient. The negative pole of course must be used here.

In the treatment of vascular nævi, electrolysis is likewise of service, but more particularly in those in which the area of skin involved is small, and the vessels forming the growth are simply capillaries. The object of the treatment here is either to cause the absorption and atrophy of the blood-vessels or to effect their destruction. Various procedures, all of them more or less inefficient, have been suggested for the accomplishment of these objects, but as the space at our command is limited, we shall describe only those which have stood well the test of time.

There are two methods for using the ligature. First of all, it is a good plan in smaller nævi to circumscribe the growth with a single or double silk ligature, drawing tightly and tying on opposite sides of the growth, when the double ligature is used. In the case of the larger nævi, the ligature is applied at a point a little remote from the growth. An incision is made above the vein, or small artery, a catgut ligature is applied, and the wound closed. In either instance the growth begins to pale after several days. In superficial nævi the whole patch grows bluish in color. Here and there a spot grows white where the blood has been absorbed, and finally, in the successful cases, the whole patch grows whiter and whiter. When it is thought best to resort to excision, as in the case of deep-seated nævi, it will often be found advisable to ligate a few days or weeks before the excision. When the cautery is employed, several methods may be followed. A fine platinum needle may be attached to the galvano-cautery, raised to a red heat, and then introduced into the growth several times in succession. Linear cauterization may equally well be carried out by means of the needle or with the small plat-

FIG. 3479.—Right Side.

FIG. 3480.—Left Side.

FIGS. 3479 AND 3480.—Linear Nævus: Verrucose, Deeply Pigmented, and Affecting Different Parts of the Surface of the Body. (Case of Dr. Isadore Dyer.)

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inum knife. The Paquelin cautery will serve the same purpose.

Caustic pastes (Bougard, Felix, Marsden, etc.) act as the cautery does, by producing an eschar, and finally a slough. With caustics, however, the slough is apt to be more extensive than when the cautery is used. Hence the need for caution in using them.

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Vaccination has been used in locations where an irregular scar is no objection. The slight bleeding need not be stopped, except by a temporary compress.

The injection of pure carbolic acid or the tincture of iodine is followed quite often by gratifying results. Little scarring remains, plugging of the vessels is rapidly obtained, and the operation is less painful and of shorter duration than when other methods are employed. The injection of a one-per-cent. solution of chloride of zinc is used for the same purpose. The perchloride of iron may be used by injection, or, as is frequently indicated in the more elevated growths, silk threads, saturated with the perchloride solution, should be passed in several directions through the nævus, and be allowed to remain until they are absorbed in the contraction, or else slough out.

Except in the case of small nævi, the treatment is never highly satisfactory, and the methods employed may have to be changed several times before the whole of the growth is removed. It is always well to impress upon the patient the necessity of perseverance in the matter.

Where the patient will submit, the use of repeated ignipuncture with the Paquelin cautery under a general anæsthetic will effect good results; otherwise the electric needle is of most service. A number of cures have been reported after long use of electrolysis. For extensive nævi of the capillary variety, multiple needles (as many as a dozen) attached to the negative pole of the galvanic current may be employed. This does not answer so well as the single needle frequently introduced. The amount of current required varies with the patient and should be regulated accordingly, a mild current being used at the start.

The technique of this operation is as follows: The patient should hold the sponge electrode and should turn on the current when the needle is introduced and turn it off when the needle is withdrawn; or, if he does not mind the greater painfulness of the procedure, he should keep the sponge constantly applied. The needle may be pushed in to a depth of at least half an inch below the surface of the skin and parallel with it, and it should be allowed to remain until a distinct eschar, in the form of shrivelled skin, shows itself along the line of the needle. This procedure is to be repeated at each sitting as often as the patient will permit. As this linear operation almost always leaves ridges as the ultimate result, it is probably better to introduce the needle simply at a right angle to the surface of the skin, leaving it in position until a small blister forms. Several such punctures should be made at each sitting, and they should be located as closely together as possible. At each sitting, for a few succeeding days, a new area should be selected, and then each area in turn, beginning with the one first selected, should be gone over a second or even a third time, until finally the region so treated presents the appearance of a white superficial scar.

For the cavernous variety of nævus the electrolytic method is not so well adapted. In the treatment of this condition by electricity the positive pole is supplied with a platinum and the negative pole with a gold needle, or *vice versa*, and both are introduced at once, deeply. The strength of the current is gradually increased to the limit of the patient's endurance, and is kept applied as long as possible.

In both varieties of nævus it requires months of treatment before any result is obtained, but usually the patient's endurance is finally rewarded.

Isadore Dyer.

[1] Foster: Encyclopedic Medical Dictionary.
[2] Unna: Histopathology of Diseases of the Skin, Walker's translation, p. 1128.

NAFTALAN is a greenish-black, soft, gelatinous material, with a slight empyreumatic odor, and consists of 96 to 97.5 per cent. of a peculiar Russian naphtha, purified and mixed with anhydrous soap. It is readily miscible with oils, fats, ether, and chloroform, and is insoluble in water, alcohol, and glycerin. Kolbl found it of distinct value in minor skin lesions such as urticaria, scabies, psoriasis, burns, and bee stings. Bloch considers it almost specific in burns, but in psoriasis not so good as chrysarobin. Several authors report good results from its use in chronic eczema, though it is not recommended in acute eczema, or when the skin is moist. Skin parasites are destroyed. It is applied as a thick coat and does not melt at body temperature (melting point, 70° C. or 158° F.).

W. A. Bastedo.

NAILS, DISEASES OF THE.—TERMINOLOGY.—As the study of the nails demands its own vocabulary, it is necessary to define clearly the various terms which will be employed in this article.

The root or matrix is that part of the finger under the lunula from which the nail substance is formed.

The bed is that portion of the finger lying directly anterior to the matrix, which forms the floor on which the nail rests, but which plays no part in the formation of the nail.

The plate is what is commonly termed the nail. The lunula is the white, opaque, rounded part of the plate which lies over the matrix and under the eponychium.

The walls of the nail are those parts of the finger which lie along the sides of the plate.

The eponychium or "quick" is the horny layer which forms a selvage to the skin over the bed of the nail.

Pterygium is a forward growth of the eponychium over the plate.

Transverse or horizontal will signify the direction across the plate, while vertical will mean the direction from eponychium to free or distal border of plate, *i.e.*, the line in which the nail grows.

ANATOMY.—The normal shape of the plate is convex both horizontally and vertically. The vertical ridges which appear on many nails in youth and adult life, and which increase markedly in old age, are due to the presence of the papillæ in the underlying bed of the nail. The color of the nails should be a delicate pink, due to the subjacent capillaries which transmit their color through the normal, translucent plates above. The plate is composed of flat, polygonal, keratinized, nucleated cells between which are air spaces. Wherever these air spaces exceed their normal size the plate becomes opaque and white, a condition which is called leuconychia. The lunula is white in color because the underlying matrix is not supplied with vessels. On the thumb the lunula appears distinctly anterior to the eponychium, but on the other fingers it does not extend so far forward.

The nail bed is not sharply marked off from the adjacent parts of the finger, there is never a clearly defined boundary, and the contiguous parts blend into each other. The lower layer of the bed merges gradually into the periosteum of the last phalanx without the interposition of the panniculus adiposus. The blood-vessels are arranged in an upper and a lower layer as in other parts of the skin, and the lymph vessels are well marked.

EMBRYOLOGY.—The nail arises from the ectoderm and makes its first appearance between the third and fourth months of fœtal life.

GENERAL PATHOLOGY.—Disorders of the nail may be symptomatic of general infections of the skin or of the body, or may be simply local affections.

Inheritance.—Diabetes, tuberculosis, cretinism, eczema, psoriasis, or epidermolysis in the parents have been known to cause marked disturbances in the nails of the child, while serious disturbances in the nails and hair have been a family dyscrasia for several generations (*vide* observations of Nicolle and Halipré in France and of the present writer in America).

Psychic disturbances are frequently the cause of nail

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derangements. Such examples have been recorded after "apparitions," severe lightning, hysteria, delirium, mania, overwork, or worry.

Disturbances of the nutrition are common causes, among which Heller mentions typhoid fever, gastric disorders, icterus gravis, infantile atrophy, pneumonia, anæmia, phthisis pulmonalis, erysipelas, epididymitis, severe angina, parotitis suppurativa, scarlatina, measles, influenza, gout, rheumatism, accidents, and childbed. These conditions are often followed by the appearance of transverse furrows in the nail plate.

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Localized Nail Affections.

Anonychia or absence of nails may be congenital or acquired. The former origin is rare, but the latter is not uncommon, and loss of the nails is frequently observed after syphilis, injuries, chemical irritants, burns from *x*-rays, constitutional diseases, eczema, psoriasis, pus under the nail, ringworm, felon, paronychia, shock, hydroa æstivale, and ichthyosis.

Onychatrophia almost always results from the separation of the plate from the bed of the nail, a condition which usually follows any hyperkeratosis of the bed itself. Another source of separation is the invasion of blood after trauma or in connection with certain nerve diseases—for example, cerebral paralysis, multiple sclerosis, or tabes dorsalis.

Onychorrhexis.—This term is applied to the condition of the brittleness of the nail which follows decreased production of nail substance, and is usually associated with some trophic disturbance.

Onychauxis.—An increased growth of nail substance, and when associated with curving or hooking of the nail the word *onychogryphosis* is used. The etiology of this condition is somewhat obscure, but the deformity has been observed in connection with wounds, pressure of shoes, old age, deformities of toes, especially hallux valgus, syphilis, tinea tricophytina, central or peripheral nerve disorders, old tuberculosis, circulatory disturbances, such as thrombosis and aneurism, leprosy and confinement to bed.

The pathology of onychogryphosis was carefully studied by Virchow in 1855, and his description which follows remains the best to-day. There are three gradations in the formation of a truly gryphotic nail: First, the flat or plate shape; second, the conical form; and third, the perfected claw. At first the bed becomes shortened and the pulp of the last phalanx diminishes in size; the subungual vessels dilate and the stratum spinosum proliferates with the formation of abnormally high, transverse ridges, and an accompanying hypertrophy of the stratum corneum. These changes separate the plate from the bed, especially at the distal border, and the plate itself thickens, becomes yellow or dark brown in color, and shows on its surface overlapping transverse ridges. These ridges, of course, denote an intermittent process. The second or conical stage results from a continuation of the previous changes. The bed becomes deeper and forms a distinct transverse ridge, behind which the plate is almost perpendicular, yellow, translucent, and very hard; while in front it is opaque. The cells of the plate are no longer nucleated and apparently lose their boundaries. In the deeper portions of the bed the cells soften and blood finds its way into the intercellular spaces as in cutaneous horns. The third stage shows a still further advance from the normal. The downward pressure of the plate has caused an almost total disappearance of the bed. The ridge noted in the second stage has widened and the distal portion of the plate has become smaller; in fact, the last stage is one of atrophy. The resulting claw may grow simply downward or downward and backward, or in rare cases may assume the spiral curves of a ram's horn.

Leuconychia (leukopathia unguium, canities unguium).—The appearance of white areas in the nails follows three types, the punctate, the striate, and the total. Pathologically, we find this normal color due to the faulty production of nail cells with subsequent imbibition of air. This abnormality has been observed following wounds, trophic disturbances, relapsing and typhoid fevers, stimulation of nerves by electricity, and, rarely, congenital examples have been recorded.

Koilonychia, or spoon-nail, is the concave appearance which the plate assumes at times. This condition is usually the result of an underlying eczema, but may appear after other diseases, or without any apparent etiological cause.

Agnail, or hangnail, is caused by the drying up of the eponychium after insufficient nourishment. With the formation of the hangnail an easy entrance is afforded to bacteria, and in this way arise many of the syphilitic chancres and the more numerous cases of paronychia and of panaritium.

Hemorrhage.—The invasion of blood below the nail is usually traumatic in origin. A squeeze or a blow is followed by the bursting of a vessel in the bed or in the matrix; and when in the latter, the plate is sure to fall. The blood forms a clot between bed and plate, and if small, is usually absorbed while a large hemorrhage will often lift up the plate and produce subsequent atrophy or possible loss of the nail. Cases of vicarious subungual menstruation have been recorded, while other etiological factors in hemorrhage of the nail are scorbutus, morbus maculosus Werlhofii, tabes dorsalis, or the introduction of foreign bodies below the nail plate.

Trauma.—Wounds of the plate mean nothing serious to the nail, while similar injuries to the matrix always lead to scars which produce permanent deformities.

Unguis incarnatus.—Ingrowing of the nail is most commonly met with in males between the ages of fifteen and twenty, and is usually coincident with lack of care of the feet and the wearing of ill fitting shoes, but flatfoot, wounds of the nail walls, and great convexity of the nail are other possible etiological factors. The first symptom is pain, followed by swelling and the formation of pus, and finally a granulating sore is produced, which shows no tendency to heal. Constitutional symptoms sometimes make their appearance, and finally the disease may result in necrosis; but this event is fortunately rare.

Subungual Tumors.—The presence of new growths under the nail is distinctly uncommon, but, according to Heller, cases of subungual corns or horns, fibroma, papilloma, leiomyoma, angiosarcoma, angioma, colloid sarcoma, exostoses, cancer, and enchondroma have been recorded.

Symptomatic Pathological Involvement of the Nails.

Onychomycosis tricophytina.—Ringworm of the nail is a rare condition, and is usually caused by the megalosporon. The disease first appears at the distal end of the nail and gradually spreads backward. The plant first attacks the bed, producing an opacity and discoloration of the plate, which usually assumes a whitish-yellow tint. As the disease progresses, the color darkens even to a brown, but never reaches black, as is so often the case in favus. Coincident with the progressive color changes the bed becomes more and more hyperkeratosic, the plate is raised more and more from the bed and shows transverse depressions, transverse elevations, or vertical ridges, and finally the plate itself is attacked and becomes rough on the surface, exfoliates in lamellæ, atrophies or splits, and is finally cast off. The disease is essentially a very chronic one, and even when properly treated requires at least two years for its thorough eradication. If left to itself, the plant has been known to remain active in the nail substance, even up to thirty years. The diagnosis is extremely difficult, for even although we have to our satisfaction excluded all other possibilities, the spores may elude the most diligent microscopical investigation—in fact, it is only when one has demonstrated conclusively the glistening, rectangular spores with rounded corners, five to seven micromil-

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limetres in diameter, growing in chain formation that one can positively state that the disease present is ringworm of the nail. On the other hand, if the nail presents the clinical characteristics above enumerated and ringworm is present elsewhere on the patient's body, we have a certain right to assume that the nail is similarly infected. The treatment, although tedious, always triumphs in the end. It consists in the bi-weekly or tri-weekly cutting of the nail, and, in case the plate has been cast off, the curetting of the bed and subsequent painting with Lugol's solution or with acetic or pyrogallic acid.

Onychomycosis favosa.—Nails are apparently much more susceptible to tinea favosa than to tinea tricophytina. The clinical appearances of the diseases are quite similar. The plant attacks the distal end of the bed and produces an opacity and discoloration of the plate. The hyperkeratosis spreads backward and the plate is raised from its bed, becomes darker and darker in color, even to blackness, and its surface shows transverse depressions or ridges. Often the substance of the plate is attacked and assumes a honeycombed appearance, which soon leads to crumbling and splitting and final loss of the nail; or else the hyperkeratosic granules are extruded from the bed, leaving, as sometimes occurs in ringworm, a hollow space underneath the somewhat atrophied and brittle nail plate. The disease may be caught from domestic animals or from one's neighbors, and often occurs in two or more members of the same household. The Russian Jews seem to be particularly liable to infection, and in the writer's four hundred and eighty-five tabulated cases of nail diseases occurring during the last three years, his eight examples of onychomycosis occurred in this race. Histologically, one finds a thickened prickle layer of the bed, elongated papillæ, and an enormously hypertrophic horny layer in which the achorion Schönleinii appears. The fungus is not so abundant at the distal end of the plate as farther back, and its mycelium grows parallel with the cells of the stratum corneum. The process is much more chronic than in the scalp, and follows closely the characteristics of ringworm, both in its life history and in its treatment.

Diseases Caused by Animal Parasites.—This forms a class about which there is little to state beyond the fact that in extremely chronic cases the nail plates show slight changes. The chief diseases in this group are scabies, myosis, pulex penetrans, and plica polonica.

Ichthyosis and Xeroderma.—At birth, in severe cases, nails have appeared small, soft, and easily detached, with poorly developed nail walls. In older children and adults nails may show transverse depressions or vertical ridges, or may appear dull, very convex, or even gryphotic. Hyperkeratosis of the bed with gray or greenish discoloration of the plate and final loss are still further conditions which have been observed.

Elephantiasis Arabum.—The changes of nails in this disease are usually limited to the large toes where increased thickness, yellow color, and atrophic changes have been recorded.

Hyperkeratosis subungualis.—Although this is really a symptom rather than a disease, it should be considered here in order to gain a better knowledge of this important condition, which is so frequently met with in nail pathology. This lesion is strictly limited to the bed of the nail, and only after long continuance does the plate itself become involved, excepting its elevation and increase in convexity. This condition, therefore, illustrates well how little the plate depends for its nutrition upon the bed. The horny mass grows most abundantly at the distal end of the bed and constantly diminishes in height toward the matrix. Consequently the elevation of the plate is greatest near its free border. Unna describes the histological picture as follows: One sees extending into the horny layer papillary-like vascular processes which contain spindle cells and leucocytes. The prickle layer is thickened and passes without definite line of demarcation into the horny layer. A perfectly developed granular layer does not exist. The horny cells retain their nuclei and increase in size even up to the surface, and we note the same medullary processes which have been described in cutaneous horns. Swarms of cocci exist in the upper layers of the stratum corneum and exert a softening effect upon the adjacent cells.

Eczema.—The changes observed in this disease may occur in the nail walls, matrix, bed, and plate, and are produced by the same causes that bring about an eczema of the skin. The involvement of the nails before the age of twenty is distinctly uncommon—only six cases in the writer's one hundred and seven occurring before that age. The disease prevails all through adult life up to the age of seventy, when it diminishes in frequency. In the acute form the nail walls are red and swollen, the plate loses its normal convexity, pain is felt in the bed, the plate becomes rough, the lustre vanishes, discoloration is present, and soft spots appear in the plate which later form minute punctate depressions. If the cutaneous disease continues, the nail exhibits one or more of the following conditions: Transverse depressions or ridges, vertical ridges, hyperkeratosis of the bed with increase in the convexity of the plate, and subsequent disappearance of this granular detritus and thinning of the plate with increased brittleness, exfoliation of surface cells of plate, leuconychia, or finally total loss of the nail. If the matrix is affected, a deep transverse furrow may result.

The pathological changes consist in the formation of eleidin and horny matter with œdema and cellular infiltration about the vessels of the corium. The prognosis is decidedly good, and the treatment for the nail disturbances is the same as for the underlying skin disease.

Paronychia.—This is a very frequent cause of nail deformities, and consists in a severe dermatitis of the nail walls. It is an acute or subacute process, and usually occurs in women who wash dishes or scrub floors; but any individual who subjects his fingers to a constant irritation may develop this localized condition. The most common nail changes are discoloration, transverse depressions, and hyperkeratosis subungualis with its usual sequelæ. These consist of a lifting of the plate and subsequent discharge of the keratosic granules from the bed, leaving a flat, horny floor covered by a thin, dome-shaped roof. All the other alterations of the plate noted under the heading of eczema may appear in cases of paronychia, but the ones above mentioned are by far the most frequent.

Dermatitis venenata.—Under this title will be considered the acute cases of dermatitis which can be directly attributed to some noxious occupation or to some chance poisoning of the skin. Here the commonest symptom is koilonychia, which appeared in twenty-five of the fifty-eight cases recorded by the writer. Other frequent changes in the nail are round punctate depressions, discoloration, transverse depressions, vertical ridges, and hyperkeratosis subungualis with its usual sequelæ of separation from bed, thinning and brittleness of the plate.

The prognosis is good in paronychia and in dermatitis venenata of the nails, and the treatment consists in the application of soothing antiseptic washes and ointments.

Trauma and Felon.—These two accidents frequently affect the nail, and when they are of slight importance or do not involve the matrix, the results upon the nail are unimportant. When, however, the matrix is affected, then we have a permanent change which will reproduce itself as long as the individual lives. The commonest of these constant deformities are transverse depressions, vertical ridges, hyperkeratosis subungualis with its usual sequelæ, and discoloration. The more unusual changes are round, punctate depressions, thinning, exfoliation of surface of plate, increased convexity, brittleness, opacity, koilonychia, gryphosis, leuconychia, transverse ridges, vertical depressions, invasion of air into the plate with subsequent crumbling or total loss of the nail. Under this heading should be considered the results of persistent biting of the nails, which leads to shortening,

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thinning, brittleness, and koilonychia, or to the production of transverse ridges or depressions.

Psoriasis.—The involvement of the nails in cases of cutaneous psoriasis is relatively much commoner than is the rule in eczema. The disease can also exist alone in the nails, but such a diagnosis is in truth a hazardous one. The condition is most frequently observed in men, and between the ages of twenty and forty. The simplest cases consist of round, punctate depressions in the plate, and Unna and Heller regard this symptom as pathognomonic of psoriasis; but the writer cannot agree with this position, as these lesions appeared in more than one-fourth of his cases of eczema of the nails. The commonest lesion in the writer's experience is a more advanced condition, and consists in the changes subsequent to hyperkeratosis of the bed, namely, a horny floor, partly covered by a short, thinned, broken, discolored, arched plate. This change was noted in fifty-seven per cent. of the cases. Two other common lesions are discoloration, which varies from yellow to dark brown, and transverse depressions, both of which occur in about thirty-eight per cent. of the cases. After these four deformities come, in the order of their frequency, simple hyperkeratosis subunguealis, brittleness of the plate, thinning, opacity, vertical ridges, exfoliation, increased convexity, total loss of the nail, broken nail, koilonychia, disappearance of lustre, transverse ridges, and vertical depressions.

Pathologically, the psoriasic papules form on the bed, raising up the plate and allowing the air to be imbibed by the plate cells. This leads to opacity and discoloration. In the subungual corium there is great dilatation of vessels instead of the inflammatory œdema observed in eczema. The prognosis is almost always good, but there are severe cases of many years' standing in which the nails have completely fallen, never to return. The treatment, as in all nail disease, is the same as for the skin, only one must remember that Roentgen rays have an atrophic influence on nails and hair, while they exert a tonic action on undifferentiated epithelium, and for this reason one cannot expect the marvellous and rapid results which one often experiences after subjecting chronic patches of cutaneous psoriasis to *x*-rays.

With the completion of the descriptions of the last five diseases, the most important part of nail pathology is finished, for in my experience eczema, paronychia, dermatitis venenata, felon or trauma and psoriasis constitute nearly eighty per cent. of all nail affections, and instead of finding any lesions pathognomonic of any given disease, we note how constantly the same lesions appear in the different processes. This is certainly disappointing; but as we continue the study of diseased nails, we shall be more and more struck by the frequency with which the same lesions occur over and over again in entirely different processes.

Pityriasis rubra pilaris.—Here we may find transverse depressions, subungual hyperkeratosis with increased convexity of plate and onychauxis, yellow discoloration, vertical ridges, and depressions and hyperæsthesia.

Lichen ruber.—The nails become atrophied, light yellow brown, fissured and brittle at the free end, and uneven upon the surface.

Psorospermosis.—In this rare affection the nails are almost always involved, and show one or more of the following abnormalities: thickening, opacity, vertical ridges and depressions, fragility at border, hyperkeratosis subunguealis with elevation of the plate, gryphosis, crumbling away, and final loss.

Alopecia.—During the last three years I have observed five cases of partial or total alopecia with bad teeth and diseased nails. The nails exhibited round punctate and transverse depressions, vertical ridges, or subungual hyperkeratosis with subsequent separation of the plate from the bed, discoloration, and brittleness. In mild alopecia areata, one occasionally finds vertical ridges and an increased brittleness of the plate, while in the severe cases of nervous origin the nails have been completely shed.

Pemphigus.—As a rule the disease is not accompanied by nail disorders, but when the exception is present we find atrophy and brittleness of the plate. When, however, a vesicle or bulla forms under the nail, deformities inevitably result, the commonest of which are hyperkeratosis of the bed, vertical or horizontal ridges, discoloration, thickening, crumbling, and loss. If a bulla occurs in the matrix the plate is always shed.

Epidermolysis bullosa hereditaria.—This condition usually leads to atrophy and exfoliation of the plate, but examples of gryphosis have also been observed.

Hydroa æstivale.—When a vesicle or a bulla forms under or near the nail, we must have a resulting deformity, and in one case I noted vertical ridges and loss of the plate.

Dermatitis herpetiformis.—Usually the nail takes no part in this disease, but when the vesicles form near the nail or the process affects the whole economy, then we find round, punctate, or transverse depressions, vertical ridges, exfoliation on surface of the plate, or invasion of air.

Scarlatina.—Nail lesions are not common, but transverse depressions and loss of the nails are symptoms which have been recorded.

Dermatitis exfoliativa.—In light cases the nails remain perfect, but when the general condition becomes severe, then the most marked disturbances occur in the nail, including round, punctate, or transverse depressions, hyperkeratosis subunguealis, discoloration, opacity, gryphosis, or breaking of the nail.

Pityriasis rubra.—Heller mentions as concomitants of this disease thickness, opacity, fissuring, crumbling, separations from the bed, and gryphosis.

Dermatitis calorica.—In mild cases of dermatitis following exposure to heat or cold transverse depressions, discoloration, separation from bed, and onychauxis have been recorded, but in severe cases the nails fall.

Dermatitis from Roentgen rays.—As in the case of the skin the involvement of the nails usually occurs in the operator rather than in the patient. After repeated exposure to the rays, the nails show transverse depressions, often very deep, increased convexity, vertical ridges, discoloration, separation from the bed, crumbling of plate, and finally total loss of all nails which has persisted in one of the writer's cases for three years.

Scleroderma.—Heller records many accidents upon the nails as sequelæ of this disease. As will be seen by the subjoined list, the variations in degree and variety are unusually large: gryphosis, local asphyxia of bed, thickening of the skin of the bed, vertical ridges of the plate, transverse furrows and ridges, increased convexity, brittleness, atrophy, erosions of plate, and loss.

Atrophoderma.—In this rare dermatosis the nails often become influenced and exhibit vertical ridges, brittleness, atrophy, and vertical depressions, while in severe cases the lunulæ disappear altogether.

Vitiligo may exhibit at times lesions on the nails, and in my experience I have observed transverse depressions and leuconychia.

Pruritus.—With any of the pruriginous diseases the nails may become altered and show transverse depressions, vertical ridges, or even koilonychia.

Syphilis.—Syphilis of the nails is not common, and forms only about five per cent. of all nail disturbances in my observations. Like the general constitutional disease syphilitic manifestations on the nail may be divided into those resulting from the primary lesion, from the secondary eruption, and from the late changes of the disease.

A chancre on the nail wall is followed in a short while by a series of parallel transverse depressions with or without discoloration, or the change may be more intense and the plate will ulcerate and drop off in part or *in toto*.

The secondary stage of the disease shows itself usually in one of two ways: first, by the formation of a papule on the bed, and second, by a general moist ulceration of the nail. The formation of a papule on the bed is indicated by a red spot in the plate, which becomes yellow with the subsidence of the lesion. The plate over the papule becomes thinner and may even be broken, while the horny layer of the bed thickens, and as a result leu

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conychia may ensue. The secondary ulcerations of the nail are the most frequent syphilitic manifestations, and the disease is characterized by the large number of the nails involved. The first signs are redness and swelling of the last phalanx accompanied by pain. The nail walls become affected and the epidermis is raised by fluid and finally ulcerates. Pus appears from the eponychium and from under the plate on the sides, and causes the plate to look yellow. Blood is imbibed by the plate cells and the nails become red and later black. Ulcerations appear along the bed, and as a result the nails fall. If the matrix is affected, nails may not be reproduced, or may grow again gryphotically deformed. The restitution of such nails is always a long and tedious task, and must be brought about by mild local antisepsis and prolonged general antisyphilitic treatment.

The nail lesion associated with late syphilis usually assumes a dry form, and has been termed scabrities unguium syphilitica or onyxis craquelé. At the root of the nail white, punctate depressions form in vertical series brought about by parakeratosis and acanthosis of the bed. These pathological processes prevent the formation of onychin, and as a result we find hyperkeratosis subunguinalis with its usual sequelæ, or a thickened, yellow, crumbling plate.

In hereditary syphilis Neumann states that the nails may assume atrophic forms and appear thin and brittle, or poorly developed.

Lepra.—In pure cases of lepra tuberosa nail changes are rarely met with, but in mixed types or in pure anæsthetic forms all degrees of deformities are encountered, extending from simple brown spots to gryphosis and permanent loss.

Variola.—Virchow states that if a pustule of smallpox appears upon the bed, the plate will show a yellow, sunken spot, and may eventually be cast off; and if such an accident occurs, the loss will be a permanent one.

Addison's Disease.—In this affection the nail lesions are practically pigmentary ones. The nails appear white on account of the general anæmia and deposit of pigment in the nail bed or brown streaks or universal darkening of the nails may appear.

Cutaneous Tuberculosis.—The nails show involvement only when the tuberculous process exists in the neighborhood of the nail walls. Transverse depressions and ridges, vertical ridges, discoloration, hyperkeratosis subungualis with its resulting deformities, *i.e.*, raising of plate from bed, increase in convexity of plate, casting off of granular débris, thinning and breaking of nail, and final loss, which in this disease may be permanent, are the lesions usually experienced.

Morbid Processes in the Nail in Connection with Non-Cutaneous Diseases.

Phthisis Pulmonum.—Hippocrates was the first to describe the increased convexity of the nails in consumptive patients, and thus the term Hippocratic is used to denote the high arching which often exists, both longitudinally and vertically, in this disease. Women are affected in this manner oftener than men, and as a rule the thumb nail is the first to show the change. After the thumb the frequency of involvement extends seriatim to the little finger. A plausible explanation of this phenomenon is given by Pigeaux, who says that the regions farthest from the heart are subject to œdema, which lifts up the matrix of the nail and causes elevation of the plate, while imbibition of this same fluid produces a thickening of the plate itself. The dilatation of the vessel causes the disappearance of the lunula.

Empyema.—Hippocratic nails have been observed in this disease also, but have disappeared with the subsidence of the purulent fluid.

Rachitis.—Esbach has noted a shortening of the last phalanx.

Carcinomatosis.—In all cachexias nails become softer, probably on account of the anæmia of the matrix, bed, and walls. Observers have recorded also leuconychia and onychorrhexis.

Heart Disease.—Here, as in consumption, circulatory disturbances are at work, and consequently blueness and Hippocratic nails with "drumstick fingers" appear.

Embolism and Thrombosis.—Observations upon these accidents to the fingers are decidedly rare, but Heller speaks of blackness, gryphosis, and loss as possibilities.

Diabetes mellitus.—The presence of sugar in the blood or the subsequent changes in the vessel walls and tissues, induced by the circulating sugar, may produce transverse furrows, brittleness, exfoliation, or complete loss of the nail.

Malaria.—Writers have noted the phenomenon that before the advent of the chill the nail turns to a pale blue or slate color.

Scorbutus.—In this disease hemorrhage is apt to occur under the nail, producing the variations in color due to oxidation and loss of the nail involved.

Chlorosis and Anæmia.—The lack of nourishment brings about paleness, thinning, and tendency toward koilonychia, while in pernicious anæmia a different class of disturbances have been noted, namely, thickening of the nail with subsequent tissuring and crumbling.

Gout.—Here again apparently opposite results may be reached. On the one hand, the nails may become thin and brittle or, on the other hand, vertical ridges and depressions may form together with elevation of nail from bed, with brownish discoloration and subsequent gryphotic changes.

Rheumatism.—This affection may attack the nails, causing transverse depressions, elevations of the plate with yellow discoloration, brittleness, or gryphosis.

Changes in the Nails in Connection with Diseases of the Nervous System.

Peripheral System.—Paralysis or wounds of cutaneous vessels produce trophic alterations in the nails. Hypertrophic changes cause thickening, vertical ridges or gryphosis, while atrophic modifications are thinning, cracking, loss, slowness in growth, discoloration, vertical or horizontal ridges, and opacity.

Neuritis of Internal Origin.—Here changes are less frequent than after wounds of nerves, but nevertheless writers have described loss of gloss, discoloration, transverse and vertical depressions, brittleness, and bending of the nail.

Morvan's Disease is frequently characterized by disturbances of the nails, such as thickening, blackness, hardening, and gryphosis.

Raynaud's Disease.—Mild cases of this condition may exist without changes in the nails, but in the severer examples we find vertical ridges and furrows, increase in convexity and thickening, hyperæsthesia, and possible loss. When the disease is accompanied by panaritium, then we find the usual results of shortening, bending, vertical ridges, and gryphosis.

Erythromelalgia is often accompanied by nail changes, among which have been recorded transverse furrows, yellow discoloration, thickening of the bed at distal end, bending and thickening of the plate, and loss.

Spinal Diseases.—*Tabes Dorsalis.*—A very frequent concomitant of this disease is loss of the big toe nail, which may fall repeatedly. This phenomenon is caused by trophoneurotic changes and by the invasion of blood between the bed and the plate. Other nail changes are possible, and examples have been recorded of brittleness, thickening, hardening, and transverse and vertical depressions.

Syringomyelia.—The almost constant presence of paronychia and of panaritium in this rare affection accounts for the frequent and severe involvement of the nails. Here we find brittleness, lack of lustre, cracks, thinness, exfoliation, and after panaritium gryphosis, atrophy, loss and stumps of nails growing at various angles.

Anterior Poliomyelitis.—In this disease instances of softening and loss of the nails have been recorded.

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Injured Spine.—After such an accident I have noted transverse depressions and ridges and hyperkeratosis subungualis.

Multiple Sclerosis.—The nail changes in this affection are very similar to those observed in locomotor ataxia; namely, brittleness, pain, and invasion of blood between bed and plate, causing the loss of the nail.

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BRAIN DISEASES.—*Apoplexy.*—The possible deformities of the nail resulting from strokes of paralysis are vertical ridges, transverse furrows, increased arching, thinness and greater transparency, smallness, brittleness, koilonychia, ecchymosis of bed with subsequent loss, and gryphosis.

PSYCHOSES.—*Dementia Paralytica.*—The changes occurring in this disease are quite similar to those following apoplexy, and may consist of increased transparency, vertical and transverse furrows, subungual hemorrhage, transverse ridges, yellow or brownish discoloration, and gryphosis.

Melancholia.—In the course of this disorder different observers have noted transverse furrows, increased thickness, and slowness of growth.

FUNCTIONAL NEUROSES.—*Hysteria.*—Nail changes are seldom met with in this condition, but instances of lack of lustre, vertical and transverse furrows, exfoliation, thickening and roughness of surface, and final loss have been recorded.

Epilepsy.—Another disease in which nail disorders are rare, but when present they may include thinness, brittleness, deep transverse furrows, roughness of the plate, and subungual hemorrhage.

Neurasthenia.—In this disease I have observed discoloration and transverse ridges.

Nervous Shock.—As a result of such accidents patients have come to my notice with transverse depressions and ridges, thinning, discoloration, and subungual hyperkeratosis with its usual results.

TROPHIC NEUROSES.—*Myxœdema.*—In my experience the only changes in the nails in connection with this disease have been those of vertical ridges and subungual hyperkeratosis and its resulting deformities.

DISEASES OF THE BONES.—Fractures are often followed by discoloration, which varies from yellow to black, by transverse furrows and by slowness of growth of the nails.

Acromegaly.—This interesting process is almost always accompanied by onychauxis where the nail is enlarged transversely and vertically and appears flat, brittle, and lustreless with vertical ridges upon its surface. In addition to these symptoms I have observed discoloration and subungual hyperkeratosis, but have not observed the usual sequelæ of this condition.

Arthritis Deformans.—In this disease I have recorded vertical ridges and depressions, transverse ridges and depressions, discoloration, thinning, and brittleness and koilonychia.

Acro-arthritis.—In this somewhat allied condition nails have been shown me bearing round punctate depressions, vertical and transverse ridges, discoloration and hyperkeratosis of the bed with subsequent elevation of the plate.

NAILS IN CONNECTION WITH YOUTH AND OLD AGE.

The sucking of nails renders them soft and small, while advancing years produce vertical ridges and a tendency toward increase in size.

Keratosis senilis.—In conjunction with this disease I have seen round, punctate, and transverse depressions, leuconychia, and subungual hyperkeratosis with increased convexity of the bed.

INTOXICATIONS.

Heller records the following changes in connection with the use of poisons:

Arsenic may cause pain, yellow or brown discoloration, raising of plate from bed with eventual loss. Brooke and Roberts observed in the recent English epidemic of arsenical poisoning from beer abnormally rapid growth of the nails with transverse ridges and subungual hyperkeratosis.

Mercury rarely produces changes, but transverse furrows, blackness, thickening, and loss of the nail have resulted from the abuse of the drug.

Nitrate of silver may be deposited in the tissues and discolor the nail bed blue or gray. I have recently observed a very marked example of this condition.

Lead has been known to destroy the nails.

When one has read the facts enumerated and described in the preceding paragraphs, I think one must be greatly impressed by the similarity of symptoms resulting from the many diseases which may induce changes in the nails. This is the effect produced upon the writer, who at the end of three years' special study of these affections feels more than ever that the physician who states that he can make a positive diagnosis from the nails alone is making a rash statement. In closing this article the writer wishes to acknowledge his great indebtedness to Heller, whose unique book, "Die Krankheiten der Nägel," has been the model upon which he has based this article.

Charles J. White.

NANTUCKET, MARTHA'S VINEYARD, AND CAPE COD.—The islands of Nantucket and Martha's Vineyard and the southern district of Cape Cod are climatologically

FIG. 3481.—Nantucket, Martha's Vineyard, and Cape Cod, Mass.

and structurally so similar, and are grouped in such close proximity to each other that it has seemed best in the present description to consider them under one head. Nantucket, as being situated farthest away from the mainland, is to be taken as the climatological type, its climate resembling most nearly the climate of the ocean as experienced on shipboard, of any island on the Atlantic seaboard from Old Point Comfort to the Grand Manan. The climatic attributes may be briefly summed up as follows: (*a*) as being at the ocean level the air contains the maximum amount of oxygen, aqueous vapor, and ozone; (*b*) it contains saline particles, *i.e.*, iodine and bromine; (*c*) it presents the most regular variations of barometric pressure; and (*d*) it presents the minimum diurnal variation of temperature. Other stations included in this article resemble it more or less nearly, according to their proximity to the sea and to modifying local conditions subsequently to be considered.

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The Island of Nantucket (41° 15' North Lat., 70° W. Long.) lies in the Atlantic Ocean twenty-five miles due south of the metacarpal joint of the beckoning finger of Cape Cod. It is of a long-horned crescentic shape, and, roughly speaking, is fifteen miles long and four miles wide. It comprises in its entire extent about twenty-nine thousand acres. It is the most easterly of the group of islands known as the Elizabeth Islands, in which are also included Martha's Vineyard, Tuckanuck, Muskeget, and Naushon. It is almost exactly one hundred miles from Boston.

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Structurally considered, it is a vast mound of sand lightly covered with vegetable mold, gently undulating in surface, and presenting a series of high bluffs to the sea. At different points its surface is dotted by fresh-water ponds of varying size. The soil is of a light, porous, sandy nature. Rocks are so rare that it would be easily possible to count those worthy of the name upon the fingers of the hand. There are, practically speaking, no trees. The flora is large and varied. Five hundred varieties of species are described as growing without cultivation. The botanic range is wide; heather grows upon the moors; cactus is to be found freely flowering in the month of July, while in August a visit to a vast field of hollyhock-like blossoms of the pink hibiscus is a favorite excursion. A large variety of birds pause at the island upon their semi-annual pilgrimages; black duck and quail live there the entire year, and the neighboring island of Muskeget is a breeding place upon which thousands of families of sea-gulls are annually reared.

Nantucket, the chief town, is situated upon the northern side of the island, on Nantucket Sound. The resident population in 1894 was 3,300, though the summer population is, of course, largely in excess of these figures. In that year 16,306 passengers, not including children, were brought to the island. At the height of its prosperity, when the whaling industry flourished, the population of the island was 10,000. The town is very old (the oldest house bearing the date 1686). Many of the dwellings and warehouses are built of brick, and the number of buildings in general is surprisingly large in proportion to the present population. A general impression of size and antiquity is given to the town. The streets for the most part are paved with stone and asphalt; outside the town clay roads extend in many directions, and the State road, a fine piece of macadamized road, eight miles long, connects the town with Siasconset. At a greater distance from the town the roads consist chiefly of "ruts," and one may ride or drive in almost any direction at will over the moors.

Siasconset, formerly a small fishing village, eight miles from the town and connected with it by a narrow-gauge railroad, is now an exceedingly popular summer resort. It is situated on the ocean and is possessed of several hotels and boarding houses, a casino, and a fine golf course. The surf bathing is excellent.

NANTUCKET, MASS., FIVE YEARS, 1897–1901.

Climatic Data.	June.	July.	August.	Sept.
Average maximum	67.1° F	73.9° F	73.9° F	69° F
Average minimum	55.7°	63.1°	63.2°	58°
Average daily range	11.3°	10.9°	10.7°	10.4°
Absolute maximum	78	85	87°	85°
Absolute minimum	44°	54	56°	46°
Average number of clear days	7.6	7.8	10.2	11
Largest number of clear days	11	10	12.	13
Smallest number of clear days	4	1	5	9
Average number cloudy and partly cloudy	22	23	20.8	19
Largest number cloudy and partly cloudy	26	30	26	21
Smallest number cloudy and partly cloudy	19	21	19	17
Average number rainy	8.6	10	9.6	8
Largest number of rainy days	10	13	11	11
Smallest number of rainy days	8	8	7	4
Average total rainfall	1.45	2.45	2.22	1.75
Average relative humidity for four years	86.5	89.2	88.3	81
Average hourly wind velocity for for years	10	9.5	8.2	10.2

The preceding table, compiled from statistics prepared for me by Mr. A. W. Crosby of the weather bureau in Boston, shows climatic data for the five years 1897–1901.

From the foregoing table it is seen that the average number of rainy days for the four summer months, for five years, was nine per month. This number represents the days during which it rained at some portion of the day. The number of days in which an invalid could not exercise out of doors was of course much smaller. In 1894, for the months of July, August, and September, there were ninety-two consecutive pleasant days.

The prevailing direction of the wind is westerly, blowing, as will be seen by the map, over miles of ocean. One of the most remarkable meteorological phenomena of the island is the rarity of electric storms. Thunder storms are exceedingly rare, passing north or south of the island. In the twenty-one summers I have passed at Nantucket I have known the lightning to strike but on three occasions. Fogs are a more variable feature, their prevalence differing in different years. As a rule it is not more foggy than at other seashore resorts.

The average temperature of the water for the summer of 1894 was 72° F. At the bathing beach it is somewhat higher. The cause of this high temperature of the water is a much-discussed question. It is believed by some to be due to the proximity of the gulf stream, but this theory is not borne out by fact. Any one interested in the matter is referred to Dr. Peterman's charts.

The water supply of the town is derived from a large fresh-water pond. It is between two and three miles from the town, and is in an isolated position so far as dwelling-houses are concerned, the house of the engineer being the only human habitation within the water-shed. It would be difficult to conceive of its ever sustaining dangerous pollution.

The sewerage of the town has been greatly improved in recent years by the construction of a sewer to the deep waters of the outer harbor.

The average velocity of the wind for the three months of the summer of 1894 was nine miles.

From its isolated position Nantucket is particularly free from contagious diseases. In the ten years 1890–1900, there have been forty-four deaths from tuberculosis, or eleven per ten thousand; and fourteen deaths from diphtheria, or about four per ten thousand. In 1901 one case of typhoid fever was reported. It was, however, an exceedingly doubtful case, and did not give the Widal reaction. Contagious diseases, when present, are for the most part imported, and are generally so managed as to reduce to a minimum their further dissemination. This is the more readily accomplished because of the intelligent and energetic co-operation of the Board of Health.

The amusements afforded the summer visitors are unusually varied. Boating is excellent. Large cat-rig boats, under the charge of experienced skippers, are provided in abundance. Those preferring still water may sail in the landlocked waters of the inner harbor, eight miles in extent. More accomplished sailors can pursue their excursions upon the rough waters of the Sound. A daily trip by sailboat and by launch is made to Wauwinet, about seven miles up the inner harbor. Still water for rowing is always found in the inner harbor, and excellent light boats may be hired by the hour. It is particularly safe for women and children because of the shallowness of the water. The fishing is excellent; bluefish abound in the season; scup and plaice fish (the latter a large species of flat fish) are found in great abundance, as is also the English turbot. Lobsters, clams, quohogs, and oysters are also abundant. Pickerel and fresh-water perch are found in the ponds. There is some shooting. Marsh birds are present throughout the summer, plover and snipe are frequently killed during their respective flights, and black duck and rabbits are numerous. Driving is very agreeable; the moors are for the most part unfenced and level, and it is the custom to ride and drive across them in any and every direction. Bicycling is also excellent. The State road is a perfect piece of macadam; the clay roads are fair, and there are several agree-

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able bicycle paths. Golf is the principal amusement. The course is particularly fine, and in many respects an exact counterpart of the Scotch links. It consists of eighteen holes, is about six thousand yards in extent, and extends over gently undulating ground, in which neither a tree nor a stone interferes with the pastime. The turf is excellent, and fine views of the sea are to be had from many of the trees and greens. Afternoon teas and tournaments are held every week during the season.

From twenty years of summer practice on the island the writer feels able to recommend the climate as especially suited for the extremes of life, the very old and the very young; the smallness of the diurnal range being a most important factor. The absence of contagious diseases also renders it a highly desirable locality for children. It is well suited to those suffering from functional nervous affections, neurasthenia, insomnia, and neuralgia; for valvular diseases of the heart, for convalescence from diseases of the respiratory organs, for chronic dysentery and diarrhœa, and especially is it specific for the entero-colitis of children. Cases of tuberculosis and of the scrofulous diseases of children also do exceedingly well at Nantucket.

Nantucket possesses an excellent public library; a museum, containing many objects of interest; the valuable and interesting collection of the Historical Society; an old mill; several light-houses and life-saving stations; churches of nearly every denomination; gas and electric plants. There is an excellent hot salt-water bathing establishment.

There are several hotels, among which may be mentioned, The Sea Cliff Inn, owned by a syndicate, and the largest hotel on the island, The Ocean House, Point Breeze, and Springfield House.* Prices vary from $10 to $35 per week. There are also a large number of excellent boarding-houses. A. T. Mowry, real estate agent, solicits correspondence upon all matters pertaining to Nantucket, and has a list of available cottages. Rents of the latter vary from $150 to $1,000, average about $400. An eminent Boston surgeon and an equally well-known oculist from Philadelphia are among the summer residents, and can be called on for special service.

Martha's Vineyard.—Twenty miles west of Nantucket and ten miles south from Wood's Hole lies the island of Martha's Vineyard, an island considerably larger than Nantucket and similar to it in climate, its chief differences consisting in its nearer approximation to the mainland and in the fact that it is comparatively thickly wooded.

At the easterly end of the island Edgartown is situated, a small and very picturesque town with a resident population of about eight hundred persons, and a summer population much in excess of these figures. Bathing, fishing, sailing, and driving are excellent, and there are well-arranged golf links.

Nearer the centre of the island and on the northerly shore is the town of Cottage City, probably the most populous summer resort of the cape district. The resident population is about the same as that of Edgartown, but the summer population is estimated as being about twenty thousand.

Vineyard Haven, situated on the north side of the island, lies about a mile to the west of Cottage City, and is an exceedingly popular summer resort. The resident population is about one thousand; the summer population is largely in excess of these figures.

West Chop is a small summer colony northwest of Vineyard Haven. The hotel, casino, and the major portion of the land are owned by a syndicate of Boston gentlemen. The bathing and boating are excellent and the views are particularly attractive.

Similar in climate and in the configuration of land are the summer resorts situated upon the southern border of Cape Cod. Among these resorts may be mentioned Wood's Hole, Falmouth, Cotuitport, Osterville, Hyannis, Yarmouth, Harwichport, and Chatham.

Harold Williams.

* Not intended to be a complete list.

NAPA SODA SPRINGS.—Napa County, California Post-Office.—Napa Soda Springs. Hotel and cottages.

Access.—Take Oakland Ferry (from San Francisco) at 8 A.M. for Napa City, forty-six miles distant, arriving at 10:10 A.M. Then take stage to springs, five miles distant. Spring, summer, and autumn are suitable seasons for visiting the springs.

The resort is charmingly located on the southwestern slope of the Coast Range, at an elevation of about 1,000 feet above the level of the sea. From the Rotunda Hotel many beautiful views are spread before the eye in all directions. Looking southward over the beautiful valley of Napa County one sees a landscape seldom surpassed for loveliness, and which always remains fresh in the memory. The climate is warm, dry, and salubrious, uniting the advantages of mountain air with breezes direct from the sea. The mineral springs here are among the most noted in the State. They number twenty-seven in all, with an average daily flow of about four thousand gallons. The temperature of the water ranges from 65° to 68° F. The main spring, the Pagoda, from which most of the commercial Napa soda is obtained, is an alkaline-chalybeate water, strongly charged with carbonic anhydride. It is delightfully clear and sparkling, and has an agreeably pungent taste. Following is Dr. Anderson's analysis:

Pagoda Spring (Napa Soda Spring).

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	7.14
Sodium bicarbonate	12.95
Sodium carbonate	1.10
Sodium sulphate	1.62
Potassium bicarbonate	Trace.
Magnesium bicarbonate	3.04
Magnesium carbonate	21.76
Calcium bicarbonate	.78
Calcium carbonate	9.55
Ferrous carbonate	7.90
Silica	.74
Alumina	.57
Organic matter	Trace.
Total solids	67.15

Free carbonic acid gas, 143.62 cubic inches. Temperature of water, 67.7° F.

Over this spring is a beautiful pagoda, supported by solid stone pillars, and, resting upon a tessellated marble floor, a natural stone basin has been artistically arranged, through which sparkling soda bubbles in all its freshness. There are many other important springs at Napa, including the well-known Iron Spring and the Lemon Spring. The former was analyzed by Professor Lanzwurt in 1870, with the following result:

Iron Spring (Napa Soda Spring).

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	5.20
Sodium bicarbonate	13.12
Sodium sulphate	1.84
Magnesium carbonate	26.12
Calcium carbonate	10.83
Ferrous carbonate	7.84
Silica	.62
Alumina	.60
Total solids	66.17

Free carbonic acid gas, undetermined. Temperature, 68° F.

The waters of all the springs have the same general characters—alkaline-chalybeate, clear, and sparkling. Napa soda water is highly esteemed as a beverage. It is sold in every city and town of the coast, and is one of the pleasantest summer drinks to be found. The water is an efficient aid to digestion, being antacid and tonic. When taken early in the morning before breakfast its action is gently aperient. The ferruginous salts, held in solution by the carbonic-acid gas, are valuable in anæmia and chlorotic conditions, malarial toxæmia, and many disorders requiring iron for the constructive metamor

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phosis of red corpuscles. The grounds at Napa Soda Springs cover over a thousand acres of hill and valley. The place is thoroughly improved, and the visitor will find every arrangement provided for his comfort and recreation while sojourning there. Among the attractive features should be mentioned the excellent bathing facilities, both tub and plunge. There is also a swimming bath measuring one hundred and fifty feet in length by fifty feet in width, and with a depth of water varying from four to ten feet. *James K. Crook.*

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NAPHTALIN. Under the title *Naphtalinum*, Naphtalin, the United States Pharmacopœia makes official the hydrocarbon *naphthalene* ($C_{10}H_8$), known also by the common name of "tar camphor." Naphtalin (to use the pharmacopœial spelling), like benzene, is the fundamental member of a series of aromatic compounds. Naphtalin is a common constituent of tars, and is obtained from coal tar by fractional distillation. Naphtalin, when purified, presents itself in large, colorless, crystalline, rhombic plates of a pearly lustre and an unctuous feel. It has a burning taste and a faint peculiar odor. It is insoluble in water, but dissolves in alcohol, ether, benzene, oil of turpentine, glacial acetic acid, and warm oils, both fixed and volatile. It melts at 80° C. (176° F.) and boils at 218° C. (424.4° F.), but yet sublimes at a much lower temperature than that of its boiling-point, and, mixed with boiling water, rises in vapor with the steam. Even at ordinary temperatures a gradual sublimation occurs. It should be kept in well-stoppered bottles.

Naphtalin is, locally, but slightly irritant, and constitutionally is not ordinarily poisonous—probably because of incomplete absorption due to its insolubility in aqueous fluids. Yet naphtalin is decidedly "antiseptic" in the common medical sense of the word. Taken internally, some absorption certainly occurs, since naphtalin, swallowed, reappears in the urine. Naphtalin has been used in medicine to prevent decomposition of the urine in cystitis, by administration, by the mouth, of an aggregate of five grains daily; but its main use internally has been for local antiseptic purposes in the intestinal canal, as in diarrhœa and dysentery, and as a vermifuge. It has been vaunted also as an expectorant in bronchitis and as a constitutional remedy in typhoid fever. The ordinary dose ranges from 0.13 to 1 gm. (gr. ij. to xv.), and, because of the disagreeable taste, the medicine is best given in capsule. A case of poisoning—an exceptional circumstance—has been reported from the taking of a dose of eight grains; and it is certainly risky to give much of the drug if there be any kidney disease or weakness. As an anthelmintic for the "seat-worm," naphtalin may be given by enema, in sweet oil (1 gm. in two or three tablespoonfuls of the oil). For ordinary internal uses naphtalin has been largely supplanted by naphtol.

Externally, naphtalin has been used for the making of antiseptic dressings in surgery. In this application naphtalin combines the features of a fair degree of efficiency on the one hand, and freedom from irritant or poisonous effects, and from offensive smell, on the other. The only untoward effects charged against naphtalin so far have been that the sharp points of the crystals may wound tender granulations, and that the powder may cake with fluid exudates, and so tend to obstruct the free drainage of discharges. Most reporters upon the use of naphtalin in surgery, however, have failed to observe either of these effects. Naphtalin may be applied in bulk, in fine powder, to wound surfaces, or by means of gauze or wool charged with the substance, by the device of steeping the dressing in a strong solution of naphtalin, and then permitting the solvent to evaporate. By this means a porous material becomes thoroughly impregnated with a fine powder of the hydrocarbon. A common solution for the making of such dressings is a twelve-and-a-half-per-cent. solution of naphtalin in a mixture of alcohol and ether in equal proportion. [See also Naphtalin in the article on *Antiseptics in Surgery*.] *Edward Curtis.*

NAPHTO-CRESOL is an alcohol-soluble substitute for creolin. *W. A. Bastedo.*

NAPHTOFORMIN is a condensation product of alpha- and beta-naphtol with formaldehyde and ammonia. It is an insoluble powder, and, being readily split into its components, is a powerful antiseptic for use in surgery. *W. A. Bastedo.*

NAPHTOL.—By the substitution, in the molecule of the hydrocarbon *naphthalene*, of a molecule of hydroxyl (—OH) for one of the atoms of hydrogen, a derivate, $C_{10}H_7.OH$, is obtained, bearing precisely the same relation to naphtalin that common phenol ("carbolic acid") does to benzene. Such derivate is styled *naphthol*, and according to the position in the naphtol molecule of the hydroxyl substitution, two distinct naphtols are obtainable, known respectively as *α-naphthol* and *β-naphthol*. Of these two bodies *β-naphthol* is the more easily made, and is the article used in medicine. It is official in the United States Pharmacopœia under the title and spelling *Naphtol*, Naphtol.

The common naphtol of the markets is an impure article, occurring in reddish or deep violet-brown crystalline masses of a disagreeable, pungent smell. Such a naphtol, because of the poisonous nature of some of the impurities, needs purification for medicinal use. Properly purified, naphtol presents itself in beautiful silver crystalline scales, nearly or entirely odorless, but of a sharp, burning taste. The crystals are very slightly soluble in water (in about one thousand parts of cold, and in seventy-five parts of boiling water), but dissolve freely in alcohol, ether, chloroform, benzol, and oils. Gently heated, naphtol sublimes, and may be distilled with steam. It should be kept in dark amber-colored bottles, well stoppered. Naphtol is locally distinctly irritant, exciting upon tender surfaces redness, smarting, and even inflammation, and, upon the healthy skin also, if in *alcoholic* solution, acting occasionally with sufficient energy to develop an eruption resembling nettle rash. Solutions in oils or fats, however, are said to be without effect upon the sound skin, although acting energetically upon an eczematous surface (Kaposi). *Constitutionally*, naphtol, in therapeutic doses, produces but little derangement. Some experimental dosings of animals have been followed by hæmoglobinuria, with convulsions and death, and, in one instance in the human subject, an external application of naphtol produced hæmaturia, ischuria, unconsciousness, and eclampsia (Kaposi). But since these effects are exceptional, it is likely that the samples used in the cases cited were not pure. Ordinarily doses of from 0.20 to 0.32 gm. (gr. iij. to v.), given a number of times daily, are innocent of harm beyond some possible disturbance of the stomach. The medicine therefore ranks among the non-poisonous, and its value lies in the fact that while it is thus non-poisonous to the human system it is yet quite potent to arrest the development of many micro-organisms. It is said to be five times as powerful in this regard as carbolic acid. Naphtol is accordingly used as an internal medicine to disinfect the alimentary canal, as in cases of diarrhœa, dysentery, intestinal dyspepsia, and especially in typhoid fever, in which disease its efficacy was first proclaimed by Bouchard. The doses are those already mentioned. The article is also used as a local application in many skin diseases, notably *scabies*, *psoriasis*, and *eczema*. It is commonly applied in ointment ranging in strength of naphtol from one half to ten per cent., or even fifteen per cent. The remedy should not be used upon denuded parts, and weak applications only should be made to irritated parts such as so commonly present themselves in eczema.

For *iodonaphtol*, see under the caption *Di-iodo-beta-naphtol*, in Vol. III. *Edward Curtis.*

NAPHTOL ARISTOL. See *Di-iodo-naphtalin.*

NAPHTOL BENZOATE is benzonaphtol (*q.v.*).

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NAPHTOL BISMUTH, orphol, basic beta-naphtol bismuth $[(C_{10}H_7O)_3Bi]_2 + Bi_2O_3$ or $(C_{10}H_7O)_3Bi + 3H_2O$, is a neutral, non-irritating, light-brown powder of very slight odor and slightly aromatic taste. In the intestines and to some extent in the stomach orphol is split up into its components, bismuth oxide and beta-naphtol, and so acts as an intestinal sedative and antiseptic in diarrhœa, dysentery, and intestinal putrefaction. The dose is 0.5 to 1 gm. (gr. viij. to xv.), usually given in capsule. Chaumier gave 5 gm. (gr. lxxv.) a day to young children without ill effects. In such large doses probably most of the drug passes through unchanged. Orphol is also applied externally as an antiseptic dusting and drying powder for impetigo, herpes, etc., and has been used locally in gonorrhœa and other mucous-membrane inflammations. *W. A. Bastedo.*

NAPHTOL CARBONATE, $(C_{10}H_7O)_2CO$, is a di-naphthyl ester of carbonic acid prepared by acting on beta-naphtol sodium with phosgene gas. It occurs as shining colorless scales which are insoluble in water. Recommended as a non-irritating intestinal antiseptic in dose of 0.12 to 1 gm. (gr. ij. to xv.). *W. A. Bastedo.*

NARCEINE. See *Opium*.

NARCOTINE $(C_{22}H_{23}NO_7)$.—Narcotine is, next to morphine, the most abundant alkaloid of opium, varying widely in percentage, both in different varieties and in different lots of the same variety. The amount has been reported as low as one per cent. and as high as ten per cent. It occurs in colorless, shining, acicular or prismatic crystals, melting at 176° C. (349° F.), almost insoluble in water, soluble in 100 parts of alcohol, 35 parts of ether, 2.7 parts of chloroform, 22 parts of benzene, and rather freely in hot acetic acid, by which it is usually extracted. It is only faintly basic and its salts are not crystalline. It is not bitter, but its salts are so, and are at the same time acid. Sulphuric acid turns it, after a time, to a yellow, changing to orange and red; the same, mixed with nitric acid, turns it blood-red. It is decomposable into meconin and *cotarnine* $(C_{12}H_{13}NO_3)$, the latter far more strongly basic than narcotine itself. Various other substances are obtained from it by different methods of treatment, but they are not of importance except from a chemical standpoint.

Crawford and Dohme (Proc. Amer. Phar. Assn., 1902) report experiments on warm-blooded animals, showing that it produces a fall in blood pressure and slowing of the heart, accelerated but weakened respiration, diminished saliva by small doses, increased by large doses, an anodyne effect upon the intestine, prompt and marked diminution of the urine, and a diminished size of the kidney. Partial elimination through the kidneys and stomach was observed, but none from the bowels, at least not as narcotine. Similar symptoms have been observed in man, together with profuse diaphoresis. The alkaloid, if pure, is in no sense a narcotic, for which reason the name "anarcotine" has been proposed for it, though it does not seem wise to introduce this element of confusion.

Therapeutically, narcotine is an antiperiodic, recognized as of considerable value in five-grain doses. Fortunately, since it is used in such large doses, its weakly basic character renders it easily freed from the associated active alkaloids, a character to which careful attention should of course be given. It is a valuable stomachic and digestive tonic in one- or two-grain doses three times daily.

Narcotine has been considerably employed as a secret remedy for the cure of the alcohol and other narcotic habits. Ebert reports many such cases cured or benefited through its use, and his results are confirmed by Schulte. The form of administration in these cases was a grain hourly. No harm resulted from the use of a gram or more per day, beyond the temporary loss of the appetite for food, followed later by an increase of appetite, and by weakening, amounting in some cases to semi-prostration, from the profuse perspiration.

Henry H. Rusby.

NASAL CAVITIES: ANATOMICAL RELATIONS AND RHINOSCOPY.—I. ANATOMY.—The nose forms the commencement of the air tract, and is composed of two large air channels in the centre of the face. The lower portion of this tract is used to convey air; the upper portion has distributed throughout its mucous membrane the terminal filaments of the olfactory nerve; while the whole cavity is employed in voice production.

The nose is divided into the external nose and the nasal cavities. The nasal cavities are separated from one another by a thin partition of bone and cartilage, called the septum. Each nasal cavity is surrounded by a set of accessory cavities, all of which communicate with the nasal cavity. In considering the anatomy of the nose, we find that three divisions may readily be made: (1) The external nose; (2) the nasal cavities; (3) the accessory cavities of the nose.

1. *The External Nose.*—The external nose forms the pyramidal projection in the centre of the face, extending from the brow to the upper lip. It is directed downward and forward. It is composed of bone, cartilage, and muscles which are covered externally with the facial epidermis and internally with the nasal mucous membrane.

The apex of the pyramid—the root of the nose, the radix nasi—joins the forehead; the lateral walls form by their junction the dorsum nasi, or back of the nose, which extends from the tip, the apex nasi, to the root of the nose; the lateral borders slope outward to form two wing-like leaflets, which are known as the alæ nasi or wings of the nose; the free edges of the alæ nasi form the outer borders of the two nasal orifices, known as the anterior nares, which are separated by a median pillar, or columna, the ponticulus nasi. The two anterior nasal orifices open downward and communicate with the vestibule of the nose, which is composed of that portion of the nose which is contained within the cartilaginous framework and extends from the anterior nasal orifice to the commencement of the osseous framework.

The walls of the nose proper are composed of the nasal bones and nasal spine of the frontal bone, the nasal processes of the superior maxilla, the premaxillary portion of the upper maxilla, the pars incisiva, and the lateral cartilages of the nose. The nasal bone articulates above with the frontal bone; its outer border articulates with the nasal process of the maxilla; while along their inner border, by their union, the nasal bones form a crest for articulation with the nasal spine of the frontal bone, the perpendicular plate of the ethmoid and the triangular cartilage of the nose. The outer surface of this bone is smooth; its inner surface presents a longitudinal groove for the nasal nerve. Lying external to the nasal bone is the nasal process of the maxilla, which articulates along its anterior border with the nasal bone, above with the frontal, and posteriorly with the lachrymal bone. Its external surface is smooth, while its inner surface presents two crests for the attachment of the middle and inferior turbinate bones. The pars præmaxillaris of the superior maxilla unites with its fellow below to form the lower rounded portion of the apertura pyriformis, the pear-shaped opening of the osseous nasal cavity. To the apertura pyriformis is attached the lateral cartilage of the nose, thus completing the outer portion of the external nose. The cartilages of the nose are the septal cartilage; the triangular, or superior lateral cartilages; the alar, or inferior lateral, cartilages; the accessory, or sesamoid, cartilages; and the accessory quadrate cartilages.

The cartilage of the septum is the most anterior structure of the septum, and is irregularly quadrilateral in form. Its anterior inferior border is unattached, and lies above and behind the inner plates of the two inferior lateral cartilages, extending to the anterior nasal spine, which it embraces. Its anterior superior border is attached to the crest on the under surface of the nasal bone, and below the nasal bones the sides of its border are continuous with the superior lateral cartilages. Its posterior superior border is in contact with the perpendicular plate

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of the ethmoid, and the posterior inferior border is received within a groove formed in the anterior nasal spine of the superior maxilla and the vomer for its reception.

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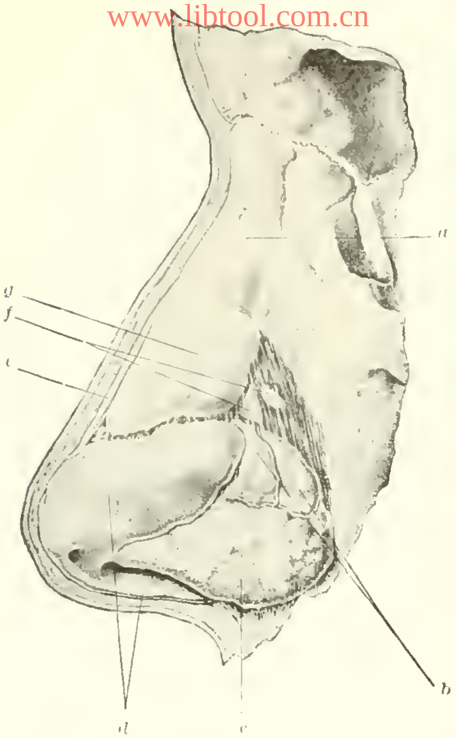

FIG. 3482.—Dissection of the External Nose, Demonstrating the Cartilages and Bones of this Part of the Nose and their Relations to One Another. *a*, Nasal bone; *b*, sesamoid cartilages; *c*, fibrous tissue of ala of nose; *d*, inferior lateral cartilage; *e*, cartilage of nasal septum; *f*, accessory quadrate cartilages; *g*, superior lateral cartilage.

The cartilaginous septum is thinnest in the vestibule of the nose, and increases gradually in thickness as it approaches its attachment to vomer and ethmoid.

The superior lateral cartilage is flat and triangular in shape, partially continuous with the anterior border of the septal cartilage, of which it forms flange-like extensions. It is closely attached along its superior and posterior border to the nasal bone and the nasal process of the superior maxillary bone. Its inferior border is attached to, and partially covered by, the inferior lateral cartilage. The inferior lateral cartilage is bent sharply around in front of the anterior nares so as to form an inner and outer plate. The outer plate lies in the plane of the superior cartilage of the nose, and makes up a part of the outer surface of the nose, while the inner plate lies in contact with the corresponding fellow of the opposite side and forms a portion of the inner border of the anterior nares. The lower lateral cartilages unite over the dorsum, but extend only about half-way back to the maxillæ, so that the intervening space in the alæ nasi not filled with cartilage is made of dense fibrous tissue.

The accessory cartilages are four in number in each lateral wall of the nose. Two of these cartilages are situated in the fibrous tissue which fills in the space between the posterior border of the lower lateral cartilage and the nasal process of the maxilla. Situated immediately above these are two others which are known as the accessory quadrate cartilages. The nose is supplied with certain external muscles which are concerned with the movements of the alæ nasi and with facial expression. These muscles are the pyramidalis nasi, compressor naris, levator labii superioris alæque nasi and depressor alæ nasi. The vessels which supply the external nose are branches of the facial and ophthalmic arteries. The veins empty into the angular vein. The lymphatics empty into the submaxillary lymphatic glands. The muscles of the nose are supplied by branches of the facial, and the general sensation by branches of the first and second divisions of the fifth nerve.

The Nasal Cavities.—The nasal osseous cavities are two large quadrangular-shaped cavities in the centre of the face, and are separated from one another by the septum narium, which extends from the vestibule anteriorly to the choanæ or posterior nasal orifices.

Each nasal cavity has a floor which is almost horizontal; a roof which is horizontal in its middle portion, but inclined downward and forward in its anterior portion, and downward and backward in its posterior portion; an inner wall which is vertically directed; and an outward wall which is directed downward and slightly outward. The inner wall, or septum, is partly cartilaginous and partly osseous. The osseous septum is formed by the crest at the juncture of the nasal bones, the nasal spine of the frontal bone, the perpendicular plate of the ethmoid, the vomer, the crest of the sphenoid bone, and the crest situated at the juncture of the two palatal processes of the superior maxillæ and the two horizontal plates of the palate bones.

The vomer is irregularly quadrilateral in form, its lower border articulating with the nasal crest of the superior maxillæ and the palate bones. Its superior border is attached to the rostrum of the sphenoid bone by two winglike expansions, or alæ. The posterior border is concave and lies free between the posterior nasal orifices. Its anterior border is the longest, the upper portion of which articulates with the vertical plate of the ethmoid, while to the lower portion is attached the cartilage of the septum. Running downward and forward nearly at its middle is a shallow groove for the naso-palatine nerve. The vertical plate of the ethmoid is pentagonal, and its short anterior border articulates with the nasal spine of the frontal bone and the crest of the nasal bones. Its superior border is continuous with the cribriform plate of the ethmoid, and its posterior border with

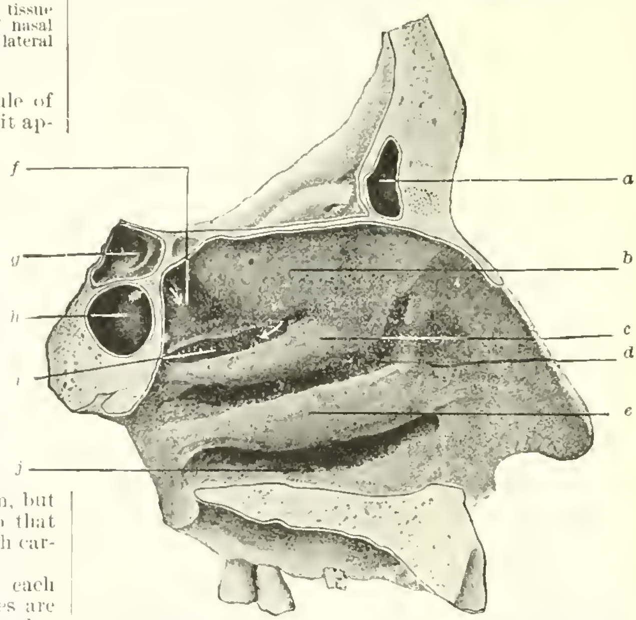

FIG. 3483.—Vertical Antero-Posterior Section of the Nasal Cavity, Demonstrating the Outer Wall of this Cavity. *a*, Frontal sinus; *b*, superior turbinate; *c*, middle turbinate; *d*, middle meatus; *e*, inferior turbinate; *f*, spheno-ethmoidal recess; *g*, right sphenoid sinus; *h*, left sphenoid sinus; *i*, superior meatus; *j*, inferior meatus.

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Nasal Cavities.

the crest of the sphenoid. The anterior inferior border gives attachment to the cartilage of the septum, and its posterior inferior border articulates with the vomer.

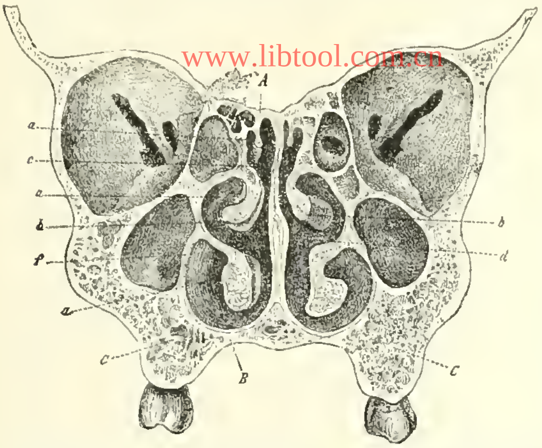

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FIG. 3484. Vertical Transverse Section through the Nasal Fossæ, somewhat Behind their Centre. (Zuckerkandl.) A, Roof of nasal cavity; B, floor of nasal cavity; C, C, alveolar processes; D, external wall of nasal cavity; a, a, a, three meatuses; b, b, middle turbinated bodies; c, olfactory slit; d, respiratory region.

The septum is covered with mucous membrane, which is continuous with that which lines the whole of the nasal chambers.

The roof of the nasal cavity is divided into naso-frontal, ethmoidal, and sphenoidal parts. The naso-frontal portion is directed downward and backward, and is composed of that portion of the roof which is formed by the nasal bone. The ethmoidal portion is horizontally directed, and is formed by the cribriform plate of the ethmoid. It is lined with two rows of foramina for the passages of the median and lateral branches of the olfactory nerve. The most anterior foramina give passage to the nasal nerve. The sphenoidal portion looks downward and forward, and is formed by the body of the sphenoid bone.

The opening of the sphenoidal sinus is to be seen on the anterior vertical surface of the body of the sphenoid. The floor of the nose is flattened from before backward, concave from side to side, and wider in the middle than at either extremity. It has a slight inclination downward and backward. It is formed in front by the pars incisiva of the superior maxilla and its palatine process, and behind by the palatine process (horizontal plate) of the palate bone. It presents, just behind the nasal spine, the upper orifice of the anterior palatine canal. In the region of the anterior palatine canal, the mucous membrane presents a small diverticulum, which is the rudimentary Jacobson's organ. This organ is more highly developed in some of the lower animals, and is an organ of the sense of smell.

The outer wall is the most complicated and interesting portion of the nasal cavity. It is formed, in front, by the nasal process of the superior maxilla and the lachrymal bone; in the middle, through the lateral mass of the ethmoid, by the body of the superior maxilla and the inferior turbinated bone; and posteriorly by the perpendicular plate of the palate bone and the pterygoid process of the sphenoid. The lateral mass of the ethmoid bone, which forms a portion of the outer wall of the nasal cavity, and contains the ethmoid cells, reaches from the roof of the nasal chamber, where it articulates with the frontal bone, to the level of the floor of the orbit, where it articulates with the orbital portion of the superior maxilla and the palate bone. Anteriorly, it articulates with the lachrymal bone and the nasal process of the superior maxilla; posteriorly, with the rough surface on the side of the body of the sphenoid bone. These various articulating surfaces serve to complete the ethmoid cells, and the participating bones frequently contain accessory cells. From the anterior end of the medial plate of the lateral mass proceeds a curved process known as the processus uncinatus, which serves to complete the orifice of the maxillary sinus and forms the lower boundary of the hiatus semilunaris. This process is a narrow bony plate, which curves downward and backward almost parallel with the lower border of the middle turbinate bone. It articulates with the superior maxillary and inferior turbinate bone, and, through this union, aids in closing the orifice of the maxillary sinus.

Encroaching upon the lumen of the nasal cavity are three scroll like shells of bone which are known as the turbinate bones. These bones are scroll-like in form, each larger than the other from above downward; their convex surfaces look upward and inward, with a more or less irregular free border. The superior and middle turbinate bones are projections from the lateral mass of the ethmoid; the inferior is an independent bone.

The superior turbinate bone forms a distinct ridge posteriorly, but merges into the middle turbinate anteriorly. The middle turbinate is a broad, thin, bony plate, scroll-like in outline, curling down upon itself, and has at its anterior inferior surface a slight projection which is known as the agger nasi. The inferior turbinate articulates anteriorly with the inferior turbinate crest of the superior maxilla, behind this by the lachrymal process with the lachrymal bone, and posteriorly it articulates with the ethmoid and the lower crest of the palate bone. Through its maxillary process it aids in closing the lower part of the opening to the antrum. The body of the inferior turbinate curls downward and outward. These three bones, through their situation and outline, necessarily divide the nasal chambers into three anterior-posterior incomplete canals, which are designated as the three meatuses of the nasal cavity. The inferior meatus lies between the under surface of the inferior turbinate and the floor of the nose. Slightly in front of

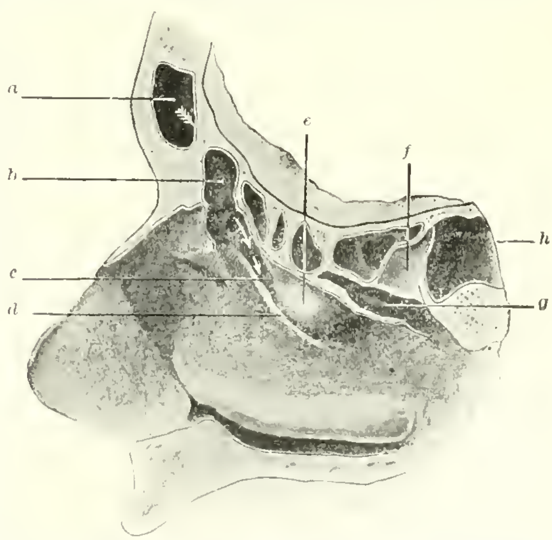

FIG. 3485.—Outer Wall of the Right Nasal Cavity. The superior and middle turbinates have been removed, thus demonstrating the hiatus semilunaris, the bulla ethmoidalis (c), the frontal (a), the ethmoidal (b) and the sphenoidal (h) sinuses, the infundibulum (e), and the openings of the frontal and anterior ethmoidal cells into the nasal cavity (indicated by white arrow heads). The processus uncinatus is shown at d, and the spheno-ethmoidal recess at f.

the centre of that portion which is covered by the inferior turbinate bone is the inferior or nasal orifice of the lachrymal canal.

The middle meatus presents many points of great interest to the rhinologist. This meatus lies between the concave under surface of the middle turbinate bone and

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the convex upper surface of the inferior turbinate bone; and it extends anteriorly from the vestibule of the nose, into which it opens widely, through the communication which is known as the atrium of the middle meatus, to the anterior fold of the Eustachian tube posteriorly. It is truncated in form with its widest portion directed anteriorly. The outer wall of the middle meatus presents a deep groove, or semilunar sulcus, known as the hiatus semilunaris. This groove extends from the lower border of the infundibulum, at the anterior extremity of the middle turbinate, to just below its centre. The average length of the hiatus is from 15 to 20 mm. The upper boundary of the hiatus semilunaris is created by a bulbous expansion of ethmoid cells, which is designated as the bulla ethmoidalis. This groove is crescentic in shape, and varies from a shallow furrow to almost a complete canal; its direction is from above downward and backward, with its concavity directed upward and backward. At its upper extremity we have the orifice of the frontal sinus, while at its posterior shallow portion is the orifice of the maxillary antrum; slightly irregular in their locations, but usually quite near the orifice of the frontal sinus, we find the openings of the anterior ethmoidal cells. Behind the opening to the antrum we occasionally find a second orifice communicating with the same cavity, known as the ostium maxillare accessorium. The superior meatus is closed in front and opens downward and backward. This meatus presents the orifices of the posterior ethmoidal cells and the sphenoidal sinus. In reality, the orifice of the sphenoidal sinus is near the roof of the nasal fossa, on a level with the superior turbinate bone in the recessus spheno-ethmoidalis, which is the recess formed by the junction of the ethmoid with the body of the sphenoid.

3. *The Accessory Cavities of the Nose.*—Surrounding the nasal chamber are a set of pneumatic cavities which through their location, as well as by their direct communication with the nasal cavity, have an important anatomical as well as pathological relationship to this organ. The sinuses are called the frontal, ethmoidal, sphenoidal, and antral. The frontal sinus is a small triangular cavity situated between the plates of the frontal bone above the inner angle of the orbit. There are two cavities which are separated, the one from the other, by a thin septum of bone. The dividing septum is usually placed in the mesial plane, although it occasionally shows deflections to one or the other side. This cavity extends from the mesial plate outward a short distance beyond the supra-orbital foramina. The frontal sinuses are very irregular as to their size, shape, and uniformity of relationship one with the other. The average vertical measurement is 31.60 mm., the average horizontal measurement 18 mm., and the average transverse measurement 25.8 mm. The shape is usually triangular, but rarely it may be very irregularly pyramidal through its projecting upward inordinately between the two plates of the frontal, or outward toward the outer angle of the orbit. The cavities are usually of uniform size and outline, although marked variation in this respect is found to exist. There may be only one cavity filling in the space occupied by two, or one larger cavity projecting over toward a second small cavity; in fact, perfectly symmetrical cavities are rare. This cavity is rarely irregularly placed, and more rarely accessory cavities are found. Inspection of the interior of the cavity shows rarely imperfect partitions which form recesses, giving the interior an irregular outline. It has an anterior wall formed by the outer plate of the frontal bone, a posterior wall formed by the inner table of this bone, an inner wall formed by the mesially placed septum, and the floor which is formed by the orbital plate of the frontal bone. The fronto-nasal opening, the ostium frontale, lies in relation to the septum of the sinus, and is situated in the lowest part of the floor. This opening terminates in the middle meatus through the naso-frontal canal at the commencement of the hiatus semilunaris. The ethmoidal cells fill in the space between the orbital and lateral walls of the nasal fossa. They vary greatly in shape and size, and are divided into an anterior and a posterior group. These sinuses are composed of a number of small cavities separated from one another by thin partitions of bone. These small cellular cavities vary in number from one to eight in each mass and usually open by a common duct. Those cells which communicate with the middle meatus of the nose, below the line of origin of the middle turbinate bone, are the anterior ethmoidal cells. Those cells which communicate with the superior meatus above the origin of the middle turbinate are the posterior ethmoidal cells. The space occupied by each collection of cells in the lateral mass is not uniformly constant, nor is there any regularity in the number of cells in each collection. The anterior cells may extend far backward, almost to the sphenoid, while the posterior group may extend as far forward in another specimen. The plate of bone separating the two groups of cells is placed diagonally between the outer and inner walls of the lateral mass, and does not normally present any communication of the one group with the other. The ethmoid cells are bounded externally by the os planum, the lamina papyracea, and internally by the two ethmo-turbinates. The superior wall of the cells is completed by the depressions or foveæ on the ethmoidal edge of the orbital plate of the frontal bone. Inferiorly they are completed by the ethmoidal edge of the orbital plate of the superior maxilla. Anteriorly they are closed in by the nasal process of the superior maxilla and the lachrymal bone. Posteriorly they articulate with the sphenoidal spongy bone.

The maxillary sinus, or antrum of Highmore, is a pyramidal-shaped cavity situated wholly within the body of the superior maxilla. Its roof is a thin plate of bone which also forms the floor of the orbital cavity. The infra-orbital canal, which serves to convey the superior maxillary nerve and infra-orbital vessels in their passage to the face, lies in the roof of the cavity. The floor of the sinus is formed by the alveolar border of the superior maxilla. This wall bears an important relation to the teeth. The converging of the facial and nasal walls at their angle of junction is frequently so acute as to leave a mere groove to form the floor, which is then called the sulcus alveolaris. The floor of the antrum is usually on a level with the floor of the nasal cavity. The layer of spongy bone between the floor of the antrum and the root of the teeth varies greatly. Occasionally this layer is so thin that a mere shell of bone separates the teeth from the antral cavity. Ofttimes slight elevations are seen in the floor corresponding to the fangs of the teeth. When of average dimensions, the floor has in relation to it the second bicuspid and the three molar teeth. The posterior wall is the thin plate of bone which forms the anterior boundary of the zygomatic fossa. The inner or nasal wall of the antrum, as it forms the outer wall of the nasal chamber, is the most interesting aspect of this sinus. That portion of the inner wall which is situated below the inferior turbinate bone is continuously osseous, thinnest immediately below the attachment of the turbinate bone, and forms the outer boundary of the inferior meatus of the nose. In the thin portion of this wall, immediately below the attachment of the inferior turbinate, is the point of selection for exploratory puncture. That portion of this wall which is situated above the inferior turbinate is partly osseous and partly membranous. The aperture, the ostium maxillare, by which this cavity communicates with the middle meatus, is situated here. As the ostium maxillare lies just beneath the level of the roof of the antral cavity, it permits of only imperfect drainage. Sometimes an additional opening exists in the membranous portion of the nasal wall, designated as the ostium maxillare accessorium. This accessory opening is said to exist in about ten per cent. of cases. The accessory opening communicates with the middle meatus at a plane lower than and posterior to that of the ostium maxillare, and this accounts for the occasional draining away of fluids from the antrum posteriorly into the pharynx. The anterior or facial wall is thin; at its upper

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margin is the infra orbital foramen. In front this surface is marked by the canine ridge, which corresponds to the socket of the canine tooth. The facial wall is limited externally by the malar ridge. Between these two prominent ridges, the canine and malar, is a depression, the canine fossa. The canine fossa varies greatly in depth. It is at this point that the external or facial opening is made into the antral cavity. The antral cavity varies also in shape and size, and occasionally septa divide the cavity more or less completely by vertical or horizontally placed lamellæ of bone. The average dimensions are as follows: Vertical height, 3.5 cm.; the transverse breadth, 2.5 cm.; and the antero-posterior depth, 3.2 cm.

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The sphenoidal sinus, on account of its intimate relationship with the cranial, orbital, and nasal cavities, forms one of the most interesting of the accessory sinuses. They are two in number and occupy the anterior portion of the body of the sphenoid bone; a vertical mesial plate of bone forms the division wall between the two cavities. Each cavity presents six walls: a roof, floor, an anterior, a posterior, an external, and an internal wall. The roof is formed by the root of the lesser wings of the sphenoid, the olivary process, and the sella turcica. This wall is in intimate contiguity with important cranial structures. The plate of bone which forms the roof of the sinus is extremely thin. At the junction of the external wall with the roof of the sinus, the optic nerve and the ophthalmic artery pass forward to the orbital cavity. The floor of the sphenoidal sinus forms the posterior part of the roof of the nasal chamber. The anterior wall is in the vertical plane, although at its lower border it inclines slightly downward and backward to join the floor. This wall is extremely thin, and contains the orifice of communication with the nasal cavity. This wall may be divided into an internal portion, which presents the orifice of the ostium sphenoidale (which opens into the spheno-ethmoidal recess), and the outer portion which articulates with the posterior extremity of the lateral mass of the ethmoid, and thus completes the posterior ethmoidal cells. The posterior wall is formed of the posterior portion of the sphenoidal body. The external lateral wall of the sinus varies in thickness, and is in important relationship to neighboring structures. On its cranial aspect, it is in relation to the groove for the internal carotid artery and cavernous sinus. At its anterior aspect it forms the internal boundary of the sphenoidal fissure and the inner wall of the orbit. The internal wall, or septum, is a thin vertical plate of bone which is usually situated in the mesial plane, separates completely one cavity from the other, and rarely is defective. The septum may be irregularly placed, or wanting, thus giving rise to great irregularity in the shape and size of the sphenoidal cavities. These vary in size, shape, and relation to each other. Occasionally accessory cavities are found in the wings of the sphenoid. The average dimensions are as follows: Vertical height, 20 mm.; antero-posterior depth, 21 mm.; transverse breadth, 18 mm. All of these sinuses are lined with a muco-periosteal covering, which is continuous with the mucous membrane of the nasal cavity. The surface of the mucosa is lined with columnar ciliated epithelium.

The Mucous Membrane of the Nose.—The mucous membrane lining the nasal cavities is continuous with that of the pharynx, and extends into the pharyngeal orifice of the Eustachian tube and the accessory sinus.

Anteriorly the integument of the face supplied with hair and sebaceous glands enters the nostrils and extends to the inner extremity of the alar cartilage. At the junction of the superior lateral cartilage and the alar cartilage, the limen nasi, there is a narrow zone where the integument presents the characteristics of mucous membrane, and is lined with pavement epithelium and supplied with muciparous glands. From this point the transition is rapid into the characteristic mucosa of the nasal chamber. The anterior portion of the inferior turbinate, as well as the opposite portion of the septal cartilage, may have a mucosa lined with pavement epithelium, or with the columnar ciliated variety. The portion of the nasal tract, known as the olfactory region, is lined with columnar non-ciliated epithelium. This area extends from the roof as low down as the middle turbinate and the upper third of the septum. The remaining portion of the nasal cavities, the respiratory tract, is supplied with a columnar ciliated epithelium. These cells are long and spindle-shaped, and interspersed numerously among these cells are the so-called goblet or chalice cells. The thickness of the epithelial layer is from 30 to 70 μ. The cilia wave toward the post-nasal orifices. The cilia are stated to move in a thin layer of fluid. The nasal mucous membrane is inseparable from the perichondrium, or periosteum. The mucous membrane is very thin in the accessory sinuses, very thick over the turbinals, somewhat thinner over the septum, and very thin again over the floor and the under surface of the turbinated bodies.

The muciparous glands are of the tubular and racemose variety, and are present in great numbers. These glands do not differ in any essential particulars from similar glands located elsewhere in the mucous membrane, being most abundant at the middle and posterior portions of the nasal cavities, and of greatest size at the lower and posterior part of the septum. Beneath the columnar cells of the mucous membrane, we find a homogeneous basement membrane, and below this there is a connective-tissue layer, which is continuous with the periosteum.

The submucous connective tissue and the epithelial elements contain evidences of lymphoid tissue in the presence of leucocytes, lymphoid collections, and occasional lymph follicles.

In the olfactory region, the mucous membrane has quite a different histological structure from that in the respiratory tract. Here the mucous membrane is very thin, and not so vascular. The epithelium is of the columnar type, but is devoid of cilia, having a branching base and a large nucleus. Lying among them are the olfactory cells of Schultze, which are connected directly with the non-medullated filaments of the olfactory nerve. Beneath the epithelial covering, and opening upon its surface, are numerous branched tubular glands, which secrete a serous fluid. These glands are known as Bowman's.

The gross appearance of the colorization of the mucous membrane in the living subject varies in the different portions of the nasal chambers. In the upper, or olfactory, region the membrane is of a yellowish-pink in color; in the respiratory tract it is a light pink; at the posterior ends of the turbinates it is almost white; while in the accessory cavities it is of a pale pink.

A most interesting feature of the soft structures of the nasal chambers is the arrangement of the submucous tissue over the middle and inferior turbinates and the lower part of the septum. This important feature is the aggregation of venous sinuses and their large size, forming plexuses of blood-vessels over the turbinate bones. These are designated as the turbinate bodies. This term, the turbinate body, is applied to the bone and the investing soft tissue. The mucous membrane over the turbinates is divided into two layers, the adenoid layer with its epithelial covering, and a deep layer forming the periosteum of the turbinate bones. Between these two layers we have a stroma which contains lymph structure. Within this lymph structure we have an abundance of venous channels forming plexuses, which, on account of their rapid dilatation and contraction, under various stimuli, have been designated as erectile tissue, the Schwellkörper of the Germans.

This peculiar action of the venous plexus in the so-called turbinal tissue is not so much due to the arrangement of the veins and their relation with arterial twigs as to the characteristic walls possessed by these vessels and the arrangement of the muscular fibres and elastic tissue in the surrounding stroma. The muscular layer of these walls is very thick, greater than the walls of the corresponding arteries, and the walls are known to be thrown into irregular folds. The arrangement of the

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muscular fibres is irregular, although the circular fibres predominate. This arrangement of the vessel walls, as well as the character of surrounding stroma, adapts these walls for the rapid emptying and filling of the venous plexuses. The venous plexuses are more pronounced over the inferior www.libtool.com.cn to its anterior and posterior extremities, over the middle turbinate, especially along the lower border and posterior extremity; and on the septum, in a line with the middle turbinate, corresponding with the anterior extremity of this turbinate—the tuberculum septi.

The vascular supply to the nasal chambers is obtained from the anterior and posterior ethmoidal arteries, branches of the ophthalmic; from the spheno-maxillary and the alveolar arteries, branches of the internal maxillary artery; and from the artery of the septum, which is derived from the facial artery. The spheno-palatine artery enters the nasal chambers through the spheno-palatine foramen with the naso-palatine nerve. Its internal branch, the naso-palatine, accompanies the nerves of the same name, passing downward and forward upon the septum (which it supplies) toward the anterior palatine foramen.

The external branches supply the outer wall of the nose, the nasal fossæ, the ethmoid cells, the frontal sinus, and the antrum of Highmore. The antral and posterior ethmoid supply the roof, upper portion of the septum, outer wall of the nasal fossa, the ethmoidal cells, and the frontal sinuses. The alveolar branch of the internal maxillary supplies the lining membrane of the antrum. The artery of the septum is a branch of the superior coronary, a branch of the facial. The septal artery supplies the columnar and the lower part of the septum.

The veins of the nasal cavity form plexuses beneath the mucous membrane, and these in turn are drained by various veins. The veins which perform this function are the veins which accompany the spheno-palatine artery and empty into the pterygoid plexus, those which accompany the ethmoidal artery and empty into the ophthalmic vein, and those which empty into the facial vein; and still other veins convey the return blood through the foramen cæcum and the cribriform plate to the superior longitudinal sinus and the intracranial veins.

The lymphatic vessels of the nasal cavity empty into the post-pharyngeal, the internal maxillary, the parotid, and the upper deep cervical lymphatic glands. Through the cribriform plate of the ethmoid, the nasal lymphatic vessels communicate with the intracranial lymphatics and the subdural space.

The nerve distributions for the nasal cavity consist partly of nerves of olfaction and partly of nerves of general sensation. The olfactory nerve, the nerve of the special sense of smell, arises by three roots: an external root, commencing in the deep substance of the middle lobe of the cerebrum; a middle root, from the caruncula annularis; and an internal root, from the inner and back part of the anterior lobe of the cerebrum. The three roots unite and run forward as a flat band on the under surface of the brain until it reaches the cribriform plate of the ethmoid, where it expands into what is known as the olfactory bulb. From the under surface of the olfactory bulb are given off from fifteen to eighteen filaments, which, piercing the foramina of the cribriform plate, are further subdivided and distributed to the nasal mucous membrane. They can be divided into three groups: an inner group which spreads out over the upper third of the septum, an outer group supplying the superior turbinate and the upper surface of the middle turbinate, and a middle group which is distributed to the roof of the nasal cavity.

General sensation is supplied to the nasal mucosa through the nasal branches of the ophthalmic division of the trigeminus. This nerve enters the nasal cavity through a slit beside the crista galli, and then divides into two branches. The internal of these two branches supplies the mucous membrane of the anterior part of the septum; while the other, the external, descends in a groove on the inner surface of the nasal bone where, at the junction of the nasal bone with the lower lateral cartilage, it passes out of the nasal cavity. This branch, in its passage through the nasal cavity, supplies the mucous membrane of the outer wall as low down as the inferior turbinate body. Branches of the anterior dental nerve are distributed to the mucous membrane of the inferior meatus and the inferior turbinate body. Branches from Meckel's ganglion gain access to the nasal cavity through the spheno-palatine foramen, and, after further subdivision, supply the mucous membrane covering the superior and middle turbinate bodies, the ethmoidal cells, and the upper and posterior part of the septum. The naso-palatine, in its passage forward across the roof, distributes filaments in its course, and descends downward and forward along a groove in the septum to the anterior palatine foramen, where it joins the anterior palatine nerve. The Vidian nerve supplies the upper and posterior part of the septum and the superior turbinate. Branches of the sympathetic are also distributed to the nasal mucous membrane, being derived principally from the spheno-palatine ganglion of the sympathetic.

II. Physiology.—The physiological function of the nose is of a threefold character: (1) In relation to respiration; (2) in connection with olfaction; and (3) in phonation. The respiratory function of the nose is by far the most important physiological duty that this organ performs. It is during the passage of inspired air through the nasal chambers that it is warmed, saturated with moisture, and freed from coarse material therein floating. According to the experiments of Aschenbrandt, which have been confirmed by others, a column of air, in its passage through the nasal chambers, on reaching the pharynx, has had its temperature raised to 86° F., and its degree of humidity raised to the point of almost complete saturation.

This function takes place whatever may be the degree of temperature or humidity of the external atmosphere, and is so complete in its action as to functionate perfectly during sudden and very marked changes in both of the enumerated conditions. This function is performed through the exquisite working of the so-called turbinal tissue. When we consider the constant and excessive changes in its functional activities that are persistently taking place, one cannot but marvel at the wonderful nature of this mechanism.

The second important physiological function of the nose is that of olfaction. The sense of smell is dependent upon the impinging of the odorous particles upon the terminal filaments of the nerve ends in the olfactory apparatus. In order for various substances contained in the atmosphere to be appreciated as having an odor, it is necessary that the air should reach the olfactory region and that the peripheral apparatus should be normal. According to Paulsen, the inspired air passes first directly upward under the dorsum of the nose, and then follows the roof, the greater portion of the column passing through the superior and middle meatus and then descending downward to the post-nasal orifice. Odorous particles reach the nose in various forms. Various theories have been offered to explain the mechanism of olfaction, the most important of which are the mechanical, the vibratory, and the chemical. (For further information in regard to the sense of smell, consult the article on *Olfactory Nerve*.)

The third physiological function of the nose is the part which it plays in connection with phonation. The nasal cavities, in connection with the pharynx and the buccal cavity, constitute that portion of the vocal apparatus by which quality and character are given to the voice. The importance of the nasal organ in that office is well demonstrated by the alteration of the character of the voice when from any cause one or both nasal cavities are obstructed.

III. Rhinoscopy.—In order to obtain a successful inspection of the nasal cavities and neighboring parts, it is necessary to have the best illumination that it is possible to obtain, means for projecting this light, and aids

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through which this light can gain ingress into the remote parts to be examined.

Previous to the inspection of the interior of the nasal cavity, it is always well to make a thorough examination of the external nose. The external configuration of the nose, the aspect which it presents at the root, the evidences of deviation, the presence or absence of marked movement of the alæ nasi, the pres-

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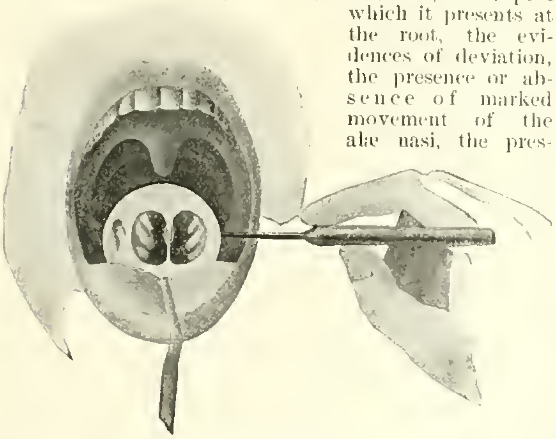

FIG. 3486.—Posterior Rhinoscopy Mirror in Position Showing Image Reflected Therein.

ence or absence of sound in nasal breathing, the relation of the alæ to the septum, and the outlines of the anterior nares should all be thoroughly considered before the interior of the nose is inspected. The appearance of the cutaneous covering of the external nose, the presence of excoriation on the upper lip, the odor of the breath, and the character of the voice should all be thought of in this preliminary examination.

In order that the examination may be successful, it is necessary to have, first, a good source of light; second, a concave reflecting mirror for projecting this light; third, variously devised instruments called speculums by which the vestibule of the nose is expanded and a greater volume of light admitted to the interior; and small plane mirrors for diverting the reflected light and receiving the image which is thus created.

The Light. On account of the exigencies of circumstances, the use of the best light obtainable, sunlight, is not possible. The light which is sought is one as nearly white as possible. The three sources of light which are most frequently used are gaslight, electric light, and lamplight. Any source of light of sufficient intensity and penetrating power can be used when circumstances demand it, and one should adapt himself to these varying conditions. In office work the source of light can be controlled, and one should select that which gives the best illumination with the least inconvenience. For average general utility, gas fed through an Argand burner serves the best purpose. To increase its efficiency use may be made of the Welsbach mantle, which gives a whiter light. With a moderate degree of care the mantles last for many months. The light thus obtained may be fixed or movable. It is better to have the burner attached to a movable bracket which can be placed at various angles and raised or lowered at pleasure. The apparatus is completed by surrounding the light with a cylindrical japanned tin or asbestos chimney, which has a circular opening of two and a half inches in diameter through its lateral wall at the middle. This contrivance shuts off all the rays of the light excepting those coming through the lateral aperture. A further part of the equipment is the device known as the Mackenzie condenser. This latter device is not essential, but renders the examination easier for the examiner.

The electric light may be used in two methods, directly and indirectly. The direct method is the use of the electric headlight; the indirect method is the use of the electric light by reflection, as we use gaslight. The objection to the electric headlight is its weight and its want of penetration. With the use of the ground-glass globes we have a very good source of indirect illumination in electricity. The student's, or Rochester lamp, forms the best form of oil light. This light can be made whiter by the addition of a small piece of camphor to the oil, as suggested by Sajous.

The instrument by which the light is reflected into the various cavities to be examined is known as the head mirror. This mirror is a round, concave mirror, from three to four and a half inches in diameter, with a focal distance of from eight to fifteen inches. It should be supplied with a central orifice. The central orifice is for the purpose of more exact observation, as, through its use, the angles of incidence and reflection are made to coincide, and, therefore, the picture is rendered more perfect. This mirror is more serviceable if it is worn suspended through a ball-and-socket joint from a head-band which encircles the forehead. It may also be suspended from a rod which is attached to the lamp which furnishes the source of light. Steadiness and immobility, when it is fixed at the proper angle, are the most desirable features in the reflecting mirror. One having a diameter of three and a half inches has, in my hands, proved the most serviceable. For the purpose of permitting as much light to enter the nasal cavity as possible, it is necessary gently to dilate the vestibule through the means of a speculum which is introduced into the anterior nares. Those speculums which are constructed on the bivalve system are the most serviceable. Their numbers are legion. I prefer the Schnitzler's. Hartmann's, Ingals', Roth's, and others are of this style. A number of fine, wire-like speculums, such as the Jarvis, the Bosworth, the Goodwillie, and the Ives, are made on the bivalve principle. Others are made to be self-retaining. The Schnitzler instrument, as offered for sale in the shops, is too cumbersome. I have it in a light frame, which not only makes a neater but a more useful instrument. The individual preference in speculums is also a question of adaptability and use. In making examination of the post-nasal space and the nasal cavities from behind, what is called posterior rhinoscopy, it is necessary to have, in addition to a good light and the head reflector, small plane mirrors constructed like those used in examining the larynx, and a tongue depressor. These small plane mirrors are fixed at an angle of 105° to the shaft, and vary in size from three-eighths to three-quarters of an inch in diameter. The largest mirror which it is possible to use in the individual case should always be employed. This mirror is used to reflect the light behind the curtain of the palate.

Usually it is necessary to control the tongue, as only a few patients are able to hold it relaxed in the floor of the mouth during an examination; therefore it becomes necessary to depress it through the aid of a tongue depressor.

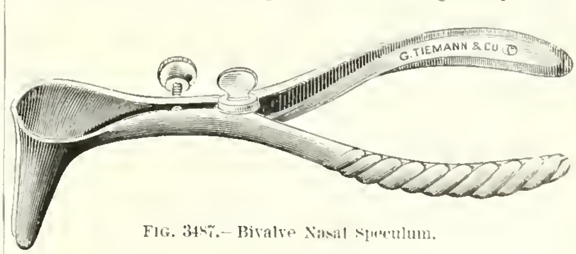

FIG. 3487.—Bivalve Nasal Speculum.

Numerous forms of depressors are on the market, but one that especially recommends itself, on account of its simplicity and of the ease with which it may be kept aseptic, is the one invented by Dr. D. Braden Kyle (Fig. 3488).

The nasal probe is indispensable to a thorough examination and understanding of diseased conditions in the nasal cavities.

Examination of the nasal chambers through the anterior nares is called anterior rhinoscopy, while examina-

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Nasal Cavities.

tion of the upper pharynx and nasal chambers from behind is known as posterior rhinoscopy.

In these examinations of the nasal cavities the relationship of the patient and physician with regard to the source of light is absolutely the same as it is in laryngoscopic examinations. The patient sits in a simple straight-back chair, without head support. The physician sits directly in front of the patient, or, what is preferable, directly beside and on the left hand side of the patient. The source of light should be to the right of the patient, just to the side of and on a level with the upper border of the right ear. The patient should sit in an easy, erect, comfortable position, when the examiner reflects the light in a circle just upon the area to be examined. Either may then move, within a certain latitude, from this fixed position; nevertheless, it will be noted that when they return to the examining position the light will fall directly on the point upon which it originally fell. The method of examination, as well as the character of furniture used for patient and doctor, is a question of individual preference and perfected method on the part of the operator.

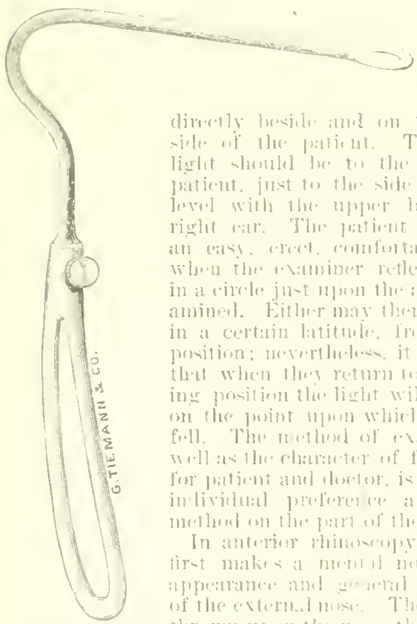

FIG. 488. — Kyle's Tongue Depressor.

In anterior rhinoscopy the operator first makes a mental notation of the appearance and general configuration of the external nose. The light is then thrown upon the nose, the head of the patient is slightly tilted backward, and the general appearance, the patency, and the outline of the anterior nares are noted, after which the tip of the nose is slightly tilted upward and the vestibule is thoroughly inspected. Little children fear instruments, and, as their hairs are undeveloped, we can often make a thorough inspection without the use of specula. Special care should be made to note fissures, abrasions, or pimples on the inner surface of the nares, which would make the introduction of the speculum painful.

We are now prepared to introduce the speculum. This instrument should be gently insinuated into the anterior nares in a closed state. After the speculum is placed slightly within the vestibule, it is moderately dilated until slight resistance is felt. No pain should ever be given. With the instrument in position, the two crura being controlled by the pressure of the thumb and index finger of the left hand and with the little finger of the same hand hooked under the lower jaw, the patient is practically under control of the examiner. Slight pressure is usually all that is sufficient to make the patient move in a required direction. With the patient's head slightly tilted forward, the first object that attracts attention is the prominent rounded red mass on the outer wall projecting nearly to the floor of the nose and which we recognize as the anterior end of the inferior turbinate body. Opposite this we recognize the cartilaginous wall of the septum, and below, the floor of the nose and the inferior meatus. According to the amount of space between the inferior turbinate and the septum we can see to a greater or less depth within the nasal cavity toward the pharynx. In many cases, with a fair amount of space between these parts, or when the turbinal tissue is contracted under the use of cocaine, we can well see the posterior pharyngeal wall. A tilting of the patient's head slightly backward brings into view the middle turbinate, which is paler and more translucent than the inferior, and just opposite its anterior extremity on the septal wall is seen often an aggregation of erectile tissues, which is designated the tuberculum septi. The whole extent of the visible upper surface of the inferior turbinate is seen in this position, as well as the middle meatus. It is only when the middle turbinate is removed or has undergone great atrophy that the interesting features contained within the middle meatus are brought under observation. Tilting of the patient's head still farther backward brings into view the upper portion of the middle turbinate and the roof of the nasal cavity. It is rather unusual to be able to demonstrate the superior turbinate body. Occasionally the orifice of the sphenoidal sinus can be made out. The use of the probe is indispensable in making this examination, and so also is the instillation, after the preliminary examination, of a very mild solution of cocaine, —a procedure which should be followed by a re-examination of the parts after the effects of the drug have become manifest. Great care should be exercised in examining the septum; it should be viewed from both sides, and the head should be held carefully in the middle line.

Posterior rhinoscopy is the most difficult procedure in the examination of the upper air tract, and therefore requires more tact and skill in its prosecution. The position of the patient and of the source of light, and the methods of reflection are the same as in anterior rhinoscopy. The only instrumental addition is the rhinoscopic mirror and the tongue depressor. I have never found it necessary to make use of the so-called palate retractors, but see no objection to the use of such an instrument, for holding forward the soft palate, if the examiner so desire. The most desirable instrument for retracting the palate is that invented by Dr. J. A. White. Occasionally the examination can be made without the use of a tongue depressor, but this is exceedingly rare. After depressing the tongue, and noting the space between the soft palate and the pharyngeal wall, as well as that between the pendent uvula and the base of the tongue, the largest size mirror which it is possible to use is gauged. The mirror is first heated to a proper temperature and the tongue carefully depressed. In introducing the tongue depressor care should be exercised in so introducing it that the tip of the tongue depressor first comes in contact with the tongue just posterior to its arch, which is somewhat anterior to the circumvallate papillæ. The tongue is then drawn downward and forward into the floor of the mouth. Backward pressure of the tongue is always to be avoided, as it is certain to give rise to retching and gagging.

If the depressor is so placed as to excite distress on the patient's part it should be immediately removed and replaced. The depressor should be held between the thumb and index finger of the left hand, while the other fingers pass under the patient's chin. The mirror, which has been properly warmed, being lightly held between the thumb and index finger of the right hand, is now quickly introduced into the widely open mouth along its left wall until we come to the dependent palatine arch. The important feature in the introduction of the mirror is so to insert it as not to come in contact with any of the tissues. As the palatine arch is reached, the mirror is gently insinuated by slight depression and rotation so as to glide through the space between the left pillar and the base of the tongue without coming in contact with either.

After the mirror has passed behind the palate and has reached the pharyngeal space, the operator, by slightly rotating the handle, may bring the reflecting surface around so as to face him, and then he should slightly depress the handle so as to carry the mirror upward until its upper border is slightly hidden behind the soft palate. The mirror now being in position, its handle is so held toward the left angle of the patient's mouth that there is no interference with the thorough illumination of the buccal cavity. Finally, the mirror is to be rotated from right to left, depressed and elevated, and given different degrees of angles while in position so as to bring into view in rapid succession the various surfaces and parts of the upper pharynx and back of the nose.

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Nasal Cavities.

The success of the procedure depends upon the depression of the tongue, the careful introduction of the mirror, and the ability of the patient, not only thoroughly to relax the soft palate, but also to hold it immobile in this relaxed state long enough for the operator to make a thorough inspection of the parts. The patient is an uncertain quantity. Many can submit to a rhinoscopic examination without any difficulty; others require careful manipulation and several efforts have to be made before a successful view is obtained; and, finally, there are a few who are so constituted as to present almost insurmountable difficulties to the exploration. The greatest difficulty is the retraction of the soft palate, which in some individuals takes place immediately upon the introduction of the mirror into the mouth. Careful training in nasal breathing with the open mouth and with the sounding of the nasal consonants en and em, will often overcome this obstacle. Among the other methods which have been suggested for overcoming these obstacles may be mentioned the application of a five-per-cent. solution of cocaine to the palate and post-pharyngeal wall, and the employment of the palate hook. The image reflected in the mirror at any given moment represents only a small section of the whole region. Consequently, in order to gain a fairly complete view, it is necessary to construct it in one's mind from the separate smaller pictures obtained by changing from time to time the angle at which the mirror is placed. Usually one observes first the upper surface of the soft palate and the lower portion of the posterior border of the septum which forms the inner boundary of the post-nasal orifice, the choanæ. Then, by giving the mirror a slight upward inclination, it will bring into view the whole length of the septum, broad above and tapering to a narrow edge below, and the posterior view of the nasal cavities as displayed through the choanæ. On either outer wall, from above downward, will be noted the ridge of the superior turbinate body; immediately below it and separated from it by a dark line—the superior meatus—will be observed the middle turbinate body which stands out as a somewhat elongated fusiform body of a very faint pinkish-white appearance. Below the middle turbinal body will be seen the middle meatus, and immediately below this the upper half of the inferior turbinate body, which oft times seems to merge into the floor of the choanæ.

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The color of the inferior turbinal body is of a grayish-white, resembling much the color that an ordinary mucous membrane assumes when œdematous. By slightly inclining the mirror to right or left, the corresponding mouth of the Eustachian tube will be observed, as well as the depression which separates it from the post-pharyngeal wall—the fossa of Rosenmüller. By changing the angle of the mirror to a more obtuse angle, the dome-like vault of the pharynx will be brought into view, as well as the upper portion of the post-pharyngeal wall. The vault of the pharynx is usually dome-like and smooth in its contour. In some individuals it may show elevations and depressions, or be so filled out as to appear flat, these alterations depending upon the amount and degree of enlargement of the pharyngeal tonsil.

Besides the rhinoscopic methods of exploration of the nasal chambers and post-nasal cavity we have, as additional aids to diagnosis, the digital exploration and the use of electric transillumination. Digital exploration is especially of value in exploration of the post-nasal cavity in very youthful patients and in adults in whom it is impossible to make use of posterior rhinoscopy, or in whom, for various other reasons, it is desirable to make use of this method. This procedure can usually be made in little ones, without causing alarm, by the use of judicious tact. No instruments are necessary. The hands should be well washed and the index finger scrubbed with a nail brush before the examination is made. The child is seated in the examining chair while the parent sits in front of the child and holds the little one's hands. The operator stands to the left side of and facing the patient, with the right hand firmly grasping the vertex of the head. I usually find it wise to tell the patient what I propose doing and of its unpleasant nature but at the same time I assure him that the procedure does not cause pain. The patient is then told to open widely the mouth, the hands and head are firmly grasped, and the index finger of the right hand is quickly but dextrously introduced into the mouth and behind the soft palate into the post-nasal place. In this manner the character and condition of this region may be quickly determined through the tactile sense.

Another method of making the examination is by placing the child in the position described by Dr. A. A. Bliss. By this method the child is placed in the lap of a nurse or parent, facing forward. The little one's legs are held firmly between the legs of the assistant, while the arms of the assistant are slipped under the armpit of the patient and the hands extended upward and held firmly on either side of the head. The child is thus held immobile. Transillumination of the accessory cavities is resorted to as an aid to the diagnosis of the condition of these pneumatic cavities. The value of this method of exploration lies in the fact that most of the pneumatic spaces in the normal state allow the transmission of rays of light through their thin walls. The light used for this purpose is electric, furnished through the medium of a small lamp of about six candle-power. The method of its application will be described in the article devoted to the diseases of the accessory sinuses.

Charles W. Richardson.

NASAL CAVITIES, DISEASES OF: ABSCESSES OF THE NASAL SEPTUM.—Abscess of the septum may be either acute or chronic. The former is generally the result of hæmatoma, erysipelas, typhoid fever, or small-pox, and is located upon one or both sides of the cartilaginous septum. The chronic abscess is generally due to syphilitic infection, but it may be the result of poisoning by arsenic, copper, or mercury, or it may possibly be traumatic.

While the acute abscess is commonly found over the cartilaginous septum, the chronic abscess generally extends to the bony part, and it is often caused by disintegration of gummatous infiltration of the mucous surfaces. The swellings are usually rounded, and they appear red and inflamed and sensitive to the touch. When a syphilitic abscess is opened it emits foul-smelling pus, and if a probe be introduced into the abscess cavity necrosed cartilage or bone may be detected. In most chronic cases the treatment, after the abscess has been opened, is the same as that recommended for nasal syphilis. *E. Fletcher Ingals.*

NASAL CAVITIES, DISEASES OF: ACTINOMYCOSIS.—I have been unable to discover any report of well-marked cases of actinomycosis of the nose, though it is probable that the disease sometimes affects this organ. *E. F. I.*

NASAL CAVITIES, DISEASES OF: ACUTE INFLAMMATIONS.—The many varieties of acute inflammation of the nasal mucous membrane that are mentioned in medical literature may be comprised under the following headings: (1) Acute Catarrhal Rhinitis, (2) Acute Purulent Rhinitis, (3) Acute Membranous Rhinitis, (4) Acute Phlegmonous Rhinitis, and (5) Acute Rhinitis due to Occupation or to Trauma.

(1) ACUTE CATARRHAL RHINITIS.—Synonyms: Acute Coryza, Cold in the Head, Acute Nasal Catarrh, etc.

This disease is an illustration of the simplest form of exudative inflammation occurring in a mucous membrane and affords us the most accessible illustration of such a process inasmuch as the changes occur under direct observation. Any special peculiarities which it presents are amply explained by the vascular mechanism of the nose, which calls for a somewhat extended consideration.

Vascular Mechanism of the Nose.—The vascular mechanism of the nose (and the glandular as well) is somewhat unique, and a full understanding of it is called

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for in order to explain the sequence of various pathological changes. To the blood supply of the turbinates does this observation apply with special force. The larger arterioles are well supplied with muscular coats and lie in the deepest layers of the mucosa close to the bone. They give off branches which supply, by a network of capillaries, the periosteum, glands, and the epithelial layer. These capillaries are collected into veins which dilate into venous sinuses, the larger lacunæ of which are the deeper, while with them the superficial lacunæ (cortical network) communicate. These lacunæ again empty into the veins accompanying the primary arterioles into the periosteal layer. As a rule the capillaries do not enter directly into the sinuses but are at first collected into veins. It is a matter of doubt whether the arterioles empty directly into the sinuses, as is the case in the erectile tissues of the genital tract. There is in the nose nothing comparable to the tunica albuginea of the genitals to exert direct compression on the sinus contents.

These views as to anatomical structure are those of Zuckerkandl (as quoted by J. Wright), who also reminds us that the arteries enter the nose through various bony foramina along with the veins. If the artery dilate from any cause, such dilatation must compress the vein against the bony wall. While therefore the inflow of blood to the part supplied is increased, the outflow is diminished and engorgement results. Arterial contraction produces of course the reverse effect.

Another point deserves mention. Sections of the mucosa taken from infants show veins compressed between the parallel fibres of the periosteal layer and the elastic fibres and glands external thereto. It is here also evident that engorgement of the superficial tissues supplied by dilated arterial twigs will bring an increased pressure to bear against the vein and obstruct the outflow of blood. As a result of this general arrangement here and in the radical vessels there may be serous transudation, especially in the region of olfaction, without any necessary glandular intervention. It is estimated that under normal conditions this transudation amounts to one pint in twenty-four hours. Zuckerkandl has also described a special network of veins surrounding the glandular mouths in such a way that the engorgement of the former would necessarily close the latter. Wright believes that the foregoing facts clearly explain the phenomena of ordinary acute inflammations of the nasal mucosa. The first visible stage of a coryza is a nasal occlusion following upon vascular engorgement of the erectile bodies. A preceding vascular constriction is assumed, but this is problematical. Now with the blood-vessels all full and with the stimulation of the glands, we should expect the secretion of mucus to be discharged almost coincidently with the congestion; but this is not so, for secretion is scanty for the first few hours, and even for days it may be almost watery. Later, when vascular tension relaxes, it begins to assume a mucous character. Evidently this absence of secretion is due to the occlusion of the glandular conduits by the surrounding plexus of veins. The primary watery exudate comes by transudation directly from the blood-vessels through the areolar tissue and surface epithelium.

The contraction of the smooth muscle-fibres and of the elastic fibres of the stroma contributes to the collapse of the venous sinuses, the floodgates of the radical veins being opened by the contraction of the encroaching arterioles. Expression of glandular contents follows, the glandular mouths having been opened by the subsidence of the superficial venous engorgement.

Causes of Acute Catarrhal Rhinitis.—These are predisposing and exciting. The former include the various diatheses, especially the syphilitic, rheumatic, and gouty. The existence of the uric acid or lithæmic state strongly predisposes to coryza. A patient who eats heartily of animal food and who does not take sufficient exercise is far more liable to "take cold" than is one leading an opposite life. Furthermore, the prevalent habits of living in overheated houses and of swaddling the body with too heavy clothing, especially the wearing of tippets, mufflers, etc., powerfully invite the very dangers they are popularly supposed to avert. The combined effect of the foregoing modes of life is easy to appreciate. The system is overloaded with nitrogenous food and elimination is deficient. As a result there is set up a sort of autotoxæmia ready to be fanned into open outbreak by any one of a large class of excitants. Excesses in alcohol, tobacco, and venery also predispose to coryza.

The exciting cause is generally exposure of some kind, wet feet, draughts, standing or sitting in a cool place when the skin is covered with perspiration. Often a localized exposure, such as a draught through a partially open door or window, seems to act more powerfully than a general exposure. The amount of moisture in the air, as well as its temperature, requires consideration. A combination of cold and moist air offers the most favorable conditions for exciting an attack.

Coryza may be a symptomatic lesion in many general diseases, *e.g.*, measles, scarlatina, smallpox, scurvy, whooping-cough, typhoid fever, influenza, diphtheria, diabetes, erysipelas, and rheumatism. The affection under these circumstances offers no pathological or clinical peculiarities.

Pathology.—At first the nose is dry, but after a few hours a serous discharge comes on, and in the course of a day or so becomes very abundant. As the disease progresses it becomes mucous and finally muco-purulent. It may consist of almost pure yellowish pus. Later, it lessens and at last ceases, and the patient is well again. No special bacteriology attaches to the affection The discharge contains the usual micro-organisms which have their habitat in the nose. They are relatively, as well as absolutely, increased in quantity. Lennox Browne refers the yellow color of the later secretion to the staphylococcus pyogenes aureus, which he says exists under these conditions in nearly pure culture.

Symptoms.—An attack commences with a sense of nasal occlusion, burning, tickling, and occasional sneezing. Later come headache, mild general malaise, fever, pains in the eyes and over the regions corresponding to the various accessory sinuses. These pains may be due to direct extension of the inflammatory process into the sinus linings or to their occlusion and consequent impaired ventilation. This extension of the inflammation to the sinuses explains the large amount of discharge regularly present, for it is difficult to believe that the quantity of muco-pus voided in a severe coryza can come from the lining of the nasal fossæ alone. In an ordinary case the foregoing sequence of changes will extend over a period of from four to seven days, often longer.

Prognosis.—While the lesion is a comparatively trivial one, it must not be forgotten that frequent coryzas lay the foundation for subsequent hypertrophic changes and may possibly introduce some serious disease; they should therefore be promptly cared for.

Treatment.—This may be prophylactic, abortive, or palliative. Most of the patients who consult the physician for a cold in the head, commonly regarded as a trivial affair, do so because they are sufferers from an intermittent or continual series of such attacks. No sooner is one ended than another begins. For such patients a plain talk on the necessity of changing their mode of living is the first thing required. It will afford more satisfaction to both physician and patient than will drug administration. In season and out of season three things must be insisted on. (1st) Avoidance of too much animal food. Meat should be eaten only once a day. To the gouty the time-honored advice may be given of "no red meat and no vegetables taken from the ground"; (2d) proper daily exercise; (3d) proper care of the skin and the eliminative functions; this includes regulation of the bowels and daily bathing. Not every patient may be led to jump into a tub of cold water on rising, but every patient should go over the surface of the body daily with water. At first this may be tepid, but as tolerance is established the temperature should be lowered until the water is distinctly cool. Actual thermo-

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metric figures are not so good a guide as the patient's sensations, for a personal equation is concerned in the sensation of coolness. In winter the bath should be taken in a room properly warmed, and in case a tub-bath be taken the patient should dry himself not standing in the water but on a bath-mat or rug. In this way much of the immediate chilliness after the bath and sluggishness of reaction can be avoided. Delicate patients may be advised to sponge one-half of the body on rising and the other half on retiring, the unbathed portion being clothed. Some fortitude may be required to inaugurate the process on the part of those who have never been properly trained in this respect, but they should be encouraged to persevere until a daily bath is taken on rising. *This is the time of the day in which to bathe, not at night.* If for any reason one wishes to take an old-fashioned hot-water and soap bath at bedtime, it should be followed by a cool affusion. One soap bath weekly is ordinarily sufficient for those who take daily ablutions. In all cases, after the bath and the application of the drying towel, there should be a vigorous application of the flesh-brush, or Turkish towel, "Luffa" sponge, etc., to promote reaction. Brisk, light gymnastic exercises may be employed by those whose reactive powers are deficient.

Finally comes the matter of proper body covering. Good stout shoes should be worn with felt or cork insoles if necessary. Rubbers should be regarded as a device of the enemy of good health. Of course in a heavy rainstorm they are permissible, but the habit some people have of wearing rubbers whenever the walks are the least damp is dangerous to health. Being practically air-tight, they prevent evaporation from the feet and elimination of waste material. With equal vigor a protest is uttered against all chest protectors and pads, also against the wearing of heavy furs, etc., unless they be immediately removed on coming in from the cold. Our prevalent habit of wearing our heavy wraps when inside the house is most reprehensible. The old saying that "sealskin sacks kill more people than does smallpox" is not far from the truth. The clothing next to the skin should be woollen, or at least contain a certain proportion of that substance. Some of the meshed garments of silk and linen are also commendable. There is no sense, however, in swathing the body in heavy woollen so as to bathe it almost constantly in perspiration. "Sanitary" woollens are sanitary only in so far as they conform to physiological laws, it matters not in what country they are made or whose name they bear. The so-called "union-suit," with vest and drawers made in one piece, is the ideal garment for both winter and summer, the weight being changed according to the season. Theoretically the same weight should be worn next to the skin the year round, the outer clothing varying to fit the season, but there are not many who will take the pains to live in this physiological manner. Some textiles are composed of a woollen layer covered on both sides with a cotton mesh. In this way the porous qualities of the woollen are retained without its irritating effect on the skin. So-called "medicated" underwear belongs to the category of "medicated" flannel and "medicated" toilet-paper. Excesses in alcohol, tobacco, etc., must be sternly interdicted.

If undue space seems to have been devoted to the foregoing directions, it must find its excuse in the writer's increasing experience that full directions in these respects will often render any drugs unnecessary.

In some instances it is possible to abort an ordinary coryza, but the efficiency of the countless measures devised for this end is conditioned upon their early employment. The combination of a hot drink with five grains of quinine and ten of Dover's powder is undoubtedly one of the most common. This aims at elimination by relaxation of the skin, in other words, at diaphoresis. The plan has the following objections: digestive activity is retarded and the biliary flow diminished, and with opium in full dosage there is also an increased reflex excitability. Full dosage of quinine checks oxidation, depresses the circulation, lowers body temperature, and lessens perspiration. Under the conditions we are discussing, abstraction of water by heat is not sufficient to restore the bodily equilibrium. It is preferable to give a full dose of calomel, followed by small and frequent doses of quinine.

Many physicians use the familiar rhinitis or coryza tablet triturates. Familiar combinations are the Lincoln formula: Camphor gr. $\frac{1}{4}$, belladonna extract fl. ♏ $\frac{1}{8}$, and quinine sulphate gr. $\frac{1}{4}$; and the Edwards formula: Atropine sulphate gr. $\frac{1}{500}$, aconitine gr. $\frac{1}{500}$, morphine sulphate gr. $\frac{1}{100}$, and calomel gr. $\frac{1}{10}$. Either or both of these may be taken hourly until physiological effects are manifest, when they must be continued at longer intervals.

Recently stress has been laid upon the autotoxæmia presented by many coryza patients, especially by those who are its frequent victims. These patients are sufferers from uric-acid excess. Hence the advice is given to put the patient through some vigorous exercise such as gymnasium work or a ride on horseback, etc., scour out the bowel (not merely give a light laxative) and then give full doses of the simple alkalies such as the bicarbonates of soda or potash until the urine is freely alkaline, the patient meanwhile going to bed for a day or so or at least remaining quiet. In the case of plethoric individuals this plan of treatment is far more efficacious than are the older methods. These latter aim at establishing relaxation and favoring elimination but they take no account of the special underlying diathesis. In so far, they are but partially ideal remedies. Undoubtedly they are of service, but it must be remembered that coryza is not a long disease and will generally get well of itself. Moreover, they do not always abort an atack.

The Turkish bath has always enjoyed a high reputation for aborting coryza. If it be tried, the patient must keep in-doors for some time, and if practicable should remain at the bathing establishment over night.

In some instances the malady will yield to frequent applications, in the form of a spray, of the active principles of the suprarenal bodies (adrenalin), in say 1 to 2,000 solution. This contracts the vessels by its action on their unstriped muscular fibres. It must be added that some patients show a decided idiosyncrasy toward this remedy, and that while its immediate effect is in the line of relief there quickly comes a secondary relaxation, sometimes so severe that the patient's last state is worse than his first.

Palliative treatment consists in the thorough flushing out of the nares with some warm alkaline solution. It is doubtful whether the addition of distinctly antiseptic preparations is of much advantage. Normal salt solution or a mixture of salt, borax, and bicarbonate of soda, one teaspoonful of the mixture to the pint of lukewarm water, is as good as any. By such remedies the excess of secretion is removed from the nasal passages, and conditions are set up favoring a restoration to the normal. The smarting in the nares can be relieved by some such remedy as Ferrier's snuff (Morphine muriate gr. ij., powdered acaciæ ʒ ij., and bismuth subcarbonate ʒ vi.). A little of this may be insufflated every few hours. If the patient comes for office treatment, the nares may be cleansed with some alkaline solution, then sprayed with a little *weak* cocaine (not over two per cent.) and adrenalin, and this followed up with some oily preparation such as menthol in albolene, resorcin with benzoinol, weak camphor menthol, etc. Frequent sufferers with coryza should *never* be given cocaine solutions to be used at their own discretion.

Spiess insists that most of the sneezing in an ordinary coryza comes from a post-nasal irritation. He therefore advises the insufflation into this region of an anæsthetizing powder, such as orthoform 2 parts to sozoiodolate of soda 10 parts.

In the case of very young children a laxative should be given with a hot bath, and then they should be put to bed. Cocaine, if used at all, must be employed with the greatest caution. In infants the disease seems to be conveyed from one patient to another in the same family.

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and consequently temporary isolation is advisable. Dentition and carious teeth seem to be predisposing causes. Difficulty in nursing is one of the most important features. For local treatment a weak menthol solution in albolene may be used, the application being made through a medicine dropper.

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(2) ACUTE PURULENT RHINITIS.—Synonyms: Blennorrhagic, Gonorrheal Rhinitis.

The condition designated purulent rhinitis commonly occurs in children and runs a chronic course. There are, however, in both adults and children, cases of acute inflammation with the free discharge of almost pure pus. These are not to be confounded with sinus affections in which the nose serves merely as the conduit for the escape of discharges.

Causes.—The disease is essentially the expression of some form of infection. In very young children and babies a leucorrheal discharge in the mother seems to be the infecting agent; in fact, most of the cases occurring in early life are due to this cause.

Pathology. A high degree of inflammation of the mucosa exists with excoriations, and gonococci may be found in the discharge.

Symptoms.—If the child is only a few days old it begins to sneeze, while pus flows from the nares and excoriates the surrounding skin. This character of the discharge is in strong contrast to the earlier appearances of the discharge in a simple coryza. There is often a complicating purulent conjunctivitis and the inflammation may spread to the middle ear.

Treatment. This consists in the thorough cleansing of the nasal passages with antiseptic washes. With young children the patient must be held in the upright position with the head slightly bent forward; otherwise some of the fluid may run down into the larynx and set up spasm. Boric-acid solutions are serviceable in the earlier stages and may be followed by slightly astringent combinations. The oleostearate of zinc serves as an efficient vehicle for medicinal agents. With adults, and even with children in whom the malady runs a longer course, it may be advisable to apply cocaine and then make a single application of silver nitrate, sixty grains to the ounce. This may be followed by a temporary increase in the discharge, but its ultimate effects are advantageous. Some of the newer silver salts find here a suitable field. We may mention protargol in ten-per-cent. solution and argonin in the same strength. The latter is said to lead to the early disappearance of the gonococcus, subsidence of discharge, and prompt restoration of tissue integrity. Of less value are argentamin and largin. With any of these, insufflations of some antiseptic powder, such as aristol, dermatol, nosophen, etc., may advantageously be combined.

(3) ACUTE MEMBRANOUS RHINITIS.—By this designation we refer to that form of acute rhinitis in which we find a deposit of fibrin on the septum, on the turbinated bones, or on both.

Causes.—A consideration of the causes at once sharply divides the cases into (1st) those due to the Klebs-Loeffler bacillus (nasal diphtheria) and (2d) those due to various other micro-organisms, pus- and fibrin-producing cocci, especially the staphylococcus, streptococcus, bacillus coli, and pneumococcus. A French observer reports several cases due to the bacillus of hog septicæmia. Solutions of continuity of the intranasal tissues naturally predispose to and invite infection. The latter is not so common in the nares as might be at first supposed, for it must be remembered that there is a constant serous outpouring which cleanses the tissues, that the passages are continually flushed with air, and that the cilia of the epithelial cells tend to ward off all deleterious physical agents.

Pathology.—In membranous rhinitis the whole thickness of the mucosa becomes congested and swollen. There are an emigration of leucocytes and exudation of plasma from the vessels. Hence there is formed fibrin which infiltrates the interstices of the connective tissue elements of the mucosa, and also arranges itself as a membrane on its surface. At times there is a superficial coagulation necrosis of the superficial layers of the epithelium. Under these circumstances the membrane is formed, not of true fibrin and pus, but of necrotic epithelium alone. In most cases the combined effect of vascular congestion and pressure of the exudate is sufficient to starve out a portion of the mucosa involved, and thus sloughs are formed, the separation of which gives the familiar ulcer.

It is thus seen that the process is identical with membrane formation anywhere, and that the appearance is the same no matter what the exact exciting cause. Frequently there is partial organization of the membrane, in the sense that it becomes laminated, permeated with leucocytes and epithelial cells, and presents partial vascularization. The areas most frequently affected are the faces of the inferior and middle turbinates and the anterior portion of the septum.

Symptoms.—In many cases the onset of symptoms is not unlike that of an ordinary coryza. There is dryness of the nose followed by irritation and sneezing, with headache, fever, and general malaise. Next follow the group of symptoms referable to obstructed nasal breathing, anosmia, aprosexia, sore mouth from direct impact of air, paresis of the soft palate, leading to a muffled voice, etc. In other cases, and especially in young children, there is the typical appearance of a drooping child without any special features suggesting nasal trouble, unless perchance the stoppage of the nares or the appearance of a purulent discharge at the outset calls attention to that area.

Examination shows the mucosa covered with a false membrane of a whitish gray color. Removal generally causes bleeding, but gentle manipulation may clear the membrane without this sequel. The membrane frequently exfoliates and re-forms, so that the process is extended over days and even weeks. The general health does not seem to be depleted so much as might be expected considering the nature of the lesion.

Diagnosis.—The question to be decided in the presence of a given case is, Is it diphtheritic or not? While typical cases of the two conditions may present sharply defined boundaries, there are many in which the diagnosis can be made only by the culture test. There has been much discussion as to whether there are really two distinct affections or whether all are not true diphtheria with a bacillus of diminished virulency in the milder cases. Wishart has divided the partisans on this matter into three groups: (1st) Those who consider diphtheria and membranous rhinitis to be distinct affections; (2d) those who consider that there is but one disease, but that the degree of contagiousness so varies that we may safely neglect to isolate such cases as offer no clinical or bacteriological evidence of diphtheria; and (3d) those who would isolate every case. (It may be added that Wishart does not believe in the duality of the disease and advises isolation under all circumstances.)

Out of ninety-eight cases collected by this observer from various sources and reported as membranous rhinitis, sixty-nine showed the Klebs-Loeffler bacillus. E. Mayer notes that the earlier in the disease the test is made the more likely are the bacilli to be found. In the light of our present knowledge, then, the differential diagnosis in a doubtful case is to be made by the culture test. Some cases are found in which no Klebs-Loeffler bacilli are met, yet there is incontrovertible evidence that such cases have spread contagion to others and that the membrane in the secondary cases *has* shown the bacilli. A possible explanation would be that the bacilli were overlooked in the primary cases; but this experience has happened to some of our most careful bacteriologists. If culture media are not at hand, we must rely upon the general clinical features of the disease. Factors suggesting the presence of true diphtheria would be a history of exposure, coexisting deposits in the throat, swelling of the cervical glands, distinctly fetid odor from the nose, a marked constitutional involvement, and an offensive discharge excoriating the surrounding skin. Not

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much reliance, however, can be placed on the degree of severity of constitutional symptoms. The occurrence of albuminuria and the development of paralysis would also bear in the direction of diphtheria. The opposites of the factors just enumerated would suggest mere coccus rhinitis.

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Nasal diphtheria has always been regarded as a most malignant form of the disease, and this view still holds in those cases in which the deposit begins in the throat and spreads to the nose. But we see at the present time cases of true diphtheria with the deposit confined to the nasal mucosa and in which the constitutional symptoms are very mild. In this connection reference may be made to some recent studies by R. O. Neumann concerning the forms under which nasal diphtheria may occur. He has several times seen cases in which apparently simple coryza was due to the diphtheria bacillus. In many instances the general symptoms produced were more marked than those of a simple coryza, but very much less marked than in an ordinary case of diphtheria. The discharge from the nose was sometimes sero-purulent, sometimes markedly purulent. Neumann comes to the following conclusions from his study: Simple rhinitis, associated with virulent diphtheria bacilli, is much more frequent than is commonly supposed. The symptoms of this disease are not always the same. It comes on very often in a very mild form and may even be unobserved by the patient. It is quite in contrast with the so-called rhinitis fibrinosa, as there is no formation of membrane. Both forms exist upon a similar basis, so that one should not speak of them as two different diseases; they should be divided into nasal diphtheria with membrane formation, and nasal diphtheria without membrane formation. If the fact be considered that not only rhinitis fibrinosa, but also nasal diphtheria, especially the last, may serve as a focus of contagion for the surrounding neighborhood, it would be wise to investigate bacteriologically all doubtful cases of coryza.

Prognosis.—This is always good, although after either form there may be an anæmia, especially in those living in bad surroundings. Either type of the disease may attack all classes in society.

Treatment.—As a matter of precaution every case of membranous rhinitis should be isolated until a culture test can be made. In other words, it is better to consider all cases diphtheritic until the contrary is definitely shown to be true. If the Klebs-Loeffler bacilli are found, full antitoxin dosage should be administered and the usual hygienic and quarantine measures instituted. If the test is negative, we may give calomel in half-grain doses every four hours until five grains are taken. This is given with a view of aborting the membranous formation which in young children is apt to accumulate rapidly and be very thick. For the purpose of counteracting hyperinosis we may give to a child of five years, eight to ten minims of the muriated iron tincture in glycerin, every three hours. For local applications nearly every antiseptic in use has been at some time suggested. The systematic use of any one is preferable to the desultory and changing use of several. The nares should be cleansed with a warm alkaline spray, and if there is much tenacious secretion it may be loosened up with equal parts of hydrogen peroxide and lime water. If the membrane shows the least tendency to exfoliate, this should be assisted by gentle manipulation and the passages should be carefully dried with antiseptic cotton. Then it is well to apply pure iron tincture by means of a swab and to follow it by the insufflation of some powder, as iodol, aristol, nosophen, etc. Iodoform emulsion has also been suggested.

(4) Acute Phlegmonous Rhinitis.—This is a process attended with the localized formation of pus, generally in the deeper layers of the mucosa and submucosa covering the septum, and it generally presents itself under the form of the familiar septal abscess. One or two instances of abscess in the mucosa covering the turbinated bones are recorded, but in such cases the abscess has been caused by the burrowing of pus from the maxillary sinus; so also dentists have found a purulent collection on the nasal floor from some tooth abnormality, but these cases are so rare that they need not be considered here.

Causes.—Septal abscess is practically always referable to some trauma, as from a blow or a fall. Other possible causes are some intranasal operation and infection in measles, scarlatina, diptheria, erysipelas, and typhoid.

Pathology.—Following the trauma there is an effusion of blood into the tissues (hæmatoma), and this effusion may separate the two lamellæ of the cartilage. The initial injury may have been so slight as to escape notice and yet lead eventually to abscess. If the effusion is small it becomes absorbed; if it is large, absorption is but partial and is followed by the breaking down of the remains of the clot and formation of pus in the usual manner.

Symptoms.—These naturally follow from the history of the case. There is the initial pain of the injury followed by swelling of the external parts and nasal occlusion, unilateral or bilateral. The outer swelling subsides, while nasal occlusion persists, and, in case of abscess, the formation of pus is accompanied by burning and irritation with perhaps a slight general febrile movement and malaise. Examination reveals on one or both sides a tense, bulging swelling, soft on palpation, and with evidences of severe local inflammation.

Diagnosis.—The use of the probe will differentiate the swelling from the turbinated bones and from all forms of tumors projecting down from points of attachment higher up in the nares. The swelling does not subside under cocaine. Spontaneous rupture never occurs. Any unilateral purulent discharge from the nose suggests sinus disease or a foreign body. The history of the case will generally clear up all doubt as to the nature of the lesion.

Treatment.—Cases of recent trauma in which abscess seems threatened may be treated with ice compresses over the nose, while iodine tincture or five-per-cent. carbolic solution may be applied directly to the septal mucosa. As soon as the presence of pus is determined, the latter should be evacuated by free incision on both sides of the septum, as the abscess contents are apt to form a pocket. The cavity is syringed with hydrogen peroxide and a warm alkaline solution. A delicate strip of antiseptic gauze is then carried to the bottom of the cavity to provide for drainage. This should be changed in twenty-four hours. This dressing provides for healing from the bottom; otherwise the cavity may refill. With a view of maintaining the patency of the incision, it has been recommended that the latter should be made with the galvano-cautery knife. If the case is one of any duration, the pus will have a very foul odor. Subsequent cleanliness is all that is required.

It must be borne in mind that the initial escape of blood may be between the perichondrium and the cartilage or between the two cartilaginous plates which are united by a diploëtic structure. The cartilage may fracture, allowing a communication between the two nares. In case the contents of the cavity are at all grumous it is well gently to curette through the incision and remove all necrotic particles. If the perichondrium remains, the cartilage will be reproduced. Perforation may occur. It is well to be cautious in promising a perfectly normal contour of the nose after healing is complete, for some cases show a slight depression just behind the tip.

Another condition quite rare but requiring mention in this connection is that known as acute serous perichondritis of the nasal septum. While perichondrial inflammations are, as we have seen, common enough after trauma, there is a form of inflammation which develops in this locality without known cause. It must be due to some form of infection, though the time and mode of entrance of the infecting agent cannot be determined. The clinical history is somewhat as follows.

The first symptom is nasal stoppage, gradually increasing and attended with the phenomena of local inflammation. At times there are mild general symptoms. Examination reveals the septum swollen on one or both

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sides and generally fluctuating. Incision may evacuate pus, while probing may show a carious condition of the cartilage, which may be partially gone. Sometimes cartilaginous sequestra of considerable size come away under this manœuvre. The especial danger of the condition is that it may lead to a marked depression of the contour of the nose just at the junction of the bones and cartilages.

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Thus far, the condition has been practically that of a septal abscess with a maximum destruction of tissue, but there are cases in which incision evacuates only clear serum, which is odorless, and hence a separate classification is given by some authors to the lesion, which is often called serous cyst of the septum. Treatment is the same as for abscess.

(5) Acute Rhinitis due to Occupation or Trauma.—Certain occupations lead to acute rhinitis; this is especially true of those which are attended with the giving off of dust—*e.g.*, milling, weaving, stone-cutting, cement grinding, etc., or of those which are associated with the giving off of noxious fumes—occupations, for example, which require the handling of ammonia, chlorine, arsenic, mercury, bichromate of potash, etc. Workers in phosphorus often have a coryza from the constitutional effects of the remedy, as do patients who take the iodides. Laboratory workers may be thus affected by the fumes of osmic acid. Burns, scalds, smoke, steam, foreign bodies, and operations on the nose must also be included in the list of causes. The arsenic eaters of Styria frequently show septal perforations which have originated in a similar way.

Pathology.—There are no special features in the earlier stages of an attack. In fact the affection often runs a subacute rather than an acute course. The changes are generally accentuated on the anterior part of the septum, which soon becomes irritated and, in dusty surroundings, covered with a scab of dirt and secretion. The patient rubs this off and takes some of the epithelium along with it. The deposit reforms, is again removed, and a vicious circle is thereby inaugurated. As a result there are hemorrhage, ulceration, and often perforation. After perforation has taken place the edges generally heal, and curiously enough these patients afterward seem quite immune to the ordinary causes of acute catarrh.

Symptoms.—These are the same as in acute coryza from any cause. Deformity never arises from the perforation.

Treatment.—Obviously the first thing to do is to remove the patient from the source of irritation. Workers in bad atmospheres should wear respirators. Thorough local and general cleanliness should be maintained, with application of stimulating remedies, such as camphor-menthol, to ulcerated surfaces. Healing may be assisted by astringents, such as alumnol and weak zinc chloride. Tincture of benzoin and boroglyceride may be used as local sedatives. *James E. Newcomb.*

NASAL CAVITIES, DISEASES OF: CHRONIC RHINITIS.—(Synonyms: Rhinitis chronica, Chronic catarrh, Chronic coryza, and Hydrorrhœa.) This affection consists of a chronic inflammation of the nasal mucous membrane, characterized by excessive secretion (rhinorrhœa) with discharge from the anterior or posterior nares, or by dryness of the nose with the formation of crusts. It occurs in all climates and among all classes of people, but is more frequent where the atmosphere is often damp and chilly, as beside large bodies of water; however, it is also found in the arid regions of the West, particularly at high altitudes where there is much dust, and it also occurs inland, in localities far removed from bodies of water and free from any unusual amount of dust. The symptoms are most common in the winter, spring, and fall months, and are usually aggravated by damp chilly weather. Persons who are much out of doors are less likely to be affected by it than those whose occupations confine them to the house. Although all are subject to the disease, it is more common in children and young adults, but it is not infrequent even among infants and those past middle life. According to the various manifestations of the disease it may be convenient to divide it for the sake of description into four varieties: (1) Simple chronic rhinitis, (2) intumescent rhinitis, (3) hypertrophic rhinitis, and (4) atrophic rhinitis. The first is characterized by inflammation with considerable secretion, but with little or no swelling and obstruction of the nares. The second is marked by intermittent swelling, occurring usually when a person is lying down and especially in the latter part of the night, by much aggravation of the symptoms on slight exposure to cold, by frequent clearing of the throat, often by hoarseness, and sometimes by excessive discharge. The third variety is characterized by more or less constant obstruction of the nares with hypertrophy of the soft tissues over the turbinated bones, and sometimes of the bones themselves, and also by hypertrophy of the soft tissues over the septum. The fourth variety is characterized by wasting of all of the tissues within the nares and a corresponding enlargement of the cavity, with the collection of mucous crusts, which decompose and cause a foul odor from the nose. In the majority of cases all of these varieties originate in much the same way, though there are individual instances in which neither variety can be traced to any previous affection.

Simple Chronic Rhinitis.

Simple chronic rhinitis is characterized by catarrhal congestion and inflammation of the mucous membrane with but little swelling. It is usually attended by a good deal of irritability of the Schneiderian membrane and excessive discharge of a thin watery fluid which, under the influence of the frequent exacerbations caused by cold, becomes muco-purulent in character.

Etiology.—Chronic rhinitis in many cases appears to result from debility, due to digestive disorders or improper food, or to confinement within doors and lack of exercise. In some cases it is clearly of nervous origin and is occasionally one of the manifestations of neurasthenia, but most commonly it appears to be caused by frequent colds, improper clothing, and exposure to dust-laden or damp and chilly atmosphere. In numerous cases an inherited predisposition may be detected.

Anatomical and Pathological Characteristics.—The mucous membrane is usually evenly congested and moderately swollen, but at times the swelling is limited to the turbinated bodies or upper part of the septum. Erosions particularly of the cartilaginous septum may be present, but ulceration is not a feature of the disease unless it has been caused by frequent removal of crusts by the finger nail. The epithelium and the subepithelial tissues are found infiltrated with round cells, especially about the glands and vessels. The layers of the epithelial cells become increased and the upper cells are flattened, with here and there patches of normal ciliated epithelium remaining. The conditions, it will be seen, are not very different from those of inflammation of the mucous membranes in other parts of the body, the pathology of which is described elsewhere, and therefore need not be considered in this article.

Symptomatology.—The patient usually gives a history of often recurring colds in the head, which have become more frequent and persistent until the symptoms are present the greater part of the time. Itching, burning, and tickling sensations are experienced in the nose, and sneezing may occur upon the slightest provocation, as upon exposure to a slight draught or slightly irritating vapor. Weakness of the eyes with pain and headaches is frequent, and often there are partial anæmia and defective hearing. Occasionally the sense of taste is also obtunded. Lachrymation is easily excited, and commonly there is an excessive watery discharge from the nose which, with the progress of each recurring inflammatory attack, becomes muco-purulent and acquires a more or less offensive odor. The nose is commonly obstructed

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for a few days during the recurring colds, but at other times nasal respiration is free excepting when it is impeded by the profuse secretion. The general health is usually good, but slight derangement of the digestive organs is common. In some cases cobweb-like shreds of mucus are seen stretching from one side to the other of the nasal cavity with but little secretion. In others the surfaces may be dry, and in still others watery or muco-purulent secretions may be found in abundance, especially in the lower part of the nasal cavity. In most cases the naso-pharyngeal mucous membrane is also congested and more or less covered with secretion similar to that in the nose, but generally less watery in character. This causes frequent hawking and attempts to clear the throat. The nares are usually somewhat obstructed by swelling of the mucous membrane, especially during the acute exacerbations, but in some cases it is difficult to draw a distinct line of demarcation between this condition and true hypertrophy of the mucous membrane.

Diagnosis.—The diagnosis is usually easily made by inspection, and there are no diseases excepting hyperesthetic rhinitis or autumnal catarrh and diseases of the accessory sinuses that are apt to be mistaken for simple chronic rhinitis, provided intumescent rhinitis be excluded by a careful study of the history. In simple chronic rhinitis the prolonged duration with gradually increasing susceptibility to cold, the nearly normal size of the nares, the absence of exquisite tenderness, and the occurrence of exacerbations independently of the conditions producing hay fever will generally enable us to exclude the latter and intumescent rhinitis. The occurrence of profuse secretions upon both sides instead of one, with the history, will nearly always enable us at once to distinguish this from disease of the accessory sinuses. Sometimes, particularly in children when there is excessive purulent discharge, cleansing of the nares will be necessary before a diagnosis can be made.

Prognosis.—The affection is tedious and apt to extend over several years, and may terminate in one of the other forms of rhinitis, particularly the hypertrophic or atrophic. In some instances, especially in children, owing to secondary infection with pyogenic germs, a simple watery discharge that might otherwise have continued unchanged for months or years becomes purulent and offensive in character.

Treatment.—The treatment of this form of rhinitis must be tentative and symptomatic, and is therefore not very satisfactory. Attempts to cure it by local measures alone will nearly always be disappointing. It must be remembered that in many instances it is kept up by a loss of tone of the general system or by various disturbances of the digestive organs, and until these are relieved by proper hygienic and tonic measures little can be accomplished in the treatment of the nose. Whenever practicable, the patient should be removed from the sources of irritation and his mode of life should be so ordered as to prevent unnecessary exposures; and by improvement in the general health, to steel him against those which are unavoidable. Two principal objects are to be kept constantly in view in the treatment of these cases: First, to relieve irritability of the nasal mucous membrane by sedatives and protective applications; and second, to check the secretions or to prevent their collection in the nares. When the secretions are watery and profuse, nothing is needed for cleansing the nasal cavity; but when they become muco-purulent detergent washes or sprays may be necessary to clear the nose before local remedies can have any effect. Wherever practicable, watery applications should be avoided, as these tend to increase the swelling of the parts and appear to have little influence in checking secretion; furthermore, the watery applications not infrequently find their way through the Eustachian tubes to the middle ear and cause deafness. Commonly, excepting in cases in which the secretions dry and form crusts, oily applications are sufficient, aided by the patient's efforts at blowing the nose to cleanse the cavity. It is only in the most exceptional cases that these cause inconvenience by passing into the Eustachian tubes, and the protection which they afford the mucous membrane from irritating substances or from the cold or damp atmosphere is a distinct advantage. Non-irritating disinfectant and slightly astringent powders are usually beneficial. For detergent purposes a weak solution of potassium permanganate, an alkaline solution containing about four grains of the bicarbonate and the chloride of sodium to the ounce; Dobell's solution, or a solution prepared from Rhodes' or Seiler's tablets may be employed in warm water, care being taken that it be not forced into the Eustachian tubes. These solutions cannot safely be used with the nasal douche, but ordinarily they may be snuffed from the hand or from a glass without danger. Freer's irrigating tube, which consists of a straightened Eustachian catheter perforated with three or four fine openings just back of the closed end, throws very fine streams which may be employed to wash out the nose and naso-pharynx without danger to the ear. The removal of the drying crusts is aided by treating them with oily substances applied either by the atomizer or by a medicine dropper. The sensitiveness of the mucous membrane varies greatly in different patients, and therefore it is necessary to begin the treatment with the mildest remedies, and it should be the invariable rule that the applications be not strong enough to cause discomfort for more than five minutes; this applies to those made by the patient three or four times a day; those which are made by the physician once or twice a week ought not to cause discomfort for more than half an hour. Commonly it is better that little or no irritation be caused by any application that is made. Oily sprays tend to coat the surface and protect it from irritating particles, and therefore are most advantageous in hypersensitive conditions of the mucous membrane. Those most commonly employed consist of various volatile oils in melted vaselin, or, better, in oleum petrolatum album. These should be applied by the patient four or five times daily by means of an atomizer which throws a large spray, or they may be applied by a medicine dropper or even a small oil can. Various substances may be combined with these bases for the purpose of diminishing the secretion. One of the most efficient of these is terebene in the proportion of ten or twenty minims to the ounce. Thymol half a grain to the ounce, menthol from two to five grains to the ounce, oleum pini sylvestris one-half drachm to the ounce with oleum caryophylli from three to five minims, or oleum cinnamomi from one to two minims to the ounce, have proved most satisfactory in my hands; but other similar applications may be employed with advantage if care be taken that they be not too stimulating or irritant. A watery solution of adrenalin chloride, 1 part to 5,000, containing about eight grains of boric acid to the ounce, will be found beneficial in some cases, and weak solutions of silver nitrate, copper sulphate, and zinc sulphate or chloride, from one to two grains to the ounce of distilled water, are sometimes efficient. Sedative powders are frequently more advantageous than sprays, and are commonly employed in addition to the oily applications already recommended. Boric acid, bismuth, iodol, benzoin, and various other substances may be employed for this purpose, mingled with starch and sugar of milk. A sedative powder containing ten per cent. of boric acid, twenty-five per cent. of iodol, two per cent. of starch, and enough sugar of milk to make one hundred parts, with occasionally one per cent. of cocaine, will sometimes give much relief. When there is an offensive odor, aristol may well be used in place of iodol; and various combinations may be made with other remedies, such as bismuth, oxide of zinc, and pulverized gum benzoin. It is well to use these powders after the oily spray has been applied.

In cases in which there is marked hyperæsthesia of the nasal mucous membrane, the greatest good will be obtained by superficial cauterization of the sensitive spot. The spot should be searched for with a flat probe lightly rubbed over the surface; when found, and after it has been anæsthetized with cocaine, it should be cauterized with a flat guarded electrode with sufficient thorough-

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ness to whiten the mucous membrane over an area about a centimetre in diameter, but the cauterization should not be carried far enough to destroy this tissue. The effect of this treatment is to destroy the terminal fibres of the hypersensitive nerve and thus the cause of the disagreeable symptoms is removed. The sedative sprays and powders should be used in the intervals between the cauterizations, and the latter should not be repeated oftener than once in five or ten days.

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Intumescent Rhinitis.

This affection is often spoken of merely as chronic catarrh, and is sometimes classed as hypertrophic rhinitis; but on account of the pathological condition it might well be called coryza vasomotoria chronica. It is characterized by swelling of the Schneiderian mucous membrane, especially of the inferior turbinated bodies, but also of the middle turbinals and sometimes of the tuberculum septi. This swelling causes obstruction to respiration through the occluded naris. It often involves only one side at a time, though it changes frequently from side to side, and both nares may be obstructed at once. One of the characteristic features of the disease is the swelling which occurs upon one side while the patient is lying upon that side, and which may be transferred to the other side within a few moments when the position is changed. These sudden changes in the seat of swelling are also noticeable even when the patient is erect, and sudden disappearance of swelling upon exercise is a common symptom.

Anatomical and Pathological Characteristics.—The pathology of inflammation of mucous membranes is described elsewhere; but we should note that in this condition, although congestion is usual, the membrane is not infrequently paler than normal. The swelling occurs most frequently over the inferior turbinated body, but may involve other parts, as already mentioned; it results from a paretic state of the muscular elements of these structures and of the muscular walls of their cavernous vessels. The inflammatory changes are the same as those in the variety known as chronic rhinitis and hypertrophic rhinitis, though less extensive than in the latter. The naso-pharynx and pharynx are nearly always involved, and not infrequently the inflammation extends to the larynx and trachea. In consequence of extension of the inflammation along the Eustachian tubes, partial deafness is present in many cases, and this is usually aggravated by exposure.

Etiology.—The causes are the same as those of simple chronic rhinitis.

Symptomatology.—Patients suffering with this disease usually give a history of unusual susceptibility to colds which are present during the large part of the changeable weather in the spring and fall, though in some cases they are also present in the winter and even in the warmer summer months. The disease gradually increases until eventually the patient is annoyed much of the time, especially at night, by obstruction of the nasal cavities. This occlusion causes mouth breathing, and sooner or later in most instances sets up inflammation of the naso-pharynx, the pharynx, and even the larynx and trachea. Indeed, the great majority of cases of chronic mild laryngitis are due to intumescent rhinitis, the effect of the intermittent swellings appearing to be even more disastrous to the larynx than is the more persistent obstruction due to hypertrophic rhinitis or nasal mucous polypi. As a result of disturbed sleep, the patient is apt to awaken unrefreshed and with a headache. In most of these cases the nasal mucous membrane is hypersensitive, and the paroxysms of sneezing may be excited by breathing cold air or the inhalation of dust, and in some cases even by stepping into a bright light. Sudden changes of temperature, whether from heat to cold or the reverse, are very apt to bring on attacks of sneezing with occlusion of the nares. Sometimes the obstruction is brought on quickly by exposure to cold, but usually the reverse is true, and it is only in the temperate atmosphere within doors that the patient experiences the greatest annoyance. A patient who may get along comfortably with the temperature at 72° F. will frequently find the nasal passages obstructed when the mercury rises three or four degrees higher. Occasionally such patients are annoyed by attacks of redness and inflammation of the end of the nose; and not infrequently they are troubled with itching or tickling of the nose, or by similar sensations in the mouth associated with dryness. A stuffy sensation in the nares or one of pressure with actual pain is not infrequent, and these patients are often the victims of a temporal or occipital neuralgia or hemicrania due to the pressure. It should be understood, however, that these are not common symptoms. Mental hebetude, loss of memory, and inability to concentrate the thoughts are due to this disease in rare cases. Among other nervous phenomena that sometimes result from intumescent rhinitis may be mentioned paroxysmal cough, spasm of the larynx, and even spasmodic asthma, which may occasionally be removed by curing the catarrhal condition. Excessive lachrymation and photophobia are also sometimes caused by this form of catarrh. In a considerable number of these patients the secretions from the nares are increased, but in the majority the patient does not have to use a handkerchief excessively, and the greatest complaint is of the desire to hawk and clear the throat, especially in the early morning or after eating. The secretions are essentially the same as those of simple chronic rhinitis, though usually they are not so abundant. However, the amount of discharge may vary much from time to time, and exacerbations are frequent from slight colds in the head. Many patients who present the usual symptoms of intumescent rhinitis deny the existence of obstruction of the nares, even though upon examination the cavities may be found more than half closed. The reason for this is that they have become so accustomed to breathing through the narrow orifice and to existing upon a minimum amount of air that they have no realization of the comfort of normal respiration. In intumescent rhinitis the tongue is so commonly coated and the digestive organs are so frequently disturbed that the suspicion arises that, in some cases at least, gastric disturbance is the primary disease. Upon inspection of the nares the mucous membrane may or may not be seen to be congested, or it may be even paler than normal. Usually it is swollen upon one side or the other, although frequently at the first examination one must rely largely upon the history in making the diagnosis, for both nares may be perfectly free. If the membrane upon the turbinals or the tuberculum septi be swollen it may be made to contract speedily by the application of a small quantity of cocaine, or it may be readily compressed by a probe. Sometimes, indeed, the mere dread of an examination will cause rapid retraction of a swollen membrane. The normal width of the nares in an adult is about one-eighth of an inch, and the color of the mucous membrane is a few shades deeper than that of the gum. Probably in four-fifths of all cases of intumescent rhinitis the congestion is considerably greater than this, and the constriction of one or other or both of the cavities may be from thirty to seventy-five per cent. The swollen membrane over the tuberculum septi is generally a few shades darker in color than the normal tissues; but the swollen membrane at the back part of the septum, when brightly illuminated either from the front or by posterior rhinoscopy, is apt to appear of a grayish color. The posterior ends of the turbinated bodies may also, when swollen, appear grayish in color, and may somewhat resemble mucous polypi; but these changes are more apt to be found in hypertrophic rhinitis. The mucous membrane of the naso-pharynx is often congested and bathed in secretion, and commonly more or less follicular inflammation of the pharynx is present.

Diagnosis.—Intumescent rhinitis is to be distinguished from simple chronic rhinitis, hypertrophic rhinitis, hay fever, and nasal mucous polypi. It is distinguished from simple chronic rhinitis by the absence of swelling in the latter. If at the first examination the history in-

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dicates that the patient is troubled by frequent obstruction of the nares, although the cavities may appear free, he must be sent away and directed to keep watch of the symptoms and report specifically at another visit. At a second visit it is probable that swelling of one side will be present. Intumescent rhinitis is distinguished from hypertrophic rhinitis by the history, which indicates intermittent swelling, and usually by the presence of swelling in the intumescent form only upon one side at the examination, by the yielding of the tissues before slight pressure of the probe and their retraction under the influence of cocaine. In hypertrophic rhinitis, although the tissues retract under cocaine, they do not to so great an extent as in the intumescent variety. Hay fever is distinguished from intumescent rhinitis by the history of repeated attacks at a certain time year after year, by the excessive sneezing, and by the irritation of the eyes and throat which usually attend hay fever. Nasal mucous polypi can hardly be confounded with intumescent rhinitis excepting by the tyro. Their color a light grayish, their position as a rule in the upper part of the nasal fossa, their mobility as indicated by the probe, and the fact that a probe may be passed on both sides of them should be sufficient to establish the diagnosis in any case.

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Prognosis.—Left to itself, intumescent rhinitis occasionally subsides spontaneously, but it commonly extends over a long period of time; and eventually true tissue hyperplasias occur and hypertrophic rhinitis is the result. In rare cases, however, this form appears to pass directly into atrophic rhinitis. The frequent obstruction of the nares, occurring chiefly at night in this affection, leads to chronic pharyngitis and laryngitis, and often the Eustachian tubes and middle ear become involved and throat deafness follows. In singers the voice is likely to be ruined by persistence of this affection. The general health suffers from imperfect oxygenation; and, although to the casual observer the patients may appear robust, they have little endurance. By proper treatment the obstruction may be entirely removed, and as a rule the hypersensitiveness of the mucous membrane will disappear with it. Most of the other symptoms speedily subside soon after the nasal cavities are made free, and a final cure may be predicted in nearly all cases. The effects upon the general health of the cure of the local trouble are most gratifying. Sleep is no longer disturbed, the nasal respiration is restored, and the patient becomes more vigorous mentally and physically. There is some liability to recurrence; nevertheless it is best to relieve only the obstruction that is apparent, rather than to make the nasal cavities abnormally large. The treatment may be resumed at some future time if found necessary, but usually the symptoms do not recur for several years at the worst, and in the majority of cases the patient is completely cured.

Treatment.—All sources of irritation should be shunned, and special care should be taken to avoid cold. Exposure to draughts, cold, or even undue heat, especially in badly ventilated rooms, or the inhalation of irritating dust or vapors is especially liable to cause this variety of inflammation. Much may be done to guard against rhinitis by care as to clothing. The daily cold bath with vigorous friction and regular exercise do much to prevent the nervous exhaustion and the loss of tone of the vascular system, which are often responsible for this affection. The condition of the digestive organs should always be carefully attended to. Local treatment of a sedative character is important during the early stages, and will often be sufficient to prevent further development of the disease. The various oily preparations mentioned in the treatment of chronic rhinitis will be found beneficial at this stage of the disease, and sedatives and mildly astringent powders may do much to lessen the discharge and will sometimes give considerable relief to the obstructed respiration. Adrenalin chloride in solution or in powder, of a strength of about 1 to 4,000 or 5,000, may in some cases be used four or five times a day with great advantage. Cocaine gives the greatest relief, but unfortunately its continued use causes a paretic state of the muscular coats of the veins of the cavernous tissue of the turbinals; and after a few weeks or months the patient's condition is much worse than it was in the beginning. There is reason to believe also that the cocaine favors hypertrophy. Aside from this, its pernicious effects upon the nervous system and the great danger of the formation of the cocaine habit render it absolutely unsafe excepting for very short periods of time. The physician should never give a prescription containing cocaine lest the patient have it repeated and so form a cocaine habit; and even while the patient is under the physician's observation he should not be allowed to use more than from an eighth to a quarter of a grain daily, and this should be discontinued as quickly as possible. When it is necessary to employ it, a one- or two-per-cent. solution in a saturated solution of boric acid in distilled water may be employed, or a similar amount may be rubbed up with one per cent. each of sodium bicarbonate and sodium biborate, two per cent. of the light carbonate of magnesium, and sufficient sugar of milk to make the required quantity. These sprays may be applied with any good atomizer, but the No. 50 Davidson is the best in my opinion for oily applications. The powders are most conventiently applied by a simple insufflator with a glass tube and rubber handball and tube. For personal use the patient may have a short glass tube, about four inches in length, to which is attached a rubber tube, about ten inches in length; one end of the glass tube should be flattened. The powder is placed in the round end, the rubber is slipped over this end, and then the flat end of the tube is placed in the nostril; the other end of the rubber tube is taken in the mouth, and the patient gives a quick puff which throws the powder well through the naris. Oily applications may also be made to the nose with a medicine dropper or a small oil can when the patient finds this more convenient. More stimulating applications may be made to the nares once or twice a week.

The applications made by the physician should never cause discomfort for more than ten or fifteen minutes, and those made by the patient should not cause irritation or smarting for more than a minute, and should not be sufficiently strong to give a feeling of stuffiness in the nares afterward. Of the aqueous solutions recommended for personal use by the patient three or four times daily, some of the best are boric acid, eight grains to one ounce, sodium bicarbonate and sodium biborate, of each two grains to one ounce, listerine forty to sixty minims to one ounce, or distilled extract of hamamelis or of pinus canandensis thirty to fifty minims to the ounce. The saturated solution of boric acid in camphor water is also recommended. For personal use an excellent application consists of one-third grain of thymol with three minims of the oil of cloves to the ounce of oleum petrolatum album, or its strength may be increased by the addition of various substances, combined or singly, which should seldom exceed the following amounts to each ounce: Menthol, gr. ij.; terebene, ♏ xv.; oil of cassia, ♏ ij.; camphor, gr. i.; ol. pini sylvestris, ʒ ss. Some prefer the use of heavier oils, and many employ vaseline, which is melted each time before the application, the theory being that it remains longer in contact with the mucous membrane than would the lighter oil. When the secretions are free, the nose should be cleansed in the same manner as recommended for simple chronic rhinitis. Indeed, most of the remedies applicable to that disease may be used at times with advantage in this affection.

The foregoing measures, however, can relieve only the milder cases, and it is not proper for a physician to keep a patient under treatment more than two or three weeks before he adopts more radical measures, unless what he is doing is found to be accomplishing great good. The radical treatment of intumescent rhinitis consists in destruction of a portion of the tissues by chemical agents or by the galvano-cautery or by removal of the swollen masses by the snare, or cutting them away by knife or scissors.

Cauterization by Acids.—When satisfactory galvano-

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cauteries could not be obtained, there was much reason for the employment of the chemical caustics, and these are still preferred by some physicians, although they cause much greater irritation of the parts with corresponding discomfort to the patient, and do not, commonly at least, yield such accurate results. Of the chemical agents used for the purpose chromic acid is perhaps the best. A few crystals of this may be fused on the end of a flat aluminum probe by holding it over a light for a few moments, and then the parts may be accurately touched without much danger of the chromic acid extending beyond the part to be cauterized; however, the operator should be ready to spray the parts immediately with an alkaline solution in order to neutralize any excess of the acid. A very small amount of the acid, not exceeding in bulk a pellet 2 mm. in diameter, should be employed, and the area of membrane touched at any one time should measure not more than an eighth of an inch in width and from a half to three-fourths of an inch in length.

The cauterization should not be repeated within less than from ten to fourteen days. Some prefer touching the surface at several points with the acid, and some use solutions of various strengths instead of the fused acid, and repeat the cauterization in four or five days. The principal objections to the chromic acid are the difficulty of controlling the extent of cauterization and the pain that is likely to follow the cauterization for many hours. Monochloracetic and trichloracetic acids are also used for the same purpose, but in my hands they have not proven satisfactory. Some operators have obtained good results from the employment of electrolysis, commonly using a bipolar electrode, the needles of which are 4 or 5 mm. apart. A current of from 2 to 10 milliampères, lasting for from three to five minutes, is employed. If the effect of this electrolysis could be confined entirely to the submucous tissue, it would prove a very attractive operation, but many times a slough forms, and often the wound thus resulting is larger than that obtained by the usual forms of cauterization.

Galvanocautery.—Cauterization by the galvanocautery should be done with a wire heated to a cherry-red color only. If heated less than this the line will not burn sufficiently deep and the heat will radiate more to other parts; and if a white heat be employed, the instrument will cut almost like a knife, and bleeding will result. I like best for the purpose a knife-like electrode, about 10 cm. in length, the blade of which consists of No. 21 platinum wire and is about 15 mm. in length. A finer wire heats much quicker and cools more rapidly so that we either get a sharp cut with bleeding or fail to burn the tissues deeply enough. The parts should be first anæsthetized with cocaine, the solution of which should not ordinarily exceed a strength of four per cent.; this is best applied by a thin swab of cotton wound upon a flat aluminum probe, with which all of the part to be touched is gently rubbed about every minute and a half until from two to four applications have been made, by which time the anæsthesia will be completed. This is much better than to employ a spray or a tampon of cotton, which spreads the cocaine over a large area and causes absorption of an unnecessary amount, to the detriment of the patient. A solution which has been found by long experience to be satisfactory on account of its good effects upon the parts, and the absence of constitutional symptoms excepting in the rarest cases, consists of atropine gr. $\frac{1}{10}$, strophanthin, gr. $\frac{1}{5}$, oil of cloves ♏iij, carbolic acid gr. x., cocaine muriate gr. xx., and enough water to make an ounce. When the anæsthesia is complete, the soft tissues will be thoroughly affected, and then the electrode should be carried to the posterior end of the turbinated body where the platinum wire is pressed against the tissues, the current is turned on, and with a slight to-and fro movement the electrode is drawn to the front part of the nasal cavity, burning the soft tissues down to the bone throughout the whole line. Usually two lines extending from the back to the front part of the inferior turbinated body will be necessary, one at the junction of the upper and the other at the junction of the lower with the middle third. In sensitive persons not more than half the line can be made at one sitting, and in no case should more than a single line across the whole length of the turbinated be made. The electrode should always be lifted from the tissues before the current is cut off, otherwise it is apt to tear out the eschar and cause bleeding. After the cauterization the nose should be sprayed with a solution of about five minims of oil of cloves in an ounce of liquid albolene, and this followed by insufflation of three or four grains of iodol. The nostrils should then be closed with a pledget of cotton, and the patient should be told to wear cotton whenever out of doors, or in any position where he is liable to take cold, for four or five days; then he should be allowed to change it and put in fresh cotton as often as desired. A ten-per-cent. solution of methylene blue may be employed to touch the line of cauterization in place of iodol, or the compound tincture of benzoin may be used for this purpose. The latter in some cases has seemed peculiarly efficacious in the prevention of subsequent reaction. A similar cauterization may be made in the opposite naris in from ten to twelve days, and these may be repeated at similar intervals until the swollen tissues have been sufficiently reduced. Usually two cauterizations upon each inferior turbinated body are sufficient; sometimes one is necessary upon each middle turbinated, and occasionally two short lines will have to be drawn through the tuberculum septi. It is well to have the patient return to the office four or five days after the cauterization, and to pass the probe between the opposing sides of the nares in order to prevent adhesions. The patient is given a small quantity of powder containing three per cent. of cocaine and twenty-five per cent. of iodol with one and one-half per cent. each of biborate and bicarbonate of sodium, and three per cent. of the light carbonate of magnesium, with sufficient sugar of milk to make the whole quantity about one hundred grains. This the patient is directed to insufflate into the nasal cavity two or three times a day for the purpose of keeping down the swelling. He is also given an oily spray containing one-third of a grain of thymol and from three to five minims of the oil of cloves to the ounce of liquid albolene, which he is directed to use freely in both nares four or five times daily. The powder is continued for four or five days and subsequently is used only once a day, but the oil is continued regularly until other treatment is instituted, or for two or three weeks. The frequent superficial cauterizations which are recommended by some appear to destroy more tissue, to give the patient more discomfort, and to be much less efficient. I have seen one death from ulcerative endocarditis evidently caused by the suppuration set up by this latter method. Usually such cauterizations cause little or no pain either at the time or subsequently, and may give the patient no more discomfort than would be experienced from a severe cold in the head. However, the patient should be warned, in order to prevent unnecessary anxiety, that there is likely to be some bloody discharge from the nose for two or three weeks. The principal discomfort following cauterizations is from the effects of the cocaine upon the nervous system; therefore care should be taken to use as little of this as is practicable. There are occasionally patients who cannot tolerate a sufficient quantity of cocaine to produce anæsthesia, in whom eucaine may be advantageously substituted; ten or fifteen grains of the bromide of potassium or a cup of strong coffee will commonly relieve the immediate poisonous symptoms caused by the cocaine; but it will not always succeed, and in patients peculiarly sensitive to the drug, none of it should be employed in the subsequent treatment except to prevent the pain of actual cauterization. When the turbinated bone itself is enlarged, or when there is a prominent deflection or spur from the septum, adhesions are very likely to occur if cauterization upon the turbinated body is made upon that side. In these cases, therefore, an operation upon the bony tissue should usually first be done. In spite of all precautions, adhesions sometimes result.

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When this accident occurs it is best to wait until complete healing takes place, and then the adhesions should be cut with scissors. A pledget of wool or bit of rubber tissue may be placed between the opposing surfaces to prevent renewed adhesion, and after four or five days the healing will usually occur without difficulty. Sometimes adhesions may be prevented by touching the raw surface with monochloracetic acid, as this forms an eschar that tends to remain until the healing has taken place under it. Follicular tonsillitis occasionally follows the cauterization of the nares. I have seen it in about one-half of one per cent. of the patients operated upon, though not more than one-fourth as frequently as this if the individual cauterizations are considered. In rare cases otitis media is said to have followed the operation, and I have known of one case in which an inexperienced operator made an extensive cauterization that was followed by fatal meningitis. More or less blood is mixed with the discharges in the majority of cases for two or three weeks, and occasionally a secondary hemorrhage may occur at the end of a week or ten days. I have never had this experience myself, but have known of two cases in the practice of experienced operators in which an alarming hemorrhage recurred time after time until the patient was in the gravest danger; however, in both the bleeding was eventually checked and the patients made a good recovery. I recall two or three cases in my own experience in which erysipelatous inflammation of the skin covering the nose, lips, and cheek invariably followed cauterization. It is needless to say the operations were not repeated when this tendency was discovered. Occasionally in cases of extreme intumescence the swollen tissues may be grasped with a snare, providing this is done before cocaine has been applied; but excepting in the rarest instances this operation is reserved for hypertrophic rhinitis. D. Braden Kyle removes a prism-shaped piece with a knife instead of cauterizing, and believes that he gets better results in this way. The pharyngeal and laryngeal symptoms usually improve speedily after the nares have been made free, though it is well to carry on appropriate treatment for these parts during the treatment of the rhinitis. In professional singers whose living depends upon the voice, the cure of intumescent rhinitis is of the very greatest importance for the prevention of chronic laryngitis, and in nearly all cases, fortunately, we may confidently predict the happiest results from judicious radical treatment.

Hypertrophic Rhinitis.

Hypertrophic rhinitis is a common affection, but it is not met with so frequently as the intumescent variety. It is characterized by obstruction of the nares with discharge from the naso-pharynx and the nostrils, and frequent hawking to clear the throat. It is often associated with chronic laryngitis. The obstruction in the nares is permanent, yet it varies considerably from time to time on account of the varying degrees of swelling.

Anatomical and Pathological Characteristics.—Permanent thickening of the mucous membrane and sometimes also of the turbinated bones is found in this disease, and the nasal cavities are usually from one-third to three-fourths closed by the swelling. The mucous surface may be congested or paler than normal. It is sometimes smooth as in intumescent rhinitis, but is often more or less nodulated, and at times presents one or more tumor-like masses which are sometimes mistaken for fibrous or fibro-mucous polypi. The condition affects both the middle and the inferior turbinated bodies, and is not infrequently observed on the tuberculum septi. In many cases the inferior turbinated body is nearly as smooth in appearance as in the intumescent form of the disease, but usually its anterior extremity is more or less furrowed or nodular. The anterior end of the middle turbinated not infrequently presents numerous nodules, more or less translucent, and having something of the appearance of nasal mucous or fibro-mucous polypi. The hypertrophy at the upper part of the septum is generally smooth, and at first appears to the observer like thickening of the bony septum. Hypertrophy of the posterior ends of the turbinated bodies usually presents a raspberry-like appearance, and may vary in color from a whitish-gray to a dark livid hue; the posterior end of the middle turbinated, however, is generally lighter in color and less granular upon the surface, and it often appears much like a mucous polypus. The condition is due to overgrowth of the connective tissue and bony elements in varying degrees, but the pathology of the disease will be considered elsewhere.

Symptomatology.—The symptoms are not unlike those of intumescent rhinitis excepting that the nasal obstruction is more persistent and usually more complete. The patient generally complains much of accumulation of the secretions in the naso-pharynx and often of complicating laryngitis. Pressure symptoms, such as loss of the sense of smell, headache, nasal or supra-orbital neuralgia, and sometimes ocular symptoms, are more often present in this than in the intumescent form of the disease, and when present they are more persistent. Middle-ear disease with throat deafness is also common, and unfortunately after the hypertrophic rhinitis has persisted for some time, its effects are very likely to remain even though the disease in the nose may be cured.

Diagnosis.—Although the disease is frequently mistaken by general practitioners for nasal mucous polypi, careful inspection of the nares should exclude all affections excepting intumescent and syphilitic rhinitis. Intumescent rhinitis is distinguished from the hypertrophic form by greater variation in the degree of nasal obstruction, by yielding of the tissues readily before the probe pressed upon them, and usually by contraction of the swollen mass to its normal proportions or even less, upon the application of a weak solution of cocaine. Commonly, also, the mucous membrane is more congested in intumescent rhinitis than in the hypertrophic form. Syphilitic rhinitis causing uniform swelling of the turbinated bodies cannot always be distinguished from simple hypertrophy, but the history of the case and the effects of treatment, or the occurrence of ulceration of the Schneiderian membrane with evidences of former syphilitic involvement of the fauces or other parts of the body, will usually enable one to make an accurate diagnosis. Nasal polypi are commonly recognizable upon inspection; but if this is not sufficient, the passage of a probe upon both sides of the polypus and its movability will generally distinguish it at once from the hypertrophied turbinated body.

Prognosis.—Left to itself, there is little tendency for hypertrophic rhinitis to terminate in recovery. On the contrary, it is liable to increase gradually until the nares are three-fourths or four-fifths obstructed and then to remain permanent for a long time; in other instances the hypertrophy gives way to atrophy, and ultimately well-marked atrophic rhinitis results. There are also undoubtedly some cases in which the hypertrophy gradually subsides and the nares are left practically in a normal condition, but these are extremely rare. Subjected to proper treatment practically all cases of hypertrophic rhinitis may be cured in a comparatively short time, though the gentle or puttering treatment that is often adopted is likely to extend over years without much relief.

Treatment.—The more vigorous treatment recommended for intumescent rhinitis is equally applicable in the hypertrophic form of the disease, but the tentative soothing treatment recommended in the former is almost useless. The hypertrophied tissue must be removed in some way so as to bring the nasal cavities to a normal calibre. In doing this, however, the physician should be careful not to render the nares abnormally large, because if they are left too small they may be made larger; but once too much tissue is removed, nothing can restore it. Care should also be taken not to destroy mucous membrane when it is possible to avoid this, or rather to leave as large a surface of mucous membrane as should normally be present. The author is not at all in sym-

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pathy with the little dabs or cuts that keep a patient dancing constant attendance for months, but believes in radical operative measures that will usually not average more than one treatment per week for from six to twelve weeks, by which time the patient should be cured. Among the operative procedures to be employed are those recommended for intumescent rhinitis, namely, cauterization with acid or preferably the galvanocautery. These are to be done in the way described for that affection. When it is possible to engage a considerable portion of the hypertrophied soft tissues in the loop of a cold wire snare or of the galvanocautery écraseur, it may be removed provided that too much mucous membrane be not sacrificed. Of these methods the cold wire snare is preferable in most cases, as it leaves less scar tissue. In some cases cutting away of a V-shaped piece, as recommended by Kyle, is an excellent operation. In some the spoke shave may be used for removing redundant tissue; in others, particularly when there is a mass of soft tissues pendent from the lower edge of the inferior turbinated, the hypertrophied tissue can easily be cut away with nasal scissors, but in the milder cases the galvanocautery is preferable. In many cases it is important not to sacrifice the mucous membrane; in such, hypertrophies of the tuberculum septi or of the turbinated bodies may often be speedily reduced by the nasal trephine passed beneath the mucous membrane. When the bony tissue is also increased, removal by the nasal burr is perhaps the best operation. It is passed through the mucous membrane and the bony tissue is cut away beneath without the danger of bleeding that sometimes attends cutting with other instruments. When the hypertrophy involves the tissues just in front of the posterior edge of the vomer, linear cauterizations have proven to the author most satisfactory. A number of cases have been seen in which all other obstructions of the nares had been removed and the nasal cavities appeared free, but yet the patient continued to complain of hawking to clear the naso-pharynx, and this was not relieved until the submucous infiltration at the sides of the vomer had been cured by cauterization. In any of these operations local anaesthesia and subsequent treatment are carried out, as recommended in intumescent rhinitis. Whenever cutting operations are performed, it is safest to pack the naris with a strip of surgeon's lint, which has been saturated with boric acid and iodoform, to prevent the danger of bleeding which is apt to occur two or three hours after the operation. The packing should be allowed to remain for two or three days, after which it should be gradually removed, or removed all at once if it can be done without giving the patient pain or exciting hemorrhage.

Atrophic Rhinitis

Atrophic rhinitis is a chronic inflammation of the nares in which not only the membrane but the bony framework undergo atrophy whereby the nasal cavities become more or less enlarged. It is characterized by collection of the secretions which become dried into scabs and adhere to the wall until decomposition takes place, thus causing an extremely offensive odor which is known as ozæna. It occurs in all countries and among all classes of people, but is most frequent in young adults particularly in girls. It is seldom observed before the tenth or after the thirty-fifth year of age.

Anatomical and Pathological Characteristics.—In consequence of the atrophy of the mucous membranes or of both the mucous membranes and the bony tissues the nasal cavities become enlarged, sometimes to two or three times their normal dimensions. The atrophy may be confined to the mucous membrane, but usually the bones also are involved and they may be shortened in every direction. The turbinated bodies are most affected, and not infrequently the turbinal bones are entirely absorbed. Shortening of the nasal bones causes sinking in of the bridge and may produce a flat pug, or saddle-shaped nose. The disease is often a sequel of hypertrophic rhinitis. Moritz Schmidt has observed cases in which part of a turbinal was hypertrophied and other parts were atrophied.

Etiology.—In many cases the causation of the disease cannot be ascertained, but there is certainly a considerable number in which repeated colds lead to hypertrophy which terminates in atrophy. Many have sought to find a specific micro-organism, and Abel and Löwenberg have isolated the bacillus ozænæ which has been supposed to act as an etiological factor. D. Braden Kyle by repeated inoculations from advanced cases of atrophic rhinitis was unable to discover any specific micro-organism, though various pathogenic bacteria were commonly found, such as the pneumococcus of Fraenkel, Klebs-Loeffler bacillus, Koch bacillus, the bacillus fœtidus, and various streptococci and staphylococci. The origin of the disease not infrequently dates from one of the exanthematous fevers.

Symptomatology.—Commonly the patient's general health is not impaired by the disease, and headache and other nervous symptoms that commonly attend rhinitis are not often present; but as the affection progresses the general health may suffer and eventually pallor, loss of strength, and emaciation, strongly suggestive of tuberculosis, may occur. Often the patient presents the appearance of what is commonly known as the strumous diathesis. The nose is apt to be broad, the nostrils and the lips are prominent, and the whole physiognomy is lacking considerably in expression. There is usually but little discharge from the nose, excepting once or twice a week when the crusts come away; decomposition of the secretions causes a persistent offensive odor, which, although the patient does not recognize it himself, makes him an object of disgust to others. Occasionally this condition is unaccompanied by stench, and in almost any case thorough cleansing may prevent this symptom. Usually there is but little if any difficulty in breathing through the nose, excepting when it becomes blocked by crusts of mucus. The eyes are often weak, the sense of smell is usually lost, and partial deafness commonly exists as the result of extension of the disease to the middle ear. When the process invades the accessory sinuses, the patient may suffer from distressing headaches and neuralgia.

Although there is a tendency to formation of dry scabs and crusts in the nose, occasionally the secretions consist only of a semi-fluid adherent pus or soft purulent coagula. This condition is especially apt to be present during intercurrent attacks of acute rhinitis.

The mucous surfaces are not usually entirely covered by the crusts, and where they are exposed the membrane is commonly pale. Immediately after the scabs have been cleared away and the nares have been washed, however, the mucous membrane is apt to appear congested, though not ulcerated. Secretions are found in the nose in varying quantity and of varying consistence. Those which have remained the longest have a brownish or blackish color; others may be of a yellowish or greenish hue. There may be various patches of pasty or sticky pus, or hard yellowish, grayish, brownish, or black scabs of various size. The odor clings to the crusts after their removal, but after the nose has been kept thoroughly cleansed for a few days it will entirely disappear excepting in very rare cases in which there is persistence of a fetid odor in spite of thorough cleansing. Cases of this sort sometimes result from involvement of the accessory sinuses. In rare instances the disease is confined to one side, but it is usually bilateral.

When the nasal cavities have been cleaned the turbinals may appear as mere shrunken ridges, or they may have been entirely absorbed. Not infrequently the naso-pharynx can easily be seen through the nostrils, and sometimes the orifices of the Eustachian tubes are in sight and the motions of the soft palate are plainly visible. In some cases the atrophy of the bones proceeds more rapidly than that of the mucous membrane, and then folds of more or less congested mucous membrane will be found hanging, particularly from the upper part

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of the nares. The process is rarely confined entirely to the nasal cavities, but also involves the naso-pharynx and middle ear, and in many cases the mucous membrane of the larynx and trachea will be found congested and swollen or partially covered by adherent pus. The drying secretions not infrequently lodge in the naso-pharynx or even lower upon the pharyngeal wall.

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DIAGNOSIS.—The affection is to be distinguished from lupus, syphilis, suppuration of the frontal, ethmoidal, or maxillary sinuses, and from rhinoliths or foreign bodies in the nares. The essential factors in the diagnosis are the offensive odor, the disgusting scabs, the enlargement of the nares with a history of preceding catarrhal symptoms, and the absence of a syphilitic history, and of eruptions or scars indicative of this disease.

Lupus nearly always involves the external surface first, and the ulceration and cicatrization are quite different from the appearances found in atrophic rhinitis; there is very little danger therefore of confounding the two.

Syphilitic disease of the nares is attended by an extremely offensive odor, though different from that of atrophy, the quality being sufficient to establish the diagnosis with those who have seen much of the two diseases. Syphilis usually attacks the septum and causes destruction of bone, whereas atrophic rhinitis causes atrophy of the turbinated bodies. In syphilis there is commonly extensive and marked ulceration, which is not present in atrophic rhinitis. The history of the two is commonly quite different. In doubtful cases the diagnosis may be aided by specific treatment.

Suppuration of the accessory sinuses gives rise to an offensive odor, though somewhat different from that of ozæna. An inspection of the parts should make it easy to differentiate sinus disease from simple atrophic rhinitis. In suppuration of the accessory cavities there is usually more or less thickening of the mucous membrane instead of atrophy. The affection is commonly confined to one side, whereas atrophic rhinitis is generally bilateral. In suppuration of the sinuses the nasal cavity may be more or less filled with liquid pus, though usually it does not contain a great quantity, and there is seldom the tendency to the drying of secretions and the formation of thick scabs and crusts which is so prominent in atrophic rhinitis.

Rhinoliths and foreign bodies in the nares give rise to an offensive discharge, but this is unilateral. When the secretions have been cleared away, inspection and palpation with a probe enable one readily to differentiate between these and atrophy.

PROGNOSIS.—The disease usually continues for many years, but there is a tendency to recovery about the thirty-fifth year of age. With appropriate treatment the disagreeable symptoms may be promptly removed and the disease may often be cured in from one to three years, though sometimes the patient will have to continue cleansing the nose two or three times a day until middle life. There seems to be some relation between atrophic rhinitis and pulmonary tuberculosis, but this may be only casual; however, the gradual deterioration of health due to the persistent disease in the nose may place the system in a condition for the development of a general or localized tuberculosis. It cannot be expected that the atrophied tissues will be renewed even under the most favorable circumstances, but occasionally this result will be obtained. I have even seen hypertrophic rhinitis following atrophy.

TREATMENT.—Of greatest importance is the frequent and careful cleansing of the nares not only for the purpose of relieving the offensive odor, but also in order that the remedial agents may be brought in contact with the mucous membrane. Commonly some alkaline wash is necessary to remove the dry secretion, and for this purpose a solution of equal parts of the bicarbonate and of the chloride of sodium, from a half drachm to a drachm each to the pint of warm water, answers about as well as anything that can be employed; but various combinations of salines and antiseptics are recommended by different authors. The patient should be directed to cleanse the nares from two to four times daily, using from one to three pints of water, as occasion may require, so that the secretions shall all be removed. When this is done regularly, he will not be annoyed by the offensive odor. The wash may be snuffed from the hand or from a nasal cup, or it may be used with a syringe or nasal douche; but the last two methods are dangerous because water may pass into the middle ear and set up inflammation, resulting in deafness. As a rule it is best for the patient to snuff the fluid from the hand or from a nasal cup made for the purpose. A good instrument for cleansing the nasal passages is the Freer nasal irrigating tube mentioned in the section on simple chronic rhinitis. A powder containing six drachms each of sodium bicarbonate and sodium chloride makes an excellent wash when used in the proportion of one drachm to the pint of tepid water. Rhodes' or Seiler's tablets, from two to four each to the pint, may be used similarly. The patient should attend to the washing himself, but he should be seen by the physician at least once a week during the beginning of the treatment in order that thoroughness may be secured. After the washing the patient may apply to the nares various powders or sprays, and occasionally the physician should make stronger applications. Powders are especially useful when the secretion is thin and free, and the sprays when a tendency to desiccation is marked. The powders may be applied by any simple insufflator. I commonly recommend a glass tube about four inches long with one-eighth to three-sixteenth inch calibre; one end of this is flattened, the other end round. From a quarter to half an inch of powder is inserted into the round end—amounting to from half a grain to a grain and a half; the end of a rubber tube, about ten inches in length, is slipped over the same end, the flattened end of the glass tube is placed in the nose, the opposite end of the rubber tube is taken between the lips, and a quick puff is given whereby the powder is blown thoroughly into the nares. The powders that I have found most beneficial, and which may be variously combined, are made by rubbing up the active ingredients with sugar of milk. For this purpose we may employ yellow oxide of mercury from one-half to three-fourths of one per cent.; iodol 25 per cent., boric acid 10 per cent., aristol from 5 to 8 per cent., gum benzoin or myrrh 25 per cent., berberine muriate 10 per cent., and cocaine from 1 to 2 per cent. The latter must be used guardedly, but when carefully watched it is sometimes an excellent remedy, which by causing paresis of the vaso-motor nerves appears sometimes to induce regeneration of the tissues. Kyle also recommends the nitrate of silver, from 1 to 4 per cent. with stearate of zinc. The sprays are commonly prepared by dissolving various substances in oleum petrolatum album. The drugs most frequently used are carbolic acid from one-half to one per cent., iodine from one-tenth to one-fifth per cent., oil of cloves from one-half to one per cent., oil of cinnamon one-half per cent., thymol one-fifteenth of one per cent., menthol from one to two per cent.; five per cent. of ichthyol has also been highly recommended. It is often desirable after a thorough cleansing of the nares to apply one of these oily sprays and to follow it by the powder. Gottstein's wool tampons sometimes produce excellent results. Moritz Schmidt, Gautier, and Jouslain have highly recommended copper electrolysis by the bipolar method; or the positive pole with a copper needle may be used in the nose alone and the other pole applied indifferently to other parts of the body. In the bipolar method a steel needle is inserted into the lower turbinal while a copper needle is introduced into the middle turbinal, or the copper needle may be inserted into the lower turbinal and the steel needle into the septum, the copper needle being connected with the positive pole. If preferred a platinum needle may be used in place of the steel. The nares having been anæsthetized, the needles are introduced and currents of from 3 to 15 milliampères are passed for from five to ten minutes. The treatment may be repeated after a week or two. It is best to reverse the current for about half a minute just before removing the needle in order to

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loosen the coagulum that fastens about the positive pole. The current should, however, be reduced to zero before the switch is changed to reverse it, otherwise it will cause the patient a good deal of pain. Meningitis has followed this operation and the cribriform plate has been carelessly performed. www.libtool.com.cn and orbital neuralgia sometimes follow. Excellent results have been obtained by this treatment in some cases, but in others it has proven useless. Injections of diphtheria antitoxin have been tried but without avail. Vibration massage has also been employed with, it is claimed, good results. *E. Fletcher Ingals.*

NASAL CAVITIES, DISEASES OF: CONGENITAL AND ACQUIRED DEFORMITIES.—I. DERMATOID CYSTS AND FISTULE.—These conditions are congenital or are noticed shortly after birth. They appear at the junction of the nasal bones with each other and of both with the frontal, as rounded tumors (in case of cysts) of variable size, not freely movable but rather adherent to the deeper tissues. They are covered with normal skin, and the centre line is generally on a level with the canthi of the eyes. A trauma of the mass may lead to a fistula or the latter may be congenital. The mode of origin of these conditions is thus explained by Bland Sutton: The rudiment of the nose in the embryo is represented by that process of the primitive skull, known as the fronto-nasal plate, which is separated from the lateral portions of the face by the orbito-nasal fissures. The rounded angles of these plates are known as the globular processes, each one of which forms a portion of the ala of a nostril and the corresponding præmaxilla. These processes fuse in the median line, giving rise to a central piece (philtrum) of the upper lip. Dermatoids are invariably situated in the line of the internasal fissure and are in all probability due to incomplete fusion of the globular processes.

According to Witzel dermatoids in this situation are not to be regarded as "sequestration" growths—*i.e.*, formed by a squeezing off of tissue when the lateral halves of the body coalesce,—but result from the imperfect apposition of the two tuberosities which, projecting from the centre of the face, arising on both sides of the median nasal furrow and approaching each other to complete coalescence, ought to form the cartilaginous nose and septum.

Strictly speaking, a dermatoid tumor is composed only of tissues found in the skin and mucosa. The cysts variously contain sebaceous material, cellular débris, fat crystals, and hairs. Unstriped muscular fibres may appear in the cyst wall. The fistulæ are lined with a fibrous material covered with sebaceous matter. The walls are covered with typical pavement epithelium, while the subepidermoidal tissue shows scattered aggregations of round cells. The deeper layers show connective tissue of low grade, scattered mucous glands, and giant cells.

Symptoms may be wanting, the swelling being noticed only as something objectionable from a cosmetic point of view. Fistulæ generally give off a constant or intermittent discharge of sebaceous or muco-purulent matter, which causes an excoriated area on the surrounding skin.

Treatment calls for the laying open of the cyst or fistula, with excision of the entire fistulous tract by means of a raspatory or sharp spoon. If the fistula branches off the top and burrows beneath the nasal bones, this tract may be cauterized with the galvanocautery. The whole is then allowed to heal from the bottom. The fistula may reopen after it has once healed. Sometimes a plastic operation may facilitate recovery.

Cysts are rare. Birkett, writing in 1900, reported two instances and collected six others from various sources. Since then Krieg has reported two more. Fistulæ, however, are by no means uncommon. The *x*-ray may help to clear up a doubtful diagnosis.

II. CONGENITAL OCCLUSION OF THE NARES.—Complete congenital occlusion of the anterior nares is an extremely rare condition. Jarvis reports two cases, and claims that they are the first on record. One of his patients was a boy of eighteen, who presented, instead of the dark outlines of the nares, cup-shaped depressions about 4 mm. in depth, the barrier being of membranous consistency; one side admitted a very fine probe while the other was absolutely impervious. The other case was that of a girl of sixteen, in whom the inferior meatus on both sides was blocked by bony growths of ivory hardness. At times she had been able to expel a little air through the nose. Krieg has reported a case—probably of syphilitic origin—in a boy of three years.

Congenital occlusion of the posterior nares is by no means uncommon. The barrier may be either membranous or bony (the former being far more common), complete or partial. According to C. H. Knight, the condition may result from (1) exostosis or simple hypertrophy of the osseous structure of the middle or inferior turbinate; (2) a ridge or exostosis from the vomer; and (3) an adventitious bony plate springing from the floor of the nose or from its outer cavity. However, in most instances which belong strictly to this category, the bony plate spreads like a web over one or both choanæ, being directly continuous with the palate bone, of which it forms an integral part. Sometimes the obstruction is a deflected vomer which enlarges one choana at the expense of the other. Luschka believes that the bony plate is a continuation of the free border of the horizontal plate of the palate bone; Kundrat, that it is an extension of the vertical portion; both conditions are possible. In some cases the central portion of the barrier appears membranous, surrounded by an irregular fringe of bony spicules projecting inward from the periphery; such cases are naturally attributable to hypernutritive changes. Ingals believes that membranous closure in this region is not congenital, but always the result of syphilitic, diphtheritic, or other disease processes.

Symptoms.—These naturally vary according to the degree of obstruction. If the latter is complete at birth, the chances of survival are very few. Difficulty in nursing may be the first thing to call attention to the possibility of the existence of the lesion. If the obstruction is partial, the patients grow up, laboring under all the disadvantages of nasal occlusion, both in its local manifestations and the distal disturbances to which it may give rise. In unilateral occlusion there is often a partial lack of development of the corresponding side of the face and of the vertebral column. By animal experimentation Ziem has shown that these effects are directly due to nasal occlusion of the corresponding side. In infants there is "not only the inability to suckle and the consequent difficulty in obtaining sufficient food, but also the exposure of the bronchial tubes and delicate air cells of the lungs to the constant irritation of air insufficiently moistened, filtered, and warmed." The nose generally secretes moisture, but the secretion is apt to accumulate in an annoying manner. From mouth-breathing the oro-pharynx is generally dry. The voice lacks its normal resonance. The sense of smell is in abeyance while that of taste may persist though impaired for its finer qualities. The effect on hearing is variable. This function is often perfect. Toynbee contended that under these conditions the act of swallowing would cause a constant suction on the Eustachian tube and thus lead to a depression of the membrana tympani, but such a sequel is by no means constant. In many instances the ease with which the patient will sustain impairment of these three special senses is quite remarkable, and, as Knight observes, in notable contrast with the disturbance following a similar acquired post-nasal obstruction.

Treatment.—The barrier must be pierced, the opening enlarged, and the patency thus acquired maintained. In patients of fortitude this may be done under cocaine. For membranous occlusions the galvanocautery will suffice; bony barriers require the trephine or chisel and subsequent enlargement with revolving burrs. The openings should be made as large as possible. Much difficulty may be experienced in keeping them pervious. For some time after the operation pledgets of oiled gauze should be inserted, and after healing has taken place bougies and dilators should from time to time be passed.

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III. MALFORMATIONS.—Several cases of congenital median fissure of the nose have been reported; also cases of nasal hemiatrophy. In one instance of the latter the right half of the organ was normal. The median portion was covered with skin, but instead of the left half there was a body 1.5 cm. long by 0.5 cm. wide, and in shape like an elephant's trunk. This process was extirpated, leaving a permanent fistula. The patient was a child of five years. Such cases are among the curiosities of medicine, and each one can be considered only in the light of the problems which it presents.

Malformations of the alæ may be congenital or they may result from disease. Various plastic operations have been suggested. One devised by Koenig merits special mention. He takes a flap made up of the entire substance of the auricle and sutures this in place of the defect in the ala. As this flap contains cartilage it heals well.

Outside of the various alar deformities resulting from tissue destruction, especially from syphilis, there may be a simple collapse of the alar cartilages, so that insufficient air reaches the interior of the nose, and the impact of the inspired air tends still more to close the nasal entrance. The condition appears at times to be merely an accentuation of a congenital condition, or it may result from lack of development, or from inactivity of the nasal wings. The whole ala may be affected, or merely the plica vestibuli—*i.e.*, the outer border of the inner nasal opening. There may be a laxity of the entire nasal wall with defective action of the dilator and levator muscles. In the congenital cases it will be found that the part principally at fault is the band of tissue at the junction of the lower lateral cartilage and the bony margin of the anterior nares, its position being noted externally by the depression usually seen immediately above the lower expanded part of the nose. If the middle turbinate becomes enlarged, the entrance to the naris is apt to become smaller.

The main symptom of the condition is nasal obstruction leading to mouth-breathing.

The condition in old persons may often be relieved by the wearing of a delicate tubular spring within the nares to hold the alæ in position, or a flat metallic band may be inserted. A similar procedure is often of great benefit in the temporary collapse seen in typhoid fever, pneumonia, etc.; also in tuberculosis involving the larynx. The increased air supply is very grateful to the patient. In young persons an effort should be made to restore the tone of the dilator alæ muscles. Practice in stretching these will increase their activity. The lubrication of the interior of the nares with some unguent carried on the finger will stretch the parts and assist in the recovery of their normal tension. In other words, we should apply the principle of massage.

IV. FRACTURE AND DISLOCATIONS OF THE NASAL BONES.—Fractures of the nasal bones constitute about one per cent. of all fractures. They may be simple, compound, or comminuted. Both bones are generally involved. The injury may also affect the perpendicular plate of the ethmoid, but the vomer generally escapes. The fracture may also extend to the nasal processes of the superior maxillæ; the cribriform plate of the ethmoid is, fortunately, rarely involved. It may also involve the zygomatic arch or extend to the frontal sinuses, thus possibly opening a portal for septic infection of the meninges. Occasionally the lachrymal bone is involved, with obstruction of the tear duct. Very often the nasal bones are not really fractured but simply separated from their attachment to the superior maxillæ, or the bones may become separated from each other; this separation may allow the bones to remain in perfect apposition, or they may be depressed.

The causes of this class of injuries are blows and falls. It has been said that displacement in the infant may come from the pressure of burying the nose against the breast or in the pillow.

The exact lesion produced varies according to the direction of the trauma. If it is from below, the brunt of impact falls upon the septum, while the nasal bones may escape. The triangular cartilage is detached from its bony surroundings, including the nasal spine of the superior maxilla. Here there is merely swelling of the septum, which may run on to abscess with not much external deformity. If the trauma is from the side, both bones may be dislocated laterally, while their internal borders remain in contact. If it is from in front, the nose is flattened, the inner borders of the bones are driven outward and tilted so as to form a sharp ridge on either side of the nose. Perhaps the most common form of injury is a transverse fracture about the middle of the bones, driving back the lower fragment or possibly both bones backward between the nasal processes of the superior maxillæ, thus leaving a depression instead of the normal nasal convexity. Unless the upper half of the bone is distinctly driven in, the perpendicular plate of the ethmoid generally escapes.

The symptoms are epistaxis, deformity, and marked swelling. The latter may extend to the cheeks and eyelids. From the direct results of the trauma or from forcible blowing of the nose immediately after, there may be a subcutaneous emphysema with crackling on pressure. The latter condition on the forehead (when the nose has not been blown) is an evidence that the frontal bone has also been fractured. More or less ecchymosis quickly forms. The swelling may mask the exact nature of the injury. The nose may retain its normal shape or be but part of a diffused swelling. In the latter state, bony crepitus is elicited with difficulty; it may possibly be obtained in minor cases.

Diagnosis is made from the foregoing conditions and from careful digital examination. It is to be remembered that many of the so-called "broken noses" have never been actually fractured. Rhinoscopy should never be omitted. In doubtful cases the *x*-ray may accurately determine the relative positions of the various bony structures.

Treatment calls for the restoration of the bony parts to their normal contour and for the adoption of such means as will keep them in their proper positions. The actual relations must first be determined, and for this purpose a general anæsthetic (a little chloroform) is often necessary. The under surface of the nasal arch should be carefully probed for irregularities. In many cases the bony parts are easily replaced and only a cold compress is required. In more difficult cases an instrument, such as a metal catheter (female) or the closed blades of a dressing forceps should be introduced into the nares and the bones elevated to their proper level, while their position is regulated by the fingers on the outside. The object is to restore the nasal arch. If this can be done and the patient is a self-controlled person who will let his nose alone, the above measures are all that is required. Instruments should be covered with light rubber tubing. It is better, as a rule, to dispense with external splints and plugs in the nares. The emphysema requires no treatment. Epistaxis is treated in the usual manner. Firm union results in from two to three weeks.

If the bones should show a tendency to fall in again, they may be raised by the insertion, within the nose, of an india-rubber dilator, introduced empty and then filled with water, or a piece of rubber tubing may be used. Plugs and splints are generally useless because they rest on the floor of the nose, while the trouble is higher up, and thus is not reached by them. If the nasal bones show a tendency to separate, we may make a plaster splint by having the patient lie flat while several layers of a plaster bandage are moulded over the nose, the ends being carried out on to the cheeks. The ends carry tapes which fasten behind the head. Thus the apparatus is well worn at night. Another serviceable material is gutta-percha, which may be cut to the general shape of the part, covered with antiseptic gauze and then rendered malleable by insertion in hot water. It is then accurately fitted to the nose and secured by tapes. Block tin, thin copper, and aluminum may be used in the same way. These splints may be padded with cotton to exert

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pressure in any direction required for maintaining the proper shape of the nose. Another device is the employment, within the nose, of the Bernays sponge material, cut to fit the naris. Various head bands with forehead plates, to which nasal apparatus may be fastened, have been employed. www.libtool.com.cn It is often justifiable, if marked deformity has resulted, to cut down on the fragments, replace them, and close the wound. The resulting scar will be trivial in comparison with the deformity unrelieved by operative intervention.

V. Saddle Nose.—This term is applied to that particular deformity in which the usual convexity of the nasal bones is replaced by a depression which is the more marked from the fact that the mechanical conditions causing it also tip the point of the nose upward. The deformity is generally the result of some ulcerative process, syphilis being responsible for the majority of cases. The nasal bones are supported in their anterior third by the quadrangular cartilage, and in their posterior two-thirds by the perpendicular plate of the ethmoid. Consequently the entire cartilage may disappear without any change in the external contour of the nose; but when the destructive process encroaches upon the ethmoid or subjacent vomer, the support of the arch begins to crumble and deformity results. The latter is still further aggravated when the destructive process invades the nasal processes of the superior maxilla.

Various operations have been devised for the relief of this condition. In minor conditions a support may be introduced through a subcutaneous incision. Marked deformities require external incision. With such operations the names of Israel and Koenig are intimately associated. A deep incision is made along the dorsum of the nose, and a flap from the forehead containing skin, periosteum, and a small fragment of bone is diverted to fill the sunken area, the flap being stitched to the lower portion of the nose. The denuded space on the forehead is then closed, while secondary operations are required to close the lateral gap.

Another type of operation is that of raising the depressed area and maintaining it in position by a bridge of some light metal, such as platinum or aluminum; celluloid has also been used for the same purpose. With such procedures the names of Lerievant and Martin are associated. A very convenient form of bridge is that devised by F. E. Hopkins, in which the rounded convexity of the bridge is supported on each side by an arm which runs out on to the upper surface of the superior maxilla and is there secured. For the insertion of such apparatus it may be advisable first to perform Rouge's operation, consisting of incision through the gingivolabial fold, dissection of the lip and face from the subjacent bone as far as the border of the nares, and the division of the septum, so as to allow the entire nose to be turned up over the face, thus more or less completely exposing the bony openings of the nasal passages. The great objection to all such apparatus is that we cannot foresee that it will be comfortably worn, and moreover there is always danger that the pressure of the bridge will lead to ulceration and destruction of tissue. In several instances the pain attending the wearing of the bridge and the threatened integrity of the tissue have compelled the removal of the support.

A very recent plan of treatment, and one that promises much, is that of paraffin injections under the skin so as to raise the latter to a normal position and thus restore the normal contour of the nose. It was devised by Gersuny, of Vienna, in 1900, and while it is still *sub judice*, sufficient time has elapsed in several instances to predicate its success and wide applicability. The skin is carefully disinfected and cocainized with a four per cent. solution, which is also carried into the area to be occupied by the paraffin. The melting-point of the latter should be about 105° F. The ordinary white paraffin is too hard, while the soft variety, known as white vaseline, is too soft. A mixture of the two may be made of just the right melting-point. A syringe, made entirely of metal, is preferable, with a needle of moderate calibre. The paraffin mixture is first sterilized and then drawn into the syringe, which is kept in sterilized hot water. When all is ready for the injection the syringe is allowed to cool until its contents issue, not as a liquid but as a coherent string. The needle should be inserted at a little distance from the depressed area, but carried beyond the point of greatest defect, and the material slowly expelled, the syringe being meanwhile slowly withdrawn. The paraffin remains plastic for about half a minute, during which time the nasal convexity thus produced can be properly moulded. A temporary lymphatic œdema may follow, but it has been found that the paraffin will retain its shape, and that it produces no deleterious consequences when once lodged under the skin. It gradually becomes encapsulated by connective tissue, a fact which is still further advantageous in helping to retain the new shape of the nose.

Objections have been made to the effect that this new mode of treatment may cause some danger of lung embolism; also that any rise of body temperature might cause a melting of the paraffin. On this account some have preferred a paraffin with a higher melting-point, say one of 110° F. As far as is known, no cases of embolism have resulted from supranasal injections.

VI. Synechiæ.—Adhesions may occur in any part of the nasal chambers, but the great majority of them are visible by anterior rhinoscopy. They assume various appearances and are of various shapes.

Causes.—In many of these cases the synechiæ are the result of some operation in the nose, especially the over-zealous or careless use of the galvanocautery; less frequently, they follow the use of cutting instruments. Some cases are attributable to traumatism, such as a fall or a blow. Even when operative intervention has been fully justified and skilfully performed, neglect of after-treatment may lead to unfortunate results. Adhesions may also result from the use of chemical caustics, or of powerful hæmostatics, as the Liquor ferri chloridi. A few congenital cases are recorded. The condition also follows diphtheria, measles, scarlet fever, and occasionally acute and chronic rhinitis. Basing his statements upon autopsy records, Zuckerkandl found inflammatory cases far more common than traumatic, his figures being in the proportion of seventeen to three respectively; statistics based on clinical experience show traumatic cases to be more common. They are more apt to occur between the upper turbinates and the septum than between the latter and the inferior turbinate.

In all acquired cases the mode of production is essentially the same. Either from trauma or from some trophic disturbance leading to loss of tissue two opposing surfaces become bared, and later approaching each other become fused in the process of healing.

Symptoms.—Symptoms depend on the degree of nasal obstruction. Diagnosis is made by inspection, and the extent of the adhesion is determined by the probe.

Treatment.—This consists of the removal of tissue excess and the prevention of readhesion until both sides have healed. The question turns upon the proper method to be adopted in each individual case. In operating on either the septum or the turbinates the utmost care should be exercised not to wound the opposite surface; if inadvertently the least injury has been inflicted on the healthy tissue, some form of tampon should be worn for a few days. A pledget of oiled gauze or cotton, a thin plate of celluloid, or some form of tubular splint may be used. These should be removed daily, cleansed, and reinserted. So also in treating severe acute injuries of the septum or alæ nasi, we should bear in mind the necessity of maintaining the patency of the nostrils during healing. In cases in which the adhesion is firm and hard, it may be cut through with the galvanocautery or scissors, and the cut edges kept apart as above indicated. In narrow nostrils it is extremely difficult to prevent re-adhesion. Watson has advised persistent friction with a cotton-wrapped probe, stating that he has often seen absorption of the adhesion follow this manœuvre. Others have suggested the encircling of the adhesion with a loop

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EXPLANATION OF
PLATE XLV.

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EXPLANATION OF PLATE XLV.

Figs. 1, 2, and 3.—Papillary Growths Removed from the Nasal Mucous Membrane by Means of the Wire Snare Heated to a Red Heat. They represent simple hypertrophies of the mucous membrane.

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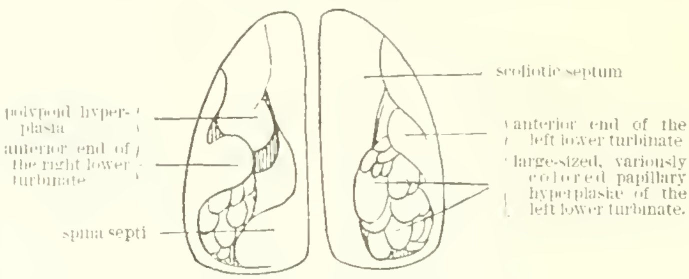
Fig. 4.—Ulcer on the Left Side of the Septum Narium, the Nasal Mucous Membrane Everywhere Else Being Quite Healthy. Syphilis many years previously. Specific treatment was tried in vain. Healing finally took place under the combined use of a long series of cauterizations and a paste containing resorcin.

Fig. 5.—Smooth Hypertrophy of Both Lower Turbinates, in a Man Fifty-three Years of Age. The most marked pathological changes existed in the pharynx and larynx. The picture gives a faithful representation of a genuine connective-tissue hyperplasia. Neither pressure with a probe nor the application of cocaine caused the mucous membrane to yield to a noticeable degree. Both sides were about equally affected.

Fig. 6.—Polypoid Degeneration of the Middle Turbinates, in the Case of a Woman, Sixty-five Years of Age, who had Suffered for Some Time from Dacryocystoblennorrhœa. Smooth hypertrophies of the middle turbinates are often scarcely distinguishable from true polypoid growths. It is only after the mass has been extracted that one is able to establish the fact that it represents an altered state of the mucous membrane covering the concha. After the operation the latter will sometimes be found denuded of all covering throughout quite an extensive area. (Note the vascularization of the tumor.)

Fig. 7.—Papillary Hypertrophy of Both Lower Turbinates in a Woman Forty-two Years of Age. Excrescences of considerable size are visible in the picture. Those situated in front and above are very vascular and red, whereas those which lie farther back and below are quite pale. The right middle turbinate shows a condition of smooth hypertrophy.



Key to Fig. 7 of Plate XLIII.

Figs. 8 and 10.—Epistaxis due to a Varicose Condition of the Blood-vessels of the Cartilaginous Septum. In both of these pictures the artist, in making the drawing of the right half of the nose, has turned the patient's head as far round toward the left as he could, in order to secure as broad a view of the septum as possible. In the case of the left half of the nose he has simply reversed the process.

Fig. 9.—Hypertrophy of the Lower Turbinates: of the Smooth Variety on the Right Side, of a Papillary Nature on the Left and at the Posterior End of the Turbinate.

Fig. 11.—Papillary Hypertrophy of the Posterior Ends of the Lower Turbinates, of such Dimensions, on the Right Side, as Entirely to Cover up the Mouth of the Eustachian Tube and Close the Posterior Entrance of the Right Narial Passage. On the left side the hypertrophy is less pronounced.

Fig. 12.—Polypoid Hypertrophy of the Posterior Ends of the Lower Turbinates. (Also remains of pharyngeal tonsil.) The patient was a young man, eighteen years of age. Although these polypoid masses are somewhat hummocked or knobbed, as they generally are, they should, in the present instance, still be classed as smooth hypertrophies.

Fig. 13.—Abscess of the Septum Narium, Probably of Traumatic Origin, in the Case of a Child Fifteen Months Old. On the left side there is a spot where softening has already taken place and where a spontaneous rupture is about to occur.

Fig. 14.—Perforation of the Septum Narium in the Cartilaginous Portion, Quite Far Forward. The margins of the opening still show irregularities of the surface and are eroded. The nasal mucous membrane as a whole is pale and atrophic. On looking through the opening, either from the right side or from the left, one can see the surface of the opposite turbinate as far back as to its posterior end. The patient was a woman thirty four years of age, and the cause of the defect was probably lupus.

Fig. 15.—Another Instance of Perforation of the Septum Narium in a Patient who Manifested No Other Evidences of Disease. The etiology in this case is unknown.

Fig. 16.—Abscess of the Septum, with Protrusion of the Overlying Mucous Membrane only on the Left Side. (Perforation occurred spontaneously.) The anterior end of the left lower turbinate is in an inflamed and swollen condition.

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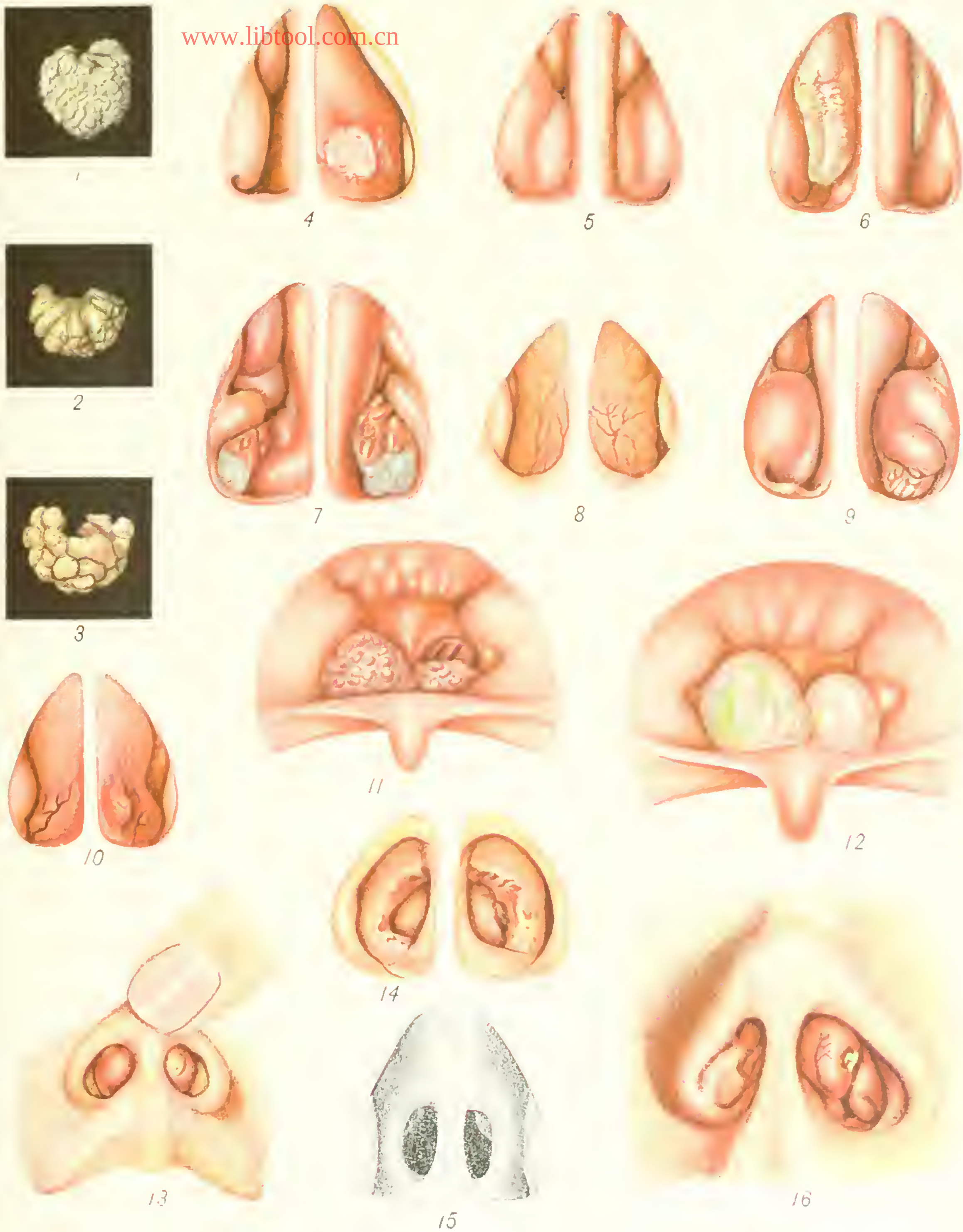

PATHOLOGICAL CONDITIONS OF THE NASAL MUCOUS MEMBRANE

(From the "Atlas der Krankheiten der Nase," by Dr. P. H. Gerber.)

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of steel wire, which is worn in the nose and gradually tightened from day to day; the adhesion is thus gradually cut through, and the parts heal as the section advances. Still others pass a silk thread loop through the centre of the adhesion, wait until the central opening has healed, and then cut from it—that is, the familiar method employed in separating the adhesions between webbed fingers from burns. Reunion is always prevented by the presence of the narrow strip of cicatricial tissue at the base of the cut. In the use of the knife to make the separation, care should be taken not to injure the tissue at its back. After healing is complete, the narrow band back of the original central perforation may be severed. In all these cases the systematic after-use of some form of dilator is for a while advisable.

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VII. Perforations of the Septum.—These may result from syphilis, typhus, typhoid, scarlet, and other fevers in which trophic disturbances lead to a local disorganization of tissue. Other causes are acute primary chondritis (rare), trauma (either accidental or surgical), pressure of tubes and splints, etc. A frequent variety of perforation is that following the lesion known as "simple perforating ulcer," which occurs in perfectly healthy persons without any dyscrasia. It is distinguished from tubercle and syphilis by the condition of its edges which are regularly smooth and healed, by the absence of accompanying lesions on the outer walls of the nose, and especially from syphilis by the fact that the latter shows a selective affinity for the bony structures, while the simple perforating ulcer is strictly confined to the cartilage. In the latter, four stages present themselves: (1) injury or long-continued irritation, as from picking the nose to remove the crusts that frequently form at this site; (2) hemorrhage into the mucosa (the xanthosis of Zuckerkandl); (3) erosion of the capillaries with consequent impairment of nutrition; and (4) partial atrophy leading to perforation or not, according to the presence or absence of infection. The exposed site of the ulcer regularly leads, however, to infection. After the perforation has taken place we find, as noted, a rounded or oval fenestra in the septum with smooth edges. It occupies the area known as the "locus Kiesselbachii." There is no specific bacteriology of the affection, the ordinary staphylococci and streptococci being found. While forming, the ulcer appears as a truncated cone with the base superficial. The area becomes macerated by the nasal secretions, and there is really a necrobiosis of the mucosa. The tissue loss is also favored by the fact that at this site the mucosa is unusually thin, and contains a small congeries of rather large vessels. Symptoms are wanting after the edges have healed. Many cases come under observation only on systematic examination, having given no symptoms whatever. (See Plate XLV., Figs. 14 and 15.)

Treatment calls for measures to combat any existing dyscrasia. If the edges are raw, a fifty-per-cent. solution of silver nitrate may be applied; later, we may use iodine gr. v., iodide of potassium gr. x., in half an ounce of glycerin.

VIII. Outgrowths from the Septum.—These may appear as crests, spurs, ridges, or rounded masses on any portion of the septum. A favorite area is along the lines of junction of its various bony and cartilaginous components. Some of these excrescences are little more than thickenings of the mucosa, and if their removal be deemed necessary, it can be effected with the galvanocautery. Reaction following the application of this agent to cartilage is often severe and it must be used with caution. If the outgrowths contain cartilage we may employ knives, scissors, gouges, draw-shaves, and electrolysis; if they contain bone salts or true bone, we may use trephines, saws, or chisels.

Previous to all such manipulations the nose should be carefully cleansed with some disinfecting agent and then cocaine and adrenalin applied. Most of these operations can be done under local anaesthesia. After-packing is best omitted. If the wound is smooth and respiration can be carried on through the affected side, bleeding will quickly cease. Packing causes retention of secretion with liability to infection. So also antiseptic powders should not be so freely employed as to form a crust in the nose. The patient must keep quiet for a time and wear just inside the vestibule a *loose* plug of cotton to strain out the dust from the inspired air. He must *keep his fingers out of his nose* and be taught the proper method of blowing the organ when using cleansing washes.

IX. Deviations of the Septum.—The causes of this condition may be trauma, the long continuance of turbinal abnormalities, or a faster growth of the cartilaginous septum than of its bony frame. It is not always easy to establish the history of trauma, for it may refer back to any one of the numerous falls of childhood. Many of these, regarded at the time as trivial, may be the starting-point of hypernutrition with consequent deviation. It is impossible to make any classification of deviations that is entirely satisfactory. They may involve the bone or cartilage, and may be vertical, horizontal, or both. They are generally associated with some local outgrowth.

The symptoms are those of nasal obstruction with its effects upon both neighboring and distant organs. Many minor degrees of deviation give no symptoms and require no treatment.

The number of operations devised for the correction of deviated septa is legion. Only a few of the more useful ones can here be mentioned.

The Asch Operation.—This is done under general anaesthesia. Nitrous oxide is an ideal agent. Previous to the administration of the anaesthetic, adrenalin solution should be applied to both sides of the septum. If any adhesions exist between the septum and turbinates, they are broken up by means of the gouges belonging to the special set of instruments devised for this operation. The blunt blade of the scissors is inserted into the obstructed nostril and the cutting blade into the other. A crucial incision is then made, the scissors being withdrawn for the change of position in the second cut; this latter crossing the first as nearly as possible at right angles at the point of greatest convexity. The forefinger is then inserted into the obstructed nostril; the segments made by the incisions are pushed into the opposite nostril and the pressure is continued until they are thoroughly broken at their base and the resiliency of the septum is destroyed. *On this point depends the success of the operation; for unless the fracture of these segments is assured, the resiliency of the cartilage will not be overcome and the operation will fail.* The septum is then to be straightened with the flat-bladed forceps. The little blood there may be in the nostrils is wiped out with a cotton pledget and a flattened hard-rubber or block-tin splint is inserted in each nostril. These act as supports for the septum and tend to prevent secondary hemorrhage. The patient should be kept in bed for two or three days, ice cloths being applied over the nose if there is swelling or pain. The nares should be sprayed through the tubes with some antiseptic. Twenty-four hours after the operation the tube on the previously patent side is removed and not replaced. The nostril is cleansed and an antiseptic powder insufflated. It is well to protect the naris with a loose pledget of cotton when in the open air. The tube on the previously occluded side may remain *in situ* for another twenty-four hours, when it is to be withdrawn, the nostril cleansed, and the *tube replaced.* It is a splint for the septum and may be withdrawn daily for a week, then on alternate days, and gradually at lengthening intervals until healing is complete. If the case can be seen daily, the tube can probably be removed at the end of from two to three weeks. It must be of such a size that it can be easily reinserted without pressure, else it will be crowded out by the tissues behind and the operation will be at best but partially successful. It is completely hidden by the alæ, and if well fitting causes no discomfort to the patient. Subsequently to its permanent removal small bits of granulation tissue may require cauterization or removal with forceps in order that an entirely smooth surface may be

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left. Care should also be taken so to make the incisions that the tube will rest on the floor of the nose.

The Watson Operation.—This is especially applicable to those cases in which the deviation is marked and low down, so that it is impossible to bring the lower fragment into line. Instead of cutting out an elliptical piece along the horizontal line, as is recommended by some authors, Watson makes a bevelled incision, the edge of the knife being directed upward and toward the opposite side, and carried *through the cartilage but not the mucosa* of the opposite side. The incision is made on the crest of the deviation. If a vertical deviation exists at the same time, a triangular-shaped portion with the apex uppermost may be removed. The upper portion in the horizontal incision is pressed over toward the other side, where it hooks on to the lower and is thus held in place. The projecting base can afterward be removed.

The Gleason Operation.—The field of operation is cocainized and exposed by a self-retaining nasal speculum. A thin saw is introduced along the floor of the septum beneath the deviation. The sawing is continued in a horizontal direction until the blade has penetrated somewhat deeply into the tissues, when the direction is rapidly changed to one nearly vertical. It is of the utmost importance that the blade be now held exactly parallel to the septum in order that the cut shall be around and not through any part of the deviation. The length of the vertical crura is then quickly increased by means of a small bistoury curved on its flat, and the flap is thrust through the hole in the septum by means of the forefinger.

While the finger is still in the nares, it is carried up along the anterior and posterior crura in order to make certain that the edge of the flap has completely cleared them, and the neck of the flap is then sharply bent. It is not necessary to denude the edges that are in contact. The pressure results in necrosis (at least of the superficial epithelial layer) of the mucosa, after which the parts unite. The special claim made for this operation is that it destroys the resiliency of the flap (a condition of success in any operation) at its neck. It is at this point, and practically at this alone, that resiliency is active—*i.e.*, at the neck of a comparatively long, narrow flap—and hence has a powerful leverage to overcome before it can thrust the inferior edge of the flap back through the septum. The neck should be bent to nearly a right angle.

The Pin Operation.—This operation, devised by Roberts, is performed by making an incision through the most prominent portion of the convexity, breaking up the resiliency with a stellate punch, and introducing a steel pin through the more open nostril, thrusting its point through the anterior part of the septum, forcing the curved portion of the latter into proper position, and then burying the point of the pin in the posterior part of the septum on the previously occluded side. The head of the pin should be covered with some smooth material to prevent irritation of the columella.

Ingals' Operation.—In cases in which the cartilage is bent almost at right angles across the nostrils, Ingals dissects up the mucosa, removes a triangular piece of cartilage of sufficient size, incises the latter farther back at its upper or lower part to destroy its resiliency, and maintains the septum in place by a plug in the occluded naris.

Roe's Operation.—Roe has devised an operation applicable to either bony or cartilaginous deviations. He insists upon the necessity, even if the deviation be confined to the cartilage alone, of fracturing the bone at or adjacent to the attachment of the cartilage. The change in direction of the latter attachment tends to hold the cartilage in its new position. Roe's operation requires a special fenestrated forceps, one blade of which is an ovate ring while the other—long, narrow, and rounded—fits loosely into it, so as not to injure the septum. The length of the handle prevents compression of the anterior portions of the septum. The male blade is introduced on the convex, and the female blade on the concave side of the deviation. The closure of the blades crowds the deflected portion of the septum into and partly through the opening, indenting and fracturing it without affecting the surrounding area. The septum is held in its new position by a plug of metal wrapped with sterilized cotton or gauze. It is placed on the originally convex side and fills the naris.

Moure's Operation.—Moure, of Bordeaux, has devised an operation which he regards as an improvement on that of Asch. Spurs and thickenings are first removed with a special instrument consisting of an elongated ring with cutting edges on its elliptical extremity. These blades are concave externally and convex on the opposite side. Bleeding is checked by the cautery. Luxations of the antero-inferior part of the septum are resected with a knife, the mucosa being sutured. After full healing has occurred, the septum is attacked. Under cocaine an incision, 2 or 3 cm. long, is made close to and parallel with the nasal floor, special scissors resembling those of Asch being employed for the purpose. A second incision is then made at an acute angle to the first and near the front of the nose. There results a movable fragment held in front by the anterior part of the base of the septum, which has been left untouched toward the tip of the nose, and behind by the perpendicular plate of the ethmoid and the vomer. The next step consists in the introduction, on the side of the deviation, of a tubular dilator formed out of the parallel blades, the outer one being rigid and the inner one malleable. The inner one is modelled to the septum by forceps introduced with a dilator. The dilator is left *in situ* for eight days, the parts being kept meanwhile scrupulously clean.

All these operations have been variously modified by surgeons according to the requirements of individual cases. The main points to bear in mind are: (1) To remove all excess of tissue before attempting to straighten the septum; (2) to weaken the support of the latter by incision, fracture, etc., making sure to destroy the resiliency of the parts so that the septum will remain in its new position; and (3) to hold it there by some form of splint until healing has occurred in the new position. Scrupulous post-operative care, frequent changing of the plugs or splints, etc., so as to avoid retention of nasal secretions, are very important factors in the attainment of a successful result. *James E. Newcomb.*

NASAL CAVITIES, DISEASES OF: FOREIGN BODIES.

See *Air Passages, etc.*

NASAL CAVITIES, DISEASES OF: GLANDERS.—

(Synonyms: Malleus, Farcy, Equinia.) Glanders is a contagious disease contracted from the horse and characterized by the formation of nodules, which soon become pustular and ulcerated, with symptoms of septicæmia and thick muco-purulent or sanious offensive discharge from the nose. It would not deserve space in this place were it not that from its rarity we are especially in need of an accurate account of its symptoms and signs, because personal experience is generally wanting. Although the disease is generally contracted from the horse, it must be understood that it also affects mules, donkeys, goats, cats, dogs, sheep, and pigs.

ANATOMICAL AND PATHOLOGICAL CHARACTERISTICS.—In men the disease is characterized by irregular and sometimes very extensive ulcers in the nose, especially if it has been of long duration. As the ulcers expose the cartilage and bone, these tissues become necrosed, and thus the entire septum and hard palate may be destroyed. Ulceration sometimes extends to the frontal sinus, pharynx, larynx, trachea, and bronchi. Œdema of the larynx may result from the inflammatory changes. Microscopically, the tubercle or nodule of glanders differs from that of tuberculosis, in that it is vascular, has no giant cells, and breaks down by suppuration instead of undergoing cheesy degeneration. At the autopsy conditions are generally found which closely resemble those of pyæmia.

ETIOLOGY.—The affection is contracted from the horse or other animals and is caused by the bacillus mallei.

SYMPTOMATOLOGY.—The disease may be either acute or

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chronic. The chronic affection runs from four to eight months, but the acute generally terminates within three weeks. The stage of incubation is from three to five days. After this period an inflammatory reaction takes place at the site of inoculation, which may be progressive and lead to abscess formation or may retrograde. Later, there are symptoms of general infection, malaise, headache, pains in the joints and muscles, and high fever, often attended by an erysipelatous rash of the nose and throat, which is soon followed by vesicles that burst and discharge a thin serous fluid. The disease may affect various parts of the body, but its most marked manifestations are in the nose and throat. The discharge from these parts is always extremely offensive and usually thin and profuse at first, but later thick and glutinous and sometimes streaked with blood. The voice commonly becomes husky or it may be lost, and cough and dyspnœa may develop. The chronic form is ushered in by a chronic nasal discharge, which may be so scanty that it merely forms crusts, or it may be quite profuse and purulent; or as the result of ulceration the discharges may be yellowish, brownish, or bloody. Upon inspection small ulcers are often found situated beneath the crusts, and sometimes characteristic nodules of a whitish color are seen seated upon an inflamed mucosa. These nodules soon break down in the centre, making small ulcers which may extend and coalesce with others. In man the nodules are much less common than in the horse, and indeed they may be entirely wanting. As ulceration progresses, necrosis of bone and cartilage occurs, and the septum may be perforated. As the disease extends backward, ulcers and inflammatory infiltration appear on the posterior pharyngeal wall, in the mouth, and on the tongue. When the larynx is reached the voice becomes hoarse and breathing may be difficult. In the lungs glanders produces symptoms of bronchitis. The intestinal canal may also be invaded, as indicated by gastric disturbances with diarrhœa, and the disease also attacks the skin, causing multiple abscesses or ulcers.

Diagnosis.—Glanders is to be distinguished from nasal syphilis and tuberculosis. Nasal tuberculosis is usually associated with tuberculosis at the apex of one lung; it is commonly much slower in its progress than glanders, and it cannot be traced to contact with the horse. Finding of the pathogenic bacilli in either case will make the diagnosis certain.

Syphilis frequently resembles glanders, but the constitutional symptoms are much less pronounced. The history is very different and the bacillus mallei cannot be detected in this disease. Notwithstanding this, however, most cases of glanders are ineffectually treated for syphilis for some time before the real nature of the ailment is discovered. The chronic disease may last for weeks or months, and whenever an obstinate nasal catarrh exists in people who are much occupied with horses, a careful examination for glanders must be made. If nodules and ulcers appear, together with abscesses and ulcerations of the skin, in stablemen and others having much to do with horses, the existence of glanders should be suspected and the pus carefully searched for the bacilli. In order to confirm the diagnosis it may be even necessary to inoculate a male guinea-pig, in which case the characteristic nodes appear in the testicles after three or four days. The inoculations are made into the peritoneal cavity.

Prognosis.—The chronic disease runs its course in from four to eight months and terminates fatally in at least ninety-five per cent. of the cases. The acute affection often is superadded to the chronic disease, and when this occurs death invariably results in from six to eight days, but primary acute disease usually lasts for about three weeks. As the disease progresses, the patient passes into a typhoid condition which, in the acute form, soon terminates in coma and death.

Treatment.—Prophylaxis is of the greatest importance, and those working about horses should be able to recognize the disease promptly, but the insidious course of chronic glanders in the horse may make the diagnosis very difficult for a long time. In all such instances the services of a veterinarian should be employed. Little can be hoped for from the treatment of the disease, but locally strong solutions of creosote, tincture of iodine, nitrate of silver, and carbolic acid have been recommended, and it is claimed that recovery has in some cases followed the use of mercurial ointment. General supporting remedies are of course indicated. The secretions and discharge coming from the nose of a patient suffering from glanders should be carefully disinfected.

E. Fletcher Ingals.

NASAL CAVITIES, DISEASES OF: HEMORRHAGE.

—The term epistaxis is applied to bleeding from the nasal cavities and adjacent sinuses. Owing to the unusual vascularity of the nasal region, the delicacy of its construction, and its liability to accident, nosebleed is of very common occurrence.

Etiology.—It may be due to traumatisms; to local affections of the nasal cavities, such as hyperæmia, dilatation of superficial blood-vessels, superficial erosions of the mucous membrane, ulceration; to the presence of foreign bodies or of pharyngeal adenoids; to various systemic affections such as anæmia, purpura, and scurvy; to diseased conditions of the brain, heart, liver, or kidneys; to typhoid and typhus fever, measles, scarlatina, diphtheria, pneumonia, etc.; it may be vicarious, occurring in women at the menstrual period; or, finally, it may arise from a variety of other causes dependent upon severe excitation of the circulation or irritation of the surface of the nasal mucous membrane.

It may occur as a result of toxic doses of certain drugs which are eliminated through the mucous surface of the upper air passages. It is present in fractures of the skull, especially at the base, and is also found with necrosis or caries of the bony skeleton of the nose. It has been caused in gunners by the severe concussion of heavy firing. It occasionally follows coitus. Sudden transition from a normal into a rarefied atmosphere may cause it. It is not infrequently the precursor of cerebral apoplexy. It is commonly met with in boys at the age of puberty, and in girls it may precede the establishment of the catamenia. It may occur in women during pregnancy and at the menopause. It is common in childhood, less so in middle life, and again more apt to occur with advancing age.

The bleeding may come from one or both nostrils. Originating from the deeper part of one nasal cavity the blood may be deflected into the nasal cavity of the opposite side, and escape outwardly through that nostril or into the pharynx. Dangerous nasal hemorrhage may occur during sleep, the blood being swallowed without attracting the attention of the patient. Serious loss of blood may thus result. The presence of bleeding in such a case would probably be demonstrated by changing the position of the patient and causing him to clear his throat.

Bleeding most frequently originates from the anterior and inferior part of the nasal septum, and when it comes from this locality it is seldom dangerous, although in some rare cases it may be severe and through frequent recurrence it may cause serious anæmia.

The bleeding point may be located in any part of the nasal cavity, or there may be a general oozing, widely diffused over the surface of the membrane, as in hæmophilia, purpura, and the anæmia of children. When coming from the anterior portion of the nares the blood escapes from the nostrils, but when from the deeper parts of the nasal cavities it may pass backward and be swallowed and later vomited, or it may pass into the trachea and be coughed up. The latter accident is not common. When the bleeding is from the upper and anterior part of the nasal cavity the hemorrhage may be serious. This is explained by the close connection between the anterior ethmoidal vessels and the intracranial circulation.

Plethora, especially when accompanied by deficient menstruation, portal congestion, and some forms of Bright's disease, may be relieved by epistaxis.

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Nasal Cavities.

Hæmatomata of the nasal cavities are more commonly met with on the septum. They are occasionally seen as the result of traumatism. Examination will often determine the location of the bleeding point, which is apt to be found upon s[illegible]ginous septum. The anterior region of the nose is the most frequent seat of this trouble.

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Diagnosis.—In hemorrhage from the anterior nares the nasal cavity, having been carefully cleansed, should be examined by anterior rhinoscopy, and an attempt made to locate the precise spot from which the bleeding takes place. This will generally be found in the region of the septum. Epistaxis must be differentiated from hæmoptysis, from hæmatemesis, and from bleeding from the lower and median pharynx. This may be done by careful examination of the nasal cavities.

Prognosis.—The prognosis is generally good. When, however, the bleeding is dependent upon a general diathesis or some systemic disease it may be very dangerous.

Treatment.—The treatment of epistaxis must depend upon its origin and upon its cause. It is necessary, therefore, to determine as far as possible what these may be. Vicarious bleedings and those which occur at the crises of certain fevers, may, if they are not excessive, be allowed to continue. In conditions of plethora and in vicarious menstruation it should not be unnecessarily checked. Under ordinary circumstances simple means will usually be effective in stopping the flow. These consist in absolute rest and in keeping the head erect and avoiding the common mistake of inclining it forward and downward. If the bleeding is from the anterior part of the nose, pressure of the ala against the septum may check it. The application of cold to the nose or the insufflation of cold water is often effective. When the bleeding point can be found, applications should, if possible, be made directly to it. This should be done by first drying the place with absorbent cotton and then applying to it nitrate of silver, chromic acid, or even the galvanocautery. Astringents, such as alum or tannin, may also be applied. The iron preparations are as a rule worse than useless, and should never be employed. Of late the use of two remedies has been suggested, both of which experience has proved to be of great value. One of these is antipyrin, the other is the extract of suprarenal glands. The antipyrin should be dissolved in water about ten grains to the ounce. The suprarenal extract should also be used in strong solution. The bleeding cavity having been freed from clots by means of cold water, about half an ounce of one of the above solutions should be insufflated and retained in the nose as long as possible. This should be repeated once or twice unless the bleeding is immediately checked.

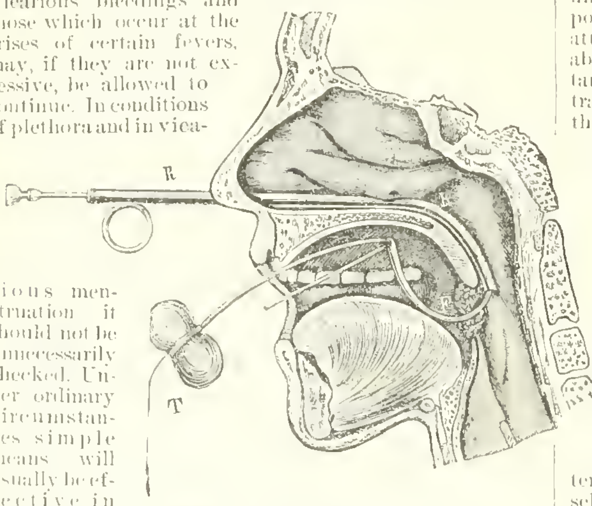

Fig. 3489. Plugging the Posterior Nares by Means of Bellocq's Sound.

The careful employment of this method is very effective. When simpler means fail, the hemorrhage may be controlled by packing that part of the nasal cavity from which the bleeding comes. For this purpose a sponge should never be used. Far better is it to introduce into the nasal cavity a narrow strip of surgical gauze and then to pack it in carefully against the required spot. If the bleeding point is in the upper part of the cavity, the lower part may be left free to permit of normal respiration. The proximal end of the gauze strip should be left free, so that in the withdrawal of the tampon only so much need be removed at one time as can be readily detached. Forcible removal is certain to cause a recurrence of the bleeding. Great care should therefore be exercised and the plug should be saturated with some solvent solution before any manipulation is applied to it. As a rule the plug should not be retained for more than one day. If it occurs posteriorly the bleeding may be checked by inserting a tampon into the naso-pharynx, and, if necessary, at the same time packing the anterior part of the nasal canal. For packing the naso-pharyngeal region a flexible catheter or a Bellocq's cannula (*R*, in Fig. 3489), to the distal end of which a loop of silk has been fastened, should be passed through the nose and its distal end brought into the pharynx. To the loop a strong ligature should be fastened and drawn upward and then forward until the attached end is outside of the nostril. A tampon of lint or cotton (*T*), saturated with vaseline and attached to the middle of the ligature which should be about eighteen inches long, should be in readiness. The tampon should then be drawn carefully into place by traction upon the string, aided by manipulation with the finger in the pharynx. The tampon having been placed, it is well to make a firm block of absorbent cotton around which the anterior end of the string may be wound and held in the vestibule of the nose. The pharyngeal end of the string should be brought out of the mouth and loosely attached to the patient's ear. To remove the tampon, the best plan, as a rule, is first to cleanse the parts as thoroughly as practicable and then apply to them a solution of suprarenal extract in order to secure the greatest possible contraction of the blood-vessels. Lastly, the parts should be covered with liquid vaseline, and time enough allowed for it to saturate the surface of the tampon as deeply as it can penetrate. Only the gentlest traction should be applied to the string while the tampon is being removed.

Severe bleeding may require the use of revulsives intended to cause reflex contraction of the nasal blood-vessels, the administration of remedies intended to quiet the action of the heart, the application of pressure, externally and internally, and in extreme cases transfusion or some kindred measure. In the most severe and intractable cases of epistaxis the nasal cavity may easily become septic, and thus another serious feature be added to the case.

D. Bryson Delavan.

NASAL CAVITIES, DISEASES OF: LEPROSY.—

Leprosy of the nose attends some cases of general leprosy or elephantiasis, and is characterized by a formation of nodular masses and diffuse thickening of the skin of the bridge of the nose, which by being thrown into vertical folds causes the condition known as facies leonina. The nose, especially below the bridge, becomes deformed by the growth around it of nodular masses that enter into the substance of the nasal tip and alæ, changing them into three tumor-like masses that lie side by side, separated by deep fissures. It is also attended by congestion of the mucous membrane with uniform or nodular swelling and considerable deformity and ulceration.

Etiology and Pathology.—This part of the subject has been fully discussed in the article entitled *Leprosy*, and the reader is therefore referred to it for information on the subject.

Symptomatology.—Among the early symptoms are diffuse thickening of the skin over the bridge of the nose. This is at first bright red, but later of a brownish red and shiny appearance; in a still later stage it becomes paler and of a light grayish-brown, or finally it darkens to a chocolate color. Deep, painful, and bleeding fissures occur between the tumor-like projections at the end of

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the nose, ulcerations develop, and cicatrices are formed leading to a great variety of deformities. In time the nose flattens, broadens, and sinks in, the nostrils often being narrowed to mere slits by thickening of the alæ nasi. The appearance of a nose in this condition is likened to that of a hound. This change is due mainly to destruction of the cartilages of the external nose and the cartilaginous septum, and to cicatricial retraction of the external nose. Sticker believes that the initial lesion of leprosy is usually an ulcer above the cartilaginous part of the nasal septum, and it has often been found that the disease attacks some portion of the nasal cavity before there are any external manifestations in other parts of the body. The primary focus may thus be hidden for a long time and the disease may easily be mistaken for other affections of the nose. At first there are obstruction to nasal respiration and a free watery discharge which later becomes purulent and extremely offensive on account of ulceration and necrosis. Severe epistaxis also frequently occurs. After a period of months or years, the discharge gradually ceases and the nares become dry. About this time leprous nodules may appear on the face and external nose. The nasal mucosa, which is at first red, gradually fades and becomes yellowish, grayish, or pure white, due to the hard leprous infiltration. This infiltration may be diffuse at first, or it may form tubercles and tumors, from 5 to 15 mm. in diameter, which spring from the anterior part of the septum and the anterior end of the inferior turbinals. Unless preceded by pharyngeal leprosy the disease first invades the anterior portion of the nares, but as it progresses the cartilaginous or bony septum may be destroyed by ulceration. In this stage the secretions often dry and fill the nares with large hard crusts that can be removed only with considerable force, a procedure which is likely to cause free hemorrhage that may be sufficient to require packing of the cavity. The destructive process may also affect the turbinated bodies. Finally ulceration ceases, cicatrization follows, and the dense scars may obliterate the nasal cavities. As a rule the ulcers and other leprous lesions display characteristic anæsthesia when touched with a probe, and the sense of smell is lost.

Diagnosis.—The diagnosis must depend upon the presence of the peculiar thickened nodular formation, ulceration, cicatricial contraction, and the odor of the secretions, and the finding in them of the bacilli lepræ, which are apt to be abundant. It is often difficult to make an examination of the nares because of the contraction of the nostrils or of the sensitiveness of the formations at the end of the nose. The thick dry crusts may also prevent a satisfactory inspection. The disease can generally be distinguished from tuberculosis by the presence, in the latter, of tuberculous deposits in other parts of the body and by the occurrence of thickening and cicatricial contraction in leprosy. In a few cases syphilitic infiltration may simulate leprous nodules, but the history and the effects of antisyphilitic treatment usually clear up the diagnosis in a short time. Again, the progress of syphilis in the nose is much more rapid than that of leprosy.

Prognosis.—There appears to be no tendency to spontaneous recovery, and unfortunately treatment offers little hope of cure.

Treatment.—Internally the gurjun and the chaulmoogra oils have been highly recommended, the former in doses of five to ten minims, the latter in doses of two drachms, but there is much doubt as to whether either does any good. By way of palliative treatment the dry secretions should be softened by ointments and alkaline or oily sprays. The obstruction of the nares may be relieved partly by severing adhesions or by other surgical measures, and bougies may sometimes be employed to keep the nares free from obstruction. However, care should be used not to cause much bleeding or to give the patient much pain.

E. Fletcher Ingals.

NASAL CAVITIES, DISEASES OF: MUCOUS POLYPI.—Nasal mucous polypi are hyperplastic, œdematous outgrowths originating commonly from the mucous membrane of the parts of the nasal cavity above the lower turbinated bodies. They cause obstruction of the nares and usually free discharge of watery mucus. Mucous polypi occur oftener in men than in women. They are seldom found before the twelfth year.

Anatomical and Pathological Characteristics.—Mucous polypi are generally smooth, glistening, and translucent, and of a grayish-white color, but they may also have a pink or yellowish tinge. Occasionally they are opaque and bright red. Portions of the growth that are exposed to the air in the nasal vestibule are sometimes covered with thick pavement epithelium that has the appearance of white paint. These growths may be sessile or pedunculated, and rarely they are found hanging by a mere thread. According to their surroundings they may be globular, pyriform, or flattened. Many may cluster together, large, small, and minute specimens arising from the same attachment. The number of the growths varies greatly, but they are generally multiple and often fill both nasal fossæ from the nostrils to the posterior nares. Polypi originate most commonly from the lower border and outer surface of the middle turbinated body and from the region of the hiatus semilunaris, though they may also grow from the superior meatus and turbinal. They are very rarely attached to the septum, and so seldom do they arise from the lower turbinal and nasal floor that their origin from these parts is a pathological curiosity. The pathology of these growths is considered elsewhere.

Etiology.—The most frequent cause of the disease is chronic rhinitis with polypoid hypertrophy of the middle turbinated body, a condition which precedes the formation of true polypi. Polypi are occasionally caused by foreign bodies, and often appear to result from chronic suppuration; they are therefore a frequent accompaniment of empyema of the accessory sinuses. They occasionally precede malignant growths originating in the deeper parts of the nasal cavity or in the sinuses. Successive crops of polypi may thus be removed until the carcinoma or sarcoma has made enough progress to become visible.

Symptoms.—Polypi often exist for years before the patient is made aware of their presence by obstruction in the nose. A watery or occasionally purulent discharge from the nostrils is one of the first manifestations of the disease. This symptom is accompanied or soon followed by gradually increasing obstruction in one or both nares. Many patients do not seek relief until the nasal passages become nearly or completely closed. The sensation of a body moving to and fro in the air current is sometimes felt. As the growths increase in size, sensations of fulness and pressure occur in the upper part of the nares, or there may be actual pain that may radiate to the forehead.

Polypi growing from the septum are often vascular and cause severe nosebleed, and rarely the growths in other locations are angiomatous and give rise to the same symptom. In most cases the sense of smell is lost. The catarrhal inflammation is liable to extend to the lachrymal duct and to cause its stoppage with resulting lachrymation, and deafness frequently results from deflation of the middle ear and catarrhal otitis media. The symptoms of polypi are aggravated during damp weather by swelling, while a dry atmosphere improves the patient's condition. The usual results of mouth-breathing, such as injury to the incisor teeth from drying of the enamel, pharyngitis, and laryngitis, follow the disease, which frequently also gives rise to reflex disorders. Prominent among the latter are fits of sneezing, lachrymation, and conjunctival irritation. Asthma is frequently caused by polypi, though not so commonly as reported by some authors. Other reflex phenomena such as nightmare, migraine, headache, giddiness, hay fever, epilepsy, and gastric disorders are occasionally observed, but they often remain unchanged after operation. Inspection usually discloses only the foremost of the growths, but the polypi at the posterior part of the group may often be seen by posterior rhinoscopy. A large polypus may appear as

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a translucent spherical tumor resting upon the soft palate, while the pedicle by which it hangs is usually hidden. Smaller growths fill the space between the turbinals and posterior end of the septum, or that between the lower and middle turbinals or between the middle turbinal and the upper border of the choana. In this location the growths are sometimes of almost glassy transparency and difficult to see. In other cases they appear like muco-pus.

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Diagnosis.—Polypi have so characteristic an appearance that they are not easily mistaken when seen by anterior or posterior rhinoscopy, and palpated with a probe. In a case of nasal obstruction the nasopharynx should always be examined, as there may be no polypi in the anterior part of the nose while the posterior nares may be occluded by them. The inexperienced might possibly confound septal deflection with a polypus, especially when the convexity of the deformity presents the appearance of a pink or red tumor in the nasal vestibule. The concavity of the deflection in the opposite naris, and the fact that a probe can be passed on only one side of the prominence of the bent septum, while it may pass on both sides of a polpyus, should prevent error.

Polypi are distinguished from thickening of the turbinated bodies by their translucence, lighter color, lack of resistance when touched, and their great mobility. When the turbinals are firmly pressed upon with the end of a probe, a characteristic sense of bony resistance and immobility is felt. The swelling of the septum, due to chronic abscess, is of a deeper color than that of a polypus; it is usually much the same in both nares, and it is not possible to pass a probe between it and the septum. Foreign bodies generally cause unilateral offensive purulent discharge, while polypi are commonly attended by bilateral, watery, and odorless secretion. The sensation given to the probe is also quite different. Malignant tumors of the nasal cavity or of one of the sinuses may be hidden from view by polypi created by the irritating effect of their growth, and they then cannot be recognized. Visible malignant growths have a grayish, pinkish, or deep red color and often a sloughing and ulcerated surface. They commonly spring from the septum, a site rarely occupied by polypi, and they usually bleed easily. Pain and rapid growth are characteristics of the malignant neoplasms, and carcinoma generally ulcerates early and gives rise to stench. The hardness and immobility of enchondroma and osteoma make it impossible to mistake these affections for polypi.

Prognosis.—This affection is not dangerous to life, and in the great majority of cases the patient need expect no worse troubles than nasal obstruction and annoying discharge. Deformity of the bones of the face, formerly attributed to mucous polypi, is seldom if ever caused by them, but is a result of the distending effect of fibroid tumors upon the skeleton of the nasal cavity or is due to the destructive and distending advance of malignant disease. In prerhinoscopic days these growths were often confounded with polypi, and hence frog face and other deformities were attributed to the latter. In rare cases vascular polypi produce dangerous epistaxis. Although single polypi are sometimes expelled, spontaneous recovery does not occur; and even after careful removal of the growths there is a notorious tendency to recurrence, so that many patients suffer from the dread of repeated operations. Assurance may be given that polypi do not change into malignant tumors, and patients should not be worried by the statement that they may possibly precede the latter.

Treatment.—Procedures undertaken without the aid of rhinoscopy, such as evulsion with polypus forceps or curettage after laying open the nose externally, inflict needless injury on the patient and are not to be recommended. The most satisfactory method of treatment is removal of the growths with the steel wire snare or écraseur. The one preferred by the author is a modification of one devised by Clarence Blake. The snare is armed with No. 5 steel piano wire, which in practice has been found to answer better than the other sizes. The loop is passed in vertically, its under edge turned beneath the polypus, and then with a backward and forward movement it is worked up as near the pedicle as possible. The loop is now tightened, and, if thought best, the polypus is cut off at once, but usually better results are obtained if it is torn from its base by traction. There is little danger in this way of removing any of the normal tissues, for it is almost impossible to include within the snare anything but the polypus. When polypi grow from broad bases, and are attached over the whole surface of a turbinated body, the bone may be torn off with the snare if much traction be made. Under such circumstances the experienced operator, noticing the increased resistance of the normal tissue, instead of continuing the traction, will tighten the wire loop and cut the growth as near its base as possible. When polypi repeatedly grow from a large surface of the middle turbinal, it is sometimes better to remove the body entirely to prevent recurrence. The operator should have at hand forty or fifty applicators wound with absorbent cotton for swabbing out the blood while the operation proceeds, as it is useless to try to catch the tumors when the nose is filled with blood. Spraying the nasal cavities before operation with a solution of adrenal extract will materially lessen the bleeding. Whatever operation is performed, the parts should first be thoroughly anæsthetized with a four- to ten-per-cent. solution of cocaine, which is best applied by means of a hypodermic syringe fitted with a long, blunt, silver nozzle bent at the end, so that the solution may be thrown up about the base of the tumors. Sometimes both cavities may be cleared at once, but it is usually preferable to remove the growths that can be easily reached, and to complete the operation at one or two subsequent sittings, as this generally gives the patient much less discomfort than one long sitting. After the polypi have been removed, the patient should cleanse the nose once or twice daily with a wash of sodium bicarbonate, a teaspoonful to the pint of lukewarm water. Antisepsis and healing will be promoted by insufflation two or three times daily of a powder containing ten per cent. of boric acid and twenty-five per cent. of iodol, with sugar of milk sufficient to complete the mixture; together with the use of a spray containing about one minim of oil of wintergreen, two minims of carbolic acid, and three minims of oil of cloves to an ounce of Oleum petrolatum album. If the secretion be profuse, ten minims of terebene may be added with advantage. The patient should return in about a week, when it will often be found that polypi which were invisible at the time of operation have descended and may be removed. He should return again in from four to six weeks, so that if the polypi are growing they may be thoroughly destroyed with the galvanocautery.

In some cases mucous polypi do not return after one thorough removal, but usually recurrence takes place and operative procedures must be repeated from time to time until complete destruction of the growths is effected. When empyema of one or more accessory sinuses exists, this must be relieved before the patient can be freed from relapses, and in those instances in which the tumors originate from the region of the hiatus semilunaris or superior meatus it is occasionally necessary to remove the middle turbinated body in order to reach the site from which they grow. In order to get at polypi located behind a deflection or large spur of the septum, it may be necessary first to correct this deformity. In the majority of cases operations upon the nasal skeleton are unnecessary, and careful treatment will eradicate the disease. Polypi in the posterior nares can in most instances be reached by passing the snare through the nostril, but the assistance of a finger in the nasopharynx to adjust the wire may be needed; and in cases in which the polypus is very large, the wire loop may have to be drawn in through the mouth and passed up behind the soft palate by an instrument devised for that purpose, as recommended by the author in the removal of retronasal fibrous tumors.

E. Fletcher Ingals.

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NASAL CAVITIES, DISEASES OF: NEUROSES.—I. Neuroses of Olfaction.—The olfactory nerve consists of about twenty fibres given off from the under surface of the olfactory bulb. These fibres pass down through the cribriform plate, dividing into two groups as they enter the nose—an inner group distributed over the upper third of the septum, and an outer group distributed over the superior turbinate bone and the upper half of the middle turbinate bone. In structure it differs from other nerves in being composed of non-medullated fibres. The olfactory centre in the cortex is not definitely known, but is generally associated with the temporal lobe (Gray).

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The nerve is liable to disorders in connection with both its point of origin and its distribution.

Parosmia is a perversion of the sense of smell. While the sense of smell may or may not be perfect for ordinary odors, there are in addition certain imaginary odors. This is comparatively common among the insane, and is found in epilepsy, hysteria, and syphilis. It has occurred in connection with the epidemic disease—the grippe, cases having been reported in which the patient was annoyed for days by unpleasant odors and tastes. The writer has observed this condition in connection with atrophic rhinitis when the ordinary sense of smell was destroyed. Here the condition is one of considerable annoyance to the individual. The affection is comparatively rare.

Hyperosmia is an exaggeration or hyperæsthesia of olfaction. In this affection odors which are not ordinarily noticeable to the healthy nose are present as exaggerations, causing great annoyance. The odor of an offending substance is often retained for several hours after the removal of the offending material. Like parosmia, it is comparatively rare. There seems to be some connection between it and certain disorders of the sympathetic nerve. Both parosmia and hyperosmia seem to be dependent more on some general nervous disorder or some neurotic predisposition than upon any disorder of the olfactory nerve within the nose itself.

The *treatment* of both the foregoing affections should be directed to the cause so far as it is possible to ascertain it, as direct treatment of the nerve is not likely to do much good.

Anosmia, or Loss of Smell.—This is by far the most common of the affections of the olfactory nerve, and may have its point of origin within the cranial cavity or within the nose.

Anosmia Intracranialis.—This may be caused by injuries, tumors, degeneration, as in locomotor ataxia, general paralysis, senile decay, intracranial syphilis, congenital absence of the olfactory nerve, hemorrhage, meningitis, and abscess. Cases illustrating these various forms of origin have been reported by several observers. Compared with the total number of cases of anosmia, those of central origin must be considered to be rather rare.

Anosmia Nasalis.—This form of anosmia, in which the pathological condition is of nasal origin, is by far the most common. It may be the result of either acute or chronic processes. For the function of the sense of smell to be properly performed, air, with odoriferous particles, must freely reach the terminal filaments of the nerve, and these are stimulated to activity only when in a moist medium; hence anything that interferes with the free access of air or with the moisture of the part will cause partial or complete loss of the sense of smell. Acute anosmia is usually due to acute processes, like colds in the head, the grippe, acute ethmoiditis, hay fever, or to any condition that temporarily blocks the nose. With the subsidence of the acute condition the sense of smell usually returns.

Owing to the close relationship between the sense of smell and the sense of taste, anosmia is usually accompanied by very pronounced loss of taste, especially of flavors. If the sense of taste is unchanged, the loss of the function of olfaction is only partial.

The chronic forms of anosmia occur in connection with anatomical changes in the nose, such as spurs, pronounced deviation of the septum, or any changes which close the nostril, especially hypertrophic conditions of the middle turbinate. They also accompany the degenerative conditions of the mucous membrane, such as atrophic rhinitis, in which the nasal cavity is abnormally widened, its walls are covered with crusts, and the mucous membrane is dry to such an extent that the sensitiveness of the terminal nerve filaments is lost.

The *symptomatology* and *diagnosis* offer no particular difficulty. In testing the question of loss of smell, acrid, sharp, or pungent substances must not be used, as they produce irritation of the sensitive nerve filaments rather than stimulation of the olfactory nerve.

In the acute affections the *prognosis* is usually good. In the chronic forms, when the disease has lasted for any length of time, degeneration has probably taken place, and the prognosis is not so good. White[1] reports two cases which were entirely cured by treatment of the nasal disease, one after twenty years and another after ten years of complete anosmia. The author has had several cases in which the sense of smell returned after the removal of nasal polypi. In one instance the sense of smell had been lacking for a period of several years. But cases like the one just referred to must be regarded as comparatively rare, as it is the rule that when the sense of smell has been deficient for a long period of time, the possibility of its recovery must generally be considered doubtful; and the correction of the apparent cause in the nose is not always followed by as gratifying results as could be desired.

The *treatment* consists in the adoption of measures which improve the general nervous system and bring the nose and throat into the best possible condition, so that all parts of the olfactory nerve distribution will be accessible to the air. The area of the distribution of the nerve should be stimulated by such agents as friction, the use of iodoglycerin, solutions of the various stimulating oils, as camphor, menthol, eucalyptol; and an attempt should be made to increase the blood supply and the secretion of the part. While the improvement secured will frequently be satisfactory, the writer has many times been disappointed as to results of treatment, and more often than otherwise in those cases of anosmia in which examination of the nose does not show any apparent physical cause for the condition. Several of these have followed attacks of the grippe, and have been only partially relieved, and occasionally not at all, by treatment; nor have all the cases resulted satisfactorily even when intranasal conditions such as polypi, etc., have been found which were apparently sufficient to account for the condition.

II. Reflex Nasal Neuroses.—The connection between some irritation of the nose and sneezing has been known and considered from the time of Hippocrates; while the writings of the early physicians, as Aurelianus, Avicenna, Pechlinus, Salmuth, and Van Helmont, show that they were familiar with various reflexes of probable nasal origin, such as rose cold, cough, headache, and difficult breathing. The influence of powerful and disagreeable odors on the organism was noted by many authors.

In the eighteenth century Gumprecht advanced the theory that irritation of the trigeminus in the nose was transferred to the pneumogastric, producing reflex phenomena in the throat, stomach, heart, and lungs. Rega carried this theory still further, and demonstrated or suggested the relationship between the genital tract and the upper air tract; while Wepfer described a large number of cases in which headache, cough, vomiting, vertigo, disturbances of vision, and other nervous symptoms were dependent upon nasal disorders.

One of the first attempts to define this connection between distant organs as a distinct reflex was made by Müller, in his physiology of 1843, when he wrote that irritation of any mucous membrane in the body could give rise to a respiratory reflex. The credit of first calling attention to the nose as a definite point of origin of various reflexes, with practical observations as to the

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treatment and cure of the same, probably belongs to Voltolini,[2] who advanced the proposition that nasal polyps cause asthma reflexly, or else by hindering respiration they change the chemistry of breathing and alter the structure of the lungs. His publication in 1871 was soon followed by a host of observations, confirmatory and otherwise, by different authors. Among these was Haenisch,[3] who observed that asthmatic paroxysms disappeared after removal of polypi, and reappeared only upon the return of these growths, and B. Fraenkel,[4] who regarded the asthma from polypi as a reflex cramp of the bronchi produced by irritation of the sensitive nerve fibres, and, in agreement with Schaeffer,[5] also stated that this irritation could depend upon or be brought about by catarrhal changes in the nasal mucous membrane.

Asthma was the first disease to be regarded as a reflex neurosis, but various other affections were soon placed in the same category, especially various colds in the head—the so-called nervous head colds.

Next came the observations of Hack, who in various publications in 1882, 1883, and 1884,[6] widened very much the range of reflex nasal neuroses, until there were included migraine, supraorbital and ciliary neuralgias, nightmare, various coughs, vaso-motor disturbances of the vessels of the skin, epilepsy, and secretory neuroses. These were later followed by reports still farther extending the field of reflex nasal trouble. Among these were cases of exophthalmic goitre, diabetes, affections of the larynx, heart and stomach, chorea, dysmenorrhœa, enuresis, and so forth, until a large part of the pathology was said to be dependent upon disorders of the nose.

These publications of Hack's, with their accompanying brilliant results, called the attention of the whole world of medicine to this subject. Considerable opposition to his views was aroused; and he admitted before his death that his theories had been carried too far by many of his followers. In the main, however, they have received general confirmation; the subject of nasal neuroses already has a considerable literature; and these neuroses are frequently seen to play an important part in pathology.

In order to produce a reflex, a sensitive or sensory nerve in connection with a ganglion, and a motor or vaso-motor nerve fibre are necessary. The chain, of which the ganglion is the centre, being present, the point of origin of the reflex can be at either extremity. All the conditions necessary for the production of reflexes are found in their highest development in the nose; since the nerves supplying the nasal mucous membrane are sensitive nerves, originating near the floor of the fourth ventricle and having connections with many ganglia, as the otic, spheno-palatine, Gasserian, ophthalmic, and others, which in turn connect with motor and vaso-motor fibres and with many sensitive areas in the respiratory tract by means of the pneumogastric and spinal accessory nerves. Connected with these is the sensory nerve of the nose, the olfactory, which supplies the upper portion of the nasal cavity over both the septal and turbinal areas.

Pathology.—The nose through its normal physiology is particularly liable to reflex influences; as its whole function of warming, moistening, and filtering the inspired air is controlled by a highly complex nervous mechanism, which anatomically adjusts itself under normal conditions to the varying atmospheric changes. Its power as a protective organ, through the information which it gives of the presence of various odors and poisonous gases, and by alarms such as sneezing, cough and glottis spasm, is also dependent upon a reflex action.

In proportion to the number of cases of nasal trouble, the number of pathological nasal reflexes is probably comparatively small. Their presence in the individual case depends largely upon the nervous make-up of the individual; and they are more apt to be present to a pathological extent whenever there is increased sensitiveness of the general nervous and reflex mechanism of the entire body.

An attempt has been made to find certain so-called reflex points or specially sensitive areas in the nasal mucous membrane, and such have been described by various authors. J. N. Mackenzie[7] thinks that the posterior portion of the inferior turbinate is the most sensitive area, though he does not claim that this is the only one. That this area is sensitive, and that its irritation will frequently bring about a severe paroxysmal cough is easily determinable in some individuals by passing a Eustachian catheter without previous cocainization; in many persons quite a paroxysm of coughing will be set up. The author has met with several instances in which it was impossible even under cocaine so to abolish this reflex that the catheter could be used satisfactorily. In one case vomiting was invariably brought about whenever the catheter was used. Other authors have regarded the middle turbinate area as the sensitive one, but Spiess[8] thinks that the principal point of irritation is the tuberculum septi. A survey of the literature, however, will soon convince one that there is no certain reflex point, but that the entire nasal mucous membrane can be the subject of reflexes in every point of its entire extent, the septum as well as the turbinate area.

Hack theorized that the condition was due to swelling of the erectile tissue through the nervi erigentes, a theory not accepted by others, as the presence of nervi erigentes in the nasal mucous membrane has not been proven.

Anatomically, the nasal mucous membrane is supplied by the first and second branches of the trigeminus as to ordinary sensation, and as to special sense by the olfactory; and impressions are taken not only directly to the brain, but also indirectly, by means of the branches of communication with the various ganglia and the brain, to the entire nervous system—sensitive, motor, sympathetic, and special sense. The nasal or ethmoidal nerve comes from the first branch of the trigeminus, and covers in its distribution the anterior portion of the nose, the septum, the anterior ethmoidal cells, and the frontal sinus. The second branch, the superior maxillary or dental nerve, supplies the floor of the nose and the maxillary antrum; while the posterior part of the nose, the septum, the posterior ethmoidal cells and the sphenoid sinus are supplied from branches of the spheno-palatine ganglion.

Irritation can be carried to the brain through the motor, the vaso-motor, the secretory, or the sensory tracts. Through the brain the olfactory is brought into contact with the entire system, while the trigeminus is in connection with the spheno-palatine, otic, and ciliary ganglia, and the point of origin of the latter in the medulla is in communication with all of the motor fibres coming therefrom. It is therefore clear that, under favorable conditions, sensory or sensitive irritation of the nasal nervous elements can be referred to far-removed parts of the body, and the most various symptoms produced.

Etiology and Pathology.—The method of origin of all of the nasal reflexes is the same. The first act is an irritation of the afferent nerve fibres, sensory or sensitive. This is followed by the transmission of this irritation to the ganglion and its appearance as an action, motor or otherwise. The exact way in which all this is brought about is still imperfectly understood. The nerves of the nose have a close relationship to the respiratory centre, aside from the fact that inflammation beginning in the nose frequently passes by direct continuity to the lower respiratory region. Irritation begun in the nose has experimentally brought about closure of the glottis, expiratory tetanus, and stoppage of respiration. The same phenomena are caused by irritation of the vagus. The origin of a number of reflex neuroses of the respiratory organs can be explained on the theory that nasal irritations are carried by way of the ganglia to the respiratory centre, and then pass along fibres of the spinal accessory and vagus or along the spinal nerves. This is seen in the case of glottis cramp, paroxysmal cough, and bronchial asthma.

Many eye affections, such as blepharospasm, strabismus, anomalies of accommodation, asthenopia, and pupil changes, seem sometimes to be dependent upon nose affections. The reflex tract is by way of the motor root of the facial and oculomotor nerves, and irritation along this

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tract can cause clonic or tonic action of the muscles. The tear function is affected directly through the lachrymal nerves, branches of which supply the mucous membrane of the nose. On the other hand, Ziem[9] thinks that the relationship of eye diseases to nose affections is brought about chiefly through the blood and lymph tracts, and only seldom through the nerves.

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According to Jurasz, these reflexes can be advantageously divided as to their causative significance into three groups:

First, those reflex neuroses in which the sensible irritation originates in the nose and the resultant reflex appears in an organ outside of the nose; in this class are asthma, cough, bronchitis, epilepsy, eye and general nervous and neuralgic disorders.

Second, reflex neuroses in which the sensible irritation is in the nose, and asserts itself as a reflex within the nose itself; under this head are embraced the various forms of nervous catarrh, vaso-motor rhinitis, hay fever, hydrorrhœa, rose colds, and others.

Third, reflex neuroses that have their sensible irritation in some other organ and are carried reflexly to the nose, producing nervous colds, hyperæmia, swelling of the mucous membrane, nosebleed, erythema, œdema, and other anomalies of the outer nose; contained in this last group are those dependent upon digestive disturbances and the class of affections caused by disorders of the sexual apparatus, to which latter the researches of J. N. Mackenzie, Grayson and others have called attention.

Pathologically, the theory of origin of the first group is one of irritation of the afferent nerves of the nose, which pass over through the ganglion to the efferent vaso-motor nerves; and the final effect is produced by changes in the volume of the blood-vessels.

In the second group we have only to do with vaso-motor and secretory disturbances in the nose itself, the pathway of communication probably passing through one of the near-by ganglia. The primary irritation comes from the trigeminus or olfactory nerve endings, to be transferred to those nerves which effect changes in the volume of the vessels and in the quantity of the secretions. In these cases the brain and spinal centres are not necessarily concerned, but the circle is made complete with the help of the peripheral ganglia, and the reflex curve is often short.

In the third group the theory of origin is not yet satisfactory. The phenomena appear as the result of the sensible irritation of organs far removed, as the skin in case of colds, the alimentary canal, and the genital apparatus, and consist in changes in circulation and secretion in the nose. The sympathetic system is probably the principal medium of communication between the parts involved.

In such a highly complex mechanism as the nervous apparatus, the localization of the irritation is frequently difficult, especially so as the irritation can be at either end of the chain. In the main, those reflexes which have their point of origin in the nose itself, and which are the most common, are due to direct irritation of the parts, which may be produced in a variety of ways—by simple changes in volume, by touching, rubbing, or pressing them, by active hyperæmia, by the direct effect of cold, or by the odor of flowers. When there is complete closure of the nostril, the reflex is less manifest than when there is variation of volume, irritation being caused at one time and not at another.

The severity of the reflex explosion does not necessarily bear much relation to the degree of apparent irritation, as slight irritants frequently cause considerable reflex irritation; in fact, the most marked reflexes seem to be associated with the least manifest pathological changes. Slight ulceration in the nose has been known to cause considerable cough, scraping of the throat, and inability to sing, and has been entirely relieved by cauterizing the spot with nitrate of silver. Such a case has been reported by M. Schmidt, and somewhat similar ones by others. These cases are more likely to occur in those of highly nervous make-up. The excessive irritability of any single portion of the reflex tract may be due to a local disturbance or may be a partial manifestation of some general neurosis, such as neurasthenia or hysteria.

Heredity does not seem to play any particular part. These cases are more common among the better classes than among the poor, and occur in those of highly nervous organization.

The arthritic diathesis has been regarded by French writers as an important factor, and there are many who regard hay fever as dependent upon this diathesis. While, as regards nasal neuroses in general, the arthritic diathesis may be a predisposing factor, it is certainly not the only one.

These neuroses are rare in children, and are most common between the ages of fifteen and forty. Race has but little influence.

Climate and the season of the year are important factors, and one class of nasal neuroses—hay fever, the term being used here generically—is especially frequent in the summer and autumn seasons. The climatic vagaries of asthma are well known; nearly every asthmatic has his private climate, one asthmatic doing well in a climate in which another does badly, and *vice versa*. The writer has known asthmatic members of the same family, one of whom was relieved by removal to a certain place while another was invariably made worse.

As regards the etiology of asthma, it is probable that many cases are dependent upon a nasal reflex condition, but not all. The pathology and etiology of asthma have not yet been satisfactorily worked out. Want of space will prevent its discussion in any detail here. It seems evident that both local and general factors are concerned in its causation. Asthma is a vaso-motor bronchitis, with —in many cases—a cause or an exciting factor in the nose. Certain it is that the correction of nasal pathological conditions relieves and not infrequently cures the disease.

The nervous area of the interior of the nose is extremely sensitive; and any abnormal nasal condition can set up reflexes. The most common of these pathological causative conditions are chronic hypertrophic catarrh, new growths, deviations and spurs of the septum, synechiæ, cicatrices, foreign bodies—that is, any condition which causes increased volume and pressure in some part of the nasal mucous membrane; while in atrophic conditions the nervous sensibility is so far diminished that the reflexes themselves are also greatly diminished and reflex neuroses are rare.

Operative procedures frequently bring about reflex disturbances, such as sneezing and cough, and may even be followed by vertigo, laryngeal spasm, or more serious conditions. The use of the galvanocautery snare has been succeeded by exophthalmos and rapid pulse; such a case has been reported by Semon. F. R. Packard[10] has reported a case of transient monocular blindness of the left side following removal of the anterior end of the left middle turbinate with the cold wire snare. The writer has seen acute insanity follow operation on the nasal septum in a boy of ten. It was evidently due to the pressure of the retaining plugs, and on their removal recovery was prompt.

There seems to be some sympathetic relationship between the erectile portions of the generative tract and the other erectile structures of the body. Ungratified sexual excitement, as well as excesses in coitus or unnatural sexual habits have brought about coryza of reflex origin. In type this closely resembles that of hay fever, and in the absence of a history might be mistaken for it.

Grayson[11] has reported a case in which turbinal engorgement in an engaged young woman was due to excessive demonstration on the part of the young man to whom she was engaged. This brought about ungratified sexual excitation, which was the cause of the nasal engorgement. He cites another case, the patient being a male, in which excessive sexual indulgence had caused nasal obstruction accompanied by marked hypersecretion, sneezing, and headache. All kinds of treatment, local and general, had been tried, the cause not having been suspected. When this was ascertained and the

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habits corrected, the nasal condition promptly got well without further treatment.

Mackenzie[12] gives an account of a somewhat similar case, the patient being a woman, and the cause excessive sexual indulgence on the part of herself and husband. Here there was difficult asthmatic breathing, with stoppage of the nostrils. Moderation in their marital relations soon brought about a cure.

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That there is a physiological connection between the sexual apparatus and the nose is shown by various reciprocal relations between engorgement of the turbinate tissues and menstruation, such engorgement occurring in some women regularly during menstruation. Occasionally in those whose menstruation is irregular there is an engorgement of the nasal erectile tissue corresponding to the regular time of the menstrual epoch. Fliess[13] made investigations, the results of which seemed to show that painful, profuse, or irregular menstruation may in some instances depend upon an intranasal cause. He cites a number of cases to show that the pain of certain forms of dysmenorrhœa may be temporarily dissipated by the application of cocaine to the nasal mucous membrane, or permanently controlled by cauterization. Such a case is reported in the table of cases appended. Fliess regarded the inferior turbinate and the tuberculum septi as those portions of the nose which have a special relation to dysmenorrhœic pains. Vicarious menstruation sometimes occurs in the nose. In boys around the age of puberty nosebleed of apparently sexual origin has not infrequently occurred.

A case of sneezing following tooth extraction in a fifteen-year-old girl has been recorded.

Hypertrophic rhinitis in connection with digestive disturbances is one of the most common of observations; and many catarrhal cases of this class, even with considerable hypertrophy, frequently get well on the correction of the digestive disturbance. It sometimes happens that complete nasal stenosis will follow a full meal. Whether these cases dependent upon digestive disturbances are true reflex neuroses or only parts of a general congestion which is circulatory in origin, may perhaps be a question; since all of the hypertrophic conditions of sudden onset that are dependent upon digestive disturbances might be brought about through a passive congestion or through a loss of the normal vaso-motor tone.

Symptomatology.—Patients usually complain of the particular condition that troubles them and not of the disease of the nose which is the cause. Asthma, neuralgia, migraine, nervous disturbances of the eye, voice, and heart, epilepsy, muscle cramp, goitre, spasmodic cough, and the like, can appear without any manifest signs of affection in the nose and yet be of nasal origin. Again, complaints of the nose, as narrowing, anomalies of secretion, itching, pressure or pain, may be so mild as hardly to be noticed, or the patient may not complain of the nose at all. Frequently cases of this sort are not correctly diagnosed until they have lasted a long time, and the diagnosis may then be reached only by the method of exclusion.

In the first group the rhinoscopic findings are swelling, hypertrophy, ulceration, new growths, foreign bodies, septal deviations, abnormal adhesions. These are also the principal objective causative factors in the second group, as these two classes are dependent upon the same general reflex mechanism, and differentiate themselves only through symptoms varying in causation and quality.

The neuroses of the second group have been given an enormous number of names. They can all be described under one head, to which Jurasz has given the simple designation of "nervous head colds." The general term "hay fever" includes them all.

Hay Fever.—The symptoms of hay fever come on in paroxysms, and in persons apparently well they last minutes or hours and then disappear. When the patient has been under the influence of a pathological condition for a long time, the attack can last weeks or months with occasional short breaks. While most frequent in summer or autumn it may also occur at other seasons of the year. Here there is a direct irritation affecting the sensory or sensitive nerves of the nose. This irritation may be due to an emanation from plants, as in pollen hay cold, hay fever and hay asthma; to the odor of flowers, such as roses, violets, and others; to the cooking of certain foods; to the odor of various aromatic substances; or to the emanations from various living animals. It is well known that now and then attacks of asthma are brought about by riding behind a horse. These are usually personal idiosyncrasies. In 1893 Bishop advanced the theory that the real cause of hay fever was an excess of uric acid in the blood, favored by profuse sweating, and common at the hay-fever period of the year. For the development of the disease specially sensitive nerve centres, hyperæsthesia of the sensitive nerves of the nasal mucous membrane, and the presence of irritating agents are necessary. His theories have been accepted by many.

The condition begins by irritation or itching in the nose, followed by sneezing and the discharge of a copious, clear, serous fluid. These symptoms are of all degrees from mild to severe, and the sneezing may be terrific. Bobone has reported a case of unconsciousness and cyanosis as a result of cramp-like sneezing. Fink[14] thinks the large amount of secretion comes from the accessory cavities, the antrum principally, and that the secretory fibres of the trigeminus are the ones affected. The secretion is usually thin, but may be thick; frequently large numbers of handkerchiefs are required. On the other hand, sneezing may be present and the condition be one of hydrorrhœa only; or with occasional attacks of sneezing the patient may complain of hindered respiration, stopped-up nose, reddened eyes, swollen conjunctivæ, abundant tears, intolerance to light, itching in neck, cough of an irritating character, pain in head, migraine, trigeminal neuralgia.

In addition to the above there are frequently a laryngitis and a pharyngitis, with cough and sense of oppression in the chest, difficult respiration, and more or less distinctive asthmatic symptoms. Fever is rare.

On inspection the nose conditions are frequently found to be not in accord with the severity of the symptoms. While marked pathological conditions are sometimes present, there may be only redness and swelling; on the other hand, the mucous membrane often appears pale or even anæmic.

This group of cases appears most frequently in the summer and autumn seasons; and the principal exciting cause seems to be the presence of the pollen of certain plants, as roses, hay, golden rod, ragweed, and others. There has to be an individual susceptibility, but the pollen is apparently the exciting cause. From June to September is, in the United States, the most susceptible period, and from the 10th to the 31st of August the worst time, as the ragweed, the pollen of which is then in bloom, is the most irritating of all the pollens.

In the third group, originating outside of the nose, the symptoms are those of a nervous head cold—swelling of the mucous membrane, stopped-up nose, sneezing, irritation, increased mucous secretion. Vicarious menstruation, abnormal dryness of the mucous membrane of the nose, anosmia, hallucinations of odor, changes of the skin of the nose, redness—all these may be of genital origin. Indigestion may also cause many of the same symptoms.

Diagnosis is not usually difficult in the group in which the whole process is in the nose, but is difficult when the origin is in the nose and the apparent seat of the symptoms is in other organs. Jurasz thinks that inasmuch as nasal neuroses sometimes follow brilliant results of nasal therapy, we have assumed that *post hoc, ergo propter hoc.* The teaching of Hack's went so far in its results that, given any pathological nose condition, it was stated as the cause of any affection present, and the diagnosis was made entirely as a result of the nasal examination. This belief gained such a foothold that it was said at one time that the whole pathology was seen through the nasal speculum, and everything abnormal that could not be defined was considered a nasal reflex.

Whenever we have a reflex neurosis which is not clear

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in its origin, or there is the remotest suspicion of one, the nose should be carefully examined, since doubtless many pathological conditions do come from changes in this organ; but, on finding some trouble in the nose, one cannot be exactly certain that the cause of the neurosis is found, as the nasal condition may be only an accompaniment and not a cause. Many people have extreme pathological changes in the nose without any accompanying reflex phenomena. The mere presence of a nose affection in the course of a disorder known to be a reflex neurosis will neither prove nor disprove that the nose is the cause of the reflex neurosis. An attempt should be made experimentally to bring about a reflex irritation of the supposed zone of origin. While this is probably accurate as a diagnostic measure, it is not absolutely certain.

Cocaine is one of the most valuable diagnostic remedies, since if under its influence the reflex disappears it is probable that it is of nasal origin. Weak solutions of adrenalin chloride will act in the same manner.

In doubtful cases treat the nasal condition and await results. If a cure is effected, the probability of the diagnosis being correct is very great.

In neurasthenic patients the moral effect of doing something in the nose may bring about relief and cure, even when the real cause is not in the nose at all; hence it will not do to label every neurosis that improves under intranasal treatment as a reflex nasal neurosis, though of course this is probable.

In the third group it is difficult to make the diagnosis, since it is not easy to demonstrate with exactness that a nose affection is the result of a remote pathological process. Here therapy has only slight diagnostic value.

The *prognosis* is good after the removal of the cause, but there are apt to be many relapses. If the affection has lasted a long time, as in asthma, secondary trouble, as emphysema, may be the result.

Therapeutics.—The treatment of the nose must be directed to the condition present. In the first group of cases, correct whatever is abnormal in the nose so far as possible, but do not promise too much. While the results are often brilliant, as in cases cited in the table, they may not be. In cases in which pressure is the cause of the reflex, leave the nose as roomy as it is possible to make it. The details of treatment will depend entirely upon the condition present. The moral effect of intranasal surgery is often considerable.

The treatment of *hay fever* must depend somewhat on the conditions found. Whether the uric-acid theory be correct or not, it is certain that remedies which favor general elimination are of great value, although the writer has not had any specially brilliant results from treatment based upon this theory. He is in the habit of getting the nasal mucous membrane into as good condition as possible before the attack; and during the attack he cauterizes with chromic acid, allows the patient a spray of adrenalin chloride (1 to 16,000) to be used as needed at home, and gives internally a tablet of: Quin. sulph. gr. ss., ammon. chlorid. gr. ss., camphor. gr. ss., opii pulv. gr. $\frac{1}{10}$, ext. acon. gr. $\frac{1}{10}$, ext. bellad. gr. $\frac{1}{10}$; one of these tablets to be taken every two to four hours, with such remedies for the general elimination as seem demanded. While this does not cure, it greatly relieves.

Fink (*l.c.*) thinks the cautery is of no permanent influence, and says he relieves his patients by insufflating raistol into the antrum. As the natural opening of the antrum is very difficult to find even by the experienced rhinologist, and especially difficult when the tissues are swollen, this method of treatment can have but limited application.

Adrenalin chloride, the active principle of suprarenal gland, is at present a much-vaunted specific for hay fever. That it causes the mucous membrane to shrink and produces immediate relief at the time it is used, and that it is the most powerful devascularizing agent for the mucous membrane yet discovered, are undoubted facts. Its effects are more positive and last longer than those of cocaine, which was formerly used for temporary relief in hay fever.

In the writer's experience with powdered suprarenal extract he did not find that its effects were lasting. It produced immediate relief, but there was a stage of reaction in which the condition was about as uncomfortable as before; indeed, any agent of so powerful a constringing nature would seem of necessity to be followed by a reactionary stage in which dilatation takes place; this has been the experience of several who have used the adrenalin chloride. On the other hand, it must be admitted that many practitioners are apparently having good success in the treatment of hay fever at the time of the attack, with a 1 to 5,000 solution of adrenalin chloride used as a spray two or three times daily. Whether it has any permanent value it is too soon to state. Inasmuch as it produces temporary relief at the time of the attack, it is a valuable adjunct to the therapeutics of the disease. Used in connection with the previous correction of any nasal difficulty, the sufferer from hay fever may be enabled to go through the attack with only slight discomfort.

In regard to the strength of the solution to be given, it seems to the writer as though the weakest solution that will produce the desired effect should be used, even though it is stated that there is no danger of acquiring the habit. As stated above, he has found a solution so weak as 1 to 16,000, to answer very well. The diluting solution may be either decinormal salt solution or some weak alkaline nasal spray solution. The 1 to 1,000 solution of adrenalin chloride is used as the base for dilution. Adrenalin solutions are probably not very stable, and if used for some time should be frequently renewed. Whenever the remedy is ordered for the patient's use, weak solutions should be given, never stronger than 1 to 10,000, the stronger solutions being administered by the physician himself in the form of spray, or applied on cotton pledgets directly to the swollen mucous membrane.

In addition to the local use of adrenalin in hay fever, the extract of the suprarenal gland is administered internally, in doses of from five to ten grains at frequent intervals, until the nasal mucous membrane shows that the vasomotor paralysis is under control, when the dose is diminished or the intervals between the doses increased so that from fifteen to twenty grains are given per day. Should giddiness or palpitation appear, the dose is to be diminished. Five to ten grains three or four times a day may also be given for one or two weeks before the expected time of attack. The internal administration is to be kept up during the hay-fever season. The adrenalin chloride, 1 to 1,000 solution, in doses of five to thirty drops, may be used instead of the extract of the gland.

Adrenalin has also been administered by instillation into the eyes, reaching the nose through the tear passage. It may also be given hypodermatically.

Curtis[15] has proposed to obtain immunization by administering the fluid extract of the plant, the pollen of which acts as the exciting cause, and he has had some success with ragweed.

In all conditions of nasal neurosis, in addition to the local measures, treatment should be directed to the general system so as to lessen the nervous irritability.

The bibliography of this subject is so extensive that space cannot be given to it here. The reader desiring to study the subject in detail is referred to the extensive bibliography given in the article by J. N. Mackenzie on the same subject in the previous edition of this Handbook; to the article by Dr. Mackenzie on the relations between the nose and sexual apparatus, already referred to; to the article on nasal neuroses in Burnett's "System of the Diseases of the Nose and Throat," by Joseph A. White; and to the very extensive and comprehensive bibliography in the article on nasal neuroses in Heymann's "Handbuch der Laryngologie," by Jurasz, to which article the author desires to express his special obligations in the preparation of the foregoing.

The following table gives a number of examples of the various reflexes considered, with the detailed treatment and the results. These cases are mostly unpublished,

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CASES ILLUSTRATING VARIE

Sex.	Age.	Symptoms complained of.	Duration.	Nasal conditions.	Relationship between nose and symptoms complained of, and how determined.
M.	42	Asthma	Three or four years; began as hay fever twenty years ago.	Deviation of septum to right apex pressing hard on lower turbinate; hypertrophy of left middle turbinate pressing on septum and of left lower turbinate pressing on floor of nose.	Wheezing, cyanosis, and dyspnœa almost instantly and completely relieved when the congestion of the interior of the nose was relieved by cocaine and contact prevented.
M.	..	Asthma	Nightly for ten years.	Bilateral ethmoiditis with polypi	By exclusion and result of operation.
M.	44	Severe asthma	Three years	Polypi	Cocaine gave relief as did partial removal of polypi.
M.	49	Asthma, severe whenever nose obstructed; neurotic temperament.	Several months....	Exostosis of left septum; hypertrophy of right inferior turbinate; mucous membrane very sensitive; watery discharge; obstructed nostrils, worse at night.	Severe asthma only when nose occluded; under nervous excitement mucous membrane would swell and asthma come on at once.
F.	40	Asthma and cough	Asthma several years during wet months; cough six months.	Right middle turbinate much hypertrophied; septal crest on right side.	Asthma always relieved by cocaine spray.
F.	30	Asthma..........	Twelve months....	Abscess of antrum..........	Evacuation of pus from antrum followed by immediate relief; recurrence of empyema caused return of asthma.
F.	46	Asthma, nasal obstruction, headache.	Years	Large rhinolith with hypertrophy of turbinate tissue.	By treatment..........
F.	40	Asthma	Five years	Hypertrophy of posterior ends of inferior turbinates with complete nasal stenosis.	No exciting cause except general nervousness outside of nose; touching diseased parts with probe brought on attacks of dyspnœa.
F.	30	Cough; larynx irritation; occasional hoarseness.	Several years......	No complaint of nose, but spurs in contact with inferior turbinate of each side were found.	Treatment for cough and larynx did little good; cautery of each inferior turbinate so as to remove contact with septum, afforded relief.
F.	30	Severe coughing	Several months....	Hypertrophied inferior turbinates, and later, stenosis at night.	Diagnosis in doubt for some time; involvement of lung and unfavorable prognosis given by competent physician; taken to a specialist who examined nose and suggested treatment for nasal conditions.
M.	57	Dyspnœa, severe, continuous........	Three months	Septal spur on right side with deflection of septum to the left and enlarged inferior turbinates.	By result of operation: no organic cardiac disease; some emphysema.
F.	68	Spasmodic breathing at night........	Fifteen years	Two small polyps at lower edge of right middle turbinate, none elsewhere; no nasal obstruction.	Irritation of polypi with probe caused spasmodic, almost convulsive breathing.
F.	23	Spasmodic cough..........	Twelve years......	Hypertrophied inferior turbinates ...	Had been treated for uterine trouble, vesical trouble, rectal trouble, and nervous trouble with no result; cocaine to nose caused cessation of cough.
M.	16	Epilepsy	Two years...	Deflection of septum with complete stenosis.	History of trauma followed by attacks of epilepsy.
M.	22	Epileptiform attacks every two to three weeks.	Six years..........	Complete closure of left nostril due to deflected septum and left nasal bone.	Followed a broken nose ....
M.	11	Epilepsy	Nine years	Marked lymphoid hypertrophy	Removal under ether was followed by cessation of attacks for eighteen months.
F.	40	Sneezing and watery discharge from nose with erythema of the skin of the external nose.	One year	Both middle turbinates hypertrophied and pressing against septum; edges of turbinates puffy and red.	Determined and verified by treatment.
F.	22	Paroxysmal sneezing	Three years	General swelling of nasal mucosa; sensitive to probe; sneezing induced by contact with flowers and intensified when nervous.	When away from flowers sneezing stopped.
F.	45	Vaso-motor periodical neurosis (hay fever) followed by severe attacks of asthma.	Twenty years without relief.	Hypertrophied inferior turbinate, left long bony spur on septum of the same side pressing on turbinate.	Other treatment ineffective; operation on nose suggested as offering some hope.
F.	75	Hay fever. Attacks began June 1st every year.	Fifty years	Hypertrophy of both middle turbinates; complete stenosis at time of attacks which have occurred in the winter also.	Relief from cocaine and from local treatment of the nose.
M.	49	Vertigo with tendency to falling ...	Three months	Hypersensitiveness of mucous membrane; general hypertrophic rhinitis; swollen middle turbinate; deviated septum.	Treated for liver, kidneys, and nervous system without avail; spasmodic cough elicited on touching sensitive area together with sense of giddiness.
M.	65	Tic douloureux..........	....	Pressure deviation of septum on anterior end of right middle turbinate which was hypertrophied.	By area of pain and result of treatment.
M.	45	Tic douloureux	....	Hypertrophy of septum and opposing middle turbinate of right side.	No treatment except to the nose gives any relief; cocaine and adrenalin give temporary relief.
M.	42	Conjunctival congestion; photophobia	Three to four years.	Deflected septum causing intranasal pressure.	....

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Nasal Cavities.

TIES OF NASAL NEUROSES.

Treatment.	Result.	If improvement, has it continued?	Reporter.	Where reported.	Remarks.
Refracture of the septum and replacement in median line; reduction of swellings and abolition of contact. This treatment continued off and on for two years as occasional colds caused renewed thickening, rendering cauterization necessary.	Attacks gradually diminished in severity and complete relief was finally attained.	So far as known; relief since 1893, last report 1899.	G. A. Leland...	Personal communication.	
Removal under general anæsthesia of all necrosed bone and polypoid tissue.	Almost complete relief.	Yes.............	G. B. Rice.....	Personal communication.	
Complete removal of polypi with cauterization at point of origin.	Cure............	....	Wm. Porter...	Personal communication.	
Exostosis removed; turbinal hypertrophies reduced; sensitive area cauterized; temporary change of climate; general tonic; treatment with regulation of habits of life; stimulants and tobacco stopped.	Apparently complete cure.	Yes.............	C. F. Theisen..	Personal communication.	Reporter thinks this case one of pure rhinitis nervosa.
Right middle turbinate removed February, 1894, followed by relief from asthma and cough for one year; recurrence was followed by further operative work, since which no further trouble.	Cure after second operation.	So far as known; last heard from in 1901.	W. A. Martin..	Personal communication.	Reporter regards impacted or hypertrophied middle turbinate responsible for more nasal neuroses than any other condition.
The usual treatment for cure of antral empyema.	Cure	Yes	Chas. W. Richardson.	Personal communication, also *Laryngoscope*.	
Removed rhinolith which weighed fifteen grains and had a cherry stone as nucleus.	Cure	Yes	M. D. Lederman.	Personal communication.	
Removal of hypertrophies..................	Cure	Yes	J. E. Schadle..	*Northwestern Lancet*, 1890.	
Occasional cautery; relieved and declined any further operative treatment.	Improvement....	Two years to present.	Author.		
Cautery to turbinates......................	Cure	Yes, for ten years.	Within knowledge of author	....	This case was a patient of the author's many years ago; the correct diagnosis was made by Dr. F. I. Knight, to whom credit for suggesting treatment is due.
Removed spurs and corrected deviation of septum.	Worse for ten days then great improvement.	Yes, but still has sensations of pressure about the chest.	M. D. Lederman.	Personal communication.	
Removal of polyps with cold snare	Complete and immediate relief.	Yes.............	L. B. Graddy..	Personal communication.	
Cautery to turbinates......................	Complete and lasting relief.	Yes.............	J. A. Stucky...	Personal communication.	Reported by author in article on "Reflex Cough," *Medical Record*, August 5th, 1899.
Operation on septum.......................	Relief for six months then returned, but after second operation there has been no attack for two years.		T. J. Harris ...	Personal communication.	
Operation of straightening septum..........	No seizures since four days previous to operation.	Yes, since January, 1902.	Name unknown.	Personal communication.	
Operation as stated and then reoperation after attacks began again.	Apparent cure after last operation until a blow on the head brought on petit mal again.		Urban G. Hitchcock.	*N. Y. Medical Journal* and personal communication.	Petit mal has continued; operated on for hypertrophy of the inferior turbinate in last two years without result.
Removal of tips of each middle turbinate...	Cure	Yes	C. N. Cox	Personal communication.	
Tonics, adrenalin 1 to 10,000..............	Two or three slight attacks in past three years.	....	C. F. Theisen..	Personal communication.	
Removal of septal spur; galvano-cautery applied to turbinate.	Four weeks after treatment annoying symptoms disappeared.	Yes, as far as known.	M. D. Lederman.	Personal communication.	
Removed anterior end of each middle turbinate.	Great improvement; no June attack; August attack less severe.	Yes.............	Author's case..	....	No attack in year 1902. Patient apparently permanently cured.
Removal of right middle turbinate; cautery of inferior turbinate.	Cure	....	O. J. Stein.....	*Laryngoscope*, December, 1898.	
Septum placed in proper position; worse immediately after, then gradual diminution of attacks in frequency and severity.	Final cure.......	No return of attack since 1896.	G. A. Leland ..	Personal communication.	
Galvanocautery	Good...........	....	W. Cheatham..	Personal communication.	Many cases nasal reflex relieved by cautery but many not; is not so hopeful as to results as formerly.
Removal of piece of septum with saw relieved pressure.	Permanent relief.	....	G. D. Murray..	Personal communication.	

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Cases Illustrating Varie

Sex.	Age.	Symptoms complained of.	Duration.	Nasal conditions.	Relationship between nose and symptoms complained of, and how determined.
F.	24	Intense supra- and infraorbital neuralgia, right side of face.	Four years.	Exostosis of right lower turbinate pressing on septum.	Shrinking under cocaine relieved pain at once.
M	36	Severe pain in head	Two years	Intranasal pressure from spur of left nostril.	Constant pain more noticeable during cold in head.
F.	23	Headache	Two to three years.	Chronic hypertrophied rhinitis.......	Headache worst when hypertrophy is greatest.
F.	40	Sick headache (migraine) with complete prostration.	Each attack several days.	Sharp exostosis buried in posterior end of inferior turbinate.	Increased tension in nose from any cause brings on attack.
M	..	Headaches, chorea, pain in eyes; inability to fix vision.	Several years	Polypus in left nostril; closed ethmoid cells.	Complete relief from treatment of nose; none from other measures.
F.	23	Following nervous excitement had increased conjunctival congestion, lachrymation and profuse watery nasal discharge.	Three to four years.	Septum thick; spur on one side; turbinates boggy; polypoid degeneration of left middle turbinate which was pressing against septum.	By result of treatment ....
F.	37	Headache; inability to fix vision; chorea in arms and legs; skin sensations neurotic type. For years in sanitoriums. Diagnosis of petit mal (neurotic family history).	Several years......	Both middle turbinates solid; no cells.	By result of treatment ....
M	13	Unable to swallow solid food since early childhood; if attempted always vomited.	Many years	Adenoids..........................	Suggested as possible cause ....
F.	37	Indigestion with cough	Several years	Reported nose perfect but examination showed spur in each nostril and hypertrophied tubercles of each septum.	By results of examination and treatment.
F.	20	Dysmenorrhœa	Several years......	Hypertrophy of middle turbinate	Results of treatment.................
F.	41	Diffuse œdema joints, hand and ankle	....	Polypoid degeneration of mucous membrane near hiatus semilunaris.	....
M	9½	Tachycardia	....	Pedunculated myxofibroma of the posterior end of middle turbinate.	....
M.	10	Temporary insanity..................	One week	Followed removal of adenoid and operation for deflection of septum, done under ether.	Seemed to be due to effect of plugs placed in nose to hold septum in position.

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having been given the author in the form of personal communications, and to the writers of which he desires to express his indebtedness.

George L. Richards.

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NASAL CAVITIES, DISEASES OF: NEW GROWTHS.—Perhaps contrary to what is quite generally believed, new growths in the nose are exceedingly rare. Mucous polypi, spurs, and thickenings of the bony and cartilaginous septum are seen more commonly than any or than all forms of new growths combined, but, being of purely inflammatory origin and not tumors in the true sense, are not described under this heading.

Moritz Schmidt, among 32,997 nose and throat patients seen in ten years, found that but 24, or 1 in every 1,370, presented some form of true neoplasm in the nose. Of these, 757, or 1 in every 43, had mucous polypi; *i.e.*, mucous polypi occurred more than forty times as often as all forms of true new growths combined. Of benign and malignant neoplasms, there would seem to be about an equal proportion, if anything, malignant growths appeared more often than benign tumors.

1. Benign Neoplasms.

Angioma.—This new growth is usually found on the septum and is composed almost entirely of blood-vessels, generally large cavernous veins, surrounded by a slight network of connective tissue, its epithelial covering being the same as that of the part from which it sprang. Bosworth says that it may be located in any part of the nasal cavity; however, if seen anywhere but on the septum, it is probably but a localized hypertrophy of the mucous membrane in which the vascular changes are most marked. It occurs at all ages, most frequently in early life, when it may be congenital, and very rarely in old age. It is a soft, rounded, mulberry-like growth, varying in color from a bright red to a purple, movable, pedunculated or sessile, bleeding easily on touching with a probe, and, as before stated, is almost invariably found on the anterior part of the septum. The tumor may be reduced or emptied by pressure, and, if connected with an artery, pulsation may be detected. Frequent attacks of nosebleed, always beginning on the same side, constitute the earliest symptom. The epistaxis may be alarming and difficult to control. Nasal stenosis on the affected side develops with the growth of the tumor, which may be rapid or slow. More or less discharge is likely to be present. There is no pain.

Treatment consists in the removal of the growth by the cold wire snare under cocaine anæsthesia and adrenalin to lessen the hemorrhage. If the growth be pedunculated, the application of the snare is simple; if it be sessile, a needle transfixes the growth at its base, the loop of the snare being thrown over this; and in either case one or two hours should be taken in removing the tumor. Recurrence does not take place if the removal has been complete.

Bony Cysts.—Osseous cysts in the nose are not rare. When present, they are found invariably at the anterior end of the middle turbinated bone in persons above twenty, and much oftener in women than in men. The etiology is interesting—several theories having been advanced as to the mode of their production. McDonald thinks the lesion was originally an "osteophytic periosti-

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TIES OF NASAL NEUROSES.—*Continued.*

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Treatment.	Result.	If improvement, has it continued?	Reporter.	Where reported.	Remarks.
Removal of right lower turbinate with saw and scissors in 1898.	Complete cessation of pain.	....	P. S. Donellan.	Personal communication.	
Removal of spur	Instantaneous relief from pain.	Yes	G. D. Murray..	Personal communication.	
Chronic acid to turbinates	Relief	Yes, for six years.	J. C. Thompson	Personal communication.	
Shrinking turbinate with cocaine, and suprarenal, as patient declines operation for permanent relief.	Temporary relief.	....	J. A. Keneflck .	Personal communication.	
Removal of polypi; opening of ethmoid cells.	Cure	Yes	P. J. Gibbons..	Personal communication.	
Removal of left middle turbinate and the septal spur.	Complete relief ..	Yes	J. F. McCaw ..	Personal communication.	
Opened through middle turbinates and drilled into left sphenoid sinus; antipyrin and suprarenal locally; general tonic treatment.	Cure	Yes, has gained thirty pounds.	P. G. Gibbons..	Personal communication.	Was of suicidal tendency and when worse iodine was detected in secretions.
Removed...........................	Swallowed solid food next day.	Yes	Unable to credit as reporter did not sign name.	Personal communication.	Reporter thinks trouble due to abnormal reflex causing spasm of pharyngeal and œsophageal muscles.
Removal of spurs and hypertrophies of septum and of diseased tonsils by electro-cautery dissection.	Entire disappearance of cough and indigestion.	Yes, six years ...	Ed. Pynchon ..	Personal communication.	
Usual surgical measures	Cure	Yes, six years ...	Henry L. Wagner.	Personal communication.	
Surgical	Cure	Yes, eight years.	Henry L. Wagner.	Personal communication.	
Surgical; removal......................	Cure	Yes	Henry L. Wagner.	Personal communication.	
After removal of plugs was all right in a few days.	Cure	Yes	Author's case.		

tis," secondary to an hypertrophy of the mucous membrane of the middle turbinate, causing the inferior border of this to curl outward and upward until it met the body of the bone above where at length adhesion took place, finally causing a closed bony cavity lined within and without with mucous membrane. Another explanation is that the cyst results from a rarefying osteitis, the inflammation beginning in the mucosa, involving later the periosteum and bone, and finally resulting in the porous formation observed in other hyperplastic processes. A simpler and more probable explanation than either of these is to be found in the fact that there frequently exists in the anterior end of the middle turbinated bone an ethmoid cell, which communicates with the middle meatus or with the other cells of the ethmoid labyrinth. Inflammation causes complete or partial stenosis of the orifice, the secretion is retained, and the cell gradually becomes larger as the walls distend, until finally there is produced a bony cyst. This is covered externally with mucous membrane that may either be normal or have undergone polypoid degeneration with polypi resulting, or, again, may have atrophied. The mucous membrane lining the cavity has columnar ciliated epithelium, and, through pressure of the retained secretion, often becomes attenuated, the glandular elements undergoing absorption, the membrane becoming polypoidal or granulating. The cyst contains air or may be filled with a yellow viscid fluid, muco-pus, or clear pus. On several occasions the writer, on opening the cyst, found a mucous polyp present in the cavity.

The tumor presents itself as a smooth, rounded, anterior end of the middle turbinated body, and varies greatly in size, being often so small as to pass unobserved, while at other times it may be so large as to reach down to the inferior turbinate or even to the floor of the nose, and frequently pushes the septum over sufficiently to cause stenosis of the opposite naris, the tumor occupying the concavity of the septum which it has produced. The symptoms are those due to pressure of retained secretion and to obstruction. Hemicrania with exacerbations of acute pain during colds in the head is the most characteristic and distressing symptom. The pain is referred to the inner side of the eye, radiating to the forehead or across the face, causing often intense trigeminal neuralgia. There is a feeling of pressure and throbbing. Actual exophthalmos may occur from the outward pressure. Attacks of megrim with vertigo and partial unconsciousness and vomiting are often complained of. Nasal obstruction, depending upon the size of the tumor, is present on the affected side and may be quite marked in the opposite naris.

Prognosis is good and recurrence is not to be expected following proper treatment.

Treatment is surgical and consists in the removal of the cyst (under local anæsthesia) by the cold wire snare, Grunwald's or other nasal cutting forceps.

FIBROMA.—Fibroma is a connective-tissue growth, somewhat resembling histologically the mucous polyp, but differing from it in the large amount of connective-tissue fibres crowded together with but few intervening interstitial spaces. The epithelial covering is the same as that of the polyp. It springs from the submucosa or outer layer of the periosteum, and arises from the posterior third of the middle or superior turbinated bodies or from the roof of the nose, and is said never to spring from the septum. It may arise in the sinuses, and often extends from the nasopharynx into the nasal fossæ. It has a rather thick, firm pedicle or may have a very broad base. If pedunculated, the growth is downward and backward into the nasopharynx, where it appears as a round or pear-shaped grayish-pink tumor, firm and hard to the finger, bleeding easily on probing, having a rather smooth surface, and tending to fill the postnasal space. In the nose it is of the same character, but is longer and more slender, conforming to the shape of the nasal cavity. Its growth is steady and persistent, pushing aside adjacent bones, causing ulceration and adhesions, invading the neighboring sinuses and orbital cavities, and producing finally much deformity, such as the characteristic frog face and exophthalmos. The tumor is very vascular and the walls of the blood-vessels are very much thinned. This form of growth occurs in early life, between the ages of fifteen and thirty or forty, and in males more often than in females. Of six cases of

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fibroma in the nose and nasopharynx seen by the writer, four were in men, two in women,—the youngest in a boy of sixteen, the oldest in a man about forty.

The *etiology* is not known, trauma possibly having to do with the development. Early in the disease the patient has repeated attacks of epistaxis, often severe, the blood coming not only from the tumor, but also from the ulcerated mucous membrane, and nasal obstruction develops first on one side, then on the other, as the nasopharynx becomes filled with the tumor. A copious watery or mucopurulent discharge constantly flows from the nose. The voice becomes thick and nasal, the mouth dry and open, the senses of smell and taste become impaired or lost, and tinnitus and impaired hearing develop. Pain is absent at first, but, as pressure on adjacent parts develops, it becomes steady. Deformity arises if the tumor is not soon removed.

Prognosis is good if the tumor be removed. If it be not removed, death will ensue from copious hemorrhages or from extension of the disease to the brain.

Removal can usually be accomplished by the cold wire snare, but it may be difficult to surround the growth. The large loop is passed through the nose into the nasopharynx, the index finger of the left hand then pushing the wire about the tumor, when the loop is drawn. The pedicle may be so hard or the base so broad that the wire may be repeatedly broken and the galvanocautery snare be required before the tumor can be severed. The pedicle or base may be cut with scissors, and in unusually large tumors it may be necessary to expose the nose by an external operation before the tumor can be removed. Profuse hemorrhage is to be expected in the removal of fibroma by whatever operation, and death has occurred during operation from this cause. Electrolysis has been employed to lessen the size and reduce the vascularity of the growth before operating.

Osteoma and Chondroma.—These true bony and cartilaginous tumors are not to be confounded with the exostoses and ecchondroses so frequently met with on the septum.

Osteoma originates from the ethmoid, vomer, accessory sinuses, and other parts of the bony framework. Both the cancellous and the eburnated varieties are met with. The tumor grows steadily, though slowly, pushing everything before it, invading the orbital cavity, displacing the eyeball, and causing intense pain. The tumor has a bony connection with its point of origin or a pedicle of mucous membrane and connective tissue. It is covered with mucous membrane, and is so hard that it cannot be penetrated by an exploring needle. It is usually single, smooth or irregular, and may be of any size, depending upon the time it has been growing. The symptoms are pain, early and continuous until the pressure destroys the nerve filaments, nasal obstruction with all its results, impaired sense of smell, muco-purulent discharge, and frequent attacks of epistaxis. Exophthalmos, with or without blindness and epiphora, is produced sooner or later, as well as other evidences of external deformity. The diagnosis is made by the history of a slow growth, by the use of the probe or the needle, and in doubtful cases by the microscope.

Prognosis depends upon the extent of the tumor at the time of examination, but it is usually good. The treatment is entirely surgical and nearly always intranasal. The tumor may have to be divided into fragments by the motor trephine, bone forceps, or saw, and removed in pieces when it is too large to be extracted through the nostril. When the tumor is quite large and inaccessible, an external operation will have to be made, but much can be done by modern intranasal surgery without resorting to the more radical external operation.

Chondroma occurs less often than osteoma. It springs generally from the anterior part of the septum, but may come from the ethmoid or other accessory sinuses. It is a smooth, rounded, sessile tumor with a broad base covered with normal-appearing mucous membrane. It is found in early life. The symptoms are those of osteoma, excepting that there is no tendency to bleed. It is differentiated from osteoma by its permeability to the needle and by its sessile base; from malignant tumors by its slower growth, absence of hemorrhage, and harder sensation conveyed through the probe.

Prognosis is good if the tumor is entirely extirpated. Removal is accomplished by the knife, saw, cold or galvanocautery snare.

Papilloma.—Both hard and soft varieties of papilloma are met with in the nose. The hard variety resembles in all respects the cutaneous wart, and is confined to the vestibule and anterior part of the septum, usually of one side, and is commonly single, but may be multiple. Many cases of the soft variety have been reported, but the majority of them are not true papillomata, being nothing more than papillary hypertrophies. These latter, sometimes known as "Hopman's papilloma," are of common occurrence in hypertrophic rhinitis, occurring along the inferior border and posterior ends of the inferior turbinated bodies—sites where true papillomata do not occur. Jonathan Wright, who has investigated this neoplasm with perhaps greater thoroughness than any other rhinologist, says that only about a dozen cases of unquestioned papillomata of the nose have been recorded in literature. True papilloma appears to be restricted to the anterior part of the septum, the floor of the nose, and the anterior part of the external wall. It occurs at any age and in either sex, and is usually single, unilateral, and of small size, but may grow to be as large as a hazelnut, obstructing the nasal orifice. It may be sessile, but almost always is pedunculated, grayish-pink in color, with irregular surface and well-marked papillæ, somewhat resembling a raspberry. It is very vascular, bleeds easily, causing frequent attacks of epistaxis, and has some tendency to ulceration. Pain is seldom present. There is more or less profuse nasal discharge. Unless the growth is completely removed, it is likely to recur.

Treatment.—Removal is best accomplished by the cold wire snare, and any part remaining should be destroyed with the galvanocautery. Vaseline or other emollient should be kept applied until healing has occurred, and irritation by picking the nose is to be avoided. Ingals recommends the application of the tincture of thuja occidentalis to prevent recurrence. The possibility of papilloma degenerating into or later becoming a malignant tumor, especially in persons in middle life or later, should always be borne in mind.

2. Malignant Neoplasms.

Adenoma, sometimes classified as a benign tumor, shows sooner or later malignant changes, undergoing either carcinomatous or sarcomatous degeneration. This has been so in nearly, if not quite all, cases which have been observed and reported. Pure, unmixed adenoma in the anterior nares is necessarily extremely rare, because of the absence of gland structure in the nose. Hopkins and Leland each reported a case of adenoma in the nose at the meeting of the American Laryngological Association in 1897, both cases ultimately taking on carcinomatous change, and Leland's showing also a transition in one part to papilloma. Mayer has recently reported (*Am. Medicine*, August 2d, 1902) a case of adenoma, showing sarcomatous degeneration in parts. The tumor is to be regarded as malignant. It presents itself as a grayish-white granular polypoid mass, firm in consistency, the surface soft and pultaceous, bleeding easily. It develops much more slowly than either sarcoma or carcinoma.

Sarcoma is the commonest form of tumor met with in the nose, if we exclude mucous polypi and other tumors of purely inflammatory origin. All varieties found in other parts of the body occur in the nose, but the round- and spindle-celled sarcomata are most frequently seen, and after these in points of frequency are myxosarcoma, melanosarcoma, and fibrosarcoma, the other forms being much more rare. Both sexes are equally attacked. The period most susceptible to sarcoma in the nose is the fifth decade, between the fortieth and fiftieth years, but

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no age is exempt, cases being seen in early infancy and in extreme old age. Of eighty-four cases collected and analyzed as to age by Harris (*Phila. Monthly Med. Jour.*, June, 1899), thirty-four, or forty per cent. of the cases, were between thirty and fifty; four were under ten years of age and two between seventy and eighty.

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As to *etiology*, little is known. Sarcoma is found so frequently associated with mucous polypi that there would seem to be some basis for the belief that under certain unknown conditions mucous polypi do undergo sarcomatous degeneration. Trauma, accidental or surgical, may be an etiological factor in this transformation from a benign to a malignant growth, and crude methods in operating have been suggested as a possible cause; but facts are wanting to substantiate this, too few cases bearing on this being reported to base any conclusions upon.

Symptomatology.—The earliest symptoms are unilateral nasal obstruction, progressing steadily and rapidly, and repeated attacks of nosebleed. Epistaxis is a prominent symptom throughout the course of the disease, and may become a very serious and alarming one. Discharge from the nose is profuse, at first watery, then muco-purulent and bloody, and later on the odor of necrosis makes it offensive. Pain is conspicuously absent in the early part of the disease, but, as the growth encroaches on the accessory sinuses, it becomes constant and steadily increases in severity. With the spreading of the tumor into the accessory sinuses and neighboring cavities more or less deformity of the face occurs, such as exophthalmos and fulness at the side of the nose and of the cheek with discoloration of the skin over the affected area. The growth may protrude forward through the nostril or backward into the pharynx, as in the case of a two-year-old child seen by the writer. Vision may become impaired from pressure on the optic nerve after involvement of the sphenoidal sinus. Nasal obstruction becomes so complete that the patient has great distress in breathing and in eating, speech becomes thick and muffled, the senses of smell and taste are lost or much impaired, nasal discharge becomes most profuse and offensive, pain is constant, insomnia adds to the distress, and the patient loses weight and strength, and finally dies, unless relieved by surgical intervention, from extension of the tumor through the cribriform plate of the ethmoid or roof of the sphenoidal sinus to the brain, or death may result from sepsis and exhaustion.

The objective appearances of sarcoma are not altogether characteristic. It is usually pedunculated, but may be sessile, and arises most often from the cartilaginous and bony septum and the middle turbinated body, but it has been seen originating from any and all parts of the nose. The color varies from that of a simple mucous polyp to a yellowish-pink or dark red, most often the latter. It is ordinarily quite soft to the touch of the probe and bleeds easily on examination, as in the round-celled variety, or it may be quite firm, as in the fibrosarcoma. The surface is smooth, unless ulceration has occurred. The tumor may have originated in any of the neighboring cavities, invading the nose secondarily. The writer, some ten years ago, had under his care a physician in whom a gliosarcoma of the dura mater perforated the base of the skull at the region of the sella turcica, invading the sphenoidal sinus, and causing softening and absorption of the cribriform plate of the ethmoid. The glands of the neck are not involved, unless it be by direct extension of the disease to them. Sarcoma is to be differentiated from simple mucous polyp, angioma, adenoma, carcinoma, and syphilis. The iodides should be administered to exclude syphilis in a doubtful case, and a microscopical examination of a piece of the tumor removed by the cold wire snare should always be made.

Prognosis depends upon the site of the origin of the tumor, the extent of its invasion, and the variety of the neoplasm. Sarcoma, having its origin in the septum, especially the cartilaginous part, offers the most favorable outlook, while one arising from the middle or superior meatus is most unfavorable. The round-celled sarcoma, the commonest variety seen in the nose, is also the most virulent. More than fifty per cent. of all cases are fatal. Of one hundred and three cases in Harris' table, the final termination was stated in but fifty five, and of the latter twenty-five ended in death and thirty in recovery. All but one of the thirty were operated upon. Twenty-two of these latter, however, were reported as cured within a year of operation, and it is probable that recurrence took place in some or many of them later.

Treatment.—Surgical intervention at present offers practically the only chance of recovery. The operation must be thorough and the tumor completely eradicated.

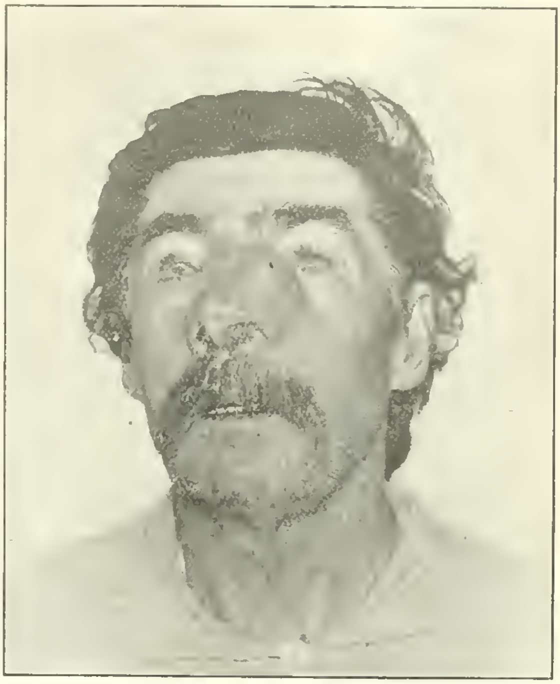

FIG. 3490.—Adenoma of the Nose, with incipient Sarcomatous Degeneration. (Case reported by Dr. Emil Mayer in *American Medicine*, August 2d, 1902.)

If the tumor is pedunculated and arises from the septum, especially at its anterior part, an intranasal operation with the snare may be entirely efficient; but if the growth comes from the middle or superior meatus or invades or involves the accessory sinuses or is inaccessible in any way, an external operation must be done. The nose is released and the parts involved are laid bare, the tumor is removed by cutting or the use of the snare, and the base is thoroughly curetted. Should recurrence take place, this should be removed at once. In inoperable cases—and many are inoperable—Coley's mixed toxins may be given with some hope of diminishing the size and retarding the development of the tumor, even if not curing it; such a course being specially indicated in the spindle-celled variety.

CARCINOMA, much more rarely seen in the nose than sarcoma, is always primary and occurs as epithelioma or cylinder-celled carcinoma. It originates most frequently from the cartilaginous septum and the turbinates, but more often still it is an extension into the nasal fossæ from the neighboring accessory sinuses, especially the maxillary. It is found during or after middle life, differing in this respect from sarcoma, which occurs at all ages. Unlike sarcoma, which has its origin in the deeper structures and forms a distinct tumor, epithelioma begins in the mucous membrane, ulcerating and destroying as it progresses. Nasal obstruction and pain of a neuralgic character are early symptoms. The discharge at first is acrid and of a sero sanguinolent character, but as ulceration occurs the discharge is more profuse and be-

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comes putrid and fetid, giving to the patient and his surroundings an odor that is persistent and offensive. Repeated attacks of epistaxis occur. Tinnitus and impaired hearing and earache are often complained of. As the growth extends into the accessory sinuses, the orbital and cranial cavities, a new set of symptoms develops. The cheek becomes full, the eyeball is pushed out, vision may become impaired, pain is greatly increased, and finally signs of meningitis or brain abscess develop.

Objectively, epithelioma presents itself early in the disease as an infiltration of the mucous membrane, suggesting a papillomatous hypertrophy, but ulceration soon takes place, leaving the edges of the ulcer hard and the surface angry and covered with a thick, grayish secretion. Bleeding follows the slightest probing. The tumor shows marked tendency to invade the deeper parts, with little inclination to extend outward to the skin. Sooner or later the submaxillary and cervical glands become involved, though this is not always so, and cachexia develops only after the disease has existed for some time. The differential diagnosis is to be made usually from syphilis, lupus, and tuberculosis. Antisyphilitic treatment will often clear up a suspected epithelioma, and when any doubt exists the iodides should be given, if but for diagnostic purposes. Lupus has a very marked tendency to extend to the skin, which is usually involved. In a case of suspected primary tuberculosis, the bacillus will be found if that disease is present. The microscope may be required to determine the diagnosis of epithelioma; in employing it, however, one must not overlook the possibility that the removal of a piece of the tumor may be followed by renewed activity of the growth.

The *prognosis* is absolutely bad, few if any authentic cases of recovery having been reported. The disease appears to be more rapidly fatal in the nose than in most other parts of the body. Treatment heretofore has been unavailing; operation seemingly not only not eradicating the disease, but not affording even temporary relief. The growth recurs rapidly. While the *x*-ray as a curative or remedial agent in the treatment of cancer is still experimental, yet the very favorable reports of its use in other parts of the body would make it seem that the patient should be given whatever benefit there may be in this treatment. Pain may be relieved somewhat by orthoform or other local anæsthetic, and toward the end narcotics should be given to relieve the sufferer, and antiseptic washes used locally throughout the disease.

Thomas H. Halsted.

NASAL CAVITIES, DISEASES OF: PARASITES.—

The presence of animal parasites within the nasal cavities is of relatively infrequent occurrence. In the majority of cases such an event is purely accidental; true parasitic infection—*i.e.*, the presence of animal forms which reproduce, or pass one or more stages of their existence, within the nose—is very rare. As is the case with the external auditory canal, the nasal orifices, under certain conditions, may form favorable avenues of entrance for such creeping forms of animal life as are fond of escaping the light by crawling into dark places. The residence of such animals within the nose is usually but temporary; during this time they do not draw nourishment from the body tissues. The effects produced are chiefly those of local irritation or obstruction. To this condition the term pseudoparasitism may with propriety be applied.

PSEUDOPARASITISM.—Among such pseudoparasites of the nasal cavities may be mentioned earwigs, centipedes, numerous beetles, insects, spiders, mites, bedbugs, leeches, and worms. Entrance into the nose is usually obtained during sleep, very often in the open air, during the daytime. The local symptoms of irritation and obstruction may be very slight or severe. Bloody or mucopurulent discharges may be produced. In many cases the chief symptoms are of a nervous character, due to fright or worry. The intruder may penetrate into the frontal sinuses. Such cases may be attended by dangerous symptoms or even result fatally. It is said that centipedes are especially likely to reach the frontal sinuses. Cases are reported of these animals remaining in the frontal sinus for years, drawing their nourishment from the secretions of the cavities.

The occasional entrance of round worms (*Ascaris lumbricoides*) into the upper air passages and into the nasal cavities is of clinical importance. As is well known, these worms may, during the sleep of the affected individual, wander from the intestine, through the stomach and œsophagus, into the mouth and upper air passages. Ordinarily no especial symptoms are produced, but the passage of the worm into the larynx may cause serious symptoms of suffocation or even result fatally. Important obstructive symptoms may also arise from the penetration of the worm into the Eustachian tube or tear duct.

The *Oxyuris vermicularis* may be transferred from the anus to the nose through uncleanly habits, but does not remain in the new location.

TRUE PARASITES.—*Protozoa.*—Various forms of protozoa (*Amœba*, *Cercomonas*, and *Trichomonas*) have been reported as occurring in the nose, in such conditions as ozæna, purulent catarrh, whooping-cough, noma, etc. It is very doubtful if any of the appearances, described in the majority of such cases, were really protozoa; it is much more likely that they represented degenerating cells, leucocytes, etc. More careful observations are needed to settle this point.

Worms.—The accidental presence in the nose of *Ascaris* and *Oxyuris* has already been mentioned. I have been unable to find in the literature any well-authenticated case of *Cysticercus* of the nasal cavities. Only two or three cases of nasal *Echinococcus* have been reported. In one of these, observed by Rogers, the patient, a woman aged thirty-four years, had had a severe nasal obstruction for two and a half years. During a violent effort to clear the nose there was an escape of a large quantity of clear, straw-colored fluid. Two months later a cyst-like body was removed by snare from the middle turbinate; this was ruptured during removal. The microscopical examination showed the presence of numerous echinococcus booklets in the walls of the cyst.

Arachnida.—*Pentastoma denticulatum*, the larval form of *Pentastoma tænioides*, is found in the nasal, frontal, and maxillary sinuses of various animals, particularly in the dog. Rarely, the parasite may be found in the human nose; the infection usually takes place from dogs, or through the accidental inhalation of the young larvæ, or by the eating of contaminated food. In the latter case the parasite later wanders from the alimentary tract into the nasal cavity. Its presence there causes inflammation, nosebleed, etc. The diagnosis rests upon the occurrence of severe irritation, and the demonstration of the parasite.

Insects.—The most common and important nasal parasite belonging to this class is the maggot or larva of certain flies, both of the biting and the stinging varieties. The fly lays its eggs upon either the normal or diseased mucous membrane of the nose; in the latter case probably attracted by the odor of secretions. Certain varieties may force their way into the healthy nose and there deposit their eggs. Such an infection occurs, in the great majority of cases, when the affected individual falls asleep in the open air during the daytime. The *Sarcophaga carnaria*, *Sarcophaga Wohlfahrtii*, *Musca anthropophaga*, *Musca cadaverina*, *Musca domestica*, *Musca stabulans*, *Piophila casei*, *Lucilia macellaria*, *Œstrus bovis*, etc., have been reported as producing maggots within the human nose. In certain tropical countries, Mexico, Central America, the tropical portions of South America, West Indies, Hindustan, etc., such infections are not uncommon. The condition is known as *Myiasis narium*. In the great majority of cases the affected individuals have a history of ozæna or purulent nasal catarrh. The *Lucilia macellaria*, however, frequently attacks the healthy nose.

The symptoms of myiasis are usually very severe; it is said that the sufferings may be so intense as to lead to suicide. The number of eggs laid upon the nasal mucosa

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may be very great, as many as five hundred eggs of *Lucilia macellaria* (Texas screw-worm) having been removed at one time. In other cases several hundred larvæ may be removed or discharged. The eggs hatch rapidly, and nasal obstruction soon results, with intense pain in forehead, cheeks, etc. A watery or bloody discharge, œdema of the neck and face, vertigo, sleeplessness, delirium, coma, reflex vomiting, and convulsions mark the affection. Fever may or may not be present. The nasal mucosa may be completely destroyed and the bones denuded through the efforts of the growing larvæ to obtain nourishment. Within a short time, one to two weeks, the larvæ leave the nose to form their cocoons outside. The character of the nasal discharges usually changes after the maggots have left the nose, becoming more purulent. The inflammation may persist for a long time, or in other cases the symptoms may abate immediately upon the removal of the parasites.

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The history of the case, the symptoms of rapid obstruction with watery or bloody discharge, and the demonstration of the presence of the maggot make the diagnosis clear. The prognosis is on the whole favorable, but fatal cases may occur.

The treatment of nasal parasites in general consists, first, in the removal of the parasite; secondly, in the treatment of the local condition caused by its presence. In the case of maggots or other parasites which are more or less firmly attached to the mucosa, various antiseptics may be used for the purpose of stupefying or killing the parasite. Inhalation of chloroform, ether, turpentine, bichloride solutions, calomel powder, decoctions of tobacco, balsam of Peru, are among the remedies suggested. The filling of the nasal cavities with warm glymol is advised, especially in the case of maggots; the oil filling up the spiracles of the larvæ kills them, and they are then easily washed out. In very rare cases it may be found necessary to explore the frontal sinus.

Aldred Scott Warthin.

NASAL CAVITIES, DISEASES OF: RHINOSCLEROMA.—On account of the wide diffusion of the lesions it has been suggested to substitute the name scleroma, without a local qualification, for this affection. It is a rare disease which is seldom found excepting in Austria, Hungary, and Italy. It is characterized by a peculiar connective-tissue growth in the mucous and submucous tissues of the respiratory tract which forms nodes, tuberosities, or slightly raised, smooth, flat, and extremely hard patches. In course of time these are seen about the nostrils or upper lip, and finally they invade any and every portion of the respiratory tract. These new growths are of a cartilaginous hardness, and owing to the atrophy of the new tissue, they form dense cicatrices without the intervention of ulceration.

Anatomical Characteristics and Course of the Disease.—Hard prominences, varying usually in size from a millet seed to a pea, and diffuse infiltrations characterize the disease. The affection usually begins in the salpingo-palatal fold or in the choanæ, and gradually progresses forward until the vestibule of the nose is reached, where it may terminate, or it may involve the external integument, occasionally invading the upper lip and changing it into a hard, snout-like protuberance. It also extends downward involving the pharynx, larynx, trachea, and bronchial tubes which become constricted by the contracting cicatrices. The diffuse infiltrations are firm and very rigid, and in proportion to their size mechanically obstruct the nares. Later, they undergo cicatricial transformation, and further obstruct or completely obliterate the nasal passages by the contraction of the resulting scars. When the cartilaginous external nose is involved in the disease, it becomes deformed by nodular protuberances of intense hardness. The integument of the nose is at first dense and white; later it reddens or acquires a livid hue. Occasionally slight ulceration occurs and fissures sometimes form, especially between the alæ and the cheek. In the nasal vestibule the disease often forms voluminous folds, which may protrude from the nostril. These are of a bluish-red color and are sometimes a centimetre in thickness.

Etiology.—Among those who have given this affection the most study it is generally believed to result from the presence of the Frisch bacterium, which is always found in considerable numbers in the cells in the lymphatic spaces of the affected part. There is no proof that it is contagious.

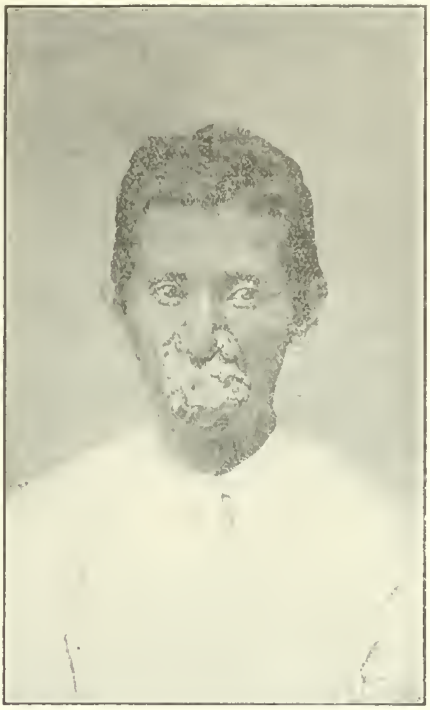

Fig. 3491.—Rhinoscleroma. (From Le Dentu et Delbet's "Traité de Chirurgie.")

Symptomatology.—In the beginning the disease is marked by symptoms of simple chronic rhinitis, which may extend over a period of several years. The secretion, at first watery, gradually becomes purulent. Afterward it dries into scabs or crusts, which as they decompose emit a very offensive odor, different from that of ordinary ozæna and apparently peculiar to rhinoscleroma. The scleromatous tissue is not usually deposited until the catarrhal symptoms have existed for several years. On account of the painlessness of the disease and its gradual accession, patients commonly do not present themselves for treatment until a number of years after its beginning.

Diagnosis.—Rhinoscleroma is to be distinguished from syphilis, epithelioma, and keloid, though as the latter is distinctly a disease of the skin which often appears in old cicatrices, it is not at all likely to be confounded with rhinoscleroma. The essential features in the diagnosis are the chronic course of the disease, the cartilaginous hardness of the infiltration, the formation of cicatrices without previous ulceration, the invasion—during the latter portion of the disease—of the larynx, trachea, or pharynx, and the broadening and deformity of the external nose by the scleromatous deposit.

Syphilis in the tertiary stage also leads to cicatrices which might be mistaken for those of rhinoscleroma, but syphilitic lesions differ from those of the disease under consideration in that their progress is more rapid and the hardness of the gummy deposits less marked. The syphilitic nodule also commonly ulcerates, whereas the scleromatous one does not. Again, the specific treatment of syphilis is usually followed by speedy improvement,

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whereas the iodides and mercurials do not affect the progress of scleroma.

Epithelioma causes induration and some nodular infiltration of the skin, but the nodules are softer than those of rhinoscleroma and they ulcerate and bleed. The disease also runs a much more rapid course than the one under consideration.

PROGNOSIS.—This affection commonly extends over many years. There is no tendency to spontaneous recovery, and unfortunately treatment is unavailing except in the way of palliation. In consequence of the tendency to cicatricial contraction, when the affection involves the larynx, the trachea, or bronchial tubes, it may prove fatal by obstruction to respiration, but it does not usually shorten life.

TREATMENT.—The treatment is entirely operative and palliative. Obstructive infiltrations may be removed and thus relief be obtained for several years, though it is impossible to prevent recurrence and extension to other parts. Even extensive radical operations in the beginning have no influence in preventing the progress of the disease. In the operative measures outgrowths in the nose may often be removed by the snare, but the harder tissues must be cut away with a scalpel or trephine, or removed with a sharp spoon, and the operation may be finished with a galvanocautery, or hardened nodules may be reduced by electrolysis. The wounds left by these operations readily heal. It is generally thought best not to interfere with facial deformities, as recurrence is practically certain and excision would only necessitate repeated plastic operations to cover the defects resulting.

E. Fletcher Ingals.

NASAL CAVITIES, DISEASES OF: SINUS AFFECTIONS.—The antrums of Highmore are irregularly shaped cavities situated in the head between the upper teeth and the orbital cavities. They vary in their dimensions, the horizontal and antero-posterior diameters averaging about 25 mm. There is one normal opening in each sinus—the hiatus semilunaris—which is situated in the uppermost part of the inner wall. This opening frequently becomes occluded by inflammatory processes, and an artificial opening is then created by the internal wall rupturing at a point posterior and inferior to the normal aperture. Occasionally the roots of the molar teeth project upward and form small pyramids on the floors of the sinuses. Semicircular membranes, bands, and bony partitions, one-fourth to one-half inch high, are frequently found dividing the lower and lateral portions of the cavities into compartments.

The walls of the canine fossæ and the inner or nasal walls, beginning at a point about one third of an inch above the floor, are very thin, excepting those parts which give attachment to the middle turbinate bones. The inner lip of the hiatus semilunaris forms a small canal which connects with the mouth of the infundibulum or naso-frontal canal; a frequent result of this being that the fluids from the frontal sinus and anterior ethmoid cells flow down into the antrum of Highmore. The principal physiological function of the nasal accessory cavities is to supply fluid secretion and warm air to the nose and to serve as resonance chambers within the head. During inspiration the apertures, including the naso-lachrymal ducts, have a tendency to open, while during expiration they partially close; at the beginning of inspiration the partial vacuum produced takes a part of the latent air from within the cells and the velocity of the inspired current further draws from them. Toward the end of the inspiratory act new air enters the cells to fill the partial vacuum, this entrance being aided by the natural law by which warm air is displaced by cold; on expiration the *vis-a-tergo* pressure partially closes the cells. These to-and-fro currents of air constantly draw the tenacious mucus from the cells, overcoming the adverse conditions of small openings and the law of gravity.

There are four groups of sinuses which communicate with the nasal cavities, viz., the frontal, the maxillary, the ethmoidal, and the sphenoidal. As the diseases of the frontal sinuses have already been fully discussed in Vol. IV., under the heading *Frontal Sinuses, etc.*, the present writer will consider only the affections which involve the other three groups of sinuses.

I. DISEASES OF THE MAXILLARY SINUSES.

ETIOLOGY.—Much has been done of late to solve the problems as to the cause of diseased conditions within the antrum of Highmore. Distinguished writers differ considerably concerning the relative frequency of different morbific agencies as causative factors. Careful observers are proving that acute infectious diseases are responsible in many cases that were formerly attributed to other causes, and this is in accord with my own investigations.

The teeth are responsible for nearly one-half of the seriously diseased cases that have come under my observation. A careful examination of the teeth extracted in a series of cases gave abundant evidence of alveolar periosteitis, caries, and necrosis at the root end. In other cases the maxillary bone was necrotic, carious, and destroyed to a variable extent. Œdema of the nasal mucosa and polypoid changes existed as definite causal factors in a large proportion of the cases of nasal origin. More or less pressure upon the middle turbinal by a deviated and thickened septum, this in turn pressing upon the ostium maxillare, approximately closing the hiatus and causing retention of secretions more or less laden with pathogenic bacteria, was a prominent factor in many cases of chronic muco-purulent discharge from the antrum.

I am convinced that the suppurative rhinitis of childhood often leaves a local suppuration in the antrum which continues generally through adult life, unless proper surgical procedures are employed to relieve it. Syphilis, tuberculosis, tumors, and foreign bodies occasionally cause suppuration of the antrum.

SYMPTOMS.—Empyema with complete occlusion gives rise to extremely painful conditions, and there is a feeling as though the antrum would rupture from the intense pressure. These symptoms disappear immediately after a vent is secured. In those cases in which the acute and subacute catarrhal processes occur in the nasal cavity and extend into the antrum by continuity, there are a slight fulness and a sensation of stuffiness in the region beneath the eye, associated with a thick muco-purulent discharge into the middle meatus beneath the bulla ethmoidalis.

Complete convalescence in these cases takes place within from three to six weeks. Postnasal catarrh is a constant symptom. In the chronic cases mucus and pus are discharged through the anterior nares. Most patients who have very thin fluid in the antrum complain of it running down over the upper lip whenever the head is inclined forward.

Asthma, tubal stenosis, and tinnitus aurium, impairment of hearing, mental lassitude, and inability to concentrate the attention for any length of time are all common symptoms. Pain is a most irregular symptom; it is absent at times even in the most severe cases. It is often localized in the temporal or the occipital region. The most constant symptom is more or less discharge of muco-pus over the lower posterior part of the lip of the hiatus semilunaris.

PATHOLOGY.—A classification which I made several years ago of the pathological conditions practically holds good to-day. In this there were eight subdivisions, as follows: I. Acute, catarrhal, suppurative, and infectious sinusitis without complete stenosis of the normal outlet. II. Acute catarrhal, suppurative, and infectious sinusitis with complete occlusion of the normal outlet. III. Subacute and chronic catarrhal and suppurative sinusitis with moderately obstructed opening, with or without decomposing puro-mucoid débris. IV. Polypoid degeneration. V. Alveolar periostitis and periodontitis attended by suppurative caries, necrosis, or other pathological changes

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at the root end. VI. Atrophic rhinitis. VII. Tumors and foreign bodies. VIII. Syphilis.

The cases of the first class are very common. The disease is usually self-limited and frequently leaves the mucous membrane much swollen and hyperplastic. Occasionally associated with an acute infectious disease there is a necrosis of the antral mucosa as well as of other parts of the mucous membrane of the respiratory tract. When there is complete stenosis, and when neither nature nor the surgeon relieves the condition, the consequent tension causes necrosis of the soft tissues, and this occasionally extends to the bone. In the subacute and chronic catarrhal suppurative cases, when the opening is moderately obstructed, the muco-purulent secretion frequently becomes partially inspissated, forms an accretion, and acts as a foreign body, causing the destruction of tissue. These by-products frequently destroy the surface of the mucosa and start small ulcerated areas which, if not cured, extend in time to the periosteum and often to the bone itself. Polypoid and œdematous changes which involve the ethmoid often have their origin in the antral membrane. If they occur on the lateral or upper walls of the cavity and remain more or less flat or mammillated, there is a possibility that the mucous membrane at these points will, under favorable circumstances, return to its normal state. But if these growths once become pedunculated it seems to be impossible for them to return to the condition of a normal mucous membrane. Caries, necrosis, and periosteitis in the molar or bicuspid roots frequently extend through the bony floor of the antrum and give rise to fistulæ, the discharge from which pushes up the periosteal lining of the cavity, and often leaves it floating in a muco-purulent medium. Ruptures may take place through this membrane at different points, causing a discharge of secretion into the antrum. The antral membrane becomes very thick and granular, and the mucosa and bony wall of the cavity degenerate. The atrophic process, which is the consequence of suppurative rhinitis in early childhood, invades the antrum, frequently destroys the epithelium and the glandular structures of the mucous membrane, and leaves a sclerosed membrane which secretes a semipurulent matter; this decomposes in the warm air of the antrum and issues through the normal opening into the nose, where it is formed into crusts by the inspired air.

Tumors, especially the syphilitic gumma and the epithelioma, may form in the antrum.

Diagnosis.—A discharge of pus from one nasal cavity is by far the most suspicious individual symptom of empyema of the maxillary sinus. It is the writer's custom in all cases of nasal and rhinolaryngeal disease to make a complete investigation of the condition of the nasal cavities and the rhinopharynx, and then to account for the condition of the accessory sinuses as far as modern methods will allow. When a disease of one of the sinuses is associated with a discharge, cocaine and adrenalin are carefully applied throughout the middle and inferior meatuses. After the shrinkage of the mucosa has taken place a soft silver probe is used in the region of the ostium maxillare. The patient's head is placed in different positions, the best one being that with the top of the head on the floor, the patient lying across a chair. When this position is assumed, and especially when the patient at the same time forcibly blows his nose, the secretion within the antrum will generally be forced to flow over the lip of the hiatus beneath the bulla ethmoidalis.

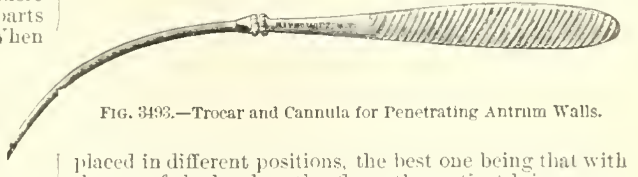

Fig. 3493.—Trocar and Cannula for Penetrating Antrum Walls.

In making the test by transillumination, I usually employ a four-candle power electric lamp of moderate brilliancy, the patient being in a dark room, and the lamp, attached to a suitable holder, being held within the closed cavity of the mouth. I do not rely entirely, however, upon the electric lamp, but use it only as an indicator for further efforts at determining the condition within the maxillary cavity. If there is a unilateral umbra, warranting the suspicion that the antrum of that side is diseased, the investigation must be pushed in other ways until the condition of the antrum is ascertained. Frequently after a curved irrigator has been passed through the normal opening, and more or less forced irrigation employed, definite evidence of a suppurative process is obtained. If this procedure cannot be accomplished, puncture should be made with a curved trocar through the antral wall near the uniciform process, at a point situated posteriorly and inferiorly to the hiatus. In other cases it may be necessary to pass a trocar through the wall of the inferior meatus, when, under forced irrigation, some of the retained secretion or débris will be expelled through the natural opening. In certain cases of cystic tumors I have found it necessary to make an exploratory opening through the canine fossæ before the diagnosis could be definitely settled.

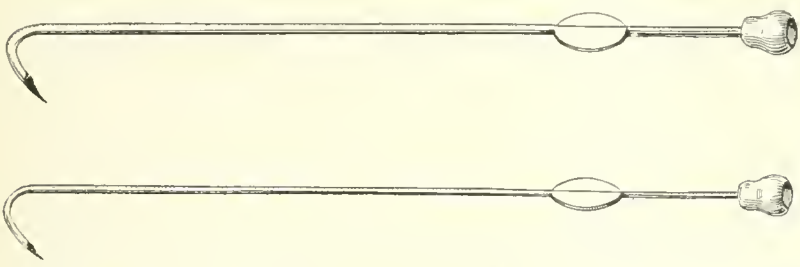

Fig. 3492.—Cannula Needle for Aspirating and Irrigating the Antrum of Highmore through the Wall of the Middle Meatus.

Prognosis.—The prognosis of diseases of the maxillary sinus will depend upon the pathological conditions present in each individual case. The ordinary cases of empyema are extremely annoying and affect the general health in many ways;—constant swallowing of the fetid pus is one of the most objectionable features.

The diseases of these sinuses are not nearly so fatal as those of the other sinuses on account of their distance from the cranial cavity. Even malignant tumors are more curable here. In empyema cases the prognosis depends upon the manner, method, and extent of the surgical procedure. If sufficient drainage can be secured, either into

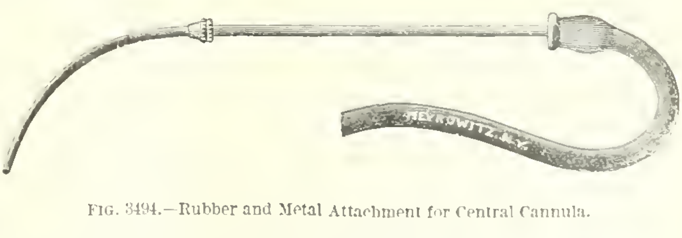

Fig. 3494.—Rubber and Metal Attachment for Central Cannula.

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Nasal Cavities.

the mouth or into the nose, and if careful curettage of the antrum be employed, the drainage and ventilation being maintained until nature's process restores approximately the mucosa, the prognosis can be said to be fairly favorable.

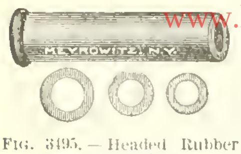

Fig. 3495.—Headed Rubber Antrum Tubes.

In all infectious cases the prognosis is favorable if complete irrigation can be carried out through the normal opening.

Treatment.—In considering the best treatment for the individual cases, one must ascertain, through every known method, the exact pathological conditions. It must be borne in mind, however, that while some of the apparently worst forms of antral empyema have been cured by the extraction of a tooth and a few weeks' irrigation through the socket, there are other cases of apparently a much less serious character, which resist all our therapeutic efforts in the most stubborn manner. Thus, for example, the writer has seen cases of trivial discharge (the only symptoms being a moderate postnasal catarrh), which, after a thoroughly radical operation, have terminated in the most obstinate purulent condition. Since we cannot obliterate the antrum without objectionable results, we must try to restore its functions without destroying too much of the lining membrane.

The author believes that he was the first to insist upon not treating the antrum in full accordance with the prevailing surgical teachings. It is his belief that thorough curettage frequently induces a worse condition than the disease for which it is employed. It is his rule, in cases of long history and severe disease manifestations, to make large openings through the region of the canine fossa and malar ridge and counter-openings through the inferior or middle meatus, and then to carry out a gentle and careful curettage of the mucosa and a firm and decided curettage of whatever bare bone may be found. After these steps have been taken the cavity is to be packed with aristol or iodoform gauze which has been passed through mercuric-bichloride solution. This packing is never allowed to remain longer than a week. At the expiration of this time the mucous membrane is inspected occasionally, the exuberant granulations are removed with the curette, and the cardinal principles of free drainage and free admission of air are utilized as far as the conditions of the individual case will permit. As supplementary measures various forms of tubing may be introduced into the antrum, for drainage purposes, and the membrane may be re-incised as it closes over the aperture. I have occasionally had patients who apparently were cured by treatment through the natural opening, but these evidently were cases in which purulent semi-decayed collections had formed and acted as a leaven to perpetuate the suppurating foci.

When one is called upon to treat a case of antral disease, the difficult problem of selecting the best operative procedure at once presents itself. If it is a case in which the evidence points to a diseased tooth as the causal factor, removal of the tooth is imperative. A certain proportion of these cases may be cured by this procedure alone without any further interference. And even if the dental disease has already involved the antral walls, causing caries and granulation tissue, in some of these cases a cure may still be effected by drilling a hole into the floor of the sinus through the tooth socket, for the purpose of securing proper irrigation and ventilation. When the granulation tissue extends practically throughout the antral walls and more or less bare bone exists, removal of the nasal wall of the antrum is indicated in either the inferior or the middle meatus, preferably in the former. During the first few weeks after the establishment of such an opening it is usually best not to use any tube. A rubber tube is extremely useful in favorable cases, but if the opening is larger than the head of the tube, the latter is apt to disappear into the antrum and cause annoyance.

With the aid of Dr. Dixon, a dentist of New York City, I have had constructed a permanent tube of gold or silver. A small band is placed around the most available tooth, a silver or gold wire is welded to the band, and then the gold tube is welded to the distal end of the wire. The patient can insert and remove these tubes at will, and when properly made and inserted they give little or no annoyance or discomfort.

The small curette with a malleable handle should be introduced from time to time to ascertain the condition of the mucosa, and if exuberant granulations abound they should be gently curetted.

Thorough cleanliness is essential, but it has been found that too frequent irrigations are injurious. A solution of boric acid or of common table salt is the most acceptable to the mucous membrane. Certain foul-smelling cases have been relieved in a few days by the injection of a mixture of three grains of iodoform in two drachms of liquid albolene; this mixture being left in the cavity for two or three days.

In cases in which polypi develop, it will sometimes be necessary to remove these, at frequent intervals, from different parts of the cavity of the antrum. In cases of sarcomatous disease a complete and thorough removal of all parts of the antrum is necessary; and the same procedure would be advisable in epithelioma if the disease could be detected in the early stages; but, unfortunately, in most cases of epithelioma the disease has already invaded the ethmoid and involved the lymphatics by the time when it is discovered.

II. Diseases of the Ethmoidal Cells.

The ethmoid cells consist of a number of cavities, irregular in size, situated beneath the anterior part of the brain, from which they are separated by a very thin lamella of bone. They lie to the inner, upper, lower, and posterior sides of the inner half of the orbital cavity. They are divided into posterior and anterior cells. The anterior cells communicate with the middle meatus of the nose, and the posterior cells empty into the superior meatus. The anterior cells have several openings. Some open into the infundibulum and cause confusion in differential diagnosis between frontal sinus and anterior ethmoidal cell disease.

The cell of the bulla ethmoidalis opens high up near the attachment of the middle turbinated bone. These cells are frequently hidden from view by the middle turbinal.

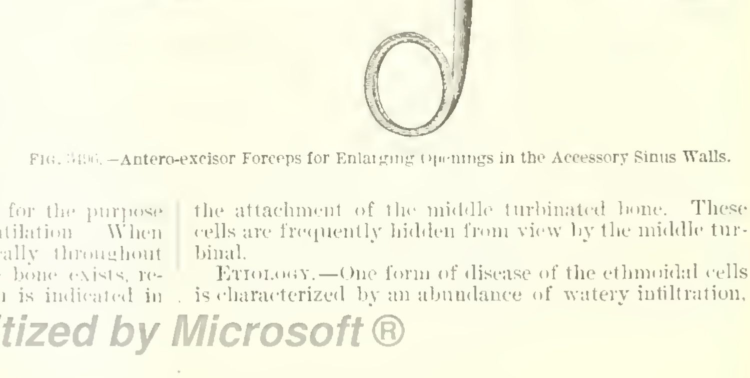

Fig. 3496.—Antero-excisor Forceps for Enlarging Openings in the Accessory Sinus Walls.

Etiology.—One form of disease of the ethmoidal cells is characterized by an abundance of watery infiltration,

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which, if not relieved, usually terminates in the development of a polypoid state. This infiltration, in the writer's opinion, is caused by intumescent pressure upon the venous vessels. The anatomical construction of these cells favors the retention of bacteria and the continuation of the so-called polypoid state when once it has been established. Occasionally the septum or an exostosis or enchondroma protruding from it presses upon the middle turbinal, so as to close the nasal openings, and then degeneration occurs within the ethmoid cells as a consequence. In a few cases an inflammatory and necrotic process in the antrum extends from this cavity to the ethmoid; in others the disease extends from the frontal sinus. Cysts occasionally form in one of the cells and extend backward and forward through the intercellular walls, finally making their appearance above the inner canthus of the eye where the bone is probably thinnest.

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Acute catarrhal inflammation of the Schneiderian membrane sometimes obstructs the openings of the cells for a period of several days. This causes putrefaction of retained secretion, and this in turn destroys the mucous lining of the cells. The pus thus formed discharges either through the normal outlet or through an artificial opening. If the pressure has been sufficient to produce necrosis and the drainage has not been free, we have as a result chronic thickening with pus production or watery œdema with polypoid changes.

In cases of syphilis tumors in the ethmoid cells sometimes break down and form the basis for polypoid degeneration. Osteosarcomata in this region are frequently the cause of pain and of a discharge of broken-down tissue products.

Symptoms.—Post-nasal discharge is one of the most common symptoms of ethmoidal cell disease. Dull and deep-seated pain around the orbit, and in the frontal, temporal, and occipital regions is often experienced. In cases in which there is retention of the secretion under tension, the pain varies according to the amount of periosteal disease and the degree of interference with the drainage. The patients show some mental dulness, and especially complain of a disinclination to mental activity. Sneezing, an escape of watery fluid, and more or less nasal stenosis, especially during autumnal weather, are some of the general symptoms of polypoid ethmoidal disease.

Diagnosis.—Diagnosis of ethmoidal cell disease is usually made without any special difficulty. In cases of latent empyema in the individual cells, however, the diagnosis is frequently not made until after the patient has been under observation for some time. The cavity should be thoroughly cocainized and sprayed with adrenalin in 1 to 10,000 solution. The nose should be cleansed of all secretion, careful note being made of the examination with a probe around and within the ostia of the respective cells. Cotton applicators should be used. To cleanse thoroughly the region of the suspected ostium, time should be allowed for the discharge of more pus before a second examination is made with the soft silver probe to ascertain whence the discharge comes. A small posterior rhinoscope is most useful in demonstrating secretion in the superior meatus. The extent to which the pathological process has advanced, and the question whether there is an œdematous, a polypoid, or a sclerosed state, are matters which can be determined partly by the patient's appearance, and especially by the character of the pus and mucus. The probe will convey a good idea of the state of the mucous membrane, but it frequently misleads us in regard to the condition of the bone. The combined periosteum and mucous membrane of these bones is very thin, and often it feels as if the probe were on exposed bone when as a matter of fact the latter is in a fairly normal state. This has led many of our best writers into controversies in regard to diseases of this region.

Treatment.—Whenever there is extensive serious disease in the ethmoid bones it is the wiser policy to remove a part of the middle turbinal at once. This rule would not hold good, however, in all atrophic cases. In the polypoid cases all visible polypoid tissue should be removed with the snare or excisor forceps; when there are intracellular polypi the floors of the sinuses should be removed with trephines provided with specially constructed guards and by means of lateral and antero-posterior cutting forceps. The curette provided with a malleable handle has proved most serviceable in removing intra- and intercellular diseased tissue and cells. The securing of free drainage and the free admission of air are just as important here as they are in the case of the antrum. In removal of the middle turbinal the lateral cutting forceps should be passed beneath the septum and the outer wall, engaging the middle turbinal between its jaws, and then a section of the bone should be removed. This enables the wire écraseur to be easily adjusted around either the anterior or the posterior end. I have found the smallest cannula and the Bosworth snare to be the most feasible instruments.

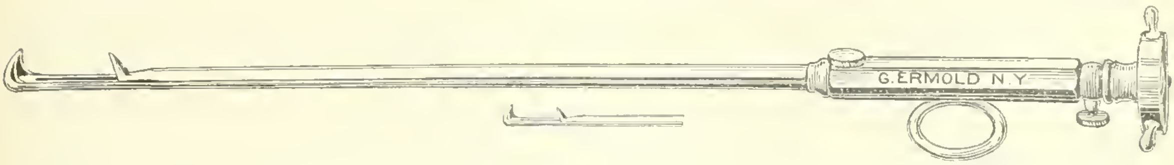

Fig. 3497.—Jackscrew Excisor Forceps for Removing Portions of the Floors and Walls of the Ethmoid Cells and Antrum of Highmore.

The proximity of the ethmoid cells to the orbital cavity and the brain, and the necessity of operating in a field covered with blood, should make the boldest operator cautious. With the aid of cocaine and adrenalin and with the patient's assistance, the difficult operation of penetration and removal of the floor of the sinus is made comparatively easy and safe. When the artificially established openings in the cells are large enough they usually drain so well that it is necessary to irrigate them at stated intervals only. When the process extends far up into the little cells above the orbital cavity or into some of the recesses under the cranium the results of treatment are not so satisfactory. I have found the daily insufflation of a powder composed of aristol two parts, boric acid one part, to be the most satisfactory after-treatment. When there is considerable pus a modified spray of Dobell's solution or of a solution made with Seiler's tablet is effective. Under this treatment the patient usually makes marked improvement. Frequently, however, a small amount of discharge continues from some inaccessible cell, and often also the condition is aggravated temporarily by taking cold.

III. Diseases of the Sphenoidal Cells.

Inflammation of the sphenoidal cells is usually consequent upon acute rhinitis, especially when due to infection. Polypoid changes are frequently the cause of chronic disease. Syphilis commonly affects the cell wall with a gummatous deposit and the ethmoidal mucocele occasionally extends through the dividing cell. Tumors sometimes develop in or extend into the cavities.

Symptoms.—The subjective symptoms of an acute inflammation of the sphenoidal sinuses are headache and a full, heavy feeling over and behind the eyes. In cases of chronic suppuration there are deep seated pains in the orbital, temporal, and occipital regions, feelings of depression and oppression, discharge of pus or muco-pus over the anterior surface of the sphenoidal cell at the posterior extremity of the middle turbinal body, and disturbances of the field of vision. The objective symptoms are hyperplastic œdema of the nasal mucosa cover-

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ing the cell, discharge of pus and muco-pus, polypi, and pharyngitis sicca, due to destruction of the epithelium by the pus, which flows constantly over the postpharyngeal wall.

PATHOLOGY.—Changes involving the bone substance and the lowering of its vitality occur in those sphenoidal cases in which the mucosa has undergone polypoid degeneration. The bone becomes brittle under these circumstances and loses much of its cohesive quality. In neglected syphilitic cases necrosis of the bone or soft tissues always follows the gummatous process. The chronic suppurative cases with more or less stenosis of the normal opening are usually protracted by the irritating qualities of the degenerating products.

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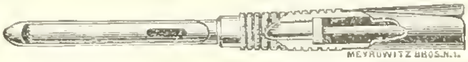

FIG. 3498.—Guarded Trephine for Removing Obstructing Portion of the Septum near Anterior End of Middle Turbinal.

DIAGNOSIS.—Diseases of the sphenoidal cells are usually easily diagnosed. The obstruction in many cases is at the posterior end of the middle turbinal, and its early removal will facilitate matters greatly. Pus under favorable conditions can be seen at the normal opening in the uppermost part of the anterior wall of the sphenoidal cell. An irrigation tube passed through this opening will confirm the provisional diagnosis.

TREATMENT.—The treatment of sphenoidal disease is more satisfactory in its results than that of the other sinuses. Complete removal of the posterior end of the middle turbinal will usually demonstrate the point from which the pus makes its exit. The upper anterior wall should be penetrated with a guarded awl or trephine and afterward curetted. Extensive removal of the anterior wall with a cutting forceps, gentle curettage, irrigation, insufflations, and repeated excisions of the membrane which forms over the opening will often cure the most obstinate and apparently hopelessly diseased conditions of the sphenoidal sinuses.

I do not favor the procedures of opening the sphenoidal cells through either the antrum or the ethmoidal cells, as I do not think such extensive destruction of tissue is warranted. *Robert C. Myles.*

NASAL CAVITIES, DISEASES OF: SYPHILIS.—Syphilis, either congenital or acquired, may appear in the nose in any of its three stages. The disease is characterized by obstruction of the passages from swelling of the mucous membrane, or by more or less extensive ulceration with destruction of cartilages and bone.

ANATOMICAL AND PATHOLOGICAL CHARACTERISTICS.—The mucous membrane may be found thickened in patches or ulcerated, or obstruction may arise from gummatous thickening of the perichondrium or periosteum. In the latter case the cartilage or bone beneath often suffers necrosis and is finally separated by the process of suppuration. Necrosis occasionally results from extension of the ulcerations from the mucous membrane, and rarely the parts undergo molecular destruction and are gradually absorbed, being replaced by granulation tissue. Primary syphilis is occasionally conveyed to the nose by picking with the finger nail, but the hard chancre is very seldom seen. On the external nose the primary sore usually appears as a flat induration of moderate size; within the nose it commonly occurs on the septum as a red flat, hard growth covered with purulent secretions, which bleeds easily, the external nose at the same time being swollen and red. Neuralgic pains and fever may coexist and the submaxillary and sublingual glands and those in front of the ear are often indurated. In secondary nasal syphilis the appearances may be simply those of an acute coryza, or mucous patches may be found upon the Schneiderian membrane similar to those so commonly observed in the throat. In this case copper colored papules or macules with fissures at the junction of the nose and the upper lip or in the sulcus alaris are apt to be present. Gummatous syphilitic infiltrations may involve the mucous membrane, the perichondrium, or the periosteum. These soften after a time and deep, sharp-cut ulcers with undermined borders result, with sooner or later destruction of cartilage or bone. Often this destruction is limited to the septum, especially its bony portion; but in some cases it involves all of the surrounding parts. When the nasal bones are destroyed the bridge falls in, but this does not occur from destruction of the septum alone.

ETIOLOGY.—The affection is caused by the specific virus which may infect the fœtus in utero or during birth or which may be acquired afterward in various ways.

SYMPTOMATOLOGY.—Primary syphilis of the nose causes the symptoms of an acute catarrhal rhinitis of a severe grade. The initial lesion is likely to be comparatively large, and various lymph glands may be infected and greatly swollen. In the secondary stage there are much congestion of the mucous membrane and abundant muco-purulent secretion with obstructed respiration. Mucous patches are likely to be found at the edge of the nostrils and upon the anterior portion of the nasal mucous membrane. At the same time secondary manifestations are apt to occur in the throat and upon the skin. The tertiary symptoms commonly come on between the first and third years after infection, but sometimes not until many years later, and they are not infrequently seen at any time between the fifth and the fifteenth years. When the disease attacks the turbinated bodies it sometimes causes an appearance very like that of simple hypertrophic rhinitis and the parts do not retract readily under cocaine; but this condition is frequently associated with yellowish ulcers having a clean-cut border and hard infiltrated base with more or less induration about the ulcer, and is therefore not apt to be confounded with hypertrophic rhinitis. When the disease attacks the periosteum or the perichondrium, a smooth elastic swelling results which is usually apparent upon only one side. Later, breaking down takes place and ulceration results. The denuded cartilage or bone dies and is subsequently separated by an ulcerative process from the surrounding tissue. Commonly the patients do not present themselves for treatment until ulceration has occurred, and then the necrosed cartilage or bone may be found firmly attached or lying partly loose in the nasal cavity. Atrophy of the turbinals may also occur and destruction of the orbital plate of the ethmoid bone and of the hard palate is not uncommon. The dead bone usually presents a blackish, uneven surface, and is the source of an extremely offensive odor.

DIAGNOSIS.—The primary lesion in the nose may be mistaken for a malignant growth. The most valuable points in the diagnosis are its hardness and the great swelling of the lymphatic glands. Frequently the true nature of the disease is not recognized until the secondary symptoms appear. The secondary stage of the disease in the nose causes the symptoms of chronic catarrhal rhinitis, but it comes on much more speedily than the latter, and by careful inspection mucous patches or condylomata may sometimes be detected. The history of the case should be very carefully scrutinized, and any external manifestations may aid in the diagnosis. Tertiary syphilis of the nose is not likely to be recognized when it involves the turbinals alone, as the appearance is that of hypertrophic rhinitis; but when gummata and ulceration occur, a careful weighing of the history of the antecedent symptoms and signs will generally enable one to make a correct diagnosis, although often the patient will deny any specific infection. There is generally no difficulty in distinguishing tertiary nasal syphilis from atrophic rhinitis if the nasal cavities be first thoroughly cleansed. It should be recollected that simple perforation of the cartilaginous septum is seldom syphilitic, whereas perforation of the bony septum is nearly always so.

Lupus is to be distinguished from syphilis, first by the fact that it usually occurs at an earlier age than syphilis, excepting when the latter is hereditary; second, that the

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reddish papules or tubercles of lupus are quite distinct from many syphilitic manifestations, and that they are often associated with distinct signs of lupus externally. Lupus also is much more prone to attack the cartilage than the bone, and it is much slower in its progress than syphilitic ulceration.

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PROGNOSIS.—The outcome of nasal syphilis is materially affected by early recognition of the disease and efficient antisyphilitic treatment. Although in many cases the destructive process is not extensive, in others not only the septum but the nasal bones, orbital plates, and hard palate are involved in widespread necrosis. In rare cases the disease progresses rapidly in spite of all treatment, and may terminate fatally within three or four months. Death has also resulted from fragments of the necrosed bones falling into the larynx.

TREATMENT.—Secondary symptoms and those of the tertiary disease, when mild, usually yield rapidly to appropriate internal and local treatment. In syphilitic affections of the nose, prompt and thorough antisyphilitic treatment should be immediately instituted, the nares should be kept clean by mild alkaline sprays or washes, condylomata or mucous patches should be touched with nitrate of silver or tincture of iodine, and the latter or solutions of from ten to twenty grains to the ounce of sulphate of copper should be used in case of tertiary ulceration. Dead bone should be removed as soon as it becomes loosened, and sometimes it is best to cut it away earlier in order to prevent the prolonged offensive odor; but it should be recollected that if the bone be cut away too early, the disease is liable to extend to tissues that would otherwise have escaped. Antiseptic sprays and powders, such as are recommended in the article on atrophic rhinitis, may also be employed advantageously.

E. Fletcher Ingals.

NASAL CAVITIES, DISEASES OF: TUBERCULOSIS.—Though tuberculosis seldom involves the nasal cavities, secondary tuberculous lesions are occasionally met with in this locality and a few cases of the primary disease have been noted. Michelson observed nineteen instances of the primary disease in thirty-eight cases of nasal tuberculosis. It should be remembered, however, that the early symptoms and signs of the pulmonary affection are not always recognizable, so that they may have been present in some of the cases believed to be primary nasal tuberculosis.

ANATOMICAL AND PATHOLOGICAL CHARACTERISTICS.—The disease may be observed as a diffuse infiltration, or as a tuberculous tumor with or without ulceration, or in the form of exuberant granulations. Ulcers may follow the infiltration or the tuberculous tumors, but they sometimes appear to be the primary lesion; however, they are nearly always secondary to pulmonary tuberculosis. The disease commonly attacks the anterior part of the cartilaginous septum, but it may involve any portion of the nose or nasopharynx. The tumors are generally small and of a grayish-white color, but may attain the diameter of 2 or 3 cm. before they finally break down. They are sometimes pedunculated, at other times sessile, and they commonly bleed easily. The tuberculous infiltration is prone to attack the septum, but may also invade the turbinals. It causes a firm, resistant swelling of a pale color having a somewhat granular surface. This, like the tumors, is ultimately followed by ulceration. The tuberculous ulcer is generally round or oval and at first shallow, but ultimately it becomes much deeper. The borders are irregular, having a worm-eaten appearance; they may be level or may be prominently raised by tuberculous infiltration. Miliary tubercles may often be seen on the floor of the ulcer and surrounding it. The floor of the ulcer is of a pale, grayish-red color and is sometimes covered with granulations, while the miliary tubercles which surround the ulcer are translucent or of a yellowish or grayish-white color. On breaking down they cause irregularity of the edge of the ulcer, and by the extension of the process the cartilage or even the bone may be destroyed, leading to perforation. Exuberant granulations may spring up and hide the ulcer or perforation or even a tumor. They are analogous to fungous granulations found in other parts of the body.

ETIOLOGY.—The causation is the same as that of other forms of tuberculosis.

SYMPTOMATOLOGY.—The disease comes on insidiously, causing the symptoms of an offensive rhinitis with free purulent discharge, which tends to collect and form scabs and crusts that hide the ulcers. Epistaxis is an occasional occurrence. At first the constitutional symptoms are slight. In the majority of cases this affection is secondary, and in nearly all instances it terminates with laryngeal or pulmonary tuberculosis.

DIAGNOSIS.—The disease is to be distinguished from lupus and syphilis. Lupus resembles the infiltrated form of nasal tuberculosis, but commonly begins in the integument and slowly extends, showing a marked tendency to cicatrization, whereas the tuberculous ulcers spread more rapidly and there is little if any tendency to healing; indeed, it is impossible to cure one of these ulcers unless the general condition improve.

Syphilis, especially in the late hereditary form, is sometimes very difficult to distinguish from tuberculosis, but usually its more rapid course, the headaches and neuralgias that are apt to accompany it, and its proneness to attack the bone instead of the cartilage distinguish it from tuberculous disease. The antecedent history may be of great value in the diagnosis, and a microscopical examination of the secretions or the scrapings from the ulcers or granulations is liable to reveal the tubercle bacilli, though the latter can seldom be discovered in the infiltrative form or in the tuberculous tumor. The results of treatment are also important—a syphilitic ulcer usually improves speedily under specific medication, whereas the same treatment is likely to aggravate tuberculosis.

PROGNOSIS.—The course of the disease is slow unless the lungs be already involved, and it may possibly extend over several years; but when the tuberculosis also affects other organs it runs a more rapid course to a fatal termination.

TREATMENT.—Detergent sprays and washes may be used to keep the nares clean, and tuberculous tumors that interfere with respiration may be removed by the snare or otherwise. The infiltrations are best destroyed by the sharp spoon or by electrolysis; fungous granulations may be scraped away with a curette and the base treated with lactic acid; indolent ulcers may be curetted and then treated with lactic acid. In these cases the parts should be anæsthetized as thoroughly as possible, and lactic acid of a strength from fifty to one hundred per cent. should be carefully applied. It is well to add to it from three to five per cent. of carbolic acid in order to prevent prolonged pain after the effects of the cocaine have disappeared. In some instances excellent results have been obtained by carefully touching the surface of the tuberculous ulcer with the galvanocautery. It is of prime importance to attend to the general health, because until this is improved we cannot hope to obtain much betterment in the nose. Even in primary cases we can scarcely hope to remove all of the tuberculous tissue by curettage or by other surgical measures, and therefore we can seldom, if ever, completely cure the disease.

E. Fletcher Ingals.

NASROL—sodium sulphocaffeate, symphorol sodium—is a bitter crystalline powder slightly soluble in cold water. It is a more powerful diuretic than caffeine, and the caffeine effect on the heart is said to be lessened. Dose 1 gm. (gr. xv.) daily. *W. A. Bastedo.*

NASSAU.—The town of Nassau, capital of the Bahama Islands, lies on the north shore of the island of New Providence, at a distance of about two hundred miles due east from the southern point of the Florida peninsula, and about thirty miles north of the parallel of latitude which passes through Key West. The exact latitude of Nassau is 25° 5′ 36″ N., only two degrees north

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of the Tropic of Cancer; its longitude is 77° 21′ 15″ W. It is the largest town in the Bahamas, and has from twelve to sixteen thousand inhabitants. The island of New Providence has an extreme length from east to west of nineteen and three-eighths miles, an extreme width from north to south of [illegible] miles, and an average width of about five miles. The highest ground in the island is only 120 feet above sea level, and nowhere throughout the whole group of the Bahama Islands, many of which are very much larger than New Providence, does the surface attain an elevation above sea level of more than 230 feet. "The formation of all the islands is the same—calcareous rocks of coral and shell hardened into limestone, honeycombed and perforated into innumerable cavities, without a trace of primitive or volcanic rock; the surface is as hard as flint, but underneath it gradually softens and furnishes an admirable stone for building. . . . The soil, although very thin, is very fertile. . . . Except in the island of Andros, no streams of running water are to be found in the whole group."

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The town of Nassau "extends along the water front for about three miles and back to the crest of a slope, on which stand the Government House and many of the finest private residences, at an elevation of ninety feet above the harbor. The streets are laid out at right angles with each other, and are uniformly macadamized, as are also the numerous excellent drives around the island; and the houses are generally built of stone, with the surrounding grounds ornamented with a tropical profusion of flowers and trees." As for the general character and appearance of the country back of the hill just mentioned, we read, in Mr. Charles Ives' work, entitled "The Isles of Summer," that, "with the exception of a very few square miles occupied by Nassau and its suburbs, there is little upon the island, except water and wilderness; the former is brackish and throbbing, and in some places appearing and disappearing with the long pulsations of the sea's diurnal tides, and the latter, to a large extent, a dense low jungle, with stretches of pine forests rising from a thick undergrowth of scrub palmettoes."

Turk's Island, and Dunmore Town, on Harbor Island, are other health stations or winter resorts of the Bahamas, but I possess no detailed information respecting either, and practically it is true, as stated by Mr. Ives, that "Nassau is New Providence and the Bahamas."

The climate of Nassau is tropical, and far warmer than that of the Bermudas; but for the fact that the Bahama Islands lie in the track of the trade winds, and for the fact that they are islands of small size and of rather sparse population, the climate could hardly fail to be an unhealthy one; as it is, the climate may be regarded as a healthy one, at least during the colder months of the year. The following figures, derived from one year's observations, were sent me by the superintendent of the Canadian Meteorological Service, being kindly procured by Mr. H. Beaumont Small, of Ottawa. They show the mean temperature (degrees Fahr.) of each of the twelve months of the year in question.

January, 69°; February, 73°; March, 76°; April, 78°; May, 79°; June, 83°; July, 87°; August, 88°; September, 87°; October, 80°; November, 74°; December, 70°. Yearly mean, 78.7°.

The data of Table A show the "Mean of Daily Observations on week days, for ten years, from 1855 to 1864." This table is quoted from Mr. Ives' book, where it is "copied from the official report of Governor Rawson for 1864, page 14, compiled from the records kept at Nassau's Military Observatory." Governor Rawson's conclusions, based upon this table and upon others given in his report, are also quoted by Mr. Ives, and from them we extract the following statements: "The greatest maximum heat exceeds the average heat by not more than 12°; the greatest minimum falls short of it 10°. . . . From May to October . . . the rainfall amounted to forty-four inches, and during the remaining six months to nineteen inches. . . . Northeasterly and easterly winds are the most prevalent from September to February, during

TABLE A.

Months.	Thermometer at 9 A.M. (Degrees Fahr.)			Wind at 9 A.M.	Rainfall on ground in month.
	Max.	Med.	Min.	Four chief points, in order of prevalence.	Inches.
January	75	70	66	N.E., E., S.E., N.	2.4
February	76	71	66	N.E., E., S.E., S.	2.4
March	78	72	66	E., S.E., N.E., N.	4.5
April	81	75	68	N.E., E., S., S.E.	2.4
May	84	78	71	N.E., S.E., E., S.	6.9
June	88	81	74	S.E., E., N.E., S.	6.4
July	88	82	75	E., S.E., S., N.E.	6.5
August	88	81	75	E., S.E., S., N.E.	6.7
September	86	81	75	E., N.E., S.E., N.	5.2
October	82	77	73	N.E., E., S.E., N.	7.4
November	79	74	70	N.E., E., E., S.E.	2.8
December	77	73	69	N.E., E., S.E., N.	2.4
Average	82	76	71	....	4.6

which months they blow during one-half or two-thirds of the whole time. Northerly winds seldom blow, except during those months, and then only for three days in a month." As for northwest winds, the bane of the Atlantic coast of North America during the winter season, they occur from November to March, about two days in a month." "The Bahamas," says Mr. Ives, "are slightly but agreeably refreshed by the coldest winds that ever reach them from the north and west." The relative frequency of the winds from the different points of the compass is given by Mr. Ives, in a table quoted from Governor Rawson's report, showing "the percentage proportion of days in a year during which they prevailed at 9 A.M.," as follows:

North	7.2 per cent.	South	11.0 per cent.
Northeast	26.2 "	Southwest	5.0 "
East	24.4 "	West	2.3 "
Southeast	18.6 "	Northwest	5.3 "

In Table B the reader will find data, derived from official reports, and quoted from two tables in Mr. Ives' book, one of which presents data for the year 1878, the other data for 1879.

TABLE B.

(Two Years' Observations.)

	Absolute maximum temperature at 9 A.M.	Absolute minimum temperature at 9 A.M.	Absolute sun maximum in 24 hours.	Average rainfall.	Mean number of rainy days.
	Degrees.	Degrees.	Degrees.	Inches.	
January	77.0	61.0	145.0	3.03	11.0
February	78.0	62.5	148.0	4.17	9.5
March	82.5	65.2	153.5	2 60	6.5
April	82.8	70.0	154.0	1.80	6.5
May	86.5	70.5	156.5	5.56	10.0
June	89.8	71.0	155.0	9.66	16.5
July	89.5	71.2	159.0	6.74	19.0
August	88.8	77.0	157.9	9.55	15.5
September	87.5	70.0	153.5	7.58	22.0
October	85.0	74.5	153.0	6.93	15.25
November	81.5	66.5	157.5	5.41	8.0
December	78.2	65.8	155.0	1.49	9.0

The maximum and minimum temperatures, and the rainfall for each month of the year in the three years, 1880 to 1882, are published in one of the English "Blue-books" for 1884 ("Statistical Abstract for the Several Colonial and Other Possessions of the United Kingdom in Each Year from 1868 to 1882"), which was kindly sent me by Mr. H. B. Small. Without quoting these in full, suffice it to say that the absolute minimum temperature throughout the whole three years of observation was 64° F., occurring in March, 1881; that the absolute maximum was 90° F., occurring in July and in August of the same year; and that the average monthly rainfall for each of the six months, November to April, was as follows: November, 1.5 inches; December, 1.5 inches; Janu-

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ary, 2 inches; February, 1.8 inches; March, 1.5 inches; April, 2.1 inches. Mr. Ives' rainfall statistics for 1879 correspond very closely with those just given, and the higher average figures found in Table B are caused by the exceptionally heavy rainfall of 1878.

Despite the high figures for minimum temperatures which have been given in the accompanying tables, I find a writer in the New York *Times*, Mr. William Drysdale, referring to the occurrence of a temperature of 55° F. at Nassau, and speaking of the desirability of securing at the hotel one of the few rooms in which a fire may be had in cold weather. He also complains of the strong wind which prevails at Nassau. The relative humidity in winter is eighty-three per cent. and in spring seventy-six per cent. (Hinsdale).

Excellent sea-bathing may be enjoyed at Nassau throughout the year, the temperature of the sea water being usually in the vicinity of 70° F. throughout the year (Solly). Yachting and boating are favorite pastimes, and the facilities for both are excellent.

Huntington Richards.

[As will be seen from the above, the climate of Nassau is a moist, warm, marine one, agreeable for a winter residence of several months. After some days of acclimatization it is found to be not uncomfortably warm, though it is more or less debilitating. It is warmer than the Azores, Madeira, Teneriffe, or Bermuda (Solly).

There is very little if any rain during the winter, and there is a continuous succession of fine days. The humidity is high and the nights are damp, so that the invalid had best be in doors after 6 P.M., and not venture out too early in the morning.

The water supply is from rain water kept in cisterns, and its purity obviously depends upon the care exercised in keeping the cisterns clean. So far as known to the writer, there is no general sewerage system at Nassau, but the natural drainage is good, as the town lies at an elevation of one hundred feet above the level of the sea. The soft, porous limestone rock absorbs water rapidly, and wells and cisterns in the vicinity of cesspools and vaults may easily become contaminated. The Bahama Islands in general are said to enjoy a reputation for healthfulness, the mortality being under eighteen in one thousand (Hinsdale).

There are two great hotels at Nassau, the "Royal Victoria" and "The Colonial," the latter affording accommodations for a thousand guests; there are also good boarding-houses, and guests can be accommodated in private families.

Nassau can be reached direct from New York by well-equipped and comfortable steamers; or one can go by rail to Miami on the east coast of Florida, and from there by steamer in about twelve hours.

There are many attractions at Nassau, although after a while life becomes rather monotonous. The vegetation is tropical and very varied in fruit and flower. The roads are very good for driving or cycling, both inland and along the shore. Sailing, fishing, and bathing are also a feature of the place. A visit to the Sea Gardens is a delightful excursion in the bay, where, through the clear blue water, coral growths of varied hues and forms and sea sponges are seen. There are a good public library, schools, and churches, and reliable medical service. There are both still-water and surf bathing, and an excellent sandy beach. "Not a beach from Panama to Para, where anything like the comfort and benefit can be found as on this beautiful sweep of sand at Nassau" (Hutchinson). Golf and other outdoor sports are also to be had here.

By chartering a small schooner pleasant excursions for several days can be made to Eleuthera Island, Governor's Harbor, and other neighboring islands.

This climate is essentially the same as that of the lower coast resorts of Florida, and is suitable for a similar class of cases. It is not favorable for tuberculosis, as no moist, warm marine climate is, as has been elsewhere discussed in this HANDBOOK. Neither is it good for rheumatism or neuralgia, on account of the dampness, especially at night. It is, however, favorable for chronic bronchitis and catarrhal affections of the pharynx and larynx. It is said to be very beneficial for Bright's disease, especially the early cases. Cases of neurasthenia and those suffering from the effects of overwork do well here. Convalescents from various diseases with lowered vitality are favorably influenced by the winter climate here, where "no rain falls at that season, and each day is a repetition of the one just passed, balmy breezes and cloud-flecked skies," and where the usual daily range is from 70° to 73° F. *Edward O. Otis.*]

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NAUHEIM. (BAD-NAUHEIM.)—Of the almost innumerable health resorts and watering places that abound in Germany, none is better known than Bad-Nauheim, incorrectly spoken of as Nauheim. I say incorrectly, because not such a great distance away is another town called Nauheim, which is devoid of all interest to sightseers or invalids. The prefix Bad signifies a bath, and hence designates any place to which it is prefixed as a watering place or spa. This explanation is necessary, since mistakes are sure to occur if letters intended for this famous resort are addressed merely to Nauheim without the distinctive prefix Bad, or if the invalid in quest of health inquire of German railway officials for Nauheim, and not Bad-Nauheim.

The chief interest attaching to this resort lies in the nature and properties of its springs and the diseases to which their waters are applicable, and yet there is much of interest in the history of the place. It is situated about twenty miles north of Frankfort, whence it is reached in forty minutes by the Main-Weser Railway. The location of the town is both healthful and picturesque, since it lies on the eastern slope of the Johannisberg, which forms a spur of the range of mountains known as the Taunus. The slope on which the town is built descends gradually to the bank of the Usa River, and thus provides excellent drainage, so that the soil dries quickly and permits visitors to walk out directly after a shower, which, judging from the summer I spent there, is of comparatively frequent occurrence.

Alighting from the train and walking down Bahnhof Allee (Depot Street), which descends rather sharply toward the west, one obtains a beautiful view of the Johannisberg beyond and of the town with its magnificent park and cluster of springs and bath-houses in the foreground. Emerging from this short Depot Street the traveller comes on to the Ludwig Strasse, which, lined with attractive villas along its eastern side, curves in a semicircular direction toward the west, and joining the river helps form the ovoid space in which are situated the bath-houses and springs that are the pride of the inhabitants and the object of the invalid's long journey.

On the further bank of the Usa spreads out the spacious park, which is said to be the finest of its kind in Germany, and with its shaded walks, covered seats, and Kursaal, offers irresistible attraction, and invites to the out-of-door pleasures of which the Germans are so fond.

The southwestern extremity of Ludwig Strasse leads into Park Strasse, which runs to the west, and is bordered by attractive shops, while the quaint town once enclosed by a wall, of which the remains may still be seen at the south, lies mainly to the south and west of the park on the slope of the Johannisberg. From this brief description it is plain that Bad-Nauheim can justly claim both healthfulness of site and beauty of scenery, which must minister to the comfort and pleasure of the summer visitor.

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The semi-invalid or tourist who can enjoy the pleasures of walks and drives is afforded ample opportunity for the indulgence in such pleasures. The more seriously ill, confined to a chair in the garden or to an apartment, can feast his eyes on the beauties of the Taunus range in the distant background, or on the beautiful park with the throngs of pedestrians, carriages, and wheel chairs moving restlessly in and out among its trees and on the shores of its artificial lake.

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The hours for recreation are many in Bad-Nauheim, for baths and the morning drinking of its curative waters consume but a small portion of the time; and hence the visitor must have varied pleasures and pastimes if he is not to find his sojourn wearisome and suffer from homesickness. It was the realization of this fact and of the powerful aid to health derived therefrom which led Dr. Friedrich Bode, one of Bad-Nauheim's early physicians and benefactors, to insist on the necessity of suitable provision for agreeable recreation as well as of desirable homes and means of treatment. He was a far-sighted physician who realized that healthfulness of body requires healthfulness of mind, and that to the latter contentment and diversion are essential.

To-day, therefore, Bad-Nauheim is no longer a meagre little village without an apothecary shop, or even tolerable lodgings for invalids as in Bode's time, but is a beautiful spot where twenty thousand invalids besides other visitors are comfortably, even luxuriously, housed and fed every year between May 1st and October. Besides fine hotels with modern comforts where the wealthy may be amply provided with all they can desire, there are innumerable private homes and boarding-houses for persons of humble means.

Bad-Nauheim is a Mecca for invalids from all over the world, and hence one there meets delightful people whose acquaintance is both a pleasure and a profit.

No lover of music who has passed a summer at this charming resort can fail to recall the delightful band concerts which are given three times a week at the Kursaal, and are enjoyed in the open air after the German custom, with the accompaniments of cigars and beer or other liquid and solid refreshments. These concerts are of high order, and the stirring music is rendered with a spirit and precision that never fail to arouse the most unimpressionable. Of a Sunday afternoon the usual weekly programme of instrumental music is varied by grand vocal performances rendered by well trained choral societies of male voices from neighboring cities. These concerts are rare treats and are very largely attended by enthusiastic and appreciative audiences. The air of the midsummer afternoon is usually comfortably cool and freed from annoying insects, so that to sit in the open ministers to health as well as to pleasure.

The history of Bad-Nauheim goes back to the days of the Romans when those stern warriors contended with the fierce Teutons for the possession of this part of Germany. Even in that early day it was a highly prized possession, not, however, for its baths, but for the salt contained in its waters. By the uncivilized Teuton the salt was procured by sprinkling the water on to a fire and then obtaining the saline precipitate from the ashes. The Romans, on the contrary, as shown by modern excavations, evaporated the water in large pans supported above the fire by foundations of brick.

Saline springs were considered so precious by the Romans that they were regarded as holy. It was the custom to cast coins into the springs as votive offerings, and to this day it is stated that pieces of copper money, bearing the impression of Hadrian, Domitian, and Trajan are often found upon cleaning out the basin of the Schwalheimer Brunnen. There are to be seen in the vicinity remains of old Roman villas and of that wonderful wall of defence which extended through Southwest Germany for a distance of five hundred and fifty kilometres, and enclosed that portion of the land which had been conquered from the native inhabitants. One of the best preserved remains, probably of a Roman temple, was disentombed near Homburg, another frequented spa, to which visitors at Bad-Nauheim may drive comfortably in two hours or less. It is thus seen that the subject of this sketch lies in a part of the Fatherland which is full of historic interest.

According to tradition it was Bonifacius who came to the heathenish inhabitants of this Wetterau district and converted them to Christianity. He is said to have built the chapel still standing on the Johannisberg, which mountain had for ages been consecrated to the worship of Baldur, the god of the sun. For two thousand years the Germans had annually assembled on the Johannisberg and celebrated the feast of the midsummer solstice, July 24th, now known as Johannistag or St. John the Baptist day.

It is also interesting to note that for many years the holy chapel dedicated to Christ by Bonifacius and the temple at which worshipped the still unconverted Germans stood not far apart, and on each 24th day of July could be heard the sacred music of the two congregations, the one in praise of our Blessed Redeemer, the other in praise of Baldur the sun god.

The subsequent history of Bad-Nauheim is eventful. It was twice ravaged by war in the Thirty Years' War, at the close of which the Wetterau country was desolated and almost depopulated, and again in the succeeding century during the Seven Years' War.

During all these centuries Bad-Nauheim remained still only a source for salt. Baths were not given as a therapeutic agency, nor were its waters drunk by invalids as were those of not far distant Homburg and Wiesbaden. In the fore part of the last century we read that the officials of the salt works used the saline water for bathing, not however therapeutically but merely for the purpose of cleanliness, since other water was not convenient.

In 1833 Salt Inspector K. Weiss persuaded Internal Revenue Commissioner Meisterlin to try a bath in this salt water, which he found so agreeable and invigorating that he determined to propose to the Kurfürst the erection of a bath-house. This establishment was first opened to the public in July, 1835. Thus was instituted this world-renowned resort which, from receiving ninety-five patients that first year, is said now to accommodate about twenty thousand invalids annually, to whom are given an average of three hundred thousand baths.

Of all the various springs that have been bored from time to time only five are now in use, namely: Kurbrunnen and Karlsbrunnen, which are saline purgative waters; Ludwigquelle, which is alkaline in consequence of its containing sodium bicarbonate; the Great Sprudel or No. 7, in use since 1839, and at that time the largest and strongest of all; and last but not least the Friedrich Wilhelmsquelle or No. 12, now the spring furnishing the greatest flow and extremely rich in CO_2. No. 14 (Ernst-Ludwig) was completed in 1900, having a depth of two hundred and nine metres.

There are six bath-houses of which No. 4 receives water, after having been freed from gas and impurities, from Spring No. 7. In this house only simple brine baths are given. Houses Nos. 1 and 6 receive water direct from the two springs at a temperature of 87° to 92° F., and very rich in acid and salts so that it can be employed in the "Sprudelstrombad" or flowing effervescing bath. The other houses also obtain waters from the two great springs, but only after they have flowed into their respective basins, so that the temperature of the water is somewhat lower (85° to 90.5° F.) and not quite so rich in CO_2.

The baths in use may be simple saline or warm saline, and the flowing saline or flowing effervescing bath, as the case may require. In addition, of course, douches, hip baths, etc., found at all watering places, are given. The analyses of the various springs will be found appended. At first the waters of Bad-Nauheim were recommended for the treatment of gout, rheumatism, anaemia, and disorders of the female pelvic organs, but their scope has been widened and now embraces diseases of the heart and nervous system.

For the first-mentioned affection patients are advised to

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Analysis of the Nauheim Mineral Waters. The Amounts of Solids are Given in Grams as Contained in 1,000 Grams of Water.

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Constituents.	Springs for the Baths. No. 7. Grosser Sprudel.	Springs for the Baths. No. 12. Friedrich Wilhelms-Quelle.	Drinking Springs. Kurbrunnen.	Drinking Springs. Karlsbrunnen.	Drinking Springs. Ludwig-Quelle.
Chloride of sodium	21.8245	29.2940	15.4215	9.8600	0.3411
Chloride of lithium	.0492	.0536	.0267	Traces.	.0012
Chloride of potassium	.4974	1.1194	.5270	.0731	Traces.
Chloride of ammonium	.0550	.0712	.0371	.0113	
Chloride of calcinm	1.7000	2.3249	1.0349	1.0578	
Chloride of magnesium	.4402	.5255	.7387	.2040	
Bromide of magnesinm	.0060	.0083	.0063	.0014	
Sulphate of calcium	.0347	.0352	.0238	.2277	.0288
Sulphate of strontium	.0390	.0499	.0324	.0087	Traces.
Bicarbonate of calcium	2.3541	2.6012	1.1461	.9515	.3692
Bicarbonate of magnesinm	....	....	....	....	.1928
Bicarbonate of sodium	....	....	....	....	.0928
Bicarbonate of iron	.0383	.0484	.0262	.0152	.0098
Bicarbonate of manganese	.0065	.0069	.0080	Traces.	Traces.
Bicarbonate of zinc	.0104	.0089	.0070	Traces.	
Silicic acid	.0325	.0213	.0186	.0087	.0121
Arseniate of iron	.00036	.0002	.00016	Traces.	
Phosphate of iron	.00046	.0007	.00034	.0002	
Oxide of copper, chloride of thallium, oxide of lead, nitric acid, organic substances	Traces.	Traces.	Traces.	Traces.	Traces.
Amount of solid constituents	27.0886	36.1695	19.0549	12.4196	1.0478
Absolutely free carbonic acid gas	2.3764 = 1216.6 c.c.	1.9777 = 1039.9 c.c.			
Semi-free carbonic acid gas contained in the bicarbonates	.7343 = 375.7 c.c.	.8123 = 416.2 c.c.			
The active carbonic acid, *i.e.*, the free and semi-free together	3.1106 = 1592.3 c.c.	2.7900 = 1456.1 c.c.			
Temperature, Celsius	31.6°	35.3°	21.4°	15°	18.8°
Temperature, Fahrenheit	88.88°	95.54°	70.55°	59°	65.84°

drink freely of the water of the Kurbrunnen, which is rich in chlorides of lithium, potassium, and the bicarbonate of lime, and, when a more strongly alkaline water is indicated, of that found in the Ludwigbrunnen. These springs are thought to be of special virtue in the removal of deposits about the joints. For the stiffness and swelling of the articulations occasioned by gout, baths are ordered which, beginning with thermal brine baths of a temperature of 93° to 95° F., are gradually changed to more stimulating ones, the effervescing water of Spring 12 being considered especially suitable. Finally, resort is had to the flowing effervescing bath, which is powerfully stimulating to the circulation, and is a specialty of Bad-Nauheim owing to the unequalled richness of Spring 12 in carbonic acid with its temperature of 92° F.

Patients suffering from anæmia and chlorosis are said to be much benefited by bathing in the waters of these springs on account of their containing iron as well as stimulating salts and CO_2, while at the same time they drink the purgative waters of the Kurbrunnen and Karlsbrunnen.

Disorders of the female pelvic viscera, particularly pelvic exudates, are said to be favorably influenced by the warm brine baths, either with or without the addition of carbonic acid.

Diseases of the spinal cord, as well as neurasthenia and other disorders of the nervous system, also receive treatment at Bad-Nauheim, and Medicinalrath J. Groedel, in his little work, "Bad-Nauheim: Its Springs and Their Uses," cites cases of the kind which have been remarkably helped. Professor Erb, of Heidelberg, sends numerous patients thither and highly praises the virtues of its waters in this class of cases.

As already stated, the waters of Bad-Nauheim are reputed to be of special efficacy in the treatment of both acute and chronic articular rheumatism, being employed in the form of baths, as has been the plan of management at other health resorts for centuries. Cases of comparatively recent development are subjected to the influence of the simple warm saline bath, but in protracted and chronic forms of the affection the stronger and carbonated waters are employed. The design of the bath is to promote healthy circulation in the affected joint, and it is believed that the comparatively cool (92° to 95° F.), strongly saline, effervescing, and hence powerfully stimulating baths of this spa accomplish this result more certainly than do the hot weaker baths given at other resorts.

The treatment of cardiac diseases, for which Bad-Nauheim has justly attained so great a renown, is an outgrowth of the treatment of articular rheumatism. It was Dr. Beneke, one of the earlier physicians at this resort, to whom credit is mainly due for the development of this use of Bad-Nauheim waters, although the Schott brothers, Groedel, Heineman, and others have brought the treatment to its state of perfection. Beneke contributed reports wherein he showed that this means of therapy is beneficial in four ways: (1) by preventing collapses of acute rheumatism, which would increase an existing valvular defect; (2) by promoting absorption of endocarditic products in the same way that these waters favor the absorption of inflammatory deposits in the joints; (3) by exerting a soothing effect on the heart's action; (4) by improving compensation in old-standing valvular disease. It was this last-mentioned effect which led Groedel to affirm in a paper contributed to the *Berliner klinische medicinische Wochenschrift* in 1878 that these baths improve cardiac energy and are a powerful heart tonic in other diseases besides valvular.

Carbonated thermal brine baths tend to quiet and regulate the action of the heart, improve its innervation, and increase its muscular tone. It is this effect which, in the experience of all physicians who have employed the treatment, makes it applicable to all forms of circulatory disorder, whether depending upon endocardial or myocardial disease, or merely upon nervous derangements. It is generally taught that severe degrees of arteriosclerosis and aortic aneurism are injuriously affected by such baths, but Groedel has shown that if they are given in such a way as not to augment blood pressure, even these two diseases may be materially benefited.

The methods of employing balneology in the management of cardiac diseases is simple and yet requires an intelligent conception of the principles concerned, and of

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the effects produced by baths of different strengths and temperatures. The warmer, less strongly saline ones serve to soothe and relieve the weak, irritable heart, whereas those that are strong in mineral ingredients and charged with CO_2, and at the same time of low temperatures (86° to 83° F.), stimulate the heart to increased work. It is clear, therefore, that these last are permissible only after compensation has been re-established, or in cases that have never displayed very obvious weakness. It is not claimed that the balneological treatment of cardiac disease can be given only in Bad Nauheim, but that here the advantages for this form of management are especially good. This is particularly true of the flowing effervescent bath, which, it is said, can nowhere else be given; and as it is powerfully stimulating, this kind of bath is highly beneficial in suitable cases.

Very briefly stated, the following is the method of ordering the treatment. At first, baths are prescribed which are weak in salts (about one per cent. of sodium chloride and one-tenth per cent. of calcium chloride) at a temperature of 95° to 92° F., and for a duration of from five to eight minutes. Carbonic acid is not added in the beginning of treatment, or at most in a very weak percentage of CO_2. As time proceeds and cardiac energy grows, the strength of the baths is increased until the salts mentioned approximate three per cent. of the sodium and one per cent. of the calcium chloride. Carbonic acid is added in the course of time, as determined by the judgment of the physician, and *pari passu* the temperature of the water is reduced and the length of each bath is increased, until at last the patient remains in the tub about twenty minutes.

In the fore part of the treatment the baths are interrupted by an occasional day of rest (one out of every three or four), but toward the end of the course such interruptions come at longer intervals. Patients are also required to lie down and rest after each treatment for an hour or so, in order that the effect of the bath may be retained and opportunity be given for a nap if inclination thereto be felt.

In addition to balneology patients are usually instructed to take exercise either in the form of massage, the so-called resistance exercises, or, as the heart becomes equal to it, by walking on the level or up the gentle inclines prepared for the carrying out of Oertel's terrain-kur. The diet and intake of fluids are also supposed to be carefully regulated.

As has been stated in numerous medical journals, this balneological treatment can be very well given at home by means of artificial waters, and, as my experience has abundantly proved, with excellent results. It is not possible, however, successfully to imitate the current bath, and in addition it is difficult to get patients to make treatment the sole aim of existence as at Bad Nauheim.

In concluding this brief sketch, which by reason of the limitation of space allotted is necessarily cursory and incomplete, I desire to express my sincere thanks to Dr. H. N. Heineman and to Dr. Groedel for valuable assistance rendered by them. I am also indebted to numerous papers by Dr. Schott and others. *Robert H. Babcock.*

NAVAL HYGIENE.—INTRODUCTION.—Naval hygiene may be briefly defined as being that branch of hygiene which applies the principles of sanitation to the conditions peculiar to life at sea, and especially as existing in ships of war. Although, in actual practice, appearing more or less modified to make them meet the peculiar conditions prevalent on board sea-going ships, the laws of general hygiene must remain essentially and fundamentally the same. Adaptation may at times necessitate and require a modification in the practice, but can never be allowed to go so far as to alter the principles of what is known as good hygiene, and so recognized by the best sanitarians the world over.

The importance of the study of hygiene to the naval surgeon cannot be exaggerated. Unless he possesses a profound theoretical as well as a practical knowledge of the essential and fundamental principles and purposes of hygiene, the naval surgeon of to-day can hardly be called "up-to-date," for without that knowledge he is barely able to perform but half his duties as sanitary officer on board a war-vessel. Since these duties must be confined, in form at least, to recommendations, made to his commanding officer, it is hardly to be expected that his recommendations will meet with the approval, required by regulations, unless the medical officer at the same time is able to prove to his captain that he possesses the necessary and requisite knowledge to entitle him and his recommendations to that attention and consideration which alone can make them effective.

To the naval architect the careful and conscientious study of hygiene is likewise of very great importance. At least one of the essential conditions implied in the construction of a warship is that it shall be so designed as to afford a given number of men a wholesome shelter during the performance of their duties; that the conditions on board be such as to preserve the life and health of the men, aiding them in, instead of interfering with, their most effective duties and excluding outside influences that are detrimental to these ends. The naval constructor owes it to himself, to the naval service, and to the people of his country that the best possible arrangements be made, that the best methods be adopted, and that the best work be done to advance the interests of hygienic living on board the ships which he designs and builds, as as far that may be within the range of his power. The ventilating system for a ship of modern construction, for instance, must be considered to be so essential that without it the ship would be of little value and its use limited.

Since the type and details of a ventilating system must be adapted to the type of the ship, it should from the beginning form a part in the design and structure of the ship and not be left to an afterthought. The constructor, realizing the difficulties, may commit them to an expert; but even then it is necessary that he have enough knowledge of the subject and of the results to be aimed at that he can readily and conscientiously accede to the demands of the expert, instead of regarding them as unreasonable; he should, moreover, possess enough knowledge on the subject to enable him to pass a just and proper estimate upon the value of the services of the employed expert himself. Thus, in giving out contracts, he is usually besieged by competitors. Competition leads to low bids and these lead to poor work and material. The result must be prejudicial to the interests of the naval service and to the constructor as well.

Scientific facts are stubborn things: they will not and cannot remain long ignored; mere opinions, whether official or unofficial, cannot sidetrack them, and thus the inevitable conclusion remains that we must bravely face these facts. In so far as the life of the sailor is influenced by the training which he must and can receive only on board a warship in commission and at sea, it is perfectly evident that that life is either increased or impaired in value to the service in direct proportion to the improvements in the hygiene of his immediate environments. These are intimately connected with the improvements in the construction of the ships on which he has his being.

Fortunately, there is abundant proof of the fact that within recent years, at least, a deeper recognition of the importance and of the profound significance of ships' hygiene on the part of all the officers of the naval service has become manifest. It has become clearly recognized that the strength, the power, the health, and the endurance of a ship of war, in action or out of it, whether on a mission of peace or one of war, can be but those of all its inmates combined, and, consequently, every man individually either adds or detracts from the sum total of the ship's power and endurance in direct proportion to the standard of his physical health. But the highest aims and objects of hygiene are not merely to preserve, but to raise the average standard of the health of our men to its maximum capacity. All training is more or less useless unless done on that basis.

Having once recognized these things, it becomes our

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Naval Hygiene.

next duty to examine into the conditions, to consider some of the facts, upon which the successful solution of so high a problem depends. The three mainstays of all living things that people this earth are air, water, and food. An efficient ventilation, a good water supply, and an abundance of good and wholesome food must ever remain the principal subjects of our study and claim our first care and consideration. But before entering upon a more detailed study of these, we are impelled at least to call attention to what seems a most necessary preliminary to the successful administration of all hygienic laws in every organized body of men such as constitutes the navy. By that we mean the instruction of the men under training in the laws of the hygiene of our daily lives.

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It has been found repeatedly and constitutes an almost daily lesson of the sanitarian that one of the greatest and ever-present dangers from disease, on the part of the men in both the army and navy, is the ignorance of the most simple and elementary laws of health that must govern the every-day conduct of their lives. Examples of this might be cited *ad infinitum*, but we need go no further than merely call attention to the lessons that have been taught us, during our short war with Spain, by some of our volunteer regiments. Many of our bravest sons, because untrained and uninstructed in these things, died within a few weeks of going into their first encampment. Hence the warning finger, fortified and supported by an experience that should never again be allowed to lapse into forgottenness, points directly and unwaveringly to the necessity for instructing the men in the simple and elementary laws of health. This is clearly and distinctly the duty of the medical officers of the navy, the only officers in the service who, by the very nature of their training and education, should and can be held responsible for initiating reforms and improvements in this direction.

> "Nous sommes si zélés partisans de la ventilation que nous n'hésitons pas à la considérer comme le premier facteur de l'hygiène des navires, plus important à lui seul que tous les autres réunis."—ROCHARD ET BODET.

I. VENTILATION.

To supply a ship's complement of men with a pure, good, and wholesome atmosphere at all times and under the most varying conditions of activity, rest, and climate, is a problem which as yet has not been completely solved. The different climates through which men-of-war have to pass within a short space of time, and the conditions which these impose upon our problem, would alone be sufficient to demand the greatest possible elasticity in the range of adaptability from any ventilating system that is known, while the large number of small water-tight compartments into which the interior of a modern warship has been systematically reduced would make it seem almost next to impossible to keep the air inside all of these in a desirable state of purity and in constant and measured circulation. While, therefore, we agree with the distinguished French hygienists whom we have quoted above as regards the very great importance, to the hygiene of war-vessels, of an efficient ventilating system, we must also recognize and acknowledge that in no other department of naval hygiene do we find ourselves confronted with as great and perplexing difficulties as we do in the ventilation of warships of recent construction. We may accordingly be pardoned for devoting to this subject more time and space than to any of the others.

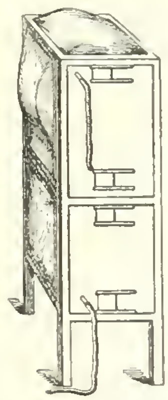

FIG. 3499. Recknagel's Model Paper Box. (From Karl Schmidt.)

Ventilation means to produce currents in the air. Currents are produced (1) by rarefying a column of air at some place, through heat or suction, and (2) by condensing at some other place, through either cold or compres-

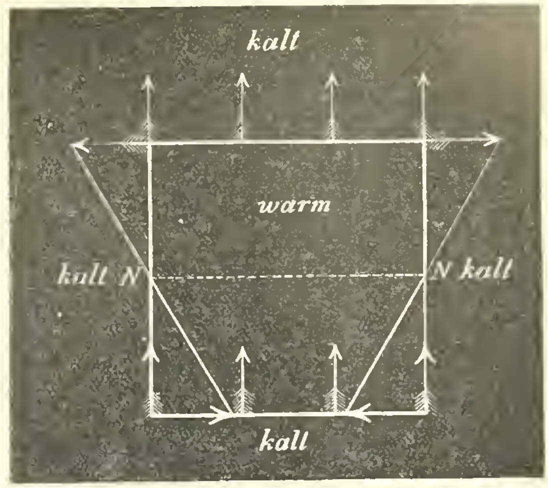

FIG. 3500.—Illustrating Distribution of Pressure in Heated Rooms. (From Rubner.)

sion. An excellent illustration of the effects of heat and cold upon the creation of aërial currents is furnished, in nature, by our regular winds. Along the equator we have a belt of calms, several degrees in width, over which the air is rarefied and expanded, rendered specifically lighter under the influence of a vertical sun, and consequently a constant current ascends into the higher regions of the atmosphere; then this current flows north as well as south from the equator, passing over the cooler trade-winds which flow in beneath them from either hemisphere. The warm equatorial currents descend toward the surface of the earth in about the thirtieth degree of latitude. The same currents cross the winds coming from the poles and proceed converging toward them as surface winds, whence they again ascend and, now, proceeding in a direction toward the equator, they descend through the calms of Cancer and Capricorn, become surface winds, and form the trade-winds already alluded to, thus completing their figure-of-eight form of circulation.

A similar process, though on a much smaller scale, may be seen daily in the large chimneys of some of our great manufacturing establishments. Through the fires, the column of air contained inside of them is heated and rarefied. The rarefied column of air, consequently, rises very much as a stick of wood forced lengthwise under water will rise, and the specifically heavier air, outside the chimney, will press inward from below. The cause of this movement is the difference in temperature between the inside and outside columns of air, for if this difference disappears equilibrium is re-established and the movement ceases.

In houses and dwellings of all kinds, these same physical forces are constantly at work, tending to bring about a change of air within them. The porous nature of our building materials, the winds, and the differences in temperature between inside and outside air are the efficient causes of this natural ventilation. In an experiment by von Pettenkofer it was found that in a room of 75 cubic metres' capacity one complete change of air was produced in one hour through a difference in temperature between inside and outside, of 20° C.

In order to illustrate the working of the principles of this natural ventilation, Recknagel made a box of thin paper (see Fig. 3499) perfectly cubical in shape, leaving the bottom side uncovered. Through this uncovered lower side he heated the air by means of an alcohol lamp,

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thus imitating the conditions under which natural ventilation occurs in any heated space in which doors and windows are closed. It was shown by manometrical measurements that in the upper portion of such a box there was overpressure, while in the lower portion of the box there was underpressure. In the upper portion the walls were pressed outward, in the lower portion they were pressed inward. About the middle part the pressure was = 0, and the line of this zero pressure was called the neutral zone. (See Fig. 5300, line *N N*).

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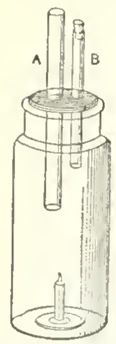

FIG. 3501.—Illustrates the Principle of Natural Ventilation of Ships. (From Munson.)

It will easily be perceived that wherever ventilation is effected by suction or exhaustion there must be underpressure, produced throughout the entire enclosure. The neutral zone will rise up to the ceiling or near the place where the exhaustion is done. The region of underpressure will rise until it prevails throughout the entire space. Under such conditions air tends to press into the enclosure from below, through cracks in the sides, or wherever underpressure extends. In case the adjoining rooms are kitchens, closets, stuffy cellars, galleys, pantries, engine- and firerooms, bilge or store-rooms, as would be the case on board ship, all the effluvia from these would be bound to pass into any of the living spaces that are ventilated after that fashion.

These facts would hold good everywhere, although a ship is vastly different in its material construction from any building on shore. A ship's bottom and sides, unlike those of a house or building, must practically be made both water- and air-tight; hence, whatever fresh air gets into a vessel must come from the top side and thence find its way, as best it can, to the various parts below. It represents a Recknagel's box with its inside air heated, but with its partly open side on top, instead of at the bottom. Whatever natural ventilation occurs in a ship can best be illustrated by the classical experiment with the unstoppered bottle. If we lower a lighted wax taper attached to the end of a wire down to the bottom of a wide-mouthed bottle, the little flame will burn brightly for a short time, then grow gradually dimmer and dimmer and finally die out altogether. If we now change the conditions of our first experiment by inserting a piece of cardboard into the neck of the bottle so as to divide the cylindrical opening into two nearly equal parts vertically, and now again introduce our lighted taper to the bottom, it will burn brightly to the end. The heated air charged with carbon dioxide will ascend through the neck on one side of the cardboard, while a current of air, pure and cold, will descend on the other side of it and support the life of the flame. As long as the hot air alone came through the neck, fresh air was prevented from entering, and whatever little did find its way into the bottle was returned before it reached the candle at the bottom.

The same principle is also well illustrated by Fig. 3501. Here the fresh air enters through the long tube *A*, and the foul air passes out through the short tube *B*.

A single central tube, being equivalent to a septum, will answer the same purpose. In this arrangement the warm-air current passes up through the central tube, while the fresh, cool current will descend outside of the tubular septum. In case, however, this central tube should be provided on top with a hood which is turned to the wind, then the cold air will pass down it and the warm air ascend around and outside it. As long as nature has her choice, the column of hot air will be found to occupy the centre and the cold-air currents will arrive from the periphery. These simple principles explain the method of ventilating ships by means of wind-sails, of no matter what construction they may be, through hatches. The essential difference in the methods of ventilating houses and ships is that, in the former, fresh air can be admitted, in fact presses in from below, with the greatest ease, while in the latter it must first be drawn from above downward, which is a matter of some difficulty, therefore also requiring special means for its accomplishment. *It should never be drawn down at a place where it meets with an ascending current of warm air.* Fresh air having arrived at the lowest compartment of the ship, its distribution to other parts of the vessel can, of course, only be effected on the same principles and by the same means that are employed in the ventilation of houses on land.

After the air has left the ventilating pipes and entered the smaller compartments and living spaces, its further distribution follows the laws of temperature and pressure differences, either existing naturally or being produced artificially. Whenever a ship happens to run against the wind, its inside temperature will be found considerably higher in the after-part of the vessel than in the forward part; with the wind on her side, the leeward side will show a higher temperature than the windward side. These differences are of course greater in the interior of the ship than on the upper deck.

These simple principles of natural ventilation would not have been dwelled on at such length, were it not that daily experience has abundantly shown that an undue lack of appreciation of them in putting them into practice is almost equivalent to entire ignorance of them, and hence their having been emphasized. The problem of ventilating ships on the best principles deserves our most serious study and devotion.

Natural-Air Currents in Steamships.—The student of ships' ventilation will do well to begin with familiarizing himself with the movements of natural-air currents within ships of different types, both under varying and under average conditions. In doing this, he will at first meet with many rather startling surprises. The currents move in quite unexpected directions and seem difficult to explain. Thus, in sailing vessels, a number of canvas wind sails are in use (see Fig. 3502); these wind-sails are usually suspended from some point high above the upper deck and have their heads turned to the wind. The air is led down into the deepest portions of the ship by the wind sail which passes straight down through the different hatches which are usually superimposed. Under these conditions, the foul air rises outside of the wind-sail to escape into the open. When, however, either by accident or design, the open heads of the wind-sails are turned away from the wind, these currents will be found to be exactly reversed, the wind-sail becoming an uptake for the foul air and the remaining space in the hatch, outside the wind sail, becoming a down-take for fresh air. In sailing vessels the temperature and pressure differences are, comparatively speaking, slight and, consequently, a rather trifling circumstance suffices to reverse the air currents within them.

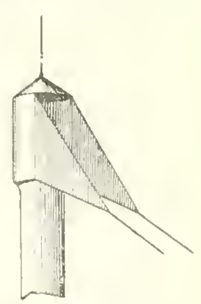

FIG. 3502.—Shows a Canvass Wind-sail of the Ordinary Pattern.

In a steamer of modern construction, such as a cruiser or battleship, with enormous fire- and engine-rooms, large steam pipes and a number of auxiliary engines, situated for the most part in the middle or central compartments of the ship's body and radiating considerable amounts of heat, air currents from all parts of the vessel would, under average conditions, move in their direction, that is, from the colder lower and peripheral parts toward the warmer higher and central compartments. Local heat-producing centres and open hatches will, however, here also produce interference currents which are sometimes difficult to explain, although perfectly natural when traced to their cause. The natural currents in steam vessels are not so easily diverted

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as those in sailing vessels, for reasons that must now seem obvious.

From the consideration and study of these normal air currents in ships, we derive one very important lesson with regard to the subject of the artificial ventilation of vessels in general, namely: That any air currents established by artificial means and intended for purposes of ventilation must be so directed as to have *concerting* rather than *conflicting* action with the normal ship's currents. It must be clear that the most effectual as well as the most economical plans for ventilating ships by artificial means, after natural ventilation has been found insufficient, consist in providing means intended to aid and increase the ventilating capacity of the natural currents.

A supply of fresh air, directed in separate air shafts to the lower and most peripheral compartments of a steamship, would be the first step to be taken and quite in harmony with the general principles of ships' ventilation. Hollow masts, hatches, engine- and fireroom gratings and chimney casings, owing to the high temperature existing about these places and the consequent tendency of a strong upward current, would send the foul air out of the ship without the aid of any other power directed to effect this end. By such a system alone will it be possible to realize the nearest practicable approach to that continuous mass movement of air so desirable in artificial ventilation. The air, fresh and cool, sent into the extreme peripheral parts of a ship and starting from these parts on its way through the ship, in a direction converging toward the various natural outlets, would do the most efficient ventilating work attainable and without being turned back. Its flow can be so graded that there will not be the slightest danger from too great a draught.

Economy in Ventilation.—The best principles of economy in ventilation are met, when the arrangements are such that the air-contaminating substances are gotten rid of without becoming mixed with the incoming fresh air. The nearest possible approach to such economical mass movement, in a continuous flow, which can be realized in the ventilation of a ship, is in the vertical movement of air, when, for instance, fresh air is admitted below and foul air passes up through hatches or other natural vents. This condition clearly demands that the supply of fresh air be directed into the lowest and most peripheral compartments of a ship through channels other than those operating as the natural outlets for foul air. To cause downward currents of fresh air through these natural outlets of foul air, by creating various degrees of underpressure in the lower compartments of a ship, through exhausting the air there, must, in view of these facts, be considered contrary to every good principle involved in ships' ventilation so far considered.

Different Methods of Ventilation.—In the words of Woodbridge ("Lecture Notes") "ventilation is by the vacuum or the plenum method according as the greater motive power is in the discharge or in the supply part of the system. That power may be solely in either one or the other of the two parts, or it may be shared between them. Its predominance in the one or the other determines the vacuum or the plenum character of the ventilation."

Vacuum Method.—This method causes a movement of air into an enclosure by creating a partial vacuum within it. Into such an enclosure the air then flows through every available channel both provided and accidental. From whatever points, therefore, the pressure may be greater than in the enclosure, ventilated by the vacuum method, from thence it will move toward that enclosure. Each such space, therefore, is more or less at the mercy of its surroundings and of conditions beyond the control of its occupants. The vacuum method of ventilation on board ship puts the breather at the point of discharge of foul air and sends into the living spaces specimens of air from every part, near or remote, whether filled with good or foul air.

Plenum Method.—This method puts each compartment under a slight pressure and thus prevents leakage of air from adjoining compartments. It tends to accelerate the flow of air through natural outlets and gives the occupants control over the source and velocity of their air supply. This method puts the breather at the point of supply and consequently in position to breathe the best of air. It is recommended as the best by Rubner, Kirchner, Karl Schmidt, Notter, Harrington, and Munson. As it applies to ships, it is more nearly a method of removal than the other, and this constitutes the highest degree of efficiency for any ventilating system. We have seen that it answers to the best principles of economy. The method is the one best adapted to warm climates in which men-of-war spend at least ninety per cent. of their time. It will supply a steady current of fresh air to all the compartments in the ship alike, and, by tending to produce even conditions of temperature and pressure, it will prevent currents and counter-currents between the different enclosures in spite of free communication existing between them.

The usual objections made to the plenum system of ventilation are that it gives rise to sensible draughts and causes dangerous colds. This is very true for houses in a cold northern climate with a temperature difference between inside and outside air of from 60° to 70° F. and in which the air coming into the rooms is not sufficiently warmed. These dangerous draughts of northern climates can, however, not be taken into account when designing a ventilating system for a ship of which it is known beforehand that it will spend ninety per cent. of its time in the tropics. We heat the air by artificial means in our northern climates before admitting it into the living rooms, in order to enable us to take in a larger supply of it without becoming sensible of it. But, in the tropics, as must be evident, we need not resort to such artificial means of heating the incoming air in order to diminish existing temperature differences, and, consequently, the dangers due to sensible draughts. Ventilation here must, on the contrary, be designed for the double purpose of having a cooling as well as a ventilating effect. Besides, a dry atmosphere of low temperature is here borne with greater ease and comfort than a moist atmosphere with a high temperature, on account of physical heat regulation being more prominently active in the warmer climates than in the colder climates. It is the common experience of hygienists and sanitarians that air currents of a temperature and velocity pronounced dangerous in northern climates must be considered well within the range of perfect safety in ships cruising in the tropics. An efficient supply of air to the lower decks of a ship in the tropics rarely, if ever, gives rise to a dangerous draught or even a noteworthy feeling of discomfort. The colds are generally caught on deck while the men are asleep in an exposed part of the ship. Many people fear draughts, and attribute to this cause not only all the colds they catch but also all their other ills into the bargain. Some are so acutely sensitive, especially within doors, that they feel air currents that are beyond being measured by the most delicate instruments of precision. The same people will sit out of doors, where the air moves at the rate of 10 metres a second, without either complaint or harm.

Of one thing I am daily growing more assured, namely: that the limits to the velocity of air currents, given in works on ventilation, for houses and buildings, do not apply to ships. To live on board ship is more like living out of doors than living within a room.

Air currents that would be both disagreeable and dangerous in rooms of houses on land are still borne with comfort and without danger on board ship; hence, also, a much larger supply of fresh outside air can be provided for in the case of ships than in that of houses and buildings on land without overstepping the safety limits.

Dilution or Removal in Ventilation.—The ideal aim of any ventilating system, in theory at least, must be the getting rid of the foul air in an enclosure and the replacing it with fresh air, without the two becoming mixed. In practice, however, and as Rubner has long since

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pointed out, we are obliged to take the air for inspiration from the same reservoir into which we send our expiratory air. It would, therefore, seem impossible for any ventilating system to separate the one from the other, and all ventilation must www.libtool.com.cn after the manner of a process of dilution and be so arranged as to keep the enclosed air from reaching a composition very much different from the outside air.

According as to whether we remove the foul air and replace it with fresh air without the two becoming mixed, or whether we maintain in the air of an enclosure a composition not dangerously far from that found outside by the constant and continuous introduction of fresh air, we may be said to ventilate either by the method of *removal* or by that of *dilution*. The removal method reaches its maximum applicability and efficiency in such cases as the fireplace, the chemical hood, the kitchen range bonnet, and the blacksmith's forge. The nearest practicable approach to this method on shipboard is effected by the escape of foul air through an open hatch. Whenever and wherever air is warmed in transit, as it is in steamships in passing from the cooler peripheral compartments toward the warmer central ones, economical and effectual escape of foul air occurs by an upward movement through a hatch. The foul air, under such circumstances, makes a direct escape into the open and does not return to mix with the incoming fresh air, providing, of course, the proper outlets are free and unobstructed and it meets or passes no compartment on its way in which underpressure exists. In such ventilation, economy, efficiency, and excellence reach their maximum. What the chemical hood is to the laboratory, what the range bonnet is to the kitchen, that the vertical foul-air shaft or hatch is to the ventilation of a ship. Providing the proper number of fresh-air inlets has been provided and distributed in such a manner as to allow the incoming air to do the most effectual ventilating work, such would be the natural air currents on board every ship of the type represented in the above description.

Would any one with the full knowledge and appreciation of these principles of natural ships' ventilation choose a ventilating system at variance with them? Let us confess that it would be difficult for any one to believe that such a one exists. Ventilation by natural means having been found insufficient, let us without hesitation, and basing our arguments upon the above grounds, put the fresh air directly where it is most needed, place our power on the supply side of our system and thus give it the plenum character; let us aid rather than antagonize natural currents, and we shall have the satisfaction of coming nearer to a perfect method of ventilating a ship than by any other known means.

Perflation signifies a blowing through. When the wind moves across the deck of a ship that has its ports open on both sides, as is sometimes the case on the decks that are above the water line in fine smooth seas with light winds, such decks may be said to be ventilated by perflation. No method of either natural or artificial ventilation is comparable to this in the volume of air moved and in the ventilating effect produced. It should, therefore, be taken advantage of and used at every favorable opportunity that offers itself for the purpose of directly aërating parts of ships not generally accessible to such direct ventilation.

Relation between Size of Hatches and Tonnage of Ships.—Notwithstanding the great importance of the hatches in their relation to the ventilation of the interior of ships, there seem to exist no fixed rules for a definite relation between the square area of them and the tonnage of vessels which the constructor is bound to follow. Thus, Rochard and Bodet mention several very striking instances, illustrating this very important point, as existing in the French navy: *L'Océan* of the French navy has hatches of a total square area of 64^{m2}, 40 and a displacement of 8,000 tons. The *Forbin* has only one-fourth of the displacement of the *Océan*, while her hatches have but one-tenth of the square area of that vessel. The *Hoche* displaces nearly one-third more than the *Océan* but her spardeck hatches have a square area of only one-half that of the *Océan*. A number of similar instances could be cited concerning ships in the American navy and showing the same lack of proper relation between the square area of the hatches and the tonnage, but the above examples suffice.

Nor are the number, size, and location of these hatches and their relation to each other on the different decks of the same vessel matters of minor importance to the interests of the ventilation of the vessel. Thus, superimposed hatches favor the natural ventilation of the lower compartments, while alternating hatches favor the circulation of air through the 'tween-deck compartments. The location of a hatch often determines its function as an up-take for foul air or a down-take of fresh air. Turrets, railings, and other obstacles in the way toward hatches and ventilators divert a large quantity of air, preventing it from going into the ship. Moreover, with the wind ahead, the forward compartments are the best ventilated, the hatches in this part becoming inlets, while the after-ones become outlets. The velocity of a head wind is increased by the speed of the vessel, so far as its ventilating effect is concerned. The opposite is true for a wind going in the same direction as the vessel. With the wind on either side, the best ventilating work is done by perflation.

Wooden gratings with which hatchways and air-shafts are covered reduce the area for ventilating purposes three-fourths of their capacity. Perforated iron gratings are recommended and come into use more and more, because they have been found superior to wooden ones. Thus, simple hexagonal openings in iron plates in which the arms, separating the openings, are just one-half the width of the openings themselves, decrease the ventilating capacity by only one-half instead of three-fourths.

Ventilation is not equally important to all compartments, and from this point of view they have been divided into four classes:

1. There are the cells of the double bottoms. These are rarely opened, and whenever opened for inspection they are never entered without the air enclosed within them being changed by means of portable ventilators. Their influence upon the hygiene of the vessel is practically nil.

2. There are the various storerooms for cordage and sails, provisions and clothing, water, ammunition, engineer's stores and others. In these it is only necessary that the air should not absolutely stagnate.

3. The 'tween-deck compartments that are inhabited by the crew are, of course, of the greatest importance and ventilation here must be ample, safe, and constant.

4. The various workshops, engine- and firerooms in which men stand watch or are kept at work for stated periods night and day. The rooms in which are located the steering, pumping, hydraulic, circulating, and condensing engines, and which in protected cruisers and battleships are found below the protective deck, need a sure and steady air supply. Ventilation of these places has the double purpose of cooling the air as well as renewing the oxygen. Inlets in these compartments should be distributed all around, in order to avoid the dangerous effects that would be produced by a single strong current.

Sources of Contamination of the Ship's Air.—The composition of the air on board ships of war is influenced: (1) By human life and activity; (2) by various nuisances of an industrial origin; (3) by the bilge water.

1. Human life and activity change both the physical and the chemical composition of an atmosphere in several ways, namely: (*a*) they take from it oxygen and replace the same with carbon dioxide; (*b*) they increase its humidity; (*c*) they add to its temperature.

From the physical side, the processes of life have been likened to the phenomena commonly observed about a steam-engine. Neither animal life nor steam-engines can be kept going without food or fuel; both do a definite amount of work, the energy for which is derived from the oxidation or combustion of substances put inside of

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them, and both produce certain effete end-products that are similar, namely: carbon dioxide, water, heat, and the various products of excretion (ashes).

An efficient ventilation to an overcrowded ship is as necessary and has the same significance as forced draught for a furnace overloaded with coal. A deficient ventilation is attended by the elimination of a series of products that are not normally present in either expired air or perspiration; to this class of compounds belongs the anthropotoxin of Brown-Séquard. These poisonous substances, produced under the influence of a deficient ventilation, may well be compared to the products of an incomplete combustion produced in a furnace and consisting of both invisible poisonous gases and visible smoke. Since a state of overcrowding must be looked upon as the normal condition of life on a warship and as a necessary accompaniment of all activity there, an efficient ventilation on board a ship becomes a much more serious problem than on shore.

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If we assume with Rochard and Bodet that, under normal conditions, a man with his respiration vitiates 1 cubic metre, or about 36 cubic feet, of air in one minute, he vitiates in one hour 60 cubic metres, in twelve hours 7,200 cubic metres. A group of 500 men, the usual number on board a battleship, would then vitiate in twelve hours 360,000 cubic metres, or about 12,960,000 cubic feet. Such a group of men living in a space of 2,500 cubic metres capacity would vitiate their available air quantum 150 times, and, to keep it pure and within respirable limits, it would need to be renewed 12.5 times per hour. How overcrowding increases, apparently in geometrical progression, the carbon dioxide, organic matter, and the number of germs in an atmosphere is shown by Carnelley, Haldane, and Anderson (Kirchner) in the following table:

TABLE I.

Living in—	Carbon dioxide. Per minute.	Organic matter. Per minute.	Number of germs. Per litre.
One room	1.12	0.0157	60
Two rooms	.99	.0101	46
Three rooms	.77	.0045	9

No wonder that the mortality tables show a corresponding increase. People living in one room show a mortality of 23.3; those living in two rooms a mortality of 18.8, and those living in three rooms 17.2, while those who live in four or more rooms have a mortality of only 12.3 per cent, out of a general mortality of 20.7 per cent. These conditions are directly applicable to life on board ship.

But human life and activity add also heat and moisture to the atmosphere. An adult man produces in his body in twenty-four hours 2,300 large calories, an amount of heat sufficient to increase the temperature of 23 litres of water from 0° to 100° C. Through the skin, by evaporation, he loses from 600 to 2,400 c.c. of water in twenty-four hours, the exact amount depending upon the temperature, relative humidity, and the amount of movement of the atmosphere surrounding him. This would correspond to a heat loss of from 343,320 to 1,373,280 calories. The total heat loss is distributed as follows:

TABLE II.

	von Helmholtz. Per cent.	Vierordt. Per cent.
Through skin	77.5	86.9
Through lungs.........................	19.9	11.1
Through bowels and kidneys........	2.9	2.0

2. Industrial nuisances. The modern battleship may be said to combine within its sides all the varied industries of a manufacturing town pressed into the smallest possible space with all its accompanying nuisances in a concentrated form; the principal ones among them being those which come from the engine- and firerooms, in the form of gases, heat, and moisture. The products of incomplete combustion of coal may find their way into living spaces through processes of diffusion or the wrong kind of ventilation such as the vacuum method. Heat may accumulate owing to faulty construction or imperfect covering of heat-radiating surfaces in certain living spaces, close to engines and steam pipes. Steam escapes more or less constantly from imperfect or worn-out joints. The mean loss of water from escape of steam through pipes alone in a modern protected cruiser has been estimated to be about four tons daily. Plumert mentions a case of poisoning with carbon monoxide which occurred in one of the compartments of a torpedo boat, and which shows how dangerous gases may be diverted and get into living spaces. A hole was bored through one of the bulkheads separating the smoke-room from the living spaces, for the purpose of laying electric wires, and through this small opening, the carbon monoxide had made its way from the smoke-room to the men. In an empty ammunition room which had remained closed up for some time on board the *Sachsen*, Gärtner found up to 51 parts per 1,000 of carbon dioxide. The men who entered this compartment became suddenly asphyxiated.

3. The bilge is a constant source of air contamination. This fluid accumulates perpetually near the keel, along the bottom of the very lowest compartment of a ship and corresponds to the ground water, surface water, or sewage of our buildings on land. It is sea water mixed with the off-fall from all sorts of cargo, provisions, wash water, coal, ashes, grease from machinery, dead rats, the organic matter from everything living in the sea, in short a portion of everything that finds its way sooner or later into ships, will gravitate finally into the bilge.

In iron ships the sea water comes in through the shaft alley alone, while in wooden ships it may at times press in through every seam below the water line. The bilge is therefore less abundant in the former than in the latter. Dr. Nocht found from 3,000 to 15,000,000 germs in 1 c.c. of bilge water. Fermentation is very naturally the normal condition, and the gases constantly produced pass either into the ship's atmosphere or accumulate within spaces not ordinarily included in the general atmospheric circulation. The farther away we pass from the keel of a ship, the higher we ascend the ship's ladder the purer, the drier, and the cooler becomes its atmosphere.

Besides the above-described sources of contamination there are others which are, however, not remedied, as are these, by an efficient ventilation, and hence they were not included in the above enumeration. These are dirty personal habits and dirty clothes as well as a dirty ship. Nothing short of water, soap, the brush, and strenuous work will reach these.

Influence of Vitiated Air on Human Life.—There is besides sudden death due to asphyxia from the inhalation of air overcharged with carbon dioxide, a process of *slow* dying, due to living in badly ventilated rooms, which is not so clearly and so generally recognized nor so directly and clearly traceable to its cause. Non-medical observers and the victims themselves do not realize the causal connection between bad ventilation and this condition, hence also the lack of complaints with regard to poor ventilation from that source. The usual and immediate effects of breathing foul air are pallor of the skin, disturbances of digestion, impairment of assimilation, loss of muscular and mental vigor, and a tendency to physical break-down and disease. The difference in the complexion between the deck-hands and the fire- and engine-room men on board a man-of-war may well be seen at a muster, when the two classes of men are drawn up in line on opposite sides of the deck of the ship. On one side you may see the ruddy and rosy faces of the deck hands, on the other the pale, sallow features and sunken eyes of the men who work below.

Anthropotoxins in Air.—Determinations of carbon dioxide often fail to give information in all respects satis-

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factory as regards the degree of atmospheric contamination, and an air must often be pronounced unfit for respiration, especially on board ship, before either lack of oxygen or the undue accumulation of carbon dioxide, and even watery vapor, can be accused of being the causes thereof.

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What exactly these poisonous substances are and whence they originate, what their nature and chemical composition may be, we do not as yet know with certainty. In their effects they are like poisons. Since they are known especially to accumulate in places overcrowded by human beings, an exact knowledge of their origin and composition would be of great interest to naval hygiene.

Brown-Séquard and d'Arsonval once believed that they had discovered in stagnant expired air a toxic alkaloid which, consequently, they named *anthropotoxin*, and which, indeed, when injected under the skin of mice, killed them within a few hours. Rauer repeated but did not confirm the experiments of Brown-Séquard. The problem has recently been taken up again by Formanek (*Archiv f. Hygiene*, Bd. xxxviii., Heft 1), who makes it appear likely that the problematic substance is an ammonia compound, not so much the result of the decomposition of expired air as it is of the decomposition of urine, fæces, and of the buccal contents of the animals experimented on. He concludes that the distress, the nausea, and the fainting fits which occur in overcrowded enclosures under poor ventilation cannot be attributed to a single and always uniform factor. It seems, therefore, that Formanek likewise has failed to confirm the results of Brown-Séquard and d'Arsonval. According to the experiments of Lübbert and Peters on guinea-pigs, the poison, if it exists at all, is not an organic, that is, not a carbon-containing or combustible substance. Wolfhügel insists that it is not contained in normal but always only in stagnant and decomposed expired air. The presence of a well-defined, well-characterized chemical poison in bad air would form one of the most convenient means of determining the degree of its contamination. Such a substance is as yet unknown. Nor is it definitely known whether these substances do their harm through being inhaled or whether their presence in the atmosphere simply inhibits the further elimination of them from our bodies, and thus gives rise to poisoning by the retention of an excretory product. Certain it is, according to Rubner, Seegen, and Nowak, that when animals are kept in closed spaces, in which care is taken to remove the expired carbon dioxide and to re-supply the used-up oxygen, the animals nevertheless succumb after a time.

Estimation of the Quality of Air.—Since, as we have just seen, chemistry has as yet failed to find a convenient chemical compound in the air by the determination of which we might standardize a normal atmosphere, we must resort to less direct methods. Experience seems to hold the chemical determination of the amount of carbon dioxide as the most reliable method for estimating the quality of a specimen of air. The method for the determination of the amount of organic matter in air with potassium permanganate has been found very inaccurate by Archarow and Emmerich, and the method proposed by Rietschel, of using the temperature as an indicator of the degree of contamination of the air, could hardly find application on board ships which produce heat in such enormous amounts as do the modern battleships and protected cruisers.

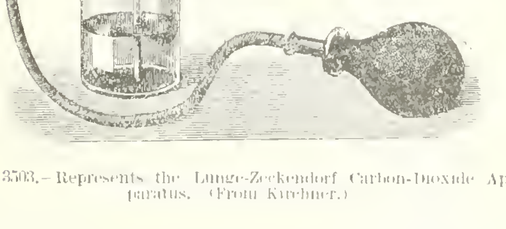

FIG. 3503.—Represents the Lunge-Zeckendorf Carbon-Dioxide Apparatus. (From Kirchner.)

Determination of Carbon Dioxide in Air.—It is known that barium oxyhydrate combines with CO_2 according to the formula, $Ba(OH)_2 + CO_2 = BaCO_3 + H_2O$. Pettenkofer proceeds as follows: A bottle containing 5 litres of the air to be examined receives 50 c.c. of baryta water. After thorough shaking and allowing to stand for a few minutes, all the CO_2 that was in the air of the bottle is now supposed to have combined with the barium oxyhydrate. The uncombined barium is now converted into an oxalate according to the formula: $C_2O_4H_2 + Ba(OH)_2 = C_2O_4Ba + 2H_2O$. From this the amount of CO_2 in the specimen of air may easily be computed. Although accuracy is decidedly in favor of Pettenkofer's method with baryta water, other considerations will sometimes cause us to sacrifice accuracy and to decide in favor of another method on account of its convenience. Several methods of this kind have been published recently. Thus, "A Rapid Method of Determining Carbonic Acid in Air" has appeared in a recent number of the *Journal of Hygiene* (University Press, Cambridge, England) by John Haldane. The apparatus, neatly fixed in a wooden portable box, represents a simple form of Haldane's gas analysis apparatus; it is so arranged that the CO_2 is absorbed by a potash solution. The final reading indicates the parts of CO_2 contained in 10,000 parts of air. The whole observation can be made in five minutes. Lunge (see Fig. 3503) ("Zur Frage der Ventilation," Zurich, 1877) uses a bottle of 50 c.c. capacity, closed by a double perforated cork and containing 7 c.c. of a 6 to 1,000 baryta solution. Through one of the holes in the cork a long glass tube reaching to the bottom of the bottle is introduced; the outer end of this tube is closed with a piece of rubber tubing and a clamp. The second hole in the cork is provided with a short tube, the outer end of which is connected with a bulb. This rubber bulb has a slit which serves the purpose of a valve, permitting the air in the bulb to be pressed out without going into the bottle, but not to re-enter the bulb, except with the air that passes through the baryta water in the bottle by way of the long tube. To this end the clamp, of course, is taken off. The bulb having a capacity of 25 c.c. the air quantum, sent through the baryta water, can be easily estimated. When the test is made, the air is drawn through the bottle until a lead-pencil mark on the side of the bottle, opposite the eye of the observer, becomes invisible through its contents. The table below gives the values. To the number of fillings must be added two volumes representing the capacity of the bottle.

TABLE III.

Number of fillings.	Volumes per 10,000.	Number of fillings.	Volumes per 10,000.
4	22.0	8	11.0
5	17.6	9	9.8
6	14.8	10	8.8
7	12.6	11	8.0

This method has more recently been greatly improved by Lunge and Zeckendorf (*Zeitschrift f. angewandte Chemie*, 1888, Heft 14, and 1889, Heft 1). Instead of baryta water, a decinormal solution of soda is used. To 1 litre of the solution there is added 0.1 gm. of phenolphthalein which colors the solution dark blue. Two cubic centimetres of this solution are mixed with 100 c.c. of air-free distilled water. The empty bottle is now filled with the air to be examined and 10 c.c. of the dilute solution are added. The bulb is now worked once and the bottle shaken for a minute. This process is repeated until the color of the fluid has changed from blue to yellow.

The values may be seen in the next table:

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TABLE IV.

Number of fillings.	Volumes per 1,000.	Number of fillings.	Volumes per 1,000.
48	0.3	8	1.2
35	.4	7	1.4
27	.5	6	1.5
21	.6	5	1.8
17	.7	4	2.1
10	.9	3	2.5
9	1.0	2	3.0

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More recently still a neat and handy method similar to the preceding, and based on practically the same principles, has been devised by Dr. G. W. Fitz. This method is carried out by shaking a small quantity of dilute lime water, colored pink with phenolphthalein, with successive portions of air until the solution is decolorized. The method has of late been made still more practicable by Woodman and Richards (*Technology Quarterly*, vol. xiv., No. 2, June, 1901). Since I have used this method quite a little and have found it to answer every purpose on board ship, being easy of application, also sufficiently accurate, a detailed description, given by Woodman and Richards, will here follow:

Description of Method of Using the Shaker for Determining the Amount of Carbon Dioxide in the Air.—"The method of preparation of the solutions and the manner of making the tests which have been found to give the best results will be described in detail, since experience has shown that these directions cannot be too minute.

"*Preparation of the Test Solution.*—The solution used is a dilute solution of lime water colored with phenolphthalein. To freshly slaked lime add twenty times its weight of water in a bottle of such size that it is not more than two-thirds full. Shake the mixture continuously for twenty minutes, and then allow it to settle over night or until perfectly clear. The resulting solution is the stock lime solution, or 'saturated lime water.' If made in the manner indicated, each cubic centimetre of it ought to be very nearly equivalent to 1 mgm. of carbon dioxide. If, however, it is desired to know the strength of it more exactly, it may be determined by standard acid.

"To prepare the 'test solution,' pour into the 1-litre bottle of the testing apparatus one measured litre of distilled water, and add 5 c.c. of solution of phenolphthalein (made by dissolving 0.7 gm. of phenolphthalein in 50 c.c. of alcohol and adding an equal volume of water). Stand the bottle on a sheet of white paper and add the 'saturated lime water,' drop by drop from a pipette, shaking the bottle thoroughly after each addition, until a faint pink color is produced which is permanent for one minute. Now add 12.6 c.c. of the 'saturated lime water,' shake, and immediately connect the bottle again to the apparatus.

TABLE A.

Standard test solution. CO_2 in 10,000.	Cubic centimetres of air.	"Half solution." CO_2 in 10,000.	Standard test solution. CO_2 in 10,000.	Cubic centimetres of air.	"Half solution." CO_2 in 10,000.
22.2	50	15.6	5.9	270	4.1
18.0	70	12.4	5.6	290	3.95
15.1	90	10.2	5.4	310	3.8
13.0	110	8.7	5.1	330	3.7
11.3	130	7.5	4.8	350	3.6
9.9	150	6.6	4.7	370	....
8.8	170	5.8	4.5	390	....
8.0	190	5.2	4.4	410	....
7.3	210	4.8	4.2	450	....
6.8	230	4.5	4.0	490	....
6.3	250	4.3	3.9	530	....

"To shorten the time required in testing air which is low in carbon dioxide, it may be found advantageous to use a solution only half as strong as the above. This 'half solution' is prepared in precisely the same way, using 2.5 c.c. of the phenolphthalein solution and 6.3 c.c. of the 'saturated lime water.'

"While this procedure does not give an exact volume of solution, it is believed to be the best for the preparation of this dilute test solution, since it obviates the necessity for pouring the prepared solution from the measuring flask into the bottle in which it is kept; 12.6 c.c. of the stock lime solution is added rather than 10 c.c., in order to keep the values obtained with the resulting solution more nearly comparable with the older values calculated on the supposition that 10 c.c. of 'saturated lime water' was equivalent to 12.6 mgm. of carbon dioxide.

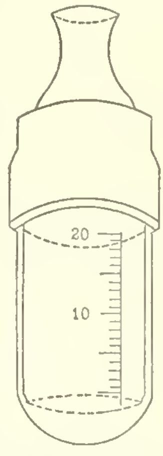

FIG. 3504.—The Fitz Shaker. Full Size. (From Woodman and Richards.)

"*Method of Making the Test.*—See that the inner tube of the shaker slides readily in the outer one, moistening the rubber collar slightly if necessary. Have the inner tube pressed down to the bottom of the larger one, and measure into the apparatus 10 c.c. of the test solution from the automatic pipette. Pull the inner tube up to the 5 c.c. mark (the bottom of the inner tube serving as the index) and close the end of the tube with the finger. Hold the apparatus horizontally, and shake it vigorously for exactly thirty seconds.

"The amount of air which is thus brought in contact with the solution is equivalent to 30 c.c., as there are 25 c.c. of air above the liquid when the small tube is forced to the bottom of the larger. Remove the finger, press down the small tube again to the bottom of the larger and draw it up to the 20 c.c. mark. Shake the apparatus again for thirty seconds. The amount of air brought in contact with the solution is now 30 + 20 = 50 c.c. Repeat the shaking, using 20 c.c. of fresh air each time until the pink color is discharged. The amount of carbon dioxide corresponding to the number of cubic centimetres of air used will be found in Table A.

"*Notes and Precautions.*—Care should be taken that the finger used to close the end of the tube is perfectly clean, since on a warm day the free acid in the perspiration might easily vitiate the results.

"If greater accuracy is desired, the shaker should be filled with the air to be tested before running in the test solution. This may be done readily by filling the shaker with water and emptying it or by forcing air into the tube by means of a small rubber bulb.

"The apparatus should be shaken vigorously and continuously during the thirty seconds in order to absorb practically all of the carbon dioxide in 20 c.c. of air. The number of shakings ought not to be less than one hundred during this time.

"Care should be taken not to contaminate the air while the sample is being taken. The breath should be held momentarily while the air in the apparatus is being replaced, and the sample should be collected as far to one side of the body as possible. It ought not to require over ten seconds to replace the air, and the entire test, with air containing, say, 8 parts of carbon dioxide per 10,000, should not require over six minutes.

"If less than 90 c.c. of air is required to discharge the pink color, the test should be repeated, using 10 c.c. of air each time after the first 30 c.c.

"It is not necessary to rinse out the shaker after making each test, but it should be carefully washed and dried after using, and the parts kept separate when not in use.

"The 'half-solution' is used in exactly the same manner and amount as the regular test solution, reference being made to the appropriate portion of the table."

Air Quantum Needed.—The ventilating plant to be designed for a place or ship must be given a ventilating

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capacity of power sufficient to do the work which it is intended to do. The air quantum needed depends upon the amount of atmospheric vitiation that may be expected to occur in the place to be ventilated. Thus, the changes that occur in a given www.libtool.com.cn single act of respiration may be seen in the following table:

TABLE V.

	Contains in Volume per Cent.	
	Dry air.	Expired air.
Oxygen	20.96	16.03
Nitrogen	79.02	79.02
Carbon dioxide	.03	4.38

According to this table, the nitrogen of the air is the only one of its constituents that remains unchanged in quantity; oxygen is decreased about one-fifth and carbon dioxide has increased a hundredfold by the respiratory act. The following calculation will serve as an example of the method that is generally employed to determine the air quantum which the ventilating system must supply to a place in a given time, before our system can be pronounced satisfactory: Given an enclosure, hermetically sealed, of 40 cubic metres capacity, filled with fresh air, originally found to contain 0.5 part per 1,000 of carbon dioxide. Every cubic metre of this air contains, consequently, 0.5 litre of carbon dioxide. An average person confined in this space would produce 22.6 litres of carbon dioxide within one hour. This quantity, when added to that normally present in the above 40 cubic metres of air, would bring the total amount of CO_2 at the end of one hour up to 42.6 litres or 1.065 per thousand.

The maximum limit of CO_2 allowed by Pettenkofer for a good quality of air is 0.7 per 1,000, and this we see has been seriously surpassed. Roth and Lex have adopted 0.6 per 1,000 for their maximum limit, and Carnelly, Haldane, and Anderson want 1.0 per 1,000 adopted for dwellings. If we adopt for the sake of illustration the limit of Pettenkofer, and further assume that fresh outside air contains, on an average, never more than 0.5 per 1,000 or every litre 0.5 c.c. of CO_2, then every litre of air may take up 0.2 c.c. of CO_2 before the normal carbon dioxide maximum limit is exceeded. Consequently, we need 113 litres or 113×0.2 c.c. = 22.6 of CO_2; we need 113 cubic metres (3,991 cubic feet) of fresh air in one hour and for an average person, in order to keep the air of a place within respirable limits. Notter quotes Roth and Lex as estimating the amount of CO_2 produced by an average person per hour at 20 litres and the hourly quantity of air required at 100 cubic metres. If we state this quantity of air, with Notter, as 3,600 cubic feet per hour, it is just one cubic foot per second.

It will be seen that we can vary our calculations considerably either by extending our maximum limit of CO_2 or by starting with an air of a higher standard of purity to begin with. If, for instance, we would ventilate our test enclosure with an air that contained only 0.3 of CO_2 per 1,000, we would require only 56.5 cubic metres to take up the above 22.6 litres of CO_2 exhaled by an average person in one hour.

The needed air quantum is generally calculated according to the following simple rule of three: (1) $n : 1 = k : (p-q)$; (2) $n = \frac{k}{p-q}$; (3) $n = \frac{22.6}{0.7-0.5} = 113$ cubic metres; (4) $n = \frac{22.6}{1.0-0.5} = 45.2$ cubic metres (Märcke and Schultze, by Kirchner). Table VI. shows how the amounts vary within the limits of purity demanded.

Some of the medical officers of the French navy appear to be keenly aware of the needs of their service from a hygienic point of view. Thus, Rochard and Bodet, in their excellent work on "Naval Hygiene" (p. 113) make a strong and timely appeal for the introduction of more scientific methods in the investigation of naval sanitary

TABLE VI.

Maximum limit CO_2 allowed per 1,000.	Air Required per Man and per Hour.	
	In cubic metres.	In cubic feet.
0.6	226	7,981
.7	113	3,991
.8	75	2,649
.9	55	1,942
1.0	45	1,589

problems, an appeal which United States naval medical officers might take seriously to heart, very much to their advantage. They say: "Nous demandons instamment qu'on munisse les médecins-majors de tous les bâtiments de guerre d'un anémomètre de Cassella," etc., and they deplore the departmental penury in not providing naval surgeons with the instruments necessary for better research work.

For the determination of the air quantum they propose to employ what they have termed the "coefficient of ventilation." In this, the hour is taken as the unit of time. Any air space, no matter what its cubic capacity, in which the air is renewed once in an hour, has a coefficient of 1. Where the air is renewed twice in an hour, that enclosure has a ventilating coefficient of 2. Wherever it takes two hours, that place has a coefficient of $\frac{1}{2}$ etc. The coefficient is expressed by the fraction $\frac{R}{H}$ in which R represents the number of times the air is renewed and H is the time required to do it in. According to this plan, the facts in ventilation could be intelligently recorded. Thus, for instance, 5 cubic metres (176 cubic feet) is the average air space allotted to one man in the French navy. This space is so small that the air in it would have to be renewed 22.6 times, *i.e.*, it would have to receive a coefficient of $\frac{22.6}{1}$ in order to bring the air quantum up to that required by our average adult in the preceding example, which was 113 cubic metres.

But almost every work on ventilation tells us that the air in any enclosure cannot be renewed more than three and at most five times, lest there be danger from draught. If we allow the French sailor to breathe into his allotted air space of 5 cubic metres for one hour, assuming that the air originally contained 0.5 CO_2 per 1,000, then that air would contain 5 CO_2 per 1,000 at the end of the first hour. If we allow the air to be renewed three times, or employ a coefficient of $\frac{3}{1}$, it would contain 2 parts CO_2 per 1,000; with a coefficient of $\frac{5}{1}$, it would reach only 1.1 CO_2 per 1,000.

A sailor on active duty generally turns into his hammock at 9 P.M. and is called at 5 A.M., when not called out for a watch before. He would sleep for eight continuous hours in a space the air of which, at the end of that time, would scarcely keep a candle burning, even under a coefficient of $\frac{5}{1}$. It is difficult to imagine that he would wake up again, as we all know he does, unless actually supplied with more air than our calculation allows him. Can any one doubt that, in practice, he somehow gets much more air, draught or no draught, than our theory allows him to get? There are ships in the United States navy, and training ships at that, in which the average air space per man is only two-thirds that allowed in the French navy, which apparently shows much more strongly than does the above instance, that more air *must* get into living spaces than even a coefficient of $\frac{5}{1}$ could put there.

The more the question is studied and the better we are becoming acquainted with the facts, the more it is found that the rules that have been worked out to govern the ventilation of houses and buildings on land do not and cannot be made to apply to ships without considerable modification. We shall have to break with fixed standards as regards the number of times we are allowed to renew the air in enclosures and part company with dangers from draughts, when going to sea in ships.

The coefficient of Rochard and Bodet may be said to

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EXPLANATION OF
PLATE XLVI.

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EXPLANATION OF PLATE XLVI.

Plans of the United States Steamships *Kearsage* and *Kentucky*, illustrating the plenum system of ventilation, installed by Naval Constructor J. J. Woodward, U. S. N.

FIG. 1.—Plan of Upper Deck, Showing Trunks and Cowls for Passage of Air.

FIG. 2.—Represents a Vertical Longitudinal Section, Showing Trunks and Cowls for the Supply of Air.

FIG. 3.—Represents Forward End of Berth Deck, Showing How Fresh Air Is Distributed from Main Deck to Living Spaces, Water Closets, etc.

FIG. 4.—Plan at Splinter Deck.

FIG. 5.—Looking Forward from Engine Room. Figs. 4 and 5 show, in plan and elevation, how fresh air is supplied to the engine rooms.

FIG. 6.—Represents Plan through Ward-room, Mess room, and Staterooms Outboard of Same, Showing Method of Distributing Fresh Air from Main Ventilating Ducts to Officers' Living Spaces.

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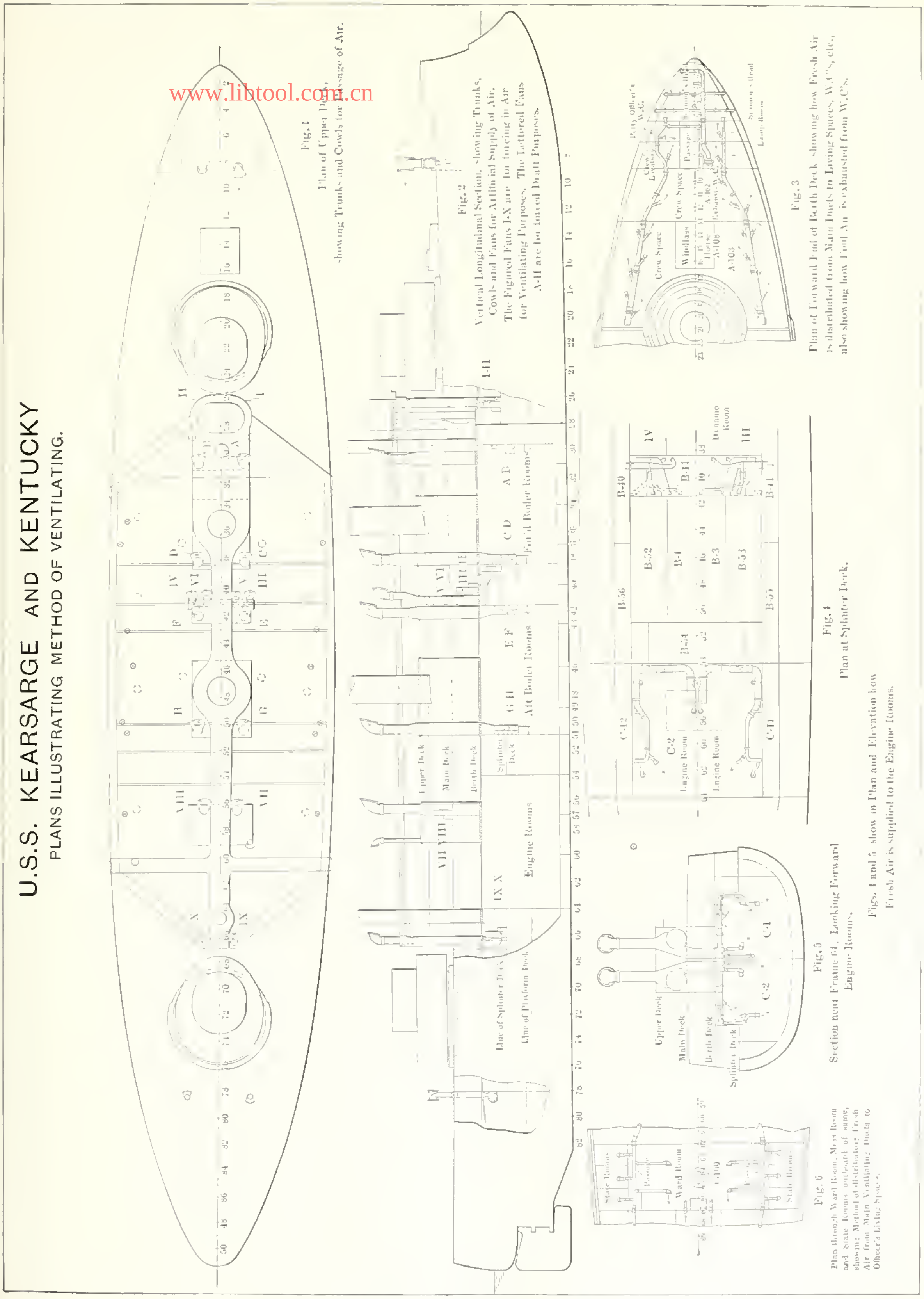
PLATE XLVI



U.S.S. KEARSARGE AND KENTUCKY

PLANS ILLUSTRATING METHOD OF VENTILATING.

Fig. 1
Plan of Upper Deck, showing Trunks and Cowls for Passage of Air.

Fig. 2
Vertical Longitudinal Section, showing Trunks, Cowls and Fans for Artificial Supply of Air. The Figured Fans I-X are for forcing in Air for Ventilating Purposes. The Lettered Fans A-H are for forced Draft Purposes.

Fig. 3
Plan of Forward End of Berth Deck showing how Fresh Air is distributed from Main Ducts to Living Spaces, W.C's, etc., also showing how Foul Air is exhausted from W.C's.

Fig. 4
Plan at Splinter Deck.

Fig. 5
Section near Frame 64, Looking Forward. Engine Rooms.

Figs. 4 and 5 show in Plan and Elevation how Fresh Air is supplied to the Engine Rooms.

Fig. 6
Plan through Ward Room, Mess Room and State Rooms on board of same, showing Method of distributing Fresh Air from Main Ventilating Ducts to Officer's Living Space.

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be a simple, convenient, and accurate means of recording the ventilation of an air space. It might with great advantage be used in company with the "air cube." The air cube is expressed by the fraction $\frac{1}{M}$. 1 stands for cubic space, M for the number of men in it. Thus a space of 100 cubic metres capacity with four men in it, has an air cube of 25 cubic metres.

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Testing the Sufficiency of a Ventilating System.—This is done (1) by determining the cubic capacity of the living spaces with the air quantum supplied to each in a given time, and (2) by examining the air both chemically and bacteriologically. For the measurement of the cubic capacity of ships' spaces, the three simple rules given by MacDonald are still sufficiently accurate and answer all the purposes of the sanitarian: (1) Take the largest measurements of length, breadth, and height that the space will admit of, for the determination of the main cubic capacity. (2) Take the cubic capacity of all irregular spaces and recesses in communication with the principal space, and add their sum to the latter. (3) Take the measurements of all obstructive bodies and projections and of everything that impinges upon the available air space and subtract the sum from the gross capacity already obtained. Since it will greatly facilitate calculation to take down the measurement in feet and tenths of feet rather than in feet and inches, the following table may prove useful:

TABLE VII.

Inches.	1	2	3	4	5	6	7	8	9	10	11	12
Decimals of a foot........	0.08	0.17	0.25	0.33	0.41	0.5	0.58	0.67	0.75	0.83	0.92	1

A few simple rules will satisfy the requirements of the sanitarian. For example, the area of the segment of a circle equals two-thirds of the product of the chord and height, plus the square of the height divided by twice the chord $(Ch \times H \times \frac{2}{3}) + \left(\frac{H^2}{2Ch}\right)$.

The area of the triangle equals the base multiplied by one-half the height. The circumference of a circle equals $D \times 3.1416$. To ascertain the area of an ellipse, multiply the product of the two diameters by 0.7854. The cubic capacity of a cylinder equals area of base multiplied by height.

The total number of cubic feet, with additions and deductions made, must now be divided by the number of berths or hammock swings in the different crew spaces and the result is the cubic space per head or air cube.

The total air quantum that passes through a space can be determined only by means of an anemometer and the area of the ventilating trunks. The velocity of an air current in metres per second is ascertained in accordance with the formula $v = a + b\frac{n}{z}$ where a and b are constant; a refers to internal friction and b to vane inclination; n is the number of turns and z the duration of the observation in seconds. The air volume is then calculated by the formula: $L = f.\ v.\ 3{,}600$, where f is the area of the intake in square metres. For example: The hands of the anemometer stand at the beginning of the observation at 3,420, and after operating $z = 120$ seconds, the reading of the hands indicates 3,900. The instrument had made $n = 480$ turns. The constants are $a = 0.18$ and $b = 0.14$, and thus we get $v = 0.18 + \underbrace{0.14\frac{480}{120}}_{0.56} = 0.74$.

The measurements of the inlet area gave 0.26×0.38 m. or $f = 0.0988$, consequently the pipes propelled $L = 0.0988$, 0.74, $3{,}600 = 263.2$ cubic metres of air per hour.

Pressure differences existing between different compartments of a ship are ascertained by differential manometers; these serve chiefly to indicate inequalities of ventilating power in different compartments with relation to each other and to determine the direction of the air currents existing between adjoining compartments from one with more into the one with less pressure.

An ingenious method for determining the amounts of air discharge which occurs in an enclosure—a method which can be applied to ships—was devised by Pettenkofer. After closing all openings into a room, he generates CO_2 by burning stearin candles. The candles furnish a definite amount of CO_2 per hour and the CO_2 of the air is also known. When the power of the ventilating system is to be ascertained, the blowers are started and the air from the centre of the enclosure is examined at intervals for CO_2. The rate at which the CO_2 disappears gives testimony of the efficiency of the ventilating capacity of the system under investigation.

Carbonic-acid examinations by any one of the above-described methods will complete the test of the ventilating sufficiency. Bacteriological examinations of the air of ships have not yet been made to my knowledge. The difficulties of preserving or making culture fluids are alone to blame for this serious omission. Special research work has, however, shown that the number of germs in a cubic metre of air decreases at sea in direct proportion to the distance from land, until, in midocean, the air is found absolutely sterile but a few feet above the upper deck of a ship. Fischer (*Zeitschrift f. Hygiene*, Bd. 1, 1886, p. 421), in examining sea air, found one germ in 44 litres of air; at a distance of one hundred and twenty miles from the coast, it was found to be sterile.

Ventilation of Different Types of Vessels.

1. *Battleships "Kearsarge" and "Kentucky"* (see Plate XLVI. and description of figures).—Most excellent examples of ventilation on the plenum principle are furnished by these two battleships of recent construction. They are practically sister ships and the ventilating system is the same in both. The *Kearsarge* and *Kentucky* are the best ventilated ships in the United States navy (see Plate XLVI.).

The United States Steamship *Kearsarge* is a twin-screw armored sea-going battleship with a displacement of 11,526 tons; she was built at Newport News, Va., and was first commissioned on February 20th, 1900. She has an upper deck, main deck, berth deck, splinter deck, protective deck, holds, and double bottoms. There are in all ten fifty-inch electrically driven fans, of twelve horse power each, and giving each a speed of 500 revolutions per minute with an output of 160 volts. Every fan forms an independent supply system for a certain part of the vessel and is located as near as practicable to that part of the vessel which it is intended to supply with air. All the air is drawn from above the spar deck and propelled down below the main deck; from thence it is driven through a system of branches into the various compartments into which these are made to open through numerous small outlets, provided with adjustable cowls or terminal trumpets that can be turned in any desired direction or closed at will by shutters.

The ten supply systems are distributed about as follows: (1) Two systems, supplying all the forward compartments of the vessel, have the blowers located symmetrically on each side of the centre line of the vessel in the blower room, on the splinter deck, and underneath the conning tower. (2) Two systems, supplying the dynamo-rooms and ammunition passages on splinter deck, with blowers symmetrically located on each side of centre line of vessel, on berth deck over dynamo-room; they receive their fresh air through two ventilators, situated between the smokestacks and outboard of the two ventilators supplying the berth deck. (3) Two systems supplying compartments in midship portion of splinter deck, including passages, also upper and lower dynamo-rooms; blowers symmetrically located on each side of centre line of vessel, in upper dynamo-room; they take the air through two ventilators situated between the smokestacks and inboard of the ventilators that supply

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the dynamo-room. (4) Two systems supplying the engine-rooms; blowers located in the engine-room hatch on main deck and taking their fresh-air supply through two ventilators abaft the after-smokestack, and in the engine-room hatch. (5) Two systems, supplying all the after-compartments of the vessel; blowers symmetrically located on each www.libtool.com.cn blower-rooms on spar deck abaft the main mast.

The fresh air supplied in this manner, after doing its ventilating work, finds its way out of the ship through the various hatches and the exhaust-leads of the smokestack. There are besides some special exhaust blowers of three horse power each for the steering engine-room, officers' water-closets and lavatories, crew's and petty officers' lavatories and closets. The large vertical exhaust-trunks from the fire- and engine-rooms are made to extend high above the upper deck in order to increase their draught and so as to prevent the escape of hot and foul air from these compartments into the living spaces.

The eight firerooms are supplied with air for forced-draught purposes. There are eight steam-fans located underneath the firerooms' ventilating trunks, each fan supplied with air by means of a separate smaller trunk, coming from above the upper deck, and fitted with a portable cowl. When forced draught is being used in any fireroom, that fireroom is kept closed and all the air that is forced in finds its way out through the furnaces and thus goes up the smokestack. Incidentally, of course, this forced draught furnishes fresh air to the firemen, stokers, engineers and others who may happen to be in the fireroom. When the forced draught fans are not running, the same ducts furnish fresh air, by natural means, such as temperature differences, to the men in the fireroom.

No fans or other artificial means are provided for forcing air into the coal bunkers. The free admission of air into these is effected by separate inlets; while the outlets are connected with the exhaust leads of the smokestack system. With regard to the working efficiency of this system on the U. S. S. *Kearsarge*, Medical Inspector J. C. Boyd, in his annual report to the Surgeon-General, 1901, says: "The total volume of air that is brought into the ship per minute has never been accurately determined, but estimating the probable capacity of the blowers, based upon the cubic feet of air per minute that can be delivered for each horse-power, it will be readily seen that the air throughout the ship can be changed within a few minutes. The cubic capacity of the ward-room is 5,376 feet, and it has been found that the air is changed 15.6 times per hour, or every 3.8 minutes."

2. *Battleship "Illinois."*—The ventilation of the *Illinois*, like that of the *Kearsarge* and *Kentucky*, has the power on the supply side of the system, and is, therefore, effected on the plenum principle. The following description is from a few notes taken during her speed trial and will only give the leading points: There are, on the *Illinois*, eight large square air shafts, serving as inlets and taking the fresh air from above the upper deck. Four of these inlets are distributed about the forward side of the forward turret of the ship and four of them are distributed similarly about the after-turret of the ship. Of the four forward ventilating shafts, two supply the dynamo-rooms and two supply the quarters, storerooms, and magazines below the protective deck, as also those of the compartments above this deck which are located forward of the diagonal armor. The four after-ventilating shafts supply the staterooms above the protective deck and the storerooms and magazines which are below this deck. They also supply those compartments of the ship above the protective deck which are included between the diagonal armor and the sides of the after-part of the ship. All the fans are driven by steam except the two that supply the dynamo-rooms; these are driven by electricity.

The discharge of foul air is effected: (1) through two large shafts, leading from the engine-rooms high above the spar deck; (2) through gratings in both the protective and the splinter decks, and (3) through the military mast which has the outlet immediately beneath the first gun platform. The exhaust side of the system has no fans and does not seem to need any.

The mid-ship section of the *Illinois*, which includes the engine- and firerooms, is supplied with four large supply shafts on each side of the centre line. The air is taken from above the spar deck and driven by strong steam fans through the fire- and engine-room spaces. Foul air escapes through hatches and gratings as well as through the fires and smokestack.

The steam steering-room is ventilated on the combined plan, having driving fans on both the supply and exhaust sides of the system, while the W.C.'s have the power on the exhaust side only. To judge by the smell that hovered about these, they did not seem to be sufficiently ventilated. Besides the above, there are two separate shafts, also provided with steam fans, which supply all the quarters located above the protective deck and between the diagonal armor and the sides of the ship.

The maximum temperature observed in the fireroom during the entire trip was 110 F. The adjoining table shows temperature in the engine-room:

TABLE VIII.—TEMPERATURES, DEGREES FAHRENHEIT.

	Engine-room, port.			Upper grating, starboard.		
Forward	121	122	122	114	116	116
Outboard	116	120	118	118	119	120
Inboard	116	116	115	109	110	111
Aft	114	118	119	106	106	108
Average	114	119	119	112	113	114

All temperatures were taken at 11, 12, and 1.

3. *The French Battleship "Hoche."*—This ship deserves special mention in connection with the subject of ventilation, because it presents a novelty in not showing a single windsail above the upper deck. All the air is taken into the ship through eight hatchways, extending from the upper deck down to the protective deck. The system has the great advantage of allowing the air to pass between decks before reaching the lowest compartments, much to the advantage of these compartments between decks during the night. The eight large hatchways of the *Hoche* on the upper deck have an areating surface of 42 square metres (see Fig. 3505); to this must be added the openings of the smoke boxes, and those of the ammunition hoists of the four turrets, which may in reality be regarded as hatchways. The access of air down to the protective deck is assured in sufficient quantity by three large hatchways, arranged like air pits between the upper and the protective decks.

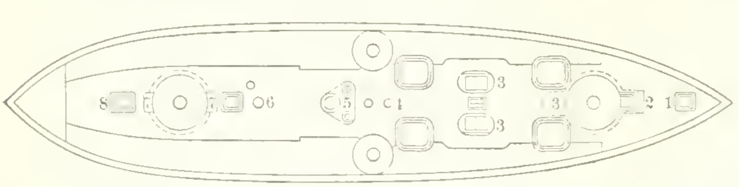

FIG. 3505.—Shows the Plan of the Upper Deck of the *Hoche* with its Eight Hatches, Marked by Treble Lines. Four small ones are in the centre line of the deck, and the four large ones (engine-room hatches) are arranged symmetrically by twos on each side of the centre line of the deck. (From Rochard et Bodet.)

There are in all twelve large inlets (see Fig. 3506), each section of the ship having its own; the last three sections alone are ventilated by a common hatchway. This last one is very large, because the spaces which it is intended to ventilate are the steering engine-room, that of the pumping engine, etc. The various firerooms

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have their own inlets, each opening being 7 metres square.

The fortunate position of the exits (see Fig. 3507) for vitiated air permits the inlets in the protective deck to have their full effect. The fourteen sections into which the vessel is divided are not, however, equally well cared for in this respect. The three forward sections being for the most part storerooms, are merely aerated by one circular opening, which serves both as a supply and an exhaust at the same time. The last two sections, which include the steering engine-room, have likewise but one hatchway. Everywhere else, a large number of conduits is arranged so as to take the hot air out from the compartments below the protective deck and conduct it above the spar deck. These are (1) the military mast system, which exhausts the forward turret, the section for the wounded, and the forward pumping engine-room; (2) the chimney mantle system, which exhausts the four firerooms; (3) the protective casing of the conning tower, through which escapes a portion of the air from a space between the engine-room and the fireroom; (4) the great central shaft, divided into several smaller trunks, lets out (*a*) the hot air from the engines, the exhaustion of which is effected by a fan through a perforated deck ceiling; (*b*) the air of the midship pumping engine-room, steam pipes, store- and ammunition-rooms; (5) an isolated conduit for the after ammunition-room; and (6) the after military mast, through which escapes the air from the after pumping engine-room and ammunition storeroom. It is interesting to note that the exhaust pipes are placed inboard of the supply shafts.

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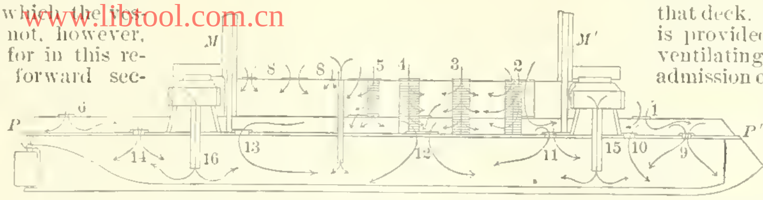

FIG. 3506.—Shows all the Supply Shafts of the *Hoche*, Especially the Three Great Superimposed Hatchways Extending from the Upper Clear Down through the Main Deck to the Protective Deck. (From Rochard et Bodet.)

3a. *H. M. SS. "Glatten" and "Devastation."*—According to MacDonald the plenum system of ventilation has been adopted without exception in Great Britain ever since the earlier seventies. Examples are H. M. SS. *Glatten* and *Devastation*. The *Glatten* has a rectangular supply shaft, five feet six inches by six feet four inches, beginning twelve feet above the upper deck and reaching down to the level of the main deck, just abaft the smokestack. At the bottom of this shaft there are four fans connected with two transverse trunks, the upper of which is sixteen by twelve, and the lower sixteen inches square. The fans, driven by steam, take the fresh air from the shaft and send it into the trunks, through which it is propelled by means of smaller pipes into every cabin and compartment of the ship, fore as well as aft, by goosenecked funicular ends that open a few inches from the floor of the deck. There are in the *Glatten* one hundred and thirty-three of these outlets. All the fans are provided with distinct sets of engines which work independently, but in the *Devastation* the arrangement is such that, in case one or two shafts get accidentally blocked or otherwise rendered useless, the third can be made to supply all the compartments whose ventilation would be thus interfered with.

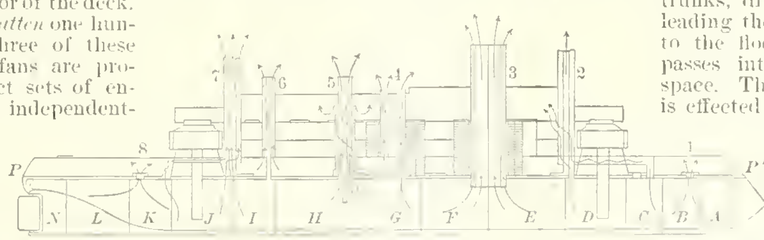

FIG. 3507.—Longitudinal Section of the *Hoche*, Showing all the Passages for the Evacuation of Foul Air, also the Independence of the Different Compartments from one another. (From Rochard et Bodet.)

The following table, IX., shows the relative number of supply and exhaust fans in some of H. M. ships; it clearly shows how even the combined system is gradually giving way to the plenum system of ventilation in the royal navy.

4. *The Austrian Coast Defence Vessels "Monarch," "Wien," and "Budapest."*—All these ships have a very large number of water-tight compartments, one hundred and forty-two of which are located beneath the protective deck and thirteen are above that deck. Each compartment is provided with its own two ventilating pipes, one for the admission of fresh air, the other for the discharge of foul air. The two pipes reach above the main deck and are themselves water-tight.

As a general rule, all efforts at ventilating water-tight compartments do in a measure endanger the purpose which these compartments are designed to serve. In all English vessels of this type the protective deck is left intact, while in French and in Austrian ships the bulk-heads are almost never perforated.

TABLE IX.—(FROM NOTTER.)

Name of ship.	Exhaust Fans.		Supply Fans.	
	Number.	Diameter.	Number.	Diameter.
Devastation	4	4 ft. 6 in.	4	5 ft. 6 in.
Thunderer	4	4 ft. 6 in.	4	5 ft. 6 in.
Trafalgar	3	Two 6 ft. — one 4 in.	4	4 ft.
Nile	3	4 ft. 6 in.	4	4 ft. 6 in.
Impériense	2	3 ft. 6 in.	4	4 ft. 6 in.
Edinburgh	2	3 ft.	6	4 ft. 1 in.
Colossus	2	3 ft.	6	4 ft. 6 in.
Inflexible	1	3 ft. 3 in.	8	4 ft.
Vulcan	2	4 ft.	2	4 ft.
Polyphemus	1	3 ft. 6 in.	2	One 4 ft. — one 3 ft.
Howe	1	3 ft.	5	4 ft.
Anson	1	3 ft.	4	4 ft.
Camperdown	1	3 ft.	4	4 ft.
Royal Sovereign	..	....	12	Six 6 ft. — six 5 ft. 6 in.
Royal Arthur	..	....	5	Four 5 ft. — one 3 ft.
Dreadnaught	..	....	6	4 ft.
Neptune	..	....	4	4 ft.
Collingwood	..	....	4	4 ft.
Severn	..	....	2	4 ft.
Galatea	..	....	2	3 ft.
Barossa	..	....	2	3 ft.
Barham	..	....	2	3 ft.
Bellona	..	....	2	3 ft.
Calliope	..	....	1	3 ft.

The engine-rooms on all these ships are ventilated on the plenum principle. The air is taken from above decks and pressed into horizontally arranged ventilating trunks, divided into branches leading the air down the sides to the floor deck, whence it passes into the engine-room space. The escape of foul air is effected through one large shaft, located amidships over the engine-room and provided with an electric exhaust fan with cowl on top.

The boiler-rooms are supplied with air through eight air shafts, four of which have fans, while the foul air escapes through the chimney, the hatch openings, and several special exhaust pipes. All the other compartments are ventilated through a large number of electrically driven fans which act on the plenum principle. The coal bunkers are

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merely connected with the system of exhaust pipes which lead into the chimney casing and the military masts. The various cells for the confinement of prisoners are traversed by the ventilating pipes intended as supplies for the ammunition storerooms. The air escapes into the cells through s[illegible] pipes and leaves the cells through openings in the bulk-heads.

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The forward station for the wounded has one, the after station two fresh-air inlets with cowls, while the foul air escapes through separate outlets. Most of the officers' cabins are dependent for their air supply on perflation, and this must be considered an important flaw in the whole system. All three of the above-named vessels are also provided with steam ash ejectors, which contribute largely toward keeping the ship's air clear of finely divided particles of inorganic matter.

5. *U. S. Training Ship "Prairie."*—We will conclude the chapter on ventilation with a description of the *Prairie's* system of ventilation, giving at the same time the results of some investigations into the working efficiency of the latter. The present training-ship *Prairie* is the converted steamer *El Sol* of the Morgan Line Steamship Company. She has a length of 404 feet over all and a beam of 44 feet; she has a gross tonnage of 6,782 tons, and is provided with a single screw, driven by a vertical, inverted three-cylinder triple-expansion engine of the ordinary marine pattern for commercial use, built at the Cramps' shipyard in 1890, and last commissioned at the Boston navy yard on November 9th, 1901; she has a spar deck, a gun deck, and a berth deck with the usual holds and storerooms below.

Since the berth deck compartments are the only ones which have artificial ventilation, all her other compartments depending upon ventilation by perflation, the former will be the only ones included in the following description. The berth deck of the *Prairie* is divided by the large engine- and fireroom hatch into a forward and an after section of nearly equal dimensions, and between them there is no communication, the two iron bulkheads of the hatch reaching clear across from one side of the ship to the other.

The forward section of the berth deck is again divided by two cross bulkheads into three compartments with two communicating doors, symmetrically placed on each side of the two dividing bulkheads. The most forward of the three compartments is used for sick-quarters, the one next to this comprises the petty officers' quarters, and the third gives berthing space to a large number of men.

The after-section of the berth deck is likewise divided into three compartments, the most forward of which accommodates the dynamos, the next gives berthing space to the marine guard, and the last is for the chief petty officers.

There are three large square and three small oblong and rather narrow hatches in her decks, all superimposed and therefore well intended to send both light and air directly down into the deeper parts of the ship. The two electric fans of 110 volts each are both on the gun deck, just fore and abaft the fire- and engine-room hatches respectively. Each of the two large ventilating trunks, after passing through the gun deck, bifurcates, and the two branch trunks with their inlets run along the sides of the various compartments which they traverse, at a height above the berth-deck flooring of six or seven feet.

The two tables, showing the results of the anemometrical observations, are intended to exhibit at the same time in a diagrammatic manner the relative position of the different compartments, their cubic capacity, the number of inlets, and also the relative distance of the inlets from the fans or blowers. As may be seen in the columns of "cubic feet exhausted per hour," the amounts of air taken up by the different inlets decrease very rapidly and directly with their distance from the blowers. Inasmuch as the observations on the inlets and outlets rarely agree exactly, the largest figure is always taken as indicating the true value of the amount of work done by the fans.

TABLE X.—ANEMOMETRICAL OBSERVATIONS ON THE VENTILATION OF THE BERTH-DECK COMPARTMENT, MADE ON U. S. S. *Prairie*, AT SEA, ON JANUARY 5TH BETWEEN THE HOURS OF 1 AND 3 A.M. NUMBER OF INLETS TWENTY-SIX, WITH AN AVERAGE SQUARE AREA OF 0.1 FEET.

I. Forward of engine- and firerooms; average difference in number of turns of anemometer between the inlets is eighty-five per minute.

Number inlets, port.	Cubic feet exhausted per hour.	Bow.	Cubic feet exhausted per hour.	Number inlets, starboard.	Sum.
13	15,900	Sick-quarters, cubic air space, 4,700 feet, exhausted 22 times per hour; available air per head and per hour, 5,370 cubic feet.	15,900	13	
12	17,880		17,880	12	
11	19,920		19,920	11	107,400
10	21,960	Forward berth deck, cubic air space, 10,200 feet, exhausted 23 times per hour; available air per head and per hour, 2,674 cubic feet.	21,960	10	
9	24,060		24,060	9	
8	26,100		26,100	8	
7	28,140		28,140	7	200,520
6	30,120	Main berth deck, cubic space, 25,604 cubic feet, exhausted 16.5 times per hour; available air per head and per hour, 1,726 cubic feet.	30,120	6	
5	32,160		32,160	5	
4	34,260		34,260	4	
3	36,300		36,300	3	
2	38,280		38,280	2	
1	40,320		40,320	1	422,880
		Blower.	Grand	total,	730,800

II. Berth-deck compartments abaft the engine- and firerooms; average difference in number of turns of anemometer between the inlets is thirty-eight per minute; decreasing in a direction from the blower.

Number inlets, port.	Cubic feet exhausted per hour.	Blower. ↑		Cubic feet exhausted per hour.	Number inlets, starboard.	Sum.
1	33,780	Dynamo.		33,780	1	
2	32,880			32,880	2	133,320
3	31,980	Marines' quarters, cubic air space, 9,827 feet, exhausted 30 times per hour; available air for breathing purposes per hour and per head, 4,875 cubic feet.		31,980	3	
4	31,080			31,080	4	
5	30,120			30,120	5	
6	29,220			29,220	6	
7	28,320			28,320	7	301,440
8	27,420	Chief petty officers' quarters, cubic air space, 10,200 feet, exhausted 25 times per hour; available air per head and per hour, 3,430 cubic feet.		27,420	8	
9	26,520			26,520	9	
10	25,800			25,800	10	
11	24,900			24,900	11	
12	24,000			24,000	12	257,280
13	23,100	Closets.	Pantry.	23,100	13	46,200
14	22,200	Stores.	Stores.	22,200	14	44,400
		Stern.		Grand	total,	782,640

The after berth-deck compartments of the *Prairie*, by reason of their relatively smaller cubic capacity, are much better ventilated than the forward compartments, both fans doing about the same amount of ventilating work. The blowers are run at night only.

The tests for the amount of atmospheric carbon dioxide, exhibited in Tables XI. and XII., were made according to the method of Fitz, as modified by Woodman and Richards and described in the preceding pages. In making these examinations, it was the intention to get, as nearly as that was possible under the circumstances, a true and absolutely fair estimate of the amount of carbon dioxide present in the atmosphere of the different parts of the ship. None of the dark places in which the air naturally stagnates, such as storerooms and holds, and where the carbon dioxide was found up to 22 to 40 parts in 10,000, were included in these observations. The tests shown in

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TABLE XI. CARBON-DIOXIDE* OBSERVATIONS. SERIES I., U. S. S. *Prairie*. HAMPTON ROADS, VA., DECEMBER 27TH TO 28TH. SHIP HEADING N.E. BY E. AND W.S.W. RESPECTIVELY. WIND N.E., STRENGTH 2. ATMOSPHERIC TEMPERATURE DURING PERIOD OF OBSERVATIONS VARIED FROM 39° TO 45° F. WEATHER PARTLY MISTY AND PARTLY CLOUDY.

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Time of day.	Sick-quarters.	Forward B. D.	Main B. D.	After B. D.	Warrant Off.	Forward G. D.	Remarks.
9 P.M	10.0	8.5	10.0	12.0	14.0	10.0	Hatches partly covered.
11:30 P.M.....	10.0	6.5	9.0	9.0	9.0	7.5	Blowers started at 12 midnight.
1 A.M	8.4	4.3	5.5	6.2	6.0	5.0	Blowers stopped at 5:30 A.M.
6 A.M	9.0	6.0	7.2	8.2	5.5	7.2	Gun-deck ports closed.
10:30 A.M	8.6	6.2	4.1	6.0	5.5	3.1	Gun-deck ports open.
11:30 A.M	7.5	3.5	3.0	4.0	4.0	3.0	Gun-deck ports open.
1 P.M	5.0	3.2	4.5	4.0	3.4	3.0	
7 P.M	7.5	4.0	10.0	4.2	4.6	14.0	Raining; hatch covers on; hammocks.
Averages.							
General	8.3	5.5	6.1	6.4	6.0	5.9	
Night	9.5	6.7	8.3	8.0	7.8	8.7	
Day	7.0	4.3	3.9	4.7	4.3	3.0	
Difference ...	2.5	2.4	4.4	3.3	3.5	5.7	Difference between night and day, averages.

* Numbers in columns indicate amount of CO_2 contained in 10,000 parts of air.

TABLE XII.—CARBON-DIOXIDE OBSERVATIONS. SERIES II., U. S. S. *Prairie*. JANUARY 4TH TO 5TH. AT SEA BETWEEN LATITUDES 16° 13′ 30″ AND 15° 08′ N. AND LONGITUDES 64° 25′ AND 63° 40′ W. COURSE E. BY S. STRENGTH OF WIND 4. ATMOSPHERIC TEMPERATURE VARIED FROM 78° TO 81° F. SKY PARTLY BLUE, PARTLY CLOUDY.

Time of day.	Sick-quarters.	B. D. main.	B. D. aft C. P. O.	Warrant Off.	G. D. aft.	G. D. forward.	Remarks.
9 P.M.........	8.8	8.8	8.8	5.6	5.6	5.6	Wind forward, weather clear.
11 P.M	4.1	4.1	5.0	3.7	3.7	3.6	Wind athwartship; ports open.
1:30-2:30 A.M.	5.8	6.2	6.3	4.3	4.0	3.9	Blowers running half speed.
11 A.M........	4.3	7.0	8.2	5.0	3.7	3.6	No one occupying sick-quarters.
1:30-2:30 P.M.	4.8	4.8	5.5	4.4	3.6	3.6	All gun-deck ports open.
5 P.M	5.0	5.2	5.8	4.2	4.0	4.6	All gun-deck ports open.
Averages.							
General	5.5	6.0	6.6	4.8	4.2	4.2	Influence of open gun-deck ports shown; tends to lessen the difference between the night and day averages.
Night	6.2	6.5	6.5	4.4	4.4	4.4	
Day	3.7	5.6	6.5	4.4	3.7	3.9	
Difference ...	2.5	.9	.0	0.0	.7	.5	

the tables represent the compartments that are included in the general circulation of the area ventilated by the blowers. The results show what the carbon-dioxide content of the ship's atmosphere available for breathing purposes may be expected to be, when the ship is at sea and is sailing under the *most favorable* conditions of weather and climate. The influence of hatches, whether open or closed, of gunports, of the direction of the winds and of the blowers upon the carbonic-acid content, may be seen in the tables and studied in connection with the column of remarks.

As the blowers operate on the vacuum principle, it must, of course, be expected that the air, when it reaches the breather, is at its worst. The differences between the night and day averages in series I. were rather large, as compared with those shown in series II. The colder climate at Hampton Roads made it necessary for the comfort of the men sleeping below to keep the hatches covered and the ports closed. Under such conditions the vacuum system of ventilation shows its weak points. The fans arranged in accordance with the plenum principle would easily remedy these defects and convert a very faulty system of ventilation into an efficient one.

In concluding the chapter on ventilation we would emphasize two leading and important factors influencing a ship's ventilation, namely: (1) The plenum system of ventilation for ship's purposes is unqualifiedly recommended. (2) That the high atmospheric temperatures and humidities prevailing in warm climates, together with the prominent part played by physical heat regulation on the part of the men, make it possible that the air in ships may be renewed from fifteen to twenty times per hour, without danger from draughts.

II. WATER.

Every living organism, every single microscopic cell of this organism, has its normal amount of water under which alone it can perform its proper function, and the slightest departure from this normal percentage amount of water peculiar to its composition begins to initiate the series of changes that can have but one ending, namely, the death of the organism. The human body has in its composition sixty-five per cent. of water, of which it loses 2,500 gm. daily. As it receives from 500 to 800 gm. in the food, the remaining loss must be made good by drink. In experimental animals death inevitably ensues whenever the loss of water amounts to from twenty to twenty-five per cent. Those of us who live in temperate climates, in which water is found everywhere in sufficient quantity to supply our daily needs, hardly ever think of the possibility of dying of thirst; but those who live in the tropics know well how pressing and dangerous thirst can become as compared to hunger. As a means of personal cleanliness, it has become well recognized that it is economy to be lavish with the water supply, especially among soldiers and sailors, who must be so trained that cleanliness of person becomes to them a necessity and a habit.

With regard to the water-supply of ships, the last fifty years have brought about great changes. The general introduction of steam has made not only the voyages shorter, but it has been the means of making ships almost entirely independent of the shore as regards their water-supply. In times of wooden ships and long passages across the seas under sail alone, the water question was one of most serious concern to all seafaring men. Besides this, the generally prevalent lack of knowledge at that time of the importance of cleanliness in collecting, storing, and distributing the water on board ship was the cause of untold misery and long suffering, due to poor water and to the separation from a base of supply. The water was carelessly collected and then stored in tanks or barrels down in the dark holds of the ship. Often neither the water nor the barrels were examined, and consequently they left much to be desired as regards cleanliness. After a time the water began to emit a disagreeable odor, the essence of which was sulphureted hydrogen. This gas was produced by the decomposition of the sulphates in the water. In the course of time this gas was reoxidized and the disagreeable odor disappeared. This periodical reduction of the sulphates and oxidation of sulphureted hydrogen recurred several times during a voyage, and it was a common saying among sailors that the water had to putrefy three times before it became potable.

It certainly was true that the water did cease fermenting after a time, and consequently it was often better at the end of a voyage than at the beginning. We now are perfectly well acquainted with the causes of this fermentation and make use of this very property of water to purify it before filtration. It is the septic-tank method which has been found so effective in removing a large percentage amount of germs and fermentable organic matter, and which makes subsequent sand filtration so much more effective in producing a pure and potable water than it would be without it.

Although most of the naval vessels are supplied with distillers for the production of drinking-water from sea-water, it cannot be said that all ships of the navy are absolutely independent of water supplies from natural

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sources on shore. Circumstances arise on every naval vessel, and arise often, under which the water tanks are filled with water coming from shore. Naval sanitarians can, therefore, not yet afford entirely to disregard the hygiene of water supplies as found in nature.

The question of the water supply to naval vessels would, accordingwww.libtool.com.cn the supply from natural sources, and (2) the supply through distillation from sea water.

1. Supply from Nature's Reservoirs. (*a*) *Rain Water.*—The quantity of water which a cubic kilometre of air is able to take up, when saturated at a temperature of 15° C. (60° F.), is no less than 15,990,000 litres. In the tropics the atmosphere covering a square mile of surface, at a temperature of 30° C. (85° F.), takes up two and a half millions of cubic metres of water. This water is driven by the wind to the different parts of the world, and returns to the earth in the form of rain, snow, or hail. The water, when it evaporates, is pure, but when it returns to the earth in the form of meteoric water it shows various forms of contamination, having absorbed not only the gases of the air, but carrying down also more substantial impurities with it. It is easily seen that rain water must differ in character with the quality of the atmosphere through which it falls; it must differ with the season of the year, and whether it falls in town or country. As rain purifies the air by taking down dust and smoke, it must become purer the later it is collected.

Of the water which is thus returned to the earth by precipitation, a small portion evaporates again immediately; the greater portion sinks to certain depths from the surface, becoming what is known as surface water; while still another portion runs off into rivers, brooks, and lakes, and the rest returns by way of the rivers and streams to the great sea whence it came.

In its passage through the atmosphere, it takes up, in the first place, a certain volume of air. The oxygen of the air being more easily soluble in water than is nitrogen, the air dissolved in water is richer in oxygen than the atmospheric air. Besides oxygen, rain water absorbs carbon dioxide, ammonia, and nitric acid. The farther above the surface of the earth rain water is collected, the more nitric acid it contains; and the nearer to the earth's surface it is collected, the more ammonia is found in it. The reason for this is that the ammonia emanating from the soil is gradually oxidized into nitric acid as it rises into the higher regions of the atmosphere. Thus 1 litre of water contains: Ammonia at 7 metres, 5.94 mgm.; at 47 metres, 2 mgm. Nitric acid at 7 metres, 5.68 mgm.; at 47 metres 7.36 mgm. Rain water contains from seven thousand to twenty thousand bacteria in 1 c.c., which explains why it undergoes rapid fermentation on standing. Bujwid, who examined a hailstone 6 cm. long and 3 cm. thick, found twenty-one thousand bacteria in 1 c.c. of melted ice. Fontin, at St. Petersburg, discovered in a hailstone a coccus that proved pathogenic to mice.

Schmeich, in examining some ice from high mountains, in high latitudes, where organic life is not abundant, found but two microbes in a cubic centimetre of ice from Iostedlasbrü in Norway. Rain water is a soft water and very good for washing purposes; when used for drinking purposes, the first portions of it should always be rejected.

(*b*) *Surface Water.*—The term surface water is applied to the water contained in rivers, brooks, and ponds, into which the earth's surface is drained, especially after heavy rains. The composition of such water is influenced by local conditions, depending partly on the geological formation of the place, partly upon the character and amount of sewage washed into it and furnished by the towns in the vicinity. Epidemics of typhoid and cholera, traceable to infected river water, continue to recur with frequency, and these would be still more frequent than they are, were it not for the self-purification of river water and the nitrifying action of a certain class of saprophytic water bacteria. Such water, therefore, needs a thorough chemical and bacteriological examination before being taken on board, unless it comes from a place where sand filtration is used, and where all sewage is thus filtered before it is allowed to pass into the river, brook, or lake.

(*c*) *Ground Water.*—That portion of rain water which neither evaporates immediately nor flows off into rivers and brooks, but which gradually drizzles down into the deeper layers of the soil, until it strikes an impermeable layer of clay, upon which it accumulates, is known as ground water. As such it may feed a neighboring well or find its way to the surface again in the form of a spring. Borings often reveal the existence of several such subsoil lakes superimposed. The water, while drizzling through the permeable layers, gives up suspended matters, but takes up soluble ones instead, and hence its composition is essentially different from that of either rain or surface water. All those particulate impurities which rain water washes down from the atmosphere it loses in the uppermost layers of the permeable soil and before it becomes ground water; the organic matters are destroyed by oxidation, furnishing carbonic and nitric acids. Ground water, when obtained at a depth of 20 metres below the surface and well protected, has an agreeable taste and should possess a temperature representing the mean annual temperature of the place, which temperature is accepted as the most favorable temperature which a good drinking-water should possess. All the superfluous ground water finally flows off into subterranean rivers and lakes, which in turn are drained into the all-engulfing sea to start on a new round in its circulation. Such water is probably the best that can be obtained from natural sources.

In the royal navy of England and in the navy of the United States, the rule is that no water is to be taken or used on board until it has been examined and passed by the surgeon. In home ports, the water is either directly pumped on board from the city mains or it comes alongside the ship in a water boat. The latter method is usually bad and the water is often found contaminated, owing to leaky bottoms and leaky decks. No wooden water barge should be allowed to bring drinking-water on board a ship. In many foreign ports, recourse is had to fetching the water from shore by clearing the ship's boats of all removable gear and then filling them with water directly from the main; finally towing the boats back to the ship and pumping the water on board. All these methods are objectionable, because no boat is absolutely water-tight and sea water is bound to leak into it.

A time may come when it becomes necessary to take a battalion of men on shore and quarter them in a town for some time. Under such circumstances experience has shown the following rules to be worthy of adoption: (1) Let the men take their water from the same places from which the inhabitants draw theirs; these places should be plotted down by the officers arranging for quarters for the men. In case the water supply of the town is not free from suspicion, avoid taking water from wells in sloping streets and from those which are located in the neighborhood of poor dwellings, factories, dungheaps, and avoid likewise, if you can, water flowing through the town; take it, if possible, from a point above the town. (2) Make provision against the contamination of the town water by the men themselves, who should be instructed in how best to avoid dangers from such a cause. (3) Mark the good wells from the bad ones. (4) Wells that have been out of use for some time must first be pumped out before they can be used again. (5) Contaminated wells must be placed under guard. (6) The too frequent and too copious use of a well is to be avoided because large draughts would cause a too rapid flow of the neighboring ground water in the direction of the well, through the subsoil, which might seriously interfere with the filtering capacity of such a soil, resulting in drawing impurities in with it. (7) In the case of wells, small rivers, and brooks, dams can be built in several places, of which the highest may be used for drinking purposes for the men, the lower for the animals and for cleansing purposes. (8) In case of rivers and shallow lakes, small bridges and waterways

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should be constructed so as to enable the men to get their water farther away from the shore and prevent them from stirring up the sediment at the bottom, which may harbor pathogenic germs. (9) In case the water has been rendered turbid by heavy rains, small wells may be sunk near the river and the filtering action of the soil or sand be taken advantage of, which should be protected and covered over by boards. (10) If the soil permits, tubular wells may be bored.

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In France, Pasteur filters have been most generally introduced into all barracks. The water runs through these filters under a pressure of 10 metres, and, in places where this pressure cannot be obtained by natural means, it is produced by artificial means.

The great danger to troops is, as we all know, typhoid fever. No army seems to escape a certain amount of it. The typhoid bacillus respects neither race nor climate and is practically ubiquitous. Extensive experiments are now under way in England and other parts of Europe on the subject of the possible chances of vaccinating soldiers against typhoid, cholera, plague, and other diseases. The mortality from typhoid among the English troops in South Africa has been so great as to induce some of the best English bacteriologists to engage in serious experimentation in that direction.

For the purpose of sterilizing a suspected water in the field, in the absence of means for boiling large quantities of it, the method of Schumburg is the best. He uses bromine to render the water germ-free and removes the bromine afterward by the addition of ammonia. The apparatus comes conveniently packed in a box with the chemicals ready for use, and in quantities weighed out so as to sterilize any given amount of water in five minutes.

2. Supply Through Distillation from Sea Water.—If rivers, brooks, and lakes are the drainage basins into which flows the surface water of certain small circumscribed geographical areas, the great oceans may be said to receive the combined drainage of all the continents of the globe. From a chemical viewpoint, perhaps one of the principal differences between ground water and sea water is found in the large percentage of salts that are contained in the latter. These salts perform an important function which it is well to keep in mind. They assist in the penetration of solar heat, which otherwise would act on the surface only; salts also retard evaporation. Sea water teems with living organisms which, but for the preserving action of the brine, would die, and the products of their decomposition would render a life at sea practically unbearable if not altogether impossible. The salts in sea water also are the efficient causes of some of its circulating currents. Those, for instance, from the Mediterranean into the Atlantic, according to Maury, owe their main strength to this agency. The freezing point of sea water is put down as 27.2° F. The specific gravities, according to location, are as follows: (1) North Atlantic, 1.02676; (2) South Atlantic, 1.02664; (3) North Pacific, 1.02658; (4) South Pacific, 1.02548.

The temperature of the sea water is higher than that of the ground water of the same region. It varies, of course, with the latitude and the depth, and is greatly influenced by the circulation of the various currents coming from different localities. The Atlantic is the coldest, the Indian Ocean the warmest.

Table XIII.

	Total solids.	Organic carbon.	Organic nitrogen.	Ammonia.	Nitrogen as nitrites and nitrates.	Total combined nitrogen.	Chlorine.	Hardness. Total.	Hardness. Fixed.
Hastings, two miles from shore	3.955	0.291	0.135	0.005	0.013	0.152	2.050	698	646
Gulf of Paria	....	....	....	.003	.027	....	1.350	580	

The composition of sea water has been found to vary somewhat in different places and at different depths. In the vicinity of the poles, the percentage amount of salts is somewhat less than at the equator, while in certain parts of the Mediterranean more salt is found than in the great oceans. The average composition of sea water is given in the preceding table from Notter, to which has been added an incomplete and partial analysis made of the water in the Gulf of Paria.

According to Hales, it was Jean Antoine Gadesden who, as early as 1516, proposed distillation as a means of rendering sea water potable, and in 1560 Sebastien de la Pallière, of Sicily, proposed to the Duke of Moedina Coeli, while the latter was besieged by the Turks, in a fortress in which the cisterns had run dry, to distil sea water. He succeeded in producing thirty-five barrels of potable water in twenty-four hours. In 1717 Gauthier made an unsuccessful attempt to introduce distillers on board ship. After him, Lind proposed to utilize the steam coming from cooking utensils and condense it by leading it through cold-water tanks. Three years later, Poissonier designed a distiller which was similar to that of Lind, but which again failed of adoption on account of its taking up too much room on board! Finally Irving designed a distiller for which he received a pension of £500 from the English Government. All this shows how much the necessity for an apparatus of this sort was felt. A rather long time, however, had yet to pass before distilling became as general and practicable as it is now. There is perhaps no seagoing man-of-war at the present day that is not provided with one or more of these distillers, of which there are a large number of patterns.

In the French navy the "Cousin," modified by Mouraille & Co., and the "Normandy," which latter has the evaporator and condenser united into one apparatus, are generally in use. A special refrigerator by Perroy and a condensor by Fraser are also in common use. In the English navy the "Normandy," "Kirkaldy and Caird," and "Raynor" are employed. In the Austrian navy the French distillers have been adopted. The United States Naval Standard Evaporator is made of several sizes, the largest of which possesses a productive capacity of ten thousand gallons of distilled water per diem. The general design is identical for all sizes. The apparatus consists of two parts, namely: (1) the evaporator and (2) the distiller, sometimes called the condenser. The evaporator consists in a hollow cylindrical shell, made of steel and placed horizontally. The lower half of this cylinder is partially or loosely occupied by tubes running lengthwise, and fixed in their position at either end to a pair of plates which permit of the tubes being removed for scaling in their entirety. The tubes are connected with the main boilers, from which steam is run into them generally at a pressure not exceeding forty pounds. The sea water intended for distillation fills that portion of the lower half of the cylinder which is outside the tubes, but not quite reaching the upper level of the highest tubes. It is indeed the intention that the tubes shall not be completely immersed in the salt water, the upper level of which is, on the contrary, maintained considerably below the top of the tubes. The customary pressure within the shell is about ten pounds. By the use of the valves, the density of the sea water is generally maintained at $\frac{1}{32}$. The tubes of the distiller are made of tinned copper or brass; the joints are soldered. Thus we see that the evaporation of the sea water is caused by the heat imparted to it through the steam in the pipes which the sea water surrounds. The steam itself does not mix with the sea water. The distiller or condenser is a cylinder, made of brass or iron in various sizes, placed vertically and fitted with straight tubes for circulating cooling water, which is made to enter at the bottom and discharge at the top. The steam to be condensed passes through the condenser in the inverse sense.

On vessels which are equipped with very large plants for distilling water, the apparatus is arranged differently from the above. The work of distilling is divided into two or three stages and the working efficiency of the plant is thereby correspondingly increased. Under this

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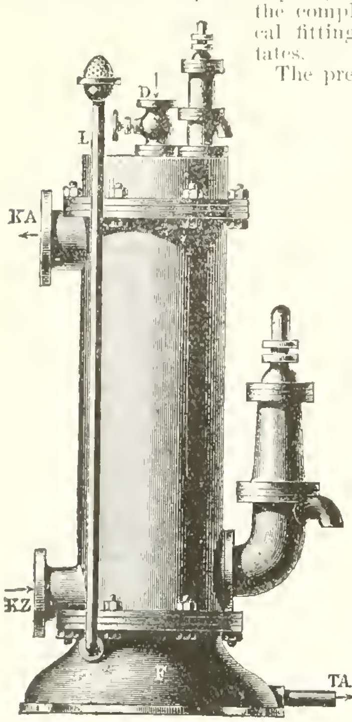
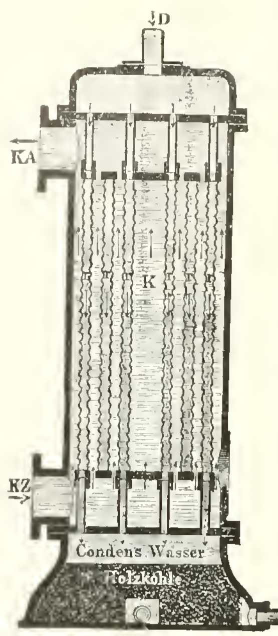
system, steam from the boilers is used to evaporate the water in the first set of evaporators; this evaporated steam is used to heat and evaporate the water contained in the second set of evaporators, and this in turn is made to evaporate the water contained in a third set. This last steam is finally condensed to water in a distiller of the above description. This system more than doubles the actual thermal efficiency of the distilling apparatus, but it is not installed except in very large ships, on account of the complications in mechanical fittings which it necessitates.



A.



B.

FIG. 3508.—(From Kirchner.) The Transatlantic liners of the North German Lloyd are equipped with distillers of the "Acme" patent. These were preferred on account of their combining great efficacy, small space and ease with which they can be handled and worked. The condenser is shown in the adjoining two figures A and B. The steam generated in an auxiliary boiler is made to enter, at D, into the condenser, which consists of a vertical cylinder, 110 cm. long and 36 cm. in diameter. The steam now passes into a number of tubes, made of thin copper r r, outside of which a constant and rapid stream of cold sea water passes from below upward, entering at KZ and leaving the cooler at KA. The distilled water, at the lower end of the condenser, enters a charcoal filter, F, where it is purified, and, at the same time, aërated by the air coming in through the tube L, with which it is here in communication. The water, both filtered and aërated, is finally collected at TA. The apparatus furnishes 18 cubic metres of good potable water in twenty-four hours. The warships of the imperial German navy are all equipped with distillers made on the same principle as those of the "Acme" patent.

The precautions usually observed are as follows: (1) The plant is operated only when pure sea water is obtainable. (2) For drinking-water, the plant is not operated to its full capacity, in order to reduce priming or carrying salt water directly over into the distillate. (3) Tests of the complete plant are made daily to insure tightness of all the joints. (4) The water level in the evaporators is kept low. (5) When the ship is under way and rolling heavily, the plant is worked at its lowest capacity. (6) The pressure of the cooling water in the distiller is limited by departmental order to thirty pounds, which is to minimize the danger of salt water leaking into the distillate. (7) Tests of the distillate are made every fifteen minutes.

The process of distillation, however, always involves an expense which sometimes may be considerably greater than the price at which good drinking-water can be bought on shore, and then it becomes the duty of commanders of vessels to secure such water when of good quality and whenever practicable. Besides, the process of distilling is not always faultless and the product occasionally needs looking into.

Water Distilled from Sea Water.—Although the water obtained from sea water by distillation may not be absolutely pure, it has nevertheless stood the test of many years' practical experience, and hence must be considered to be harmless. The mineral salts, contained in sea water, sodium and magnesium chloride, lime, alkalies, acids, bromine, iodine, etc., especially magnesium chloride, in decomposing during the process of distillation, vitiate the product to a certain degree. In order to obviate these objectionable features, Rubner ("Lehrbuch d. Hygiene") proposes the following preliminary treatment of salt water before distilling: The salt water is to be mixed with milk of lime in special tanks and kept, being constantly stirred up, for fifteen minutes; it is then heated up to a temperature of about 60° C. by steam. All organic matter is thus destroyed and coagulated. Magnesium chloride is decomposed by the lime and the magnesia is precipitated. After all has settled the water is siphoned off and distilled. This preliminary treatment, if it could be carried out practically, would no doubt result in a more uniform product of distillation; it would, however, necessitate a reconstruction of all the evaporators and condensers at present in use.

That sea water under the present system of distillation does not furnish a uniformly pure product may be seen from Table XIV., which represents an almost daily though partial analysis of such water, continued for nearly a month. Free ammonia was determined with Nessler's reagent; the nitrites were qualitatively determined with the sulphanilic acid and naphthylamine test; the nitrates with brucine and sulphuric acid; chlorine with a volumetric solution of silver nitrate, potassium chromate as indicator; hardness with standard soap solution; and the organic matter, represented in milligrams of oxygen, was determined by a standard solution of potassium permanganate. All these solutions were made on board ship and according to the methods given in Harrington's excellent manual of "Practical Hygiene." The analyses show that the water produced in our distillers always contains quite appreciable quantities of chlorine, lime, and magnesium salts (represented by hardness), and also organic matter; less frequently ammonia, and still less frequently nitrites and nitrates. All these, in the above quantities, must be considered harmless. With few exceptions the water was free from odor and perfectly colorless.

An important point, to which it is necessary to call attention in connection with the chemical composition of water distilled on board ship, is the hygienic significance of it. It will be seen at once that we must judge this from a standard entirely different from the one in accordance with which we would judge a surface or a ground water. Ammonia, nitrites, nitrates, as also chlorides, when found in a properly collected sample of river or well water, would justly arouse great suspicion, while the same chemical compounds in the water distilled from sea water arouse no such suspicion. These stand simply for a certain amount of nitrogen in different stages of oxidation and are otherwise perfectly harmless in the quantities in which they appear. No living organism, neither an animal nor a vegetable parasite, capable of producing disease could possibly survive such a process of distillation.

The following table is interesting from quite another point of view; it shows that, while a small quantity of organic matter is constantly present in the distillate, ammonia, nitrates, and nitrites are almost as constantly absent. This would indicate an almost absolute absence

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of all oxidation during distillation. When, however, we consider that the salt water, from which our distillate is obtained, does not come directly from the sea, but has already been used as condense water and gone through the distiller in which it has been heated up to a high temperature, then this is easily explained. By the time such water arrives in the evaporator as feed water, all the air has been driven out.

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TABLE XIV.—TABULATED RESULTS OF TWENTY-TWO ANALYSES OF WATER DISTILLED FROM SALT WATER BY THE UNITED STATES STANDARD EVAPORATOR.

U. S. S. *Prairie*, Gulf of Paria, January, 1902.	Free ammonia.	Nitrites.	Nitrates.	Chlorine, in milligrams per litre.	Hardness, in milligrams calcium chloride.	Organic matter, represented in milligrams of oxygen per litre.
3	+	0	0	220	10.0	0.0
4	0	0	0	30	5.0	2.0
5	+	0	0	20	4.0	3.5
6	+ +	0	0	10	6.0	1.7
7	+	0	0	50	11.0	3.6
8	+ +	0	0	20	16.0	2.0
9	+	0	0	24	7.0	3.2
10	0	0	0	130	13.0	6.5
13	+	0	0	8	4.0	2.0
14	+	0	0	12	4.0	3.0
16	+	0	0	20	5.5	3.0
17	+	0	0	20	6.0	3.0
18	+ +	+ +	+	160	10.0	4.0
20	0	0	0	30	4.5	4.5
21	0	0	0	30	5.0	5.0
22	0	0	0	20	5.0	3.0
23	0	+ +	0	90	10.0	2.5
25	0	0	0	12	7.0	2.0
26	0	0	0	20	8.0	3.0
27	0	0	0	32	6.0	2.0
28	0	0	0	80	8.0	120.0
30	0	0	0	32	5.0	3.0

The Storage and Distribution of Water on Board.—If, notwithstanding the fact that, as we have seen, no reasonable objections can be entertained from a sanitary point of view against the water distilled on board ship, complaints, and very pressing ones, are still often heard against the drinking-water supplied to officers and men, what are they due to? In almost every instance to unclean tanks and faulty pipe connections, as perhaps the following instance from my own experience will best serve to illustrate. It was not many days after our ship had been placed in commission and her officers and men had begun to live on board, that the presumably pure and distilled water was found absolutely non-potable and everybody refused to drink of it. The water was undoubtedly and indescribably bad. A sample of it was immediately collected from one of the spigots in the galley, under the usual precautions, and analyzed, with the following results:

November 26th, 1901, sample of water supposedly distilled:

1. *Color.*—Distinctly yellowish, very turbid, depositing on standing a brownish flocculent sediment.
2. *Odor.*—On being heated in a flask and shaken, a very perceptible, strong, musty odor is present.
3. *Residue.*—On evaporation grayish-white, turning black on being heated to redness.
4. *Free* as well as *albuminoid* ammonia present in large amounts, forming brownish precipitate.
5. *Nitrites.*—Positive reactions with the starch iodine test as well as with the sulphanilic acid and naphthylamine test.
6. *Chlorine.*—NaCl, 2.5 gm. per litre.
7. *Hardness.*—Equal to ninety parts of calcium chloride in ten thousand parts.
8. *Nitrates.*—Positive reaction with brucine.
9. *Lead.*—Grayish discoloration with hydrogen sulphide and acetic acid.
10. *Organic Matter.*—In abundance and not determined quantitatively.

Based upon the results of the above analysis, the probable source of contamination was put down as being dirty salt water from the harbor in which the ship was lying; also improperly cleaned tanks and pipes, as was made apparent by the water giving reactions for lead. When the result of this analysis and the inevitable conclusions it led to were communicated to the commanding officer, an immediate inspection of the entire water-supply system of the ship was made, and the source of the contamination quickly and decidedly traced to a very faulty system of pipe connection existing between the sweet and the salt water reservoirs on board. Owing to this connection, it was impossible to draw either sweet or salt water from any of the spigots without getting a mixture of both in varying proportions.

The bacteriological examination of a sample of this water, made at the Bacteriological Laboratory of the Harvard University College of Medicine, showed the presence of liquefying bacteria in large numbers, while that of a sample of water collected from the distiller proved absolutely sterile.

A more common source of lead in ship's drinking-water is found in the pipe joints, especially in newly made ones, of which several instances have recently come to our notice. The red lead used for the purpose of making joints water-tight should be forbidden and asbestos used instead, in all pipes used for water distribution. Early in the history of distilling water on board ship and the laying of pipes for its convenient distribution, A. Le Fèvre, of the French navy, discovered lead in the water; and quite recently Dr. Cautellauve (1891–92), also of the French navy, has again reported several cases of lead poisoning from the same cause, during his cruise in the East on board the *Troude*.

Time and space do not permit here to go into a detailed description of the various methods of modern water analysis. Nor is it necessary to mention the characters that a good drinking-water should possess. These are matters of general hygiene and can easily be found in every work on that subject. There is no doubt that the naval surgeon, equipped with a practical knowledge of the laboratory methods used in water analysis, will be well able to make such a selection of apparatus and reagents, before going to sea, as will enable him to make a very satisfactory water analysis, wherever and whenever called upon to do so. There may be some difficulties as regards accommodations on board some ships, but there are none that cannot be overcome. His difficulties certainly cannot be greater than are those of the army surgeon in the field.

The water-supply systems and the chemical composition of the water supplied by them, of every one of the islands near our coast, including all the Antilles, should be systematically investigated. The composition of every important well in common use and out of use on every island should be known, recorded, and plotted on geographical maps for immediate reference. With some encouragement and the necessary means and apparatus, this work could easily be done by naval medical officers.

III. THE RATION.

FOODS AND NUTRITION IN GENERAL.—While it cannot be expected, in the limited space allotted to this paper, that we enter at all into the special physiology of nutrition or into the chemistry of foods, it is, on the other hand, absolutely necessary and unavoidable briefly to touch upon those of the leading principles and methods according to which the nutritive values of those of the food substances in common use on board all sea-going vessels and included in the navy ration, are ordinarily determined.

Daily experience and observation have sufficiently acquainted us with the fact that the physical part of our existence consists in a perpetual and constant effort on the part of the living organism to adapt itself to an ever-changing series of outside conditions. In this supreme effort the organism uses up constantly part of its own organized substance, expending it as, or converting it

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into, mechanical work and heat. If the body weight is to be maintained and the life of the organism is to continue successful in the struggle, this expenditure in organized substance must be made good. The products of wear and tear incident to the process must also be promptly removed.

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Since the source of the energy thus expended by a living animal organism can be restored only through the introduction and the assimilation of certain definite quantities of organic and inorganic food substances, their supply, preservation, preparation, digestion, assimilation, and dissimilation have been among the principal subjects of study and investigation on the part of physiologists. Since, moreover, the supply of these substances and their assimilation must vary directly with the energy expended by the organism in a given time and under varying conditions of environment, a balance between supply and expenditure must be maintained and the influence upon it of different conditions be known, as well as the relative value of the food itself. We must be able to measure the energy expended and to ascertain its food equivalent, if we are to make no mistake in our provisions.

Since, finally, it is of coequal importance to the life of the organism that the products of wear and tear should be as promptly and as completely eliminated as new material is appropriated, the maximum working efficiency of the living machine is conditioned not only by a proper balance between supply and demand, in accordance with different environmental and subjective conditions, but is, moreover, determined by the individual capacity for maintaining a high balance between assimilative and dissimilative functions. The latter determine the difference between two individuals and between different races of mankind. This functional capacity on the part of both the individual and the race can be developed and increased through systematic training.

According to Verworn, tissue metamorphosis (Stoffwechsel) comprises a long series of complicated chemical processes, beginning with the entry of nutritive substances into the living cells of the body and ending with their exit. These processes follow each other like the links of an unbroken chain, and might not inaptly be represented by a binomial curve. In this curve the ascending arm would then represent all those processes which lead to the repair of living matter; the top of the curve, those highly complicated processes leading to the synthesis of protoplasm itself; and the descending arm, the processes leading to, and finally ending in, the decomposition of living matter into the simplest end-products (urea, carbonic acid, water, etc.). With the beginning and the ending of the highly complicated process and the materials found at these two points we are fairly well acquainted; the rest is as yet wrapped in darkness.

Foods, in the physiological sense, are classified into nitrogenous, also called proteids, and non-nitrogenous, in which are included the fats and carbohydrates. While fats and carbohydrates may, to a certain extent, be substituted for one another, non-nitrogenous substances can never be made to take the place of proteids in nutrition. The latter must be regarded as by far the most important food substances and as absolutely indispensable parts of a complete and perfect diet.

The *proteids* form the chief components of the cells in the tissues of all plants as well as animals, and, according to the researches of Voit and Pettenkofer the absorption and ozonization of oxygen and its effect upon all the chemical processes within the cells, are entirely under the direct control of the nitrogenous part of their tissues. Without the participation of the nitrogenous tissues, neither oxidation nor any manifestation of energy is possible. Mechanical motion and heat may be evolved through the oxidation of both fats and carbohydrates, but the initiative to the manifestations of these must be given by the tissues containing nitrogen. Proteids have, moreover, been found to produce fats and possibly also carbohydrates under certain conditions.

Fats are chemical compounds consisting of a trivalent alcohol, glycerin, and three molecules of a monobasic acid, chiefly stearic acid, palmitic acid, and oleic acid in different proportions. They all contain hydrogen and oxygen as well as carbon, but no nitrogen, their general formula being represented by $C_{16}H_{18}O$. The formula suggests that the fats need oxygen in large quantities for their complete conversion into water and carbon dioxide.

The *carbohydrates* comprise the sugars and the starches which are for the most part of vegetable origin. It has been shown that the formation of starch granules in the green plant goes on hand-in-hand with the decomposition of carbon dioxide by the chlorophyl granules, under the influence of sunlight. On the hypothesis of von Baeyer, the carbon (C) of the carbon dioxide, the moment it is set free, combines with the water (H_2O), taken up by the roots of the plant, and forms one molecule of formaldehyde (CH_2O). Six of these molecules of formaldehyde now link together by polymerization and form one molecule of a monosaccharid ($C_6H_{12}O_6$) and through further polymerization of the monosaccharids thus formed, and with the loss of one molecule of water by each, starch finally results ($C_6H_{10}O_5$). This hypothesis has met with the most general acceptance. In the group of the carbohydrates also belong cellulose and pectin. Cellulose forms the solid skeleton and, when boiled with dilute sulphuric acid, it gives dextrin and glucose. Pectin is the vegetable jelly found in various ripe fruits.

All living organisms must, moreover, have a certain amount of *oxygen*, without which life is impossible; and, lastly, *water* and *salts*. Indispensable are sodium, potassium, magnesium, calcium, and iron, and their combinations with phosphoric, sulphuric, carbonic, and hydrochloric acids.

Food Value.—The food value of an eatable substance is generally expressed by the number of calories or heat units which 1 gm. or any other definite quantity of it will develop, when completely burned in a calorimeter. The amount of heat that is developed during the combustion of, for instance, 1 gm. of substance in a calorimeter is exactly the same as that which is produced when 1 gm. of the same substance is completely oxidized within the body. In a living organism about thirty per cent. of this value can be put out in the form of mechanical work, while the remainder passes off in the form of heat. We know, thanks to the researches of Voit, that an average adult laborer, performing his daily work, puts out in mechanical work and heat the equivalent of about three thousand calories. In order, therefore, that the man shall not lose in weight, his daily diet must be such as to balance his loss and have a combined caloric value of at least three thousand units. If we, furthermore, will take into calculation that about four hundred of the units at least must come from proteids, five hundred from fats, and the remainder from carbohydrates, we have the most necessary data for the calculation of the man's diet. Thanks to the labors of Voit and Rubner and their numerous pupils, these determinations have been greatly simplified in recent years.

Outside conditions, personal and racial habits, climate, age, and sex may alter the relative proportions of proteids, fats, and carbohydrates in a certain diet, but the above proportions must stand as answering to the average requirements of an adult workingman in a temperate climate. In calculating the dietary value of a ration, we must also allow for an unavoidable loss in the preparation of the different parts of it. In meats, a loss of twenty per cent. of the raw material is generally allowed for bones; with salted herrings, thirty-seven per cent.; pickled herring, twenty-nine per cent.; potatoes boiled and then peeled, seven per cent.; potatoes peeled raw, thirty per cent.; if eggs be used, ten per cent. in weight is deducted for the shell, etc. Another source of loss from the gross weight is in the different degrees of digestibility of foods, for which allowance must also be made. As a general rule, animal foods are much more completely digested than foods of vegetable origin. Rubner has shown that proteids from meat and milk disappear almost entirely, while those from bread and espe-

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TABLE XV.

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Name.	In 100 Parts are Contained:					Nutrient Unit in:			Sum Nutrient Units in:	
	Proteids.	Fats.	Carbo-hydrates.	Ash.	Cellul.	Proteids.	Fats.	Carbo-hydrates.	100 gm.	1 ounce.
Beef, very fat	17.0	29.5	....	1.0	....	59.5	259.5	....	319.0	95.0
Beef, medium fat	21.0	5.5	....	1.0	....	73.5	48.4	....	122.0	37.0
Beef, lean	20.5	1.5	....	1.0	....	71.7	13.2	....	85.0	25.0
Mutton, very fat	16.5	29.0	....	1.0	....	57.7	255.2	....	313.0	91.0
Mutton, medium	17.0	6.0	....	1.0	....	59.5	52.8	....	112.0	34.0
Mutton, average	17.0	18.0	....	1.0	....	59.5	158.4	....	218.0	65.0
Pork, fat	14.5	37.5	....	1.0	....	50.7	330.0	....	380.7	114.0
Pork, lean	20.5	7.0	....	1.0	....	71.7	61.6	....	133.3	40.0
Pork, grease from	.5	98.2	....	....	....	1.7	864.2	....	865.9	260.0
Beef tallow	.5	98.2	....	....	....	1.7	864.2	....	865.9	260.0
Veal, fat	19.2	7.2	....	.8	....	67.2	63.4	....	103.6	31.0
Veal, lean	20.2	6.8	....	1.1	....	60.9	59.9	....	120.8	36.4
Poultry, medium	21.0	2.0	....	1.0	....	73.5	17.6	....	91.1	27.3
Horseflesh	21.7	2.6	....	1.1	....	76.0	22.9	....	98.9	29.7
Meat powder	69.5	5.8	....	1.1	....	243.2	51.4	....	294.6	88.4
Carne secca	51.7	13.4	....	....	....	181.0	117.9	....	298.9	89.7
Carne secca, boiled	34.5	8.9	....	....	....	121.0	78.3	....	199.3	59.8
Bacon	9.5	76.0	....	5.4	....	33.2	668.8	....	702.0	210.6
Bacon, roasted	1.7	94.5	....	5.4	....	6.0	831.6	....	837.6	251.3
American canned meat	29.0	11.5	....	4.0	....	101.5	101.2	....	202.7	60.7
Chicago corned beef	23.3	14.0	....	4.0	....	81.5	123.2	....	204.7	61.4
Corned beef	38.8	6.4	....	1.8	....	135.8	56.3	....	192.1	57.6
Preserved beef	29.5	8.0	....	....	....	103.2	70.4	....	173.6	52.0
Pickled beef	25.9	.2	....	21.0	....	80.6	2.0	....	82.6	24.8
Pemmican	35.4	55.2	....	1.8	....	123.9	485.8	....	609.7	182.9
Pork, pickled	9.7	75.7	....	5.3	....	34.0	666.2	....	700.2	210.0
Ham, smoked	24.5	36.5	....	10.5	....	85.7	321.2	....	406.9	122.0
Ham sausage	12.87	24.43	10.52	3.3	....	45.0	215.0	38.9	298.9	89.7
Beef sausage	27.31	19.88	15.1	5.5	....	95.6	174.9	55.9	326.4	97.9
Cervelat sausage	17.5	40.0	....	5.5	....	61.2	352.0	....	413.2	124.0
Herring, pickled	19.0	17.0	....	16.5	....	66.5	150.0	....	216.5	64.9
Sardines	23.0	2.0	....	24.0	....	80.5	1.8	....	82.3	24.7
Pike	18.42	.53	....	1.0	....	64.0	4.7	....	68.7	20.6
Carp	21.86	1.0	....	1.33	....	76.5	8.8	....	85.3	25.6
Salt cod	27.42	.36	....	22.0	....	96.0	3.2	....	99.2	29.8
Salt mackerel	18.88	25.17	....	10.4	....	60.0	221.5	....	281.5	84.4
Smoked haddock	33.68	.17	....	2.06	....	117.9	1.5	....	119.4	35.8
Smoked halibut	20.57	15.03	....	12.96	....	72.0	132.3	....	204.3	61.3
Smoked herring	36.44	15.82	....	11.66	....	127.6	139.2	....	266.8	80.0
Canned salmon	20.06	15.7	....	1.04	....	70.2	138.1	....	208.3	62.5
Canned mackerel	19.91	8.68	....	1.93	....	69.7	76.4	....	140.1	42.0
Canned tunny	21.52	4.05	....	1.69	....	75.3	35.6	....	110.9	33.3
Eel	18.3	9.1	....	1.0	....	64.0	80.0	....	144.0	43.2
Pompano	18.7	7.5	....	1.0	....	65.4	66.0	....	131.4	39.4
Salmon	21.2	12.8	....	1.4	....	74.2	112.6	....	186.8	56.0
Shad	18.6	9.5	....	1.3	....	65.1	83.0	....	148.1	44.4
Shad roe	20.9	3.8	2.6	1.5	....	73.1	33.4	9.6	116.1	34.8
Smelts	17.3	1.8	....	1.7	....	60.5	15.8	....	76.3	22.9
Spanish mackerel	21.0	9.4	....	1.5	....	73.5	82.7	....	156.2	46.9
Trout	18.9	2.1	....	1.2	....	66.1	18.5	....	84.6	25.4
Caviare	30.0	19.7	7.6	4.6	....	105.0	173.4	28.1	306.5	91.9
Clams	8.6	1.0	2.0	2.6	....	30.1	8.8	7.4	46.3	13.9
Clams, little neck	2.1	.4	4.2	2.7	....	7.3	3.5	15.5	26.3	7.9
Crabs	16.6	2.0	1.2	3.1	....	58.1	17.6	4.4	80.1	24.3
Lobster	16.4	1.8	.4	2.2	....	57.4	15.8	1.5	74.7	22.4
Oysters	6.2	1.2	3.7	2.0	....	21.7	16.6	13.7	52.0	15.6
Scallops	14.8	.1	3.4	1.4	....	51.8	.8	12.6	65.2	19.6
Shrimps	25.4	1.0	.2	2.6	....	88.9	8.8	.6	98.3	29.5
Peas	22.85	1.79	52.36	2.58	5.43	70.8	15.7	212.8	299.3	89.8
Peas, dried and boiled	7.0	.5	16.9	1.0	....	21.7	4.4	62.5	88.6	26.6
Peas, canned	3.6	.2	9.8	1.1	....	11.2	1.7	36.3	49.2	14.8
Beans, broad	24.27	1.61	49.01	3.26	7.09	75.2	14.2	207.4	296.8	89.0
Beans, kidney	23.21	2.14	53.67	3.69	3.55	71.9	18.8	211.7	302.4	90.4
Sago, fresh	2.3	.3	7.4	.8	....	7.1	2.6	27.4	36.1	10.8
Sago, canned	1.1	.1	3.8	1.3	....	3.5	.8	14.0	18.3	5.5
Soja bean	30.4	17.7	29.1	4.1	....	94.2	155.8	107.7	357.7	107.3
Lentils	25.7	1.89	53.46	3.57	3.04	79.6	16.6	181.0	277.2	83.2
Potatoes	2.2	.1	18.4	....	1.0	6.8	.8	69.7	77.3	23.2
Potatoes, sweet	1.8	.7	27.4	....	1.0	5.6	6.1	105.4	117.1	35.1
Beets	1.6	.1	9.7	....	1.1	4.9	.8	39.9	45.6	13.7
Carrots	1.1	.4	9.3	....	1.0	3.4	3.2	38.1	44.7	13.4
Oyster plant	1.0	.5	17.1	....	1.0	3.1	4.4	67.0	74.5	22.3
Parsnips	1.6	.5	13.5	....	1.4	5.0	4.4	55.1	64.5	19.3
Radishes	1.3	.1	5.8	....	1.0	4.0	.9	25.2	30.1	9.0
Turnips	1.3	.2	8.1	....	.8	4.0	1.7	32.9	38.6	11.6
Asparagus	2.1	3.3	2.2	....	.8	6.5	28.2	11.1	45.8	13.7
Cabbage	1.6	.3	5.6	....	1.0	5.0	2.6	24.4	32.0	9.6
Cauliflower	1.8	.5	4.7	....	.7	5.6	4.4	20.0	30.0	9.0
Sprouts	4.7	1.1	4.3	....	1.7	14.6	9.7	22.2	46.5	14.0
Celery	1.1	.1	3.3	....	1.0	3.4	.9	16.0	20.3	6.1
Lettuce	1.2	.3	3.2	....	2.1	3.7	2.6	20.0	26.3	7.9
Spinach	2.1	.3	3.2	....	.9	6.5	2.6	15.1	24.2	7.3
Onions	1.6	.3	9.9	....	.6	5.0	2.6	38.8	46.4	14.0
Apples	.36	....	8.26	4.3	.31	1.2	....	31.7	32.9	9.9
Pears	.36	....	7.22	1.51	.49	1.2	....	28.5	29.7	8.9
Peaches	.65	....	4.48	6.06	.69	2.0	....	19.1	21.1	6.3
Apricots	.49	....	4.69	5.27	.82	1.5	....	20.4	21.9	6.6
Plums	.4	....	3.56	4.34	.66	1.2	....	15.6	16.8	5.0
Prunes, dried	2.3	.5	65.0	1.5	1.4	7.1	4.4	245.7	257.2	77.2
Cherries	.67	....	10.24	6.07	.73	2.1	....	40.6	42.7	12.7
Oranges	.8	.2	11.6	....	.5	2.5	1.8	44.8	49.1	14.7
Grapes	.59	....	14.36	3.6	.53	1.8	....	55.2	57.0	17.1
Melons	.92	.18	9.05	1.04	.72	2.8	.9	36.1	39.8	11.9

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TABLE XV.—*Continued.*

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Name.	In 100 Parts are Contained:					Nutrient Unit in:			Sum Nutrient Units in:	
	Proteids.	Fats.	Carbo-hydrates.	Ash.	Cellul.	Proteids.	Fats.	Carbo-hydrates.	100 gm.	1 ounce.
Figs	4.0	....	50.0	....	3.0	12.4	....	19.6	32.0	9.6
Cranberries	.12	....	7.8	6.27	.15	.4	....	29.4	29.8	8.9
Strawberries	1.07	....	6.28	3.25	.81	3.3	....	26.2	29.5	8.8
Blackberries	.51	....	4.44	6.97	.48	1.6	....	18.2	19.8	5.9
Raspberries	1.42	....	3.86	8.1	.48	4.4	....	16.8	21.2	3.4
Dates	6.6	.2	59.6	1.9	1.6	20.5	1.76	226.4	248.7	74.6
Rhubarb	.9	....	3.2	....	.4	2.8	....	13.3	16.1	4.8
Egg without shell	12.5	12.0	.5	1.0	....	43.5	105.6	1.8	150.9	45.3
Milk, cow's	3.5	4.0	4.9	.7	....	12.2	35.2	18.1	65.5	19.6
Milk, skimmed	3.1	.7	4.8	.7	....	10.8	6.1	2.6	19.5	5.8
Milk, goat's	4.29	4.7	4.6	.7	....	15.0	41.4	20.7	77.1	23.1
Milk, condensed	12.0	8.4	50.8	2.0	....	42.0	73.9	31.0	146.9	44.0
Milk, condensed, Swiss	12.3	11.0	48.7	2.4	....	43.0	96.8	180.2	320.0	96.0
Milk, condensed, sweet	11.35	11.25	13.35	2.0	....	39.7	99.0	49.4	188.1	56.4
Cream	2.7	26.7	....	1.8	....	9.4	23.49	....	244.3	73.3
Butter, fresh	2.0	85.0	....	1.0	....	7.0	748.0	....	755.0	226.5
Butter, salted	....	80.0	....	3.0	....	....	704.0	....	704.0	211.2
Cheese, Dutch	28.25	22.78	....	7.1	....	98.9	200.5	....	299.4	89.8
Cheese, American	29.64	38.24	....	3.49	....	103.7	336.5	....	440.2	132.0
Cheese, Roquefort	32.9	32.3	....	4.4	....	115.1	284.2	....	399.3	119.8
Cheese, Camembert	18.9	21.0	....	4.7	....	66.1	184.8	....	250.9	75.3
Cheese, Cheshire	26.93	30.68	....	4.42	....	94.2	270.0	....	364.2	109.3
Cheese, Edam	27.0	28.3	3.0	5.0	...	94.5	249.0	11.1	354.6	106.4
Cheese, caraway	31.5	12.0	9.3	3.3	....	110.2	105.6	34.4	250.2	75.0
Bread, rye	6.0	1.0	48.0	1.5	....	20.0	8.8	177.6	206.4	61.9
Bread, wheaten	7.0	.5	52.5	1.0	....	21.7	4.4	194.2	221.3	66.4
Biscuit, navy	10.9	1.6	75.0	1.1	....	33.8	14.0	277.5	325.3	97.6
Biscuit, milk	7.18	9.28	73.1	.83	....	21.5	81.6	270.5	373.6	102.1
Flour, wheaten	11.0	2.0	71.2	.8	....	34.1	17.6	263.4	315.1	94.5
Flour, barley	12.7	2.0	71.0	3.0	....	39.4	17.6	262.7	319.7	95.9
Flour, corn	9.7	3.8	69.6	1.3	1.4	30.0	33.4	257.5	320.9	96.3
Corn, grains	10.0	6.7	64.5	1.4	....	31.0	59.0	238.6	328.6	98.6
Starches	1.0	....	82.0	....	....	3.1	....	303.4	306.5	92.0
Sugar cane	.5	....	96.5	1.0	....	1.6	....	357.0	358.6	107.6
Molasses	....	....	62.0	2.8	....	....	....	229.4	229.4	68.8
Honey	1.2	....	73.6	2.8	...	3.7	....	272.3	276.0	82.8
Buckwheat	10.75	2.0	62.75	1.25	....	33.3	17.6	332.1	383.0	114.9
Oatmeal	12.6	5.6	63.0	3.0	....	38.0	49.2	233.1	320.3	96.0
Macaroni	9.0	.3	76.8	.8	....	27.9	2.6	284.2	314.7	93.4
Rice	6.5	1.0	78.5	1.0	....	20.1	8.8	290.5	319.4	95.8
Prunes, dried	2.3	.5	65.0	1.5	1.4	7.1	4.4	240.5	252.0	75.6
Raisins	....	....	62.0	1.7	....	....	....	229.4	229.4	68.8
Sauerkraut	1.0	.2	7.6	.5	1.0	3.7	1.7	17.0	21.8	6.5
Coffee, unroasted	12.0	12.3	42.3	4.0	18.2	37.2	108.2	15[illegible]	301.9	90.6
Tea	24.5	7.1	41.7	5.6	11.6	75.9	62.5	154.3	292.7	87.8
Chocolate	6.2	21.0	67.6	1.9	1.4	19.2	184.8	250.1	444.1	133.2
Beef heart	16.0	20.4	....	1.0	....	56.0	179.5	....	235.5	70.6
Beef kidney	16.0	4.8	.4	1.2	....	56.0	42.2	1.5	99.7	29.9
Beef liver	20.7	4.5	1.5	1.6	....	72.4	39.6	5.5	117.5	35.2
Beef marrow	2.2	92.8	....	1.3	....	7.7	816.6	....	824.3	247.3
Beef tongue	18.9	9.2	....	1.0	....	66.1	81.0	....	147.1	44.1
Beef tripe	11.7	1.2	.2	.3	...	40.9	10.1	.7	51.7	15.5
Beef tripe, canned	16.8	8.5	....	.5	....	58.8	74.8	....	133.6	40.0
Beef tongue, pickled	12.8	20.5	....	4.7	....	44.8	180.4	....	225.2	67.6
Beef tongue, canned	19.5	23.2	...	4.0	....	68.2	204.2	....	272.4	81.7
Pork, feet	8.3	17.4	....	.4	....	29.0	153.1	....	182.1	54.6
Pork, kidney	15.5	4.8	....	1.2	....	54.2	42.2	....	96.4	28.9
Pork, liver	21.3	4.5	1.4	1.4	....	74.5	39.6	5.2	119.3	35.8
Veal heart	16.8	9.6	....	1.0	....	58.8	84.5	....	143.3	43.0
Veal kidney	16.9	6.4	....	1.3	....	59.1	56.3	....	115.4	34.6
Veal liver	19.0	5.3	....	1.3	....	66.5	46.6	....	113.1	33.9
Mutton kidney	16.9	12.6	....	.9	....	59.1	110.8	....	169.9	51.0
Mutton liver	23.1	9.0	....	1.7	....	80.8	79.2	....	160.0	48.0
Broiler chickens	21.5	2.5	....	1.1	....	75.2	22.0	....	97.2	30.0
Fowls	19.3	16.3	....	1.0	....	67.5	143.4	....	210.9	63.3
Young goose	16.3	36.2	....	.8	....	57.0	318.6	....	375.6	112.7
Turkey	21.1	22.9	....	1.0	....	73.8	201.5	....	275.3	82.6
Chicken liver	22.4	4.2	2.4	1.7	....	79.4	37.0	8.9	126.3	37.6
Goose liver	19.6	5.8	....	1.0	....	68.6	51.0	....	119.6	35.9

cially vegetables reappear in the fæces in quite considerable proportion.

A simple and approximately accurate method for calculating the nutritive value of a diet has recently been published by Schumburg. Schumburg makes a slight difference in the food value between animal and vegetable proteids, giving the former a value of 3.5 and the latter a value of 3.1 per gram. The fats have a value of 8.8 and the carbohydrates one of 3.7. Given, then, the various constituents of a diet, expressed in proteids, fats, and carbohydrates, their weight stated in grams, multiplied by their respective values, the several amounts added together would give a sum corresponding to the total food value of a diet in numbers of calories or nutrient units. Remembering that a sufficient diet for an adult workingman must have at least 3,000 nutrient units, and that the proportion of proteids, fats, carbohydrates, and salts in a complete diet should be as 150, 100, 500, and 35, we would have an easy and simple method of ascertaining and controlling the dietary value of any meal.

The adjoining Table XV. has been compiled from many sources, notably, Koenig, Rubner, Kirchner, Schmidt, Plunert, Ranke, Notter, Harrington, Munson, the reports of the United States Fish Commission and of the United States Department of Agriculture. The first five columns give the percentage composition of each food in proteids, fats, carbohydrates, etc.; the next three columns give the number of nutrient units contained in 100 parts; the next two columns give the sum of nutrient units in 100 gm. and one ounce respectively.

There are a few food substances of vegetable origin,

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Naval Hygiene.

not included in this list, such as the tomato, cucumber, squash, pumpkin, egg plant, and vegetable marrow; they have about the same nutritive value as celery and lettuce. The jellies and jams are semi-solid glutinous preparations, made by boiling fruit juices with sugar and allowing to cool; jams are similar preparations which include the pulp of the fruit as well as the juice. Their nutritive value must be determined by taking their ingredients separately in each case. Tea, coffee, and chocolate owe their nutritive value more to the stimulating effect of the alkaloids which they contain than to anything else; they are condiments rather than nutritious substances.

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The caloric values, originally assigned to the several proximate principles of foods, by Rubner and Stohmann, were as follows: 1 gm. of proteids, 4.8 calories; 1 gm. of fats, 9.5 calories; 1 gm. of carbohydrates, 4 calories. It was soon found, however, that, while the fats and the carbohydrates were as completely oxidized within the tissue cells as they were when burned in a calorimeter, namely, into water and carbon dioxide, the proteids left an unconsumed remnant. If, for instance, 1 gm. of proteid material is decomposed within the organism, it leaves a remnant of urea, uric acid, and a few other nitrogenous substances, excreted by the kidneys and the intestines. The 4.8 calories, therefore, that were assigned to 1 gm. of proteids, as their food-value in calories, represent only a part of that value in calories which we would obtain if 1 gm. of proteids was burned in a calorimeter, where it would, of course, be completely consumed by oxidation. According to Rubner, the unconsumed remnant amounts to 22 to 28 per cent. of the original quantity of proteids ingested. In other words, if 1 gm. of proteid material is decomposed within the body, is converted into water, carbon dioxide, urea, etc., only so much of its potential energy is converted into heat as will raise the temperature of 4.8 kgm. of water 1° C., while if 1 gm. of proteid is completely assimilated within the organism, the amount of energy added to the latter is equal to 5.7 calories, or its full caloric value. The above values for proteids, fats, and carbohydrates, in their practical application to the calculation of the food values of a certain diet or ration, have had to be modified still further. Allowance had to be made for a certain percentage amount of indigestible matter peculiar to the different articles of food, as well as for the energy that had to be expended on their digestion, in order not to overestimate their net value. After making these necessary deductions, Schumburg gives, as the net values, the following numbers in calories: 1 gm. proteids (animal), 3.5 calories; 1 gm. proteids (vegetable), 3.1 calories; 1 gm. fats, 8.8 calories; 1 gm. carbohydrates, 3.7 calories. It is on the basis of Schumburg's figures that the food values in table XV. have been calculated.

Voit's original standard requirements in proteids, fats, and carbohydrates, for a moderately hard-working adult man, are: 118 gm. of proteids, 56 gm. of fat, and 500 gm. of carbohydrates. These standard requirements have stood the test of many years of scientific controversy and have proved themselves practically unassailable.

The following table is intended to show the number of calories obtained from Voit's standard by using both Rubner's and Schumburg's figures:

TABLE XVI.

Name.	Grams.	Multiplied by—	
		Rubner's figures.	Schumburg's figures.
Proteids.........	118	× 4.8 = 566	× 3.5 = 413
Fats.............	56	× 9.5 = 532	× 8.8 = 492
Carbohydrates...	500	× 4.0 = 2,000	× 3.7 = 1,850
		Total, 3,098	Total, 2,755

(In a paper on the "Hygiene of the Navy Ration," published by me in the Proceedings of the United States Naval Institute, vol. xxv., No. 3, the total caloric value of the ration was estimated as amounting to 2,696 calories. This number was obtained after making all due allowance for indigestible matters as well as taking into account the losses incurred in cooking and the general preparation of the food; it agrees so nearly with Voit's standard, multiplied by Schumburg's figures, that this agreement is considered an additional proof of its correctness. Unfortunately, the proof of this paper not having been submitted to the writer, a few errors have crept in, owing to the wrong position of the decimal points in the numbers there given; they are, however, so easily perceived as hardly to need any correction.)

From the point of view of their digestibility, food substances vary quite considerably, and, since only that portion of a food substance which is absorbed is of any good to the organism, it cannot be immaterial in what form food is taken. The following table XVII. by Rubner is intended to show the indigestible and, consequently, unabsorbed remnant in per cent., of some of the more common articles of food.

TABLE XVII.

Remained unabsorbed.	Dry substance.	Proteids.	Fats.	Carbohydrates.
Meat, dried	5.3	2.6		
Fish........................	4.3	2.5		
Eggs, hard-boiled	5.2	6.6	4.4	
Milk	8.8	7.1	5.3	
Bread, baker's, wheaten...	4.2	21.8	....	1.1
Bread, inferior quality	6.7	21.6	...	2.6
Bread, coarse meal	12.2	30.5	....	7.4
Bread, peasants' rye.......	15.0	32.0	....	10.9
Macaroni, poor in egg......	4.3	17.1	....	1.2
Rice (Risotto)..............	4.1	20.4	....	0.9
Corn (Palenta).............	6.7	15.5	....	3.2
Peas (dried)	9.1	17.5	....	3.6
Beans (dried)	18.3	30.2		
Beans, fresh................	15.0			
Potatoes mashed	....	19.5	....	0.7
Potatoes, mashed, different preparations..............	9.4	30.5	....	7.4
Carrots......................	20.7	39.0	....	18.2

The table shows that those articles of a diet which have an animal origin and upon which we mostly depend for the necessary proteid part of our diet, such as meat, fish and eggs, are best digested and absorbed. Of the vegetables, rice, corn, and macaroni seem to be much more digestible than the vegetables properly so-called. The digestion and absorption of all kinds of fats is generally favorable.

The different composition of foodstuffs, as regards proteids, fats, and carbohydrates, in itself makes it necessary that an appropriate mixture of them be taken in order to maintain a certain necessary equilibrium in the composition of our own bodies.

For, although Pflüger has kept dogs alive and in a thriving state of health and activity for long periods at a time, man cannot live forever on an exclusively animal diet, much less on one of fats and carbohydrates to the exclusion of all proteids.

Volume of a Diet.—Regarding, as we must, our digestive organs as muscular as well as secretory organs, we shall have to admit, that, like other muscles, their strength in grinding up and propelling food material must have a maximum limit, beyond which they become liable to fatigue and exhaustion. This limit has been reached whenever we become conscious of a feeling of overfulness after taking a meal. While a feeling of satiety is, up to a certain limit, stimulating to digestion, overfulness has the very opposite effect and ought to be avoided. Experience and experimentation have shown that the volume of an average diet should not exceed 2,100 gm. nor fall below 1,500 gm. The daily volume is, of course, to be distributed among the several customary meals.

It has been found a most suitable plan, in a temperate climate at any rate, to make the following distribution of the daily ration between the different meals of the

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day: For breakfast, 12 per cent.; for midday meal, 47 per cent.; for supper, 31 per cent.

In warm climates, however, it will be found a good rule, especially on board a ship-of-war where drilling is done morning and afternoon, not to overfill the stomach of the men at midday, but to make the heavy meal the 5 P.M. meal of the day. The above percentage distribution would have to be slightly modified in accordance with these requirements.

The Dietary Value of One Week's Ration.—In order to obtain an approximately correct estimate of the dietary value of the meals as they are actually served out on board a ship in commission, the commissary yeoman of one of them was requested to furnish us with a list of the articles included in one week's allowance and divide that up into the customary three daily meals. With the aid of table XV., the food value of each meal in proteids, fats, and carbohydrates was then calculated and expressed in terms of nutrient units, obtained after the manner found described in the preceding pages. In this estimate no deductions were made for indigestible matters nor for the work expended on digestion, because these values, as will be remembered, had already been deducted in the various multiples used in the calculation of the numbers of nutrient units which each article represents. But a loss of twenty-five per cent., in round numbers, had to be allowed for the usual and unavoidable waste made in the preparation of the raw material for cooking, as well as for a less necessary but always notable waste incurred in serving.

The results of this work are exhibited in table XVIII. A careful study of this table is of some interest. It shows, for instance, that while the sum of nutrient units for almost every single day comes up to and often exceeds the required number, there is quite a considerable lack of uniformity in the several corresponding meals of the different days of the week. The number of nutrient units for one day is almost doubled on another day. It also shows that our sea ration as well as our port ration was deficient in carbohydrates, while the proteids were two per cent. below the standard in the sea ration and three per cent. above the standard in the port ration.

In table XIX., which has been borrowed from Plumert, the proteid content of the United States navy ration is given as 69.2 per cent. This estimate, obtained from our printed allowance-list, puts its dietary value on top of all the other naval rations. According to our present calculation, the dietary value of our port ration is but twenty-three per cent. in proteids, or just one-third of that given by Plumert. Although we must admit that the two estimates are not strictly comparable, this exceedingly large difference between the two nevertheless shows that there are instances in which discrepancies occur between what is found on paper and what the men, in actual practice, get on their table and inside their stomachs.

Proposed New Navy Ration.—The Secretary of the Navy, recognizing the needs of the service and the importance of a well-appointed ration, on July 15th, 1901, ordered a board of officers to examine the ration and the system of messing in the navy. This board, to which the writer was originally ordered a member, but was prevented from attendance by illness, held its sessions in Newport, R. I., and completed its labors September 4th, with a report, which has not yet been made public. A very complete abstract, however, appeared in the *Army and Navy Journal* of January 25th, 1902, from which we

TABLE XVIII.

Days.	Meals.	At Sea. Nutrient Units in— Proteids.	Fats.	Carbohydrates.	Sum.	In Port. Nutrient Units in— Proteids.	Fats.	Carbohydrates.	Sum.
Sunday	Breakfast	109.9	353.9	720.6	1,184.4	109.9	353.9	720.6	1,184.4
	Dinner	385.9	1,207.4	371.4	1,964.7	398.0	248.6	449.0	1,095.6
	Supper	192.0	119.4	593.0	904.4	93.0	184.9	822.0	1,099.9
	Total	687.8	1,680.7	1,684.0	4,053.5	600.9	787.4	1,991.6	3,379.9
Monday	Breakfast	77.0	64.9	477.0	618.9	189.0	577.0	409.0	1,175.0
	Dinner	213.5	445.0	390.0	1,048.5	664.0	280.0	390.0	1,334.0
	Supper	222.0	403.0	590.0	1,215.0	222.0	403.0	590.0	1,215.0
	Total	512.5	912.9	1,457.0	2,882.4	1,075.0	1,260.0	1,389.0	3,724.0
Tuesday	Breakfast	139.0	343.0	409.0	891.0	196.4	186.7	409.0	792.1
	Dinner	361.6	1,455.2	746.6	2,563.4	664.0	280.0	390.0	1,334.0
	Supper	222.0	247.0	492.0	961.0	90.0	247.0	492.0	829.0
	Total	722.6	2,045.2	1,647.6	4,415.4	950.4	713.7	1,291.0	2,955.1
Wednesday	Breakfast	190.9	354.9	720.6	1,266.4	190.9	354.9	720.6	1,266.4
	Dinner	230.5	455.0	390.0	1,075.5	387.0	249.0	490.0	1,126.0
	Supper	241.0	234.0	466.0	941.0	151.0	53.6	686.0	890.6
	Total	662.4	1,043.9	1,576.6	3,282.9	728.9	657.5	1,896.6	3,283.0
Thursday	Breakfast	161.0	91.0	459.0	711.0	148.2	624.0	347.0	1,119.2
	Dinner	481.0	305.0	823.0	1,609.4	390.0	249.0	490.0	1,129.0
	Supper	117.7	347.7	417.0	882.4	94.0	27.6	954.0	1,075.6
	Total	759.7	743.7	1,699.0	3,202.8	632.2	900.6	1,791.0	3,323.8
Friday	Breakfast	130.0	279.0	409.0	818.0	181.0	246.0	309.0	736.0
	Dinner	418.5	476.0	390.0	1,284.5	390.0	249.0	490.0	1,129.0
	Supper	194.6	909.4	466.0	1,570.0	149.0	182.0	675.0	1,006.0
	Total	743.1	1,664.4	1,265.0	3,672.5	720.0	677.0	1,474.0	2,871.0
Saturday	Breakfast	214.0	27.0	579.0	820.0	189.0	138.9	409.0	736.9
	Dinner	399.0	2,452.0	721.6	3,572.6	399.0	2,452.0	721.6	3,572.6
	Supper	147.0	99.0	630.0	876.0	337.0	143.0	490.0	970.0
	Total	760.0	2,578.0	1,930.6	5,268.6	925.0	2,733.9	1,620.6	5,279.5
Average values	In per cent. (round numbers daily average	18.0	40.0	42.0	100.0	23.0	31.0	46.0	100.0
	Should be	20.0	13.3	66.7	100.0	20.0	13.3	66.7	100.0
	Difference	− 2.0	+ 26.7	− 24.7	....	+ 3.0	+ 17.7	− 20.7	

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TABLE XIX.—(From Plumert.)

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Navy.	Sum Nutrient Units of Animal Origin.		Sum Nutrient Units of Vegetable Origin.			Sum Total of Nutrient Units in the Daily Ration.			Proteids in per cent.
	Proteids.	Fats.	Proteids.	Fats.	Carbo-hydrates.	Proteids.	Fats.	Carbo-hydrates.	
Austrian, in port	286	156	381	29	502	667	185	502	42.9
Austrian, at sea	280	259	421	26	542	701	285	542	40.0
German, in port	273	235	414	35	601	687	270	601	39.7
German, at sea	320	412	394	29	595	714	441	595	44.8
Italian, in port	276	107	315	25	475	591	132	475	46.7
Italian, at sea	294	146	437	35	560	731	181	560	40.2
French, in port	286	176	333	24	470	619	200	470	46.2
French, at sea	261	219	341	16	523	602	235	523	43.3
English, in port	377	138	523	52	572	900	190	572	41.9
English, at sea	318	536	362	49	593	680	585	593	46.8
Russian, in port	257	229	446	47	717	703	276	717	36.6
Russian, at sea	247	390	471	37	733	718	247	733	34.4
Swedish, at sea	379	517	386	27	558	765	544	558	49.5
Norwegian, at sea	456	473	419	49	667	875	522	667	52.1
Turkish, at sea	160	127	495	60	723	655	187	723	24.4
United States, in port	480	177	213	46	401	693	223	401	69.2
United States, at sea	343	461	402	31	590	745	492	590	46.0
Argentine Republic, at sea	518	294	344	32	536	862	326	536	60.0
Japanese, at sea	260	122	331	27	628	591	149	628	43.9

take the following. This board recommends legislation as follows:

"Hereafter the navy ration shall consist of the following daily allowance of provisions to each person: One pound and a quarter salt or smoked meat, with three ounces of dried or six ounces of canned fruit, and three gills of beans or peas, or twelve ounces of flour; or one pound of preserved meat, with three ounces of dried or six ounces of canned fruit and twelve ounces of rice or eight ounces of canned vegetables, or four ounces of desiccated vegetables; together with one pound of biscuit, two ounces of butter, four ounces of sugar, two ounces of coffee or cocoa, or one-half ounce of tea and one ounce of condensed milk or evaporated cream; and a weekly allowance of one-half pound of macaroni, four ounces of cheese, four ounces of tomatoes, one-half pint of vinegar, one-half pint of pickles, one-half pint of molasses, four ounces of salt, one-quarter ounce of pepper, and one-half ounce of dry mustard. Five pounds of lard or a suitable substitute, will be allowed for every hundred pounds of flour issued as bread, and such quantities of yeast as may be necessary.

"The following substitution for the components of the ration may be made when deemed necessary by the senior officer present in command:

"For one and one-quarter pounds of salt or smoked meat or one pound of preserved meat, one and three-quarter pounds of fresh meat; in lieu of the article usually issued with salt, smoked, or preserved meat, fresh vegetables of equal value; for one pound of biscuit, one and one-quarter pounds of soft bread or eighteen ounces of flour; for three gills of beans or peas, twelve ounces of flour or rice, or eight ounces of canned vegetables; and for twelve ounces of flour or rice, or eight ounces of canned vegetables, three gills of beans or peas.

"An extra allowance of coffee or cocoa, two ounces of sugar, four ounces of hard bread or its equivalent, and four ounces of preserved meat or its equivalent, will be allowed to enlisted men of the engineer and dynamo force when standing night watches under steam."

The Board has also recommended some other changes to be made in the system of messing and has suggested some much needed reforms in the organization of the personnel of the commissary department on board ships, but, the above changes in the food-supply being the only ones of interest in connection with the study of the actual food value of the ration, we cannot here consider them.

The same commissary yeoman who had previously furnished us with a written weekly allowance list, divided into the customary three daily meals, made up from the old ration, was now requested to do the same with this proposed new ration. This he very kindly did, after having been thoroughly advised of the promised additions to the present ration, and the following table XX. shows the food value for this new ration in nutrient units, expressed in terms of proteids, fats, and carbohydrates, which the new ration would yield *in his hands*.

While, in our opinion, the ration is very ample, the table shows that both in the port ration and in the sea ration we have an excess in fats and a deficiency in carbohydrates, while the proteids may be regarded as just about up to the standard. We also notice the same lack of uniformity as regards the distribution of the quantities between the different days of the week as well as between the three meals of the day that has been previously noted. The importance of the personal equation of the yeoman and its influence upon the whole subject of rationing on board ship is well brought out. A very natural suggestion, therefore, would seem to be that either the commissary yeomen of the navy be given a great deal more instruction as regards the value in nutrient units of the different classes of food which it is their duty to distribute, than they now possess, or that this distribution be supervised on board ship by the class of men whose training and education ought to be a guarantee of the fact that they possess the required knowledge to do so in accordance with the best principles.

The Influence of Climate upon Nutrition.—Any discussion of the navy ration would be incomplete without some consideration of the influence of the various climatic factors upon nutrition. The problem of what constitutes a proper ration for a definite climate can be solved only on the basis of an exact knowledge of the physiology of general nutrition, as modified and influenced by the different climatic conditions. When we shall be in possession of a full and complete knowledge of this, then the proper ration for almost any climate will become a matter of exact calculation and a mere application of principles to practical life. We must, in the first place, find out what climate is, and in the second place ascertain its influence upon nutrition.

Since some very important and fundamental work has, within recent years, been done in this line of research by German hygienists, which must hereafter be taken into account whenever the questions of climate and nutrition become subjects for further research or discussion, it is absolutely necessary in this connection briefly to call attention to a few of the leading points in this great work. In doing this, only so much of it will be reviewed as seems necessary for a better understanding of the subject under discussion; for a fuller and more detailed account the reader is respectfully referred to a most excellent monograph by K. E. Ranke.*

* "Ueber die Einwirkung des Tropenklimas auf die Ernährung des Menschen auf Grund von Versuchen im tropischen und subtropischen Südamerika," von Dr. Karl Ernst Ranke, München.

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Table XX.—Numbers Represent Nutrient Units.

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Days.	Meals.	Sea Ration.				Port Rations.			
		Proteids.	Fats.	Carbo-hydrates.	Sum.	Proteids.	Fats.	Carbo-hydrates.	Sum.
Sunday	Breakfast	210.3	262.2	724.8	1,197.3	210.3	262.2	724.8	1,197.3
	Dinner	283.7	881.4	501.4	1,666.5	323.4	141.5	500.4	965.3
	Supper	242.0	267.6	655.4	1,165.0	242.0	267.6	655.4	1,165.0
	Total	736.0	1,411.2	1,881.6	4,028.8	775.7	671.3	1,880.6	3,327.6
Monday	Breakfast	121.5	178.0	541.4	840.9	109.5	194.0	553.4	856.9
	Dinner	338.0	728.0	390.4	1,456.4	327.3	246.8	530.4	1,104.5
	Supper	102.6	152.0	795.8	1,051.2	231.1	191.2	700.4	1,122.7
	Total	562.1	1,058.8	1,727.6	3,348.5	667.9	632.0	1,784.2	3,084.1
Tuesday	Breakfast	147.6	569.7	476.4	1,193.7	198.0	977.0	486.3	1,661.3
	Dinner	306.9	2,480.5	724.8	3,512.2	306.9	2,480.5	724.8	3,512.2
	Supper	257.5	512.4	477.2	1,247.1	238.7	229.4	476.4	944.5
	Total	712.0	3,562.6	1,678.4	5,953.0	743.6	3,686.9	1,687.5	6,118.0
Wednesday	Breakfast	210.3	262.2	724.8	1,197.3	210.3	262.2	724.8	1,197.3
	Dinner	243.0	607.0	373.4	1,223.4	329.9	248.4	530.4	1,108.7
	Supper	151.4	434.6	634.6	1,220.6	122.5	381.0	434.4	937.9
	Total	604.7	1,303.8	1,732.8	3,641.3	662.7	891.6	1,689.6	3,243.9
Thursday	Breakfast	247.1	257.2	502.7	1,007.0	281.7	227.4	476.4	985.5
	Dinner	339.0	461.9	380.4	1,181.3	288.9	882.8	536.8	1,708.5
	Supper	215.5	248.4	350.4	814.3	211.5	723.4	476.4	1,411.3
	Total	801.6	967.5	1,233.5	3,002.6	782.1	1,833.6	1,489.6	4,105.3
Friday	Breakfast	139.9	772.5	476.4	1,388.8	260.2	312.1	490.4	1,062.7
	Dinner	158.6	221.3	695.9	1,075.8	380.3	78.4	776.4	935.1
	Supper	323.2	420.5	350.4	1,094.1	149.3	377.6	644.0	1,170.9
	Total	621.7	1.414.3	1,522.7	3,558.7	789.8	768.1	1,610.8	3,168.7
Saturday	Breakfast	268.3	189.6	382.5	840.4	201.7	203.4	476.4	881.5
	Dinner	309.9	2,431.9	754.8	3.496.6	365.9	1,235.2	754.8	2,355.9
	Supper	166.5	409.0	890.4	1,465.9	221.7	339.4	476.4	1,037.5
	Total	744.7	3,030.5	2,027.7	5,802.9	789.3	1,778.0	1,707.6	4,274.9
Averages	Daily in per cent	17.0	43.0	40.0	100.0	20.0	37.0	43.0	100.0
	Should be	20.0	13.3	66.7	100.0	20.0	13.3	66.7	100.0
	Difference	− 3.0	+ 30.0	− 26.7	....	0.0	+ 23.7	− 23.7	....

The physiological process, known as heat regulation or heat economy, consists, on the one hand, in the production of heat within the living organism through oxidative changes; and heat-dissipation, through conduction, radiation, and water evaporation, on the other. The remaining balance between these two phases of the process finds expression in the normal temperature of the animal under observation. That this heat-regulating process is influenced by a great variety of both environmental and subjective conditions has long been known, but a more exact knowledge of it has only recently been gained through the researches of Voit and Rubner and their numerous co-workers.

Environmental Conditions.—*Climate.*—Ranke has recently defined climate as being "the total mean thermic effect exerted upon a living organism, at a certain point on the earth's surface." This comprehensive definition of climate covers every point on the earth's surface, both at sea and on the continent. The total mean thermic effect is made up of several factors, namely: atmospheric temperature (direct solar rays, reflected and radiated heat), humidity, air currents, barometric pressure, and rainfall.

Against the untoward influence of these combined agencies the organism possesses certain physiological defences that are summed up in the term heat regulation, and, within a certain number of degrees of atmospheric temperature, the organism is able to accommodate itself to its environment, without losing control of its own normal temperature. This number of degrees of temperature has, accordingly, been called by Ranke the "temperature range." This range has an upper and a lower limiting point, beyond either of which the regulating influence of our physiological mechanism does not extend, and where our physiological defences begin to break down. When, therefore, the limits are surpassed, the normal temperature of the organism will either be raised or lowered, according as either the upper or the lower limiting point in the range is exceeded. We leave our normal ground and enter the pathological arena.

(*a*) *Atmospheric Temperature.* One of the most important factors in a climate is its temperature. Complete and accurate sets of experiments on the influence of atmospheric temperature on the temperature range have, so far, been made on animals only. A sufficient number of observations, however, has been made on man to enable us to summarize the different reactions thus observed into a connected whole. Thus Voit, in 1878, made the important discovery that the several factors concerned in the mechanism of heat regulation did not all act alike when followed through the whole of the temperature range. Proceeding from the lower in the direction of the upper limit, there soon comes a point on our scale where, for instance, heat production refuses to take any further part in heat economy. This point was likewise observed by Rubner and noted to occur in all his experiments on the heat regulation of animals. Ranke now proposes to designate the point "the critical point" in heat regulation. By it the whole temperature range is naturally divided into two great groups. According to the present state of our knowledge, the reactions of the different factors concerned in heat regulation, within the several groups and subdivisions of the temperature range, are about as follows: At the lowest limit of the range, we meet with the highest amount of heat production; from here on up to the critical point,

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heat production is found to be gradually diminishing. Heat regulation, then, between the lower limit of the range and the critical point, occurs principally through changes in chemical heat production. Water evaporation behaves so indifferently here that no regulating function can be attributed to it. From the critical point on upward, no further decrease in heat production depending upon temperature occurs. In place of changes in heat production we now notice changes occurring in heat elimination. This second great group of the temperature range is again divided into two subdivisions, distinctly marked out by important changes in the reactions of the regulating mechanism. In the lower of these two divisions we find conduction and radiation actively increased. Although a slight increase in heat production is noticeable within this section, due to quickened circulation and respiration, this is exactly counterbalanced by a simultaneous slight increase in water evaporation. This kind of regulation extends, in the dog, to about 5° C. above the critical point.

In the upper of the two subdivisions of physical heat regulation we find that radiation and conduction cease to be actively or reflexly increased and are considerably diminished instead. In place of these factors, water evaporation suddenly sets in.

Rubner has shown that, when active perspiration begins in man, the influence of conduction and radiation ceases to be exerted upon heat economy, but that the work of the sweat glands here causes a further slight increase in the amount of heat production.

These somewhat complicated relations will be made clear by a glance at the accompanying chart, constructed from one of Rubner's experiments on the dog and intended graphically to illustrate the essential points in the mechanism of heat regulation under the influence of varying degrees of atmospheric temperature.

The next table (table XXI.) shows the experiment of Rubner on the dog which the chart is intended to represent graphically.

TABLE XXI.—RUBNER'S EXPERIMENT.

Atmospheric temperature.	Latent heat in calories in water vapor.	Conduction and radiation in calories.	Total heat production.	Atmospheric temperature.	Latent heat in calories in water vapor.	Conduction and radiation in calories.	Total heat production.
7.6	11.8	71.7	83.5	25.0	16.9	37.3	54.2
15.0	14.0	49.0	63.0	30.0	26.2	30.0	56.2
20.0	16.2	37.3	53.5				

In the chart, the ordinates indicate the number of calories, the abscissa, the degrees of temperature. *W.E.* stands for water evaporation; *C. and R.* for conduction and radiation, and *H.P.* for heat production; all else is self-evident.

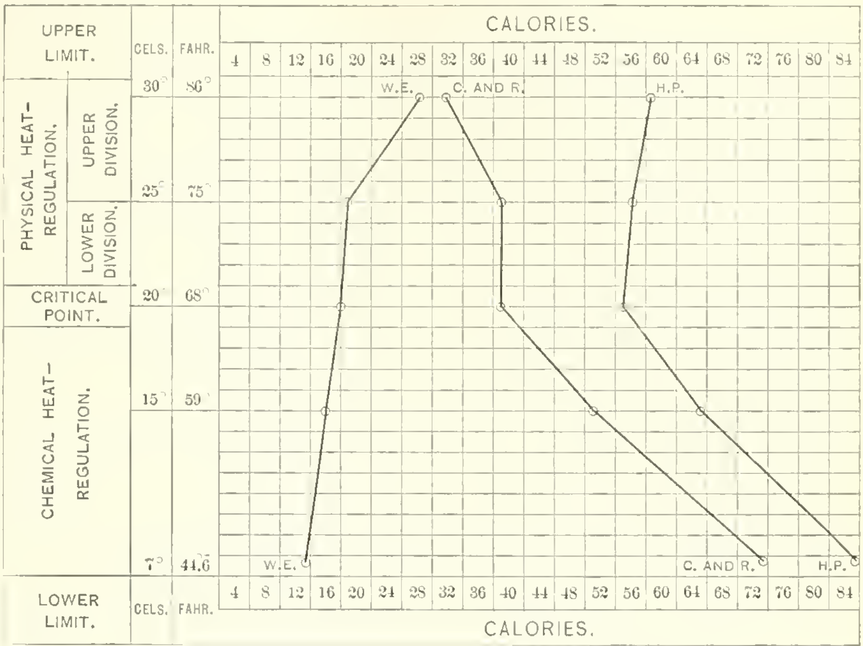

FIG. 3509.—Chart Showing Temperature Range and Heat Regulation.

(*b*) *Air Currents.* Air in motion has a very important influence upon heat economy. Rubner sums up its influence by stating that air currents cause physical heat regulation to begin at a few degrees higher temperature than during a calm. Ranke expresses the same thing by stating that air currents cause the critical point in the temperature range to move a few degrees upward.

(*c*) *Humidity.* The thermic influence of atmospheric humidity is twofold. It diminishes water evaporation and improves conduction. By increasing conduction it causes the lower limit of the temperature range to move upward, and by retarding water evaporation it moves the upper limit downward, thus narrowing the entire range. Moist cold is colder than dry cold and moist heat hotter than dry heat. It will be seen, then, that the organism possesses no defences against the combined influence of excessive humidities and temperatures.

II. SUBJECTIVE CONDITIONS.—(*a*) *Food and Feeding.*—That amount and variety of food which an organism is required to take in order to maintain its present weight is called its *need.* If more food is taken than is required for this purpose, the smaller part of the surplus only becomes converted into tissue; the greater part is decomposed and eliminated. Consequently, an increased heat production always follows the introduction of an amount of food beyond the needs of an organism to maintain its weight, and the consequence of that is that the entire range is moved downward. This is well shown in one of Rubner's experiments (also quoted by Ranke). In the experimental animal of Rubner, when it was in a state of hunger, this sudden water evaporation began at a temperature of 32.5° C.; when 200 gm. of meat were given, the sudden water evaporation began at 19.1° C., and when 320 gm. of meat were given, it began at 13.4° C. This shows the enormous influence of feeding upon the temperature range; it moves the entire range a considerable number of degrees downward. Under the influence of high temperatures, therefore, every increase in the food allowance beyond the mere need must materially increase the difficulty of heat elimination and cause the critical point to move a corresponding number of degrees downward. The proteid food substances are the

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most powerful in this respect, the fats the least effective, and the carbohydrates stand between the two.

(*b*) *Muscular Work.*—Numerous experiments have shown that the influence of muscular work upon the temperature range is a most powerful one. Since heat production is greatly increased by all kinds of muscular work, its influence upon the temperature range is, briefly stated, that it moves it downward. Near the upper limit of the range we may reach a point where a man may be able to exist while at perfect rest, but where every attempt at work will lead to heat accumulation and heat stroke and other pathological conditions.

(*c*) *Clothing* influences the temperature range by pushing it a certain number of degrees downward; it has, then, upon it an influence similar to that exerted by eating and muscular work.

The salient points of our subject have now been brought forward as thoroughly, we believe, as the scanty allowance of space will permit. We will simply add the conclusions arrived at by Ranke from a most self-sacrificing set of experiments which he made upon himself and published in the monograph already referred to. They are:

1. The temperature optimum of the European, in moderate clothing, lies between 15° and 18° C. (59°-64.4° F.), providing that the other climatic factors exercise no undue influence at the time.

2. In a climate with an atmospheric temperature between the optimum and 22° C. (72° F.) an increased water evaporation begins to show itself, but no decided influence upon nutrition is yet noted.

3. In a climate of a temperature of 25° C. (77° F.) and on the assumption that other climatic factors are without great influence, a diminished desire for food begins to become manifest; the amount of food taken sinks to that of a man doing very light work.

4. The climatic effect still rising, the amount of food taken sinks below the need of an adult at rest and in a state of hunger. The proteids remain constant, and every further diminution occurs at the expense of fats and carbohydrates.

5. If, against the instinctive diminution in the desire for nourishment, food is forcibly taken in greater amount than is desired, pathological changes in the general health, rises in the temperature, and a decreased resistance to infectious diseases will occur.

6. If, on the other hand, the quantities of food taken are permanently diminished in accordance with the demands of a tropical climate, as is usually the case, a deficient nutrition of the organism is the inevitable result, with all the dangerous consequences that follow in its train.

From these conclusions and from the preceding discussion, the leading principles that must govern the composition of a ration or the diet of a man who has transferred his residence from a temperate to a tropical climate may be easily inferred. The details of it are subjects of special research.

A sea climate is perhaps more nearly a purely solar climate than any land climate can ever be. A solar climate is defined as a climate which would be characteristic of every degree of latitude, if the earth was a mathematically perfect spheroid without unevenness, and had throughout the same composition. This is true at least for the great oceans. Although the value of the total mean thermic effect of the climate, which the seaman is exposed to as long as he confines himself to the limits of his ship, has not yet been determined with scientific accuracy, it may be safely said that that value is less than one found over a corresponding latitude on land. It would most undoubtedly be modified by the ship, especially one of the modern battleships, in which every part has a climate of its own and which must be regarded as a heat producing body; nevertheless, the total mean effect on deck will be found to be considerably less detrimental than the corresponding shore climate. With the aid of a few thermometers, psychrometers, anemometers and some interest and experience in scientific investigations, this work should present no difficulty. Until it shall have been done, any expression of opinion on the influence of the climate in which the seaman lives, upon his heat economy, and upon the composition of his ration, would be premature.

IV. Recruiting.

Recruiting for the navy signifies the separation by a medical officer of the physically fit from the physically unfit, of the mentally sound from the mentally unsound, of good timber from bad timber, for a most serious and important service, the common defence of the land and its people against a danger threatening their commerce and their liberty from the direction of the sea. Every physician in the land should be familiar with the principles and practice of recruiting, and recent experience has demonstrated the fact that every medical man in the country is liable to be called upon to do this duty. Whatever else there may be connected with the process of enlisting a man in the navy or army, the point of gravity in the duty of recruiting lies in the medico-physical examination of the recruit; but to perform this duty properly requires some knowledge as well as practice. We shall be obliged to limit ourselves here to giving a very brief outline of some of the more important principles involved.

To begin with, it is a mistaken notion to presume that any individual with a normal heart and a good pair of lungs must necessarily be a fit candidate for the navy. There are indeed many other points of equal importance which the examiner must keep constantly in mind while scrutinizing a candidate. Besides seeing to special parts in the anatomy of an individual, he must look at the man as a whole. Generally speaking, a fine form symmetrically proportioned, good development, regular features, a good clear eye, a frank and open countenance, convey an impression that is rarely misleading; they form an index to the inner life of the man, usually favorable. On the other hand, asymmetry of face and body, irregular development and features, the stigmata of degeneration, in at least fifty per cent. of the cases are unfavorable in this respect. They would indicate an abnormal deviation from the average, the juvenile offender in the young, the hardened criminal and repeater in the adult. The navy can no longer be considered a reform school for the juvenile offender nor a prison for the cure of the hardened adult criminal. Neither the time nor the training can be given in the service to such objects, however noble, and there are other institutions, maintained by the state, the special function of which is to attend to these duties.

Besides good physique, the man, to be of any real and permanent value to the service, must bring with him right from the start a good will, a high sense of duty and responsibility capable of further training, all of which he must be prepared and willing to maintain during the entire term of service to his country and his flag. This may be aiming high, but many years' experience, both in recruiting and in surveying the unfit, have proved to my satisfaction that the service is not benefited but injured by anything below such a standard.

The British Navy.—The only other navy with which our own can be compared as regards the system of recruiting is the British navy. Although the system of conscription for the army has—until recently at any rate—always been considered in England to be a detestable and insufferable encroachment on individual liberty, sailors have at all times been regarded as bound to serve in the royal navy. If they did not enter the service voluntarily, they were simply pressed into it by the press-gang, often very ruthlessly and cruelly. These press-gangs, commanded by officers, were sent into the ports to seize all available seamen. The man, thus forcibly enlisted, had a small coin (the Queen's shilling) pressed into his hand, and it is from this circumstance that the name press-gang is said to have been derived.

This peculiar method of recruiting the navy, scorning, as it did, all law and humanity, had nevertheless taken such firm root in the habits and modes of thought of the

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people of England that, even during the long period of peace after Waterloo, when humanitarian principles were taking a strong hold on all civilized communities, no attempt was made to abolish the press-gang. Down to the middle of the nineteenth century English admirals declared that the press-gang was one of the props of the greatness of England and absolutely indispensable.

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By that time public opinion resolutely and persistently objected to this forcible enlistment, so that in 1852 the Admiralty was forced to adopt new methods for the recruiting of seamen for the navy—methods which turned out to be highly beneficial, leading as they did to a thoroughly beneficial reform in the manning of the navy and to a very superior personnel at the same time. The royal navy of Great Britain and the navy of the United States are now both recruited on the voluntary system, while in the continental naval services the system is by conscription.

The average of volunteers has invariably been found superior to that derived from those who were driven into the service either by force or by necessity or who entered for reasons of convenience. So far as the navy of the United States is concerned, its personnel has markedly improved during the last twenty-five years, and the general public is beginning to look upon the naval uniform with both pride and affection instead of as a mark of degradation.

For the details and the nature of the physical examination required in both services, the reader is referred to Appendices I. and II., at the end of this article. Every physician may well be supposed to be familiar with the technique of the examination.

The Recruitment of Officers.—This presents several rather interesting as well as instructive differences in the two services. In the English service, considerable stress is laid upon the circumstance that the young naval candidate possesses a good family origin and connections. Under the more democratic form of government of the United States, this principle of selection does not prevail. Then, again, the promotion to the higher grades or command rank does not proceed by seniority in England as it does in the United States, but by selection.

There is, then, a certain amount of selection at both ends of the line in the British service that does not exist in the United States naval service. Besides, the cadet as well as midshipman in the British service is obliged to defray not only all his private personal expenses but also to pay from fifty to seventy-five pounds a year for his schooling. Thus there is, in addition to the above, a money qualification. In both services alike there is a physical and a competitive mental examination, in both of which the candidate must be successful before he can become a cadet.

Granting that a certain amount of this selection which characterizes the British service as distinct from the United States service is done from motives of interest other than the best of the service, we must perhaps admit that the resulting average, thus carefully selected, may in the end be for a steady and constant improvement of their service after all. Even the least important of the qualifications, the money qualification, may not be altogether without a certain value as a principle of selection. If we regard, for instance, the possession of a certain amount of this world's treasure by the lad's father or other relatives as representing a certain amount of brain power which must have been expended at some time in order to accumulate it, the natural conclusion would be that the boy had inherited a part of this same brain power, in a facultative state, in the same natural way as he will some day inherit the accumulated ancestral possessions. We may, moreover, further assume that early training might do much to divert this power into other channels; in other words, turn the lad into a successful naval officer as his ancestor had proved himself successful in other ways.

In the free and unhampered competition in the civil life of a republic like that of the United States and in the general scramble or struggle of the masses for social preferment, high official position, professional distinction, or financial betterment, almost any individual will in the end find his level, in accordance with his natural and inherited endowments, his abilities, acquired through education, and the use which he makes of them. The gifted, industrious, physically and mentally fittest will easily rise to the top, while the physically weak and the mentally deficient will, as naturally and according to the same law, gravitate to the bottom of this sea of human life and of the multitude. The process of natural selection in the social sphere of human existence has full sway here.

In naval and military life, in countries where all are supposed to be born equal but are not, and in which selection on the principle of true merit and ability has been found either inconvenient, impracticable, or impossible, where artificial barriers are created and placed in the way of the advancement of organized merit and ability, the results must very naturally be somewhat different. While, perhaps, a high and uniform level of efficiency on the part of the individual members of such a body of men may not be inconsistent with such methods, an extremely dangerous dearth of leaders must, nevertheless, remain the inevitable result of such a system, a dearth most keenly felt at the most inopportune moments of national trials and tribulations.

In view of the above facts and considerations the process known as recruiting, being practically the only generally recognized and accepted method of selecting those who are fit for the service from those who are not, becomes of an importance all the greater. From this view-point the physical examination of the recruit, more especially, however that of the cadet, must appear in an entirely new light and one which, in its far-reaching importance, it would indeed be difficult to exaggerate.

The Significance of Selection by Means of a Physical Examination.—With the aid of a physical examination, as this is understood at the present day, the scientifically trained and practically experienced examiner is able to select, from a given number of candidates, a group not only superior in physique, but also, and at the same time, one superior in mental qualifications to the remainder. He can, moreover, by the same means exclude the criminals, criminaloids, and the degenerates.

It has been shown by a series of observations in different parts of the United States and other countries, made by Porter, Christopher, Hastings, Beyer, and others, that children and youths who have inherited an exceptionally good physique almost invariably also manifest mental qualifications that are likewise superior. All these observations, made by different observers and by means of different methods, have led to such uniform results that the correlation must seem unavoidable to any unprejudiced observer and the application of the principles involved to the process of recruiting follows as a most natural corollary.

A necessary preliminary step to the application of these principles to recruiting is the preparation of tables according to the percentile grade system of Francis Galton from as large a number of subjects as possible and from subjects (men and boys) of as nearly the same type as those with whom the candidates under consideration are to be compared. Such tables may include any number of measurements and tests. While height, weight, and chest circumference must be regarded as absolutely essential, other dimensions are very desirable.

The tables published in "The Growth of United States Naval Cadets," United States Naval Institute No. 74, include a number of tests and measurements in various dimensions; they will, therefore, do good service in the examination of cadets. The adjoining three tables (XXII., XXIII., and XXIV.) were made from 6,901 sailor-men and boys, and may, consequently, be said to be fairly representative of the physique of that class of people who have at all times applied for enlistment in the naval service. Since, however, the averages must be preponderatingly made up from the descendants of Anglo-Saxon and Teutonic stock, the examiner will still have

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TABLE XXII.—HEIGHTS IN PERCENTAGES.

Age.	Number of observations.	Value in Inches at the Following Percentile Grades.											Averages.
		5	10	20	30	40	50	60	70	80	90	95	
15	124	59.35	59.87	60.66	61.60	62.54	66.37	64.13	64.82	65.77	66.87	67.92	63.8
16	305	60.58	61.23	62.06	62.88	63.46	64.01	64.62	65.33	66.19	67.31	68.09	64.7
17	288	61.27	61.99	63.01	63.70	64.31	64.87	65.41	65.96	66.83	67.89	68.77	65.5
18	99	62.22	62.76	63.71	64.34	64.83	65.43	66.08	66.67	67.35	68.35	69.26	66.0
19	158	62.38	63.24	64.09	64.91	65.51	65.68	66.68	67.26	67.81	68.68	69.52	66.4
20	129	63.19	63.55	64.24	64.89	65.38	65.84	66.30	66.76	67.41	68.46	69.22	66.5
21	745	62.70	63.42	64.30	64.96	65.53	66.10	66.73	67.36	68.02	68.97	69.91	66.7
22	931	62.54	63.42	64.48	65.26	65.95	66.31	67.08	67.71	68.51	69.59	70.41	66.8
23	662	62.85	63.60	64.49	65.18	65.82	66.45	67.07	67.75	68.51	69.48	70.16	66.9
24	531	62.44	63.25	64.18	64.88	65.50	66.16	66.82	67.58	68.43	69.43	69.95	66.9
25	514	62.56	63.43	64.46	65.28	65.91	66.52	67.11	67.65	68.30	69.37	70.47	66.9
26	395	62.37	63.20	64.32	65.18	65.94	66.22	66.93	67.59	68.38	69.64	70.56	67.0
27	350	62.25	63.26	64.31	65.04	65.66	66.30	66.96	67.60	68.31	69.30	70.28	66.8
28	356	62.25	63.11	64.23	65.22	65.88	66.47	66.97	67.40	68.41	69.57	70.52	66.5
29	318	62.14	63.35	64.21	64.92	65.56	66.18	66.80	67.47	68.23	69.36	70.26	66.7
30	250	62.32	63.28	64.33	65.03	65.70	66.34	66.94	67.81	68.56	69.41	69.98	66.9
31	166	61.83	63.28	64.49	65.43	66.15	66.65	67.21	67.88	68.54	69.48	70.52	67.0
32	170	62.04	62.69	64.09	64.83	65.45	66.03	66.60	67.33	68.37	69.38	69.84	66.6
33	165	61.21	62.39	64.00	64.73	65.56	66.31	66.92	67.56	68.19	68.79	69.46	66.5
34	136	62.70	63.35	64.25	65.22	66.18	66.64	67.23	67.80	68.59	69.62	70.37	67.0
35	119	61.65	63.07	63.98	64.69	65.42	66.14	66.80	67.52	68.28	69.29	70.61	66.6
Total,	6,901												

TABLE XXIII.—WEIGHTS IN PERCENTAGES.

Age.	Number of observations.	Value in Pounds at the Following Percentile Grades.											Averages.
		5	10	20	30	40	50	60	70	80	90	95	
15	124	86.80	89.70	95.95	102.33	105.84	109.00	111.35	117.80	123.05	129.44	133.80	109.5
16	305	97.08	101.21	104.89	108.13	111.56	114.42	116.73	122.50	127 18	134.12	141.76	111.0
17	288	103.13	107.69	111.66	115.77	119.68	122.60	125.53	129.27	133.34	139.82	142.72	127.9
18	99	102.90	108.90	113.80	119.70	123.53	124.94	131.47	134.66	139.20	147.10	155.25	131.6
19	158	111.95	115.90	120.30	124.23	126.30	128.45	130.96	134.53	138.90	147.20	152.55	130.6
20	129	109.45	116.45	123.90	127.34	130.12	133.90	137.57	140.47	143.40	147.70	160.55	131.6
21	745	116.47	119.97	124.44	128.59	131.92	134.90	138.81	143.59	147.44	153.77	160.92	137.5
22	931	118.73	122.67	128.15	133.05	135.92	140.08	143.88	147.80	154.24	163.36	173.11	141.5
23	662	121.52	124.83	129.83	135.68	137.85	140.85	144.22	148.24	154.04	163.10	170.95	140.0
24	531	117.11	122.34	130.13	134.30	138.15	143.27	145.86	149.75	155.23	162.82	170.36	137.4
25	514	120.62	124.10	131.45	135.18	139.33	143.67	147.53	151.78	157.44	166.60	173.30	145.6
26	395	118.94	124.10	131.80	137.63	141.08	144.81	148.17	152.92	159.90	168.17	176.42	146.0
27	350	120.00	124.70	131.20	137.00	141.63	146.27	150.75	154.93	161.60	169.87	177.50	148.3
28	356	116.80	123.65	130.37	137.30	141.62	144.32	149.18	156.32	161.56	170.28	179.07	144.9
29	318	119.56	127.27	132.33	135.78	140.55	144.09	149.01	153.15	159.85	169.64	180.42	146.6
30	250	120.88	121.56	130.75	135.83	141.43	146.20	151.71	157.20	163.00	173.00	183.50	148.6
31	166	122.46	125.53	131.60	137.97	144.28	149.00	153.52	157.60	165.27	175.13	184.70	151.0
32	170	117.50	123.80	130.00	135.00	139.88	145.67	151.50	159.00	164.50	171.00	179.50	147.5
33	165	120.75	124.80	133.50	138.50	143.17	146.70	155.17	159.88	166.50	176.50	188.37	150.1
34	136	117.60	128.30	133.60	138.80	144.13	149.71	154.86	162.55	169.52	184.40	198.40	152.8
35	119	117.85	123.30	135.40	140.90	145.40	149.38	155.80	163.30	169.24	178.20	192.15	150.8
Total,	6,901												

TABLE XXIV.—CIRCUMFERENCE OF CHEST IN PERCENTAGES.

Age.	Number of observations.	Value in Inches at the Following Percentile Grades.											Averages.
		5	10	20	30	40	50	60	70	80	90	95	
15	124	27.02	27.48	28.29	28.91	29.50	30.07	30.53	30.99	31.76	32.72	33.31	30.8
16	305	28.10	28.23	29.12	29.53	29.92	30.40	30.95	31.36	31.83	32.36	33.51	31.0
17	288	28.76	29.28	30.02	30.31	30.90	31.34	31.60	32.26	32.57	33.69	34.51	31.9
18	99	29.13	29.84	30.42	30.89	31.35	31.80	32.28	32.80	33.33	33.85	34.68	32.4
19	158	29.54	30.14	30.72	31.21	31.61	32.00	32.46	32.93	33.56	34.37	34.94	32.6
20	129	29.57	30.30	31.13	31.58	32.02	32.50	32.99	33.53	34.11	34.76	35.52	33.0
21	745	30.23	30.83	31.50	32.08	32.62	33.14	33.60	34.06	34.70	35.57	36.38	33.6
22	931	30.73	31.32	32.12	32.60	33.09	33.62	34.17	34.77	35.47	36.42	37.29	34.2
23	662	31.02	31.57	32.39	32.98	33.51	34.00	34.55	35.12	35.72	36.61	37.43	34.6
24	531	30.92	31.55	32.38	33.00	33.61	34.17	34.65	35.15	35.81	36.73	37.57	34.3
25	514	31.29	32.09	32.80	33.30	33.77	34.29	34.88	35.43	35.98	36.94	37.70	34.8
26	395	31.26	32.08	33.01	33.54	34.08	34.67	35.24	35.77	36.51	37.56	38.33	35.2
27	350	31.23	32.05	32.90	33.59	34.22	34.80	35.38	35.90	36.73	37.77	38.32	35.3
28	356	31.12	31.90	32.92	33.73	34.33	34.73	35 38	35.97	36.83	37.77	38.77	35.4
29	318	31.24	32.29	32.96	33.30	34.39	34.83	35.39	36.00	36.66	37.72	38.86	35.4
30	250	31.42	32.09	33.11	33.81	34.40	34.95	35.66	36.34	37.00	38.13	38.91	35.6
31	166	31.43	32.20	33.29	34.07	34.71	35.27	35.78	36.30	36.41	37.14	39.57	35.7
32	170	31.23	32.00	33.25	34.15	34.65	35.17	35.76	36.29	36.77	37.82	39.30	35.6
33	165	32.09	32.68	33.48	34.12	34.69	35.27	35.86	36.52	37.23	37.98	38.86	35.8
34	136	31.09	31.86	33.32	34.15	34.26	35.00	35.80	36.54	37.39	38.73	39.65	35.8
35	119	30.99	32.39	33.60	34.28	34.79	35.26	35.74	36.66	37.84	39.01	39.67	36.0
Total,	6,901												

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Naval Hygiene.

to use his judgment as regards the type of man before him in adjudging his relation to the averages given in the tables. Such tables are to the examiner what the compasses are to the navigator. One or two examples will perhaps help to make this clear.

Example I. A boy presents himself and his nearest birthday makes him fifteen years old. The measuring rod gives his height as 63.4 inches, the scale shows that he weighs 109 pounds nude, and the tape measure around his chest, taken at the level of the nipples, shows that his chest circumference is 30 inches. Looking now at the tables, along the line of averages obtained from boys of his age (fifteen) we shall find that all these figures fall under the fifty percentile grade. What does this indicate and what is his physical relation or standing when thus compared to the rest of the boys of his age? It means that out of one hundred boys of his age, our candidate is taller than forty-nine and not so tall as the remaining fifty above him; the same is, of course, true for weight and chest circumference. In other words, our boy is an average, or mean, boy for his age.

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Example II. Our second boy is sixteen years old, his height is recorded as five feet and one inch, his weight as 105 pounds, and his chest circumference as 29.5 inches. Our tables show him to be ten per cent. in height, twenty per cent. in weight, and thirty per cent. in chest circumference. These several percentages added together and averaged make him a twenty-per-cent. boy: $10 + 20 + 30 = \frac{60}{3} = 20$. In this manner a boy's physique in its relation to that of all the other boys of his age and type is brought out and the physical examiner gains an idea of the probable relation of his candidate to the rest of the community. Although it is, comparatively speaking, a rare occurrence that a recruit is found to have all his measurements fall under the same percentile grade, it is nevertheless also a fact that, whenever such is the case, our candidate shows a perfectly symmetrical development.

It has been found over and over again that the curves constructed from a number of children and youth, measured and averaged in this manner, when compared with the curves from their mental examination marks received at school, run very nearly parallel. An undoubted correlation between the physique and the mental performances of children and youths is hereby fully established and the application of the principles involved to the selection of recruits made apparent.

The minimum standards of height, weight, and chest circumference required from boys intending to enter the navy, as given in Appendix II., are all of very low percentage, when compared with the percentile grade tables, and cannot, therefore, be said to serve any purpose of selection. If notwithstanding these low limits we get a class of men into the service that is better than our requirements would indicate, this would seem to have been obtained in spite of and not with the aid of our examinations.

There seems to be nothing better established and recognized by prominent army surgeons—*e.g.*, Greenleaf, Woodhull, Munson, Woodruff, Tripler, and others—than that the lowering of the physical standard is invariably followed by a lowering of the moral standard.

Notter also believes in the correlation between the physical and the moral standards. Men of defective development are noted for the time which they spend on the sick list, in confinement; they are also known to furnish by far the greatest number of deserters.

The following table (XXV.), showing, as it does, that the percentage number of deserters has steadily increased since 1895, except during the war of 1898, would, if attributable to faulty recruiting alone, indeed be a revelation. But, although recruiting undoubtedly has its share in the production of such a large percentage of deserters, a careful and unbiassed inquiry would no doubt result in tracing such wholesale desertions to a variety of causes. Such an inquiry, if it were made without fear or favor, would throw valuable light on the subject.

Mr. Arthur H. Lee (*Nineteenth Century Magazine*, 1901),

TABLE XXV.

Year.	Naval Force.		Total.	Number of deserters.	Same in per cent.
	American.	Foreign.			
1895	....	....	10,000	888	8.8
1896	5,720	5,280	11,000	1,041	9.5
1897	6,126	5,219	11,345	1,357	12.0
1898	14,838	4,990	22,828	1,317	5.8
1899	11,446	5,386	16,832	2,452	14.6
1900	....	....	18,000	3,100	17.2

treating on the "recruiting question," says of the English army, where the standard had been lowered several years in succession: "Owing to the poor quality of the recruit enlisted, it ensues that less than 47 per cent. ever serve their full term; the remaining 53 per cent. are completely lost to the service and the country after an expensive training and a few years' inefficient service." "Owing to the same cause, the annual number of desertions has risen from 3,357 to 6,378." "Owing, moreover, to inefficient recruiting, at least 10,000 men disappear annually from the ranks of the army, for no valid cause beyond moral and physical unfitness." "The pecuniary loss to the nation from this cause alone is over 100,000 pounds sterling per annum, which, in my opinion, might be entirely obviated if the proper men were enlisted to begin with."

Mr. Lee's fundamental contention is, that the physically and mentally developed man is not only incomparably the better soldier, but is much the cheaper in the end.

Lord Kitchener has several times loudly complained of the poor and useless quality of recruits sent him to South Africa, and Kulp, from his recent experience, remarks, "The undersized, underfed, and underdeveloped boys one sees invalided from South Africa are not at all representative of the sturdy English race."

Thus it would seem that a lowering of the physical standards in order to increase the number of enlistments does not add to the value, the strength, or the efficiency of an army and is an unnecessary waste of public money.

Since there has been at all times a large percentage of men of foreign birth in the navy, it is interesting to note the difference in physique between that class and the native-born American. The adjoining table (XXVI.), calculated from—as nearly as that could be done—an equal number of both groups and of the same age (twenty-one) shows that, while the Americans have a slight advantage in height in almost all the percentile grades, the foreign-born American seaman has a more decided advantage in both weight and chest circumference.

TABLE XXVI.—AVERAGES OF 350 AMERICAN AND 316 FOREIGN BORN (ALL TWENTY-ONE YEARS OLD) COMPARED.

Per cent.	Height Inches.		Weight, Pounds.		Chest Circumference.	
	American.	Foreign.	American.	Foreign.	American.	Foreign.
5	62.91	62.61	113.2	115.4	29.4	30.3
10	63.50	63.40	116.9	119.5	30.2	31.0
20	64.48	64.30	121.5	124.5	31.0	31.7
30	65.27	64.86	125.0	128.5	31.5	32.3
40	65.96	65.40	128.0	131.5	31.9	32.8
50	66.52	65.93	131.4	134.7	32.3	33.3
60	67.06	66.63	135.0	138.4	32.7	33.6
70	67.61	67.34	139.1	142.2	33.2	34.3
80	68.21	68.05	143.5	147.5	33.7	34.9
90	68.94	68.88	149.4	153.9	34.5	35.9
95	69.86	69.52	157.2	159.2	35.2	36.7

The Significance of War to the Nation and the Race.—It is said of physicians that a large portion of their work is directed toward the prevention of disease rather than to the cure of it, and medical men have the rare distinction of being perhaps the only workmen known who make it

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their first duty to stop the sources of supply whence they derive their income. To prevent disease and suffering is, nevertheless, the highest function of hygiene and one of the noblest aspirations of modern medicine. If we look upon wars as preventable causes of disease and suffering and of death, it would seem to be one of the functions of naval and military hygiene not only to modify if not altogether to exterminate bullets, as we are trying to annihilate germs, mosquitoes, and other disease-producing agencies, but also to try to devise means for the final abolition of war itself. The gradual reduction in the calibre and the change in shape of the new small-arm projectile seem to be a step in this direction. In the same sense, arbitration may some day fill a chapter in a work on hygiene, and the great peace conference at The Hague, called into being by the august ruler of all the Russias a few years since, would then constitute historically speaking, the first great international attempt at promoting the fundamental interests and purposes of naval and military hygiene. War undoubtedly is the greatest and most merciless destroyer of the best there is of human life. The history of every war-like nation usually ends in the extinction of the best of that nation. Greece died because the men who had made her glory had all passed away; leaving none of their kin, they left none of their kind. The Greeks of to-day are the sons of those of whom she could make no use in her conquest of Asia. Indeed there is strong ground for the statement that there was more of the old heroic blood of Hellas in the Turkish army of Edhem Pacha than in the soldiers of King George who fled before them five years ago.

The cause of the fall of Rome has been traced to the extinction of the best of her race through her numerous conquests, only cowards remained and from their brood came forward the new generations, and even Cæsar noted the dire scarcity of real men, and "vir" the real man, became "homo" a mere human being.

"Send me the best you have," said Napoleon; "I want men, not boys." Since the time of the French Revolution and the Napoleonic wars, French skulls may be found piled up in Italy, Austria, Germany, Russia, Egypt, and Spain. They are the skulls of the best men that France had sent into the field. It was only after these were gone that the great general began to call for boys, saying, "A boy will stop a bullet as well as a man," and these died without leaving any offspring. From that time onward the men of the Loe became the fathers of the present men of France. M. Legoyt thinks it will take long periods of peace and plenty before France can recover the tall statures mowed down in the wars of the republic and of the first Empire.

Mr. Arthur Knapp, in his work entitled "Feudal and Modern Japan," says: "It is astonishing to find that after more than six generations or more than two hundred years of peace in which physical courage has not been demanded, these virile powers in the Japanese should be found unimpaired!" The student of history, however, finds that this is just what he would expect, for, in times of peace there is no slaughter of the strong, no sacrifice of the brave and courageous. It is in accordance with the laws of natural history and is proven by all the records of human history that the nation which has seen the least of war always develops the strongest battalions.

Germany, always systematic and thorough, taking advantage of the lessons taught by scientific research and, guided by the best principles of the times, spends her men and reduces the waste in war to a minimum by the strictest attention to scientific hygiene. She is military rather than warlike. In modern times the greatest loss to Germany has occurred through emigration, not through wars. The tendency of all emigration, whether from country districts into towns in the same country or from one country to another, has always been to weaken those left behind. Ammon has shown, for Germany, by measurements, that the average of those who emigrate is superior to the average of those who stay behind. Quetelet has shown that in some towns of Belgium the average stature was a little higher than in the country. Dunant found this to hold good with respect to the inhabitants of Geneva as compared with the country people around. Villermé, Manouvrier, and others have shown that the stature of the Parisian conscript is higher by 8 or 9 mm. than that of the men belonging to the rural arrondissement of the Seine. Germany has long since recognized this, and hence her struggle for colonies, the possession of which alone can save her ever-increasing population to her flag. It is want of room and lack of opportunity that drive her sons to foreign shores, not fear of military service!

Holland has become a nation of old men. Her sons have died in the fields of Java, and Batavia alone is said to have one million of Dutch graves. Dutch armies are to-day recruited elsewhere. Holland will not waste any more of her own blood.

"Spain died of empire years ago. She has never really crossed our path, it was only her ghost which walked at Manila and Santiago. The warlike nation of to-day is the decadent one of to-morrow" (David Starr Jordan, *Forum*, 1901).

As long as the physician cannot prevent the occurrence of disease, he will have to continue trying to do his best to cure it; as long as war will continue to recur, a nation will have to face the foe. Since, however, the most skilful physician for the care and treatment of disease will in the end prove the least expensive to the family, so the best sailor and soldier will invariably prove the more remunerative to the state. To bring a war to a speedy and successful termination, a nation must offer as recruits, and be willing to sacrifice, the best she breeds.

Henry G. Beyer.

APPENDIX I. *Requirements for Enlistment in the British Navy.*—The British navy is enlisted upon the Voluntary System. The seaman must have a good physique, though height, apart from a good development, is considered of no advantage. While no physical examination is required for the mercantile marine, none but promising lads are accepted for the training ships of His Majesty's navy, and persons of whatever age or class found to be laboring under any of the undermentioned physical defects or deformities are, by Article 1154 of the Admiralty Instructions, 1899, considered unfit for the service:

(*a*) A weak constitution, imperfect development, or important malformation or physical weakness, either hereditary or acquired.

(*b*) Skin disease, temporary or trivial; extensive marks of cupping, leeching, blistering, or of issues.

(*c*) Malformations of the head, deformity from fracture or depression of the bones of the skull, impaired intellect, epilepsy or paralysis or impediment of the speech.

(*d*) Blindness or defective vision, imperfect perception of colors, or any chronic disease of the eyes or eyelids.

(*e*) Impaired hearing, discharge from or disease of one or both ears.

(*f*) Disease of nasal bones or cartilage and nasal polypus.

(*g*) Disease of throat, palate, tonsils or mouth; cicatrices of neck, whether from scrofula or from suicidal wounds; unsound teeth or seven teeth missing or defective in persons under seventeen years of age; ten defective or deficient teeth in persons above the age of seventeen.

(*h*) Functional or organic disease of the heart or blood-vessels, deformity of chest, phthisis, bronchitis, hæmoptysis, asthma, dyspnœa, chronic cough, or any evidence of lung disease or tendency thereto.

(*i*) Undue swelling or distention of the abdomen; disease of liver, spleen or kidneys, hernia or tendency thereto, incontinence of urine, syphilis or gonorrhœa.

(*j*) Non-descent of either or both testicles, hydrocele, varicocele, or any other serious defect or malformation of the genital organs.

(*k*) Fistula of anus, hemorrhoids, or any disease of stomach and bowels.

(*l*) Paralysis, weakness or impaired motion, or deformity of either extremity, including varicosity of veins, especially of the leg, and distortion or malformation of hands, feet, fingers or toes.

(*m*) Distortion of spine, of the bones of pelvis, no matter whether from injury or disease, or from constitutional defect.

APPENDIX II. *Requirements for Enlistment in the United States Navy.* Briefly stated, the physical requirements for enlistment in the United States navy are as follows: The candidate must be of good physical proportions, and, if accepted, is required to take oath before enlistment that he is not subject to fits and has no concealed diseases. Any of the following conditions are sufficient to cause the rejection of an applicant: Greatly retarded development; feeble constitution, inherited or acquired; permanently impaired general health; depraved condition of general nutrition; liability to any disease; chronic diseases or results of injuries sufficient permanently to impair efficiency, such as weak or disordered intellect; epilepsy or other convulsions within five years; impaired vision or chronic disease of the ears; chronic or offensive nasal catarrh; tumors of the nasal passages or great enlargement of the tonsils; marked impediment of speech; decided indications of liability to pulmonary disease; chronic heart affections; rupture; non-appearance of testicles; dropsy of testicle or cord; stricture, fistula or hemorrhoids; large

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varicose veins of lower limbs, scrotum or cord; chronic ulcers; cutaneous and communicable diseases; unnatural curvature of the spine; wryneck or other deformity; permanent disability of either of the extremities or articulation from any cause; defective teeth; the loss or extensive caries of four molar teeth.

In addition to the above, candidates for enlistment as apprentice must at least fulfil the requirements of the following table of minimum measurements:

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Age in years.	Minimum height.	Minimum weight.	Minimum chest circumference.
14	4 feet 9 inches.	70 pounds.	25 inches.
15	4 feet 11 inches.	80 pounds.	27 inches.
16	5 feet 1 inches.	90 pounds.	28 inches.

NAVAL MEDICAL SERVICE.—I. NAVAL MEDICAL DEPARTMENT.—*Historical Notice.*—"The Marine Committee" of the Continental Congress made provision at an early date for a medical department of the navy, and declared "the care of the sick and wounded to be objects of great solicitude." In the "Rules for the Regulation of the Navy of the United Colonies," adopted November 28th, 1775, this service was defined. After the completion of the revolutionary struggle slow progress was made, until 1794, when the entire naval service was augmented; yet at this time the medical departments of the army and navy were one, under an officer who bore the title of physician-general. Not until 1828 were the medical departments of the army and navy divided. In 1842 the bureau of medicine and surgery of the navy department was created, and W. P. C. Barton was nominated its chief. By the act of 1871 the entire service was reorganized, the grades of medical director, and medical inspector created, and the title of surgeon-general, with the relative rank of commodore, conferred on the chief of bureau. In March, 1898, this officer was given the rank and title of rear-admiral.

The organization of the medical corps of the navy is essentially that created by the act of 1871, and amended by the acts of 1898 and 1900.

The grades, ranks, and titles in the medical corps of the navy, compared with that of the line of the army and navy, is shown in the table prepared by Medical Director Gihon, as modified by existing law.

U. S. ARMY.	U. S. NAVY.	
All Officers.	Line.	Medical Officers.
....	Admiral.	
Lieut.-General.		
Major-General ...	Rear-Admiral	Surgeon-General.
Brigadier.		
Colonel	Captain............	Medical Director.
Lieut.-Colonel....	Commander	Medical Inspector.
Major............	Lieut.-Commander.	Surgeons (Senior).
Captain...........	Lieutenant.........	Surgeons (Junior). Passed Asst. Surgeon (Sr.).
1st Lieutenant....	Lieutenant (Junior Grade)...........	Passed Asst. Surgeon (Jr.). Assistant Surgeon.

By the act of 1898 positive rank was conferred on all officers of the medical corps of the navy, and in 1900 assistant surgeons were given the rank of lieutenant (junior grade), corresponding to first lieutenant in the army.

The titles, grades, and numbers in the medical corps of the navy are as follows, viz.: 15 medical directors, 15 medical inspectors, 55 surgeons, and 105 in the combined grades of passed and assistant surgeons.

The number of officers in the grade of passed assistant surgeon is not limited, the law providing for promotion of assistants after three years' service.

The surgeon-general does not constitute an extra number, but is chosen from the grade of director or inspector for a term of four years, being eligible to reappointment. All officers of the navy retire on reaching the age of sixty-two years.

Examination and Appointment.—A candidate for entrance into the medical corps of the navy must be between the ages twenty-one (21) and thirty years (30). He appears before a board, which is under oath to report on his physical, mental, moral, and professional qualifications.

Appointments are made in the order of merit reported by the board.

The examination is: (1st) physical; (2d) mental, consisting of (*a*) written, (*b*) oral, (*c*) clinical, (*d*) practical, and embraces about six days.

The board of medical examiners sits permanently at the Naval Hospital, New York. Prior to 1897 no examination was required from the grade of passed assistant to that of surgeon, but under present law examinations occur with each promotion. The examination for the grade of surgeon relates largely to an officer's experience attained in the lower grades. It comprises the following subjects: (*a*) Naval regulations, in so far as they pertain to the medical department; (*b*) thesis on general and naval hygiene; (*c*) thesis on clinical medicine; (*d*) practical bacteriology and chemistry; (*e*) microscopy and microbiology; (*f*) military surgery.

The flow of promotion is dependent upon resignations, dismissals, retirements, and deaths.

Officers reaching the grade of surgeon at this time (1900) have been in the service about ten years. The disposition of officers entering the corps depends upon the exigencies of the service; if these permit, they are ordered to receiving ships, and gain some preliminary knowledge of the duties and life at sea. The percentage of those given permission to appear before the board of examiners, who pass, is small. Thus, of the twenty-two candidates who presented themselves during the fiscal year ending in 1896, four were rejected physically, twelve were rejected professionally, and six were found qualified for the position of assistant surgeon. It cannot be concluded from this statement that the examination is unduly rigorous, but rather it is indicative of insufficient academic study and a lack of thoroughness in the professional equipment, which we fear is far too common a condition among the graduates of a large number of medical schools in the United States.

The compensation of officers of the medical corps is that of their corresponding rank in the line, and is shown as follows:

PAY TABLE.

	At sea.	On shore.	Allowances,* per annum.
Assistant Surgeons: Rank of Lieutenant (Junior Grade)......................	$1,650.00	$1,402.50	$288.00
Passed Assistant Surgeons:			
Rank of Lieutenant (Junior Grade)...	1,650.00	1,402.50	288.00
After five years in the service........	1,800.00	1,530.00	288.00
Rank of Lieutenant	1,980.00	1,683.00	432.00
After five years in the service.......	2,160.00	1,836.00	432.00
After ten years in the service........	2,340.00	1,989.00	432.00
Surgeons:			
Rank of Lieutenant: After ten years in the service....................	2,340.00	1,989.00	432.00
After fifteen years in the service......	2,520.00	2,142.00	432.00
Rank of Lieutenant-Commander: After ten years in the service.........	3,250.00	2,762.50	576.00
After fifteen years in the service......	3,500.00	2,975.00	576.00
Medical Inspectors, rank of Commander:			
After fifteen years in the service......	4,000.00	3,400.00	576.00
Medical Directors, rank of Captain:			
After fifteen years in the service......	4,500.00	3,825.00	720.00
Surgeon-General, rank of Rear-Admiral.	5,500.00	5,500.00	720.00

The hospital corps of the navy was authorized by an act of Congress, June, 1897, thus securing for the service skilled men for the care of the sick and wounded.

The hospital corps consists of the following grades and rates: (*a*) Pharmacists, warrant officers; (*b*) hospital stewards, chief petty officers; (*c*) hospital apprentice, first class; (*d*) hospital apprentice, second class.

* Only when quarters are not furnished by the Government. Eight cents a mile is the allowance when travelling under orders.

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An examination, physical and professional, before a board of medical officers, is required for enlistment and for promotion in each of the above grades.

The naval medical department maintains hospitals at the following places: Widow's Island, Me.; Portsmouth, N. H.; Boston, Mass.; Newport, R. I.; Brooklyn, N. Y.; Philadelphia, Pa.; Washington, D. C.; Annapolis, Md.; Norfolk, Va.; Pensacola, Fla.; Mare Island, Cal.; Yokohama, Japan; Cavité, P. I. The hospitals provided by the original act of Congress were those at Boston, New York, Philadelphia, and Norfolk. That at Philadelphia has been converted into the Naval Asylum, and a fine modern structure has taken its place.

The naval hospitals of the United States and other powers have been fully described by Surgeon J. D. Gatewood, U. S. N.*

At a comparatively recent date most of these hospitals have been modernized in construction, and their equipment has been raised to present requirements.

Although the hospital ship *Maine* has done efficient service in South Africa, the floating hospital of the future will be the *Ambulance Ship*, such as was the *Solace* during the late war with Spain. The object of such a ship is to collect the sick and wounded in a fleet after an engagement, render immediate succor, and transfer the wounded to a base hospital. While the presence of such a ship amid hostile fleets had been previously proposed, the desirability of such a step was formally advanced, and earnestly advocated by the present chief of bureau, Surgeon-General W. K. Van Reypen, in a paper read before the Twelfth International Medical Congress, held at Moscow in 1897, and in less than a year it was this officer's privilege to commission the *Solace*, a ship such as he had described, which rendered such excellent service in the war with Spain.

The *Solace* had a displacement of thirty-six hundred tons, was three hundred and seventy feet over all, with an average speed of fourteen knots; she carried steam launches and barges for the transfer of the sick and wounded. Hoisting and lowering were accomplished by steam winches. A complete aseptic outfit, formaldehyde generators, disinfecting chambers, laundry, and drying room were provided. The *Solace* accommodated three hundred and fifty patients. Ventilation was accomplished by means of powerful blowers and electric fans. The ship flew the Red Cross, and was under the protection of the Geneva Convention. Indeed everything which could be suggested to make this floating, travelling hospital a success was done. The excellent results accomplished justified all expectations, and established a decided advance in the humanitarian aspect of modern war.

Hospital ships may still serve a useful purpose as before stated, when the base of a fleet is too remote to permit of the transfer of the disabled. When conditions obtain, such as those at Santiago, or such as prevail at present (1900) in Manila and China, the *Ambulance Ship* will be of inestimable value so long as Japan can be used as a base.

Service at Sea.—The progress made in the past twenty-five years in the betterment of conditions making for health on shipboard are only equalled by the advance in the sciences of medicine and surgery themselves; yet the former condition is not largely due to the latter, but rather to the improvement of naval construction and a higher appreciation of sanitary principles, which have been so persistently inculcated. Medical Director Gihon has drawn a graphic picture of this change; and since this officer's active service closed, the improvement has continued, the modern man-of-war presenting the most striking object-lessons, showing how an observance of the prime principles, involving a supply of fresh air, good lighting, and scrupulous cleanliness, has so far succeeded as to render a most unnatural life and environment a comparatively healthy one. In this connection, it must be borne in mind what a radical change has been wrought in the life of a man-of-war's crew by the change from sail to steam power; and to overcome the deleterious effect thus brought about has been the most important problem which the naval medical officer has been called upon to consider; and the splendid results obtained in our service during the late war are most creditable alike to commanding and to medical officers. We have every reasonable hope that the lessons of the past are now heeded, and that the inutility of a ship, however powerful, with a crew living in unhealthy conditions, has been amply demonstrated. Such was Admiral Vernon's expedition against Carthagena, in which the crew were crowded into dark, ill-ventilated sleeping quarters, and were fed upon salt and often decomposing food with bad water. Surgeon-General Tryon has pointed out that when iron and wood supplanted steel as the material for the construction of ships, a destructible organic substance was substituted by an indestructible, inorganic substance, and this change worked the most important reform in naval hygiene. The sequels of this change were broad inlets for the admission of air, and light, systematic ventilation, the distillation of water, its preservation in iron tanks, and the improvement of the rations by the art of preserving foods. Thus were accomplished the conditions which have made prolonged life at sea not only possible, but one closely approaching the natural. A discussion of such questions belongs to the domain of naval hygiene; they have been alluded to here, and give the reader an idea of the broader lines of duty which will engage the attention of a medical officer at sea. The details and daily rounds are soon mastered, and are important or unimportant, much more in the way in which the sanitarian of the ship conceives of his duty than in any other. The naval medical officer will soon learn that it is in the broad realm of preventive medicine that he will find his sphere of greatest utility; that to ameliorate the effects of environment and to reduce the potency of pathological factors should be his chiefest aim.

The daily duties are defined by regulation; and besides attention to and report upon the condition of the sick, they embrace an inquiry into that of the living spaces, cells, closets, pantries, and an examination of food and water issued or coming on board. A duty peculiar to army and naval medical service is that of determining whether in a given case of disease or injury it is the result of causes incident to service; on this decision rights to pension are based, and in it also are involved the rights of the individual and the Government alike, both of which are to be respected.

The facilities of the medical department on shipboard have in late years been greatly improved, involving a comfortable hospital, or sick-bay, usually supplied with bath and closet. When we consider that the primal object of a battleship is the destruction of life, we must admit that the humanitarian side of the question has had as a rule fair treatment. Medical officers at times complain of an insufficiency of accommodation, yet a generous consideration is accorded, and any agencies seriously affecting the interest of the department are, if possible, remedied. The medical supplies, including hospital stores, furnished by the naval laboratory located at New York, are usually of good quality; and this held good during the stress of the Spanish-American war. The supply table is varied and the allowance liberal. Complete antiseptic outfits are supplied, and the instrument cases are now so complete that when hospitals are inaccessible, major operations can be performed with confidence.

Inasmuch as the naval medical officer visits all climates, he should be an authority on climatic diseases, and consequently the reports of the bureau of medicine and surgery contain frequent descriptions of such maladies. Indeed, since the late acquisition of territory by the United States, the great need of more exact knowledge of diseases foreign to our own nomenclature has been greatly emphasized.

The accompanying table exhibits the amount of disease in the naval service for the years 1893–94.

* "Naval Hospitals, Medical Schools and Training School for Nurses." Press of the Friedenwald Co., Baltimore, 1893.

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	1893.	1894.
Mean strength	10,193	10,482
Daily average number of sick	161.35	172.50
Average number of days of each case under treatment	6.10	7.31
Admissions, per 1,000	821.24	821.31
Invalided, per 1,000	80.93	97.50
Deaths, per 1,000	3.82	4.57

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Recruiting for the naval service is a matter of the greatest importance, as we have here an opportunity to shut out predisposing and hereditary tendencies as well as existing disease. This work for the navy is usually done on shipboard (receiving ships) and for the marine corps at a rendezvous located in our large cities. As far as possible examination for entering the naval service should be discouraged on shipboard.

It is to-day incumbent on the naval medical officer to be familiar with the duties involved with bluejackets and marines landed to co-operate with the army. This service is becoming more than occasional, especially in the operations in the Orient.

The number of medical officers detailed for a ship of war depends principally upon her size, third and fourth rates carrying one, second and first rates two, the flag-ship as a rule carrying but three officers, the senior being the fleet-surgeon, who is on the staff of the commander-in-chief, and is by the regulations entrusted with duties largely supervisory in character.

The disposition of the medical department on a ship in action is provided for only in a general way by the regulations. The type of the ships varies to such an extent that the matter is wisely left to the discretion of the commanding and medical officers. The care of the wounded in action will be considered in the next section.

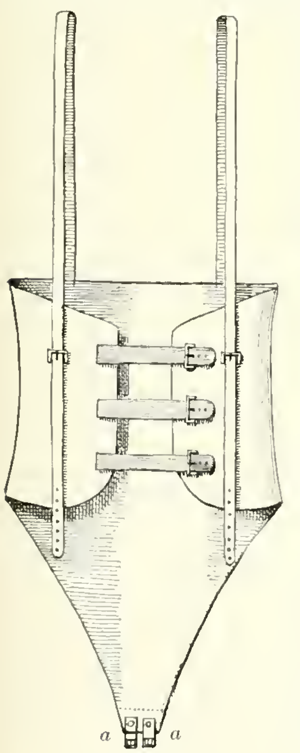

FIG. 3510.—Lowmoor Jacket.

Service on Shore.—Medical officers of the navy serving on shore are detailed, according to their rank, as members of boards, in charge of hospitals, at navy yards, recruiting rendezvous, on receiving ships, or on some form of special duty. The length of a shore detail is from one to three years (usually the latter), according to the requirements of the service. Recent law makes retired officers eligible for duty on shore and at sea.

Not since the Civil War has the lowest grade of the naval medical corps had the full number allowed by law. This condition has been attributed to various causes, such as the fact that an assistant surgeon, upon entering the service, is ranked as a steerage officer and is not admitted into the ward-room, and the further fact that he has entered a grade lower than in the army. Doubtless these facts may have exerted an influence in some cases, but they cannot, in the opinion of the writer, have operated to any considerable extent. The standard of the examining board has been a strong factor, as is evidenced by the percentage of rejections. The first two objections have been removed by recent law.

The life of a naval medical officer at sea is one of practical isolation; and, despite the literature so liberally supplied, he inevitably gets out of touch with the great mass of the profession. In discharge of the duties required of him by the regulations he may have been fully occupied, but this fortunately does not occur in so far as strictly medical or surgical work is concerned. The greatest need of the medical service of the navy is an opportunity to avail of post-graduate instruction, and it is much better, with the present numbers of the army and navy, that such instruction be followed in a civil school. It may be that in the future the importance of the interests involved will justify an army and navy medical school, such as that at Netley in England; but until then the medical officers of the two services must look to the great metropolitan hospitals for advance in the more strictly professional aspects of their duty, and some plan by which this can be more systematically accomplished will greatly enhance the efficiency of the naval medical service.

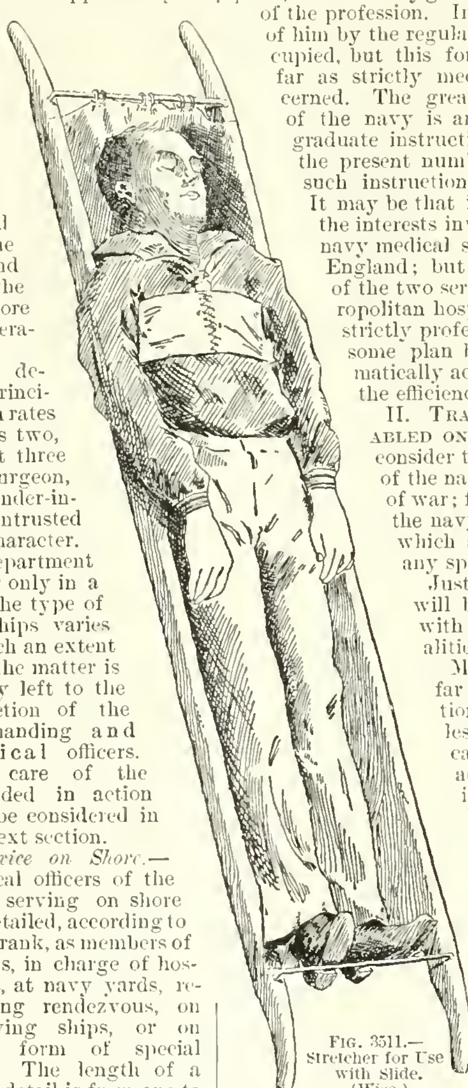

FIG. 3511.—Stretcher for Use with Slide. (Wise.)

II. TRANSPORTATION OF THE DISABLED ON SHIPBOARD.—It is proposed to consider this question as it relates to ships of the navy, and more especially in time of war; for in the merchant service and in the navy in time of peace the difficulties which are encountered do not call for any special consideration in this place.

Just what the fate of the wounded will be in a maintained naval action, with its inevitable high rate of casualities, no one can foretell.

Mr. Archibald Forbes has gone so far as to say that since the introduction of modern firearms and smokeless powder the wounded will not, cannot, be cared for until after the action (this statement was made in reference to engagements on land), or on the succeeding day; but the war in South Africa and the Philippines has totally disproved this position, as never before has the medical department been so much exposed or the wounded more scrupulously cared for.

In the old style man-of-war we had, in all ships, to deal with the same general type,—we had broad hatches, wide ladders, easily removed, and flush decks. To-day the decks are cut up and subdivided indefinitely. There is such a demand for space that great ingenuity is necessary to get the requisite equipment and all the quarters within the hull. This state of affairs is greatly accentuated in the battleship. The turrets, tops, and fire-rooms are practically isolated.

For the care and transport of the wounded on a ship like the *Brooklyn*, an armored cruiser, or the *Oregon*, a battleship, there are from two to three medical officers, an apothecary or hospital steward, and two or three hospital apprentices—an average of five persons. From each gun-crew two men are detailed as aids, numbering from eight to twelve ordinarily. With this force the wounded in a crew of six hundred must be relieved.

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A most conservative estimate of the number of wounded in naval actions of the future is thirty-three per cent; in the action between the *Bonne-Homme Richard* and the *Serapis* it reached fifty per cent. on each side. Long before thirty-three per cent. of a crew are placed *hors de combat*, no aid will be available from the guns.

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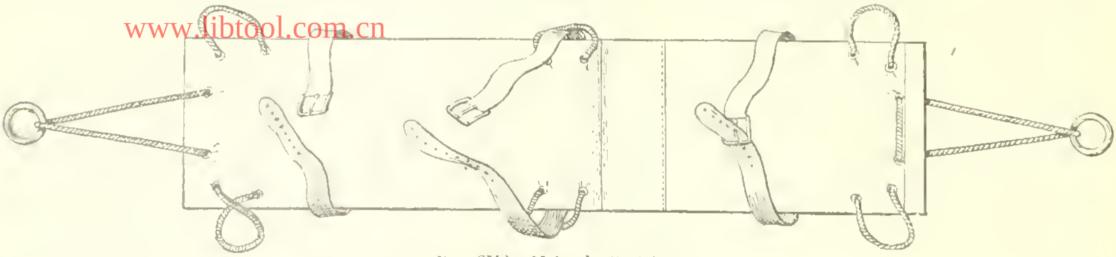

FIG. 3512.—Mahan's Stretcher.

The careful medical officer, before an action, will have studied this question as applying to his own ship. He will have established the stations for the wounded and the base of supplies. He will have indicated points of temporary shelter about the decks and will have distributed first-aid packages. In all probability there will be no systematic transport of the wounded during an action at sea. In the turrets, tops, and fire-rooms the wounded will be given emergent aid, and will be allowed to remain where they fall, or they will be pushed aside into temporary shelter.

For the dark, narrow, acute-angled passages hand portage is alone available; and this method will prevail in those heated contests in which time cannot be taken or aid secured to send all the wounded below.

During the late war with Spain the navy gained little experience in this respect, for the number of casualties on the American ships was insignificant, while on the vessels of the enemy the destruction of life was so great and the conditions were so frightful that no systematic relief could be attempted.

For the removal of the sick or injured from the hold or fire-room, or for sending them down from the tops we can conceive of no better device than the Lowmoor jacket (Fig. 3510), which may be briefly described as follows:

This jacket is T-shaped, and adapts itself to men of different sizes. The arms of the T surround the body, and extend from the axillæ to the waist, fastening in front by three leather buckles and straps; the leg of the T, passing down behind the body and over the perineum, comes up and fastens in front by two straps and buckles. Two leather straps are stitched to the back of the jacket for its whole length, and their free ends are then brought high up above the shoulders (in the form of loops) and carried down to points where they can be fastened by buckles to the front of the jacket. The ends which extend beyond these first buckles are to be passed through two other buckles which are fastened to the ends of the two perineal straps (cut off at *a*, *a*, in Fig. 3510).

The transportation of the disabled along the deck, or between decks, from above below, can be accomplished by by several different stretchers. The writer devised a stretcher and slide for this purpose, which has been favorably reported upon by a board of officers for use in the naval service (Fig. 3511). This stretcher consists of two poles seven feet eight inches in length, and a piece of canvas six feet two inches long, into the sleeves of which the poles run. Two steel stretcher-bars, three-quarters of an inch in diameter, join the poles (at points where the canvas terminates), and passing through them are secured by nut and screw. Two canvas bands are fastened to the frame on either side so as to cross the chest of the occupant at the axillæ and fasten in front with hooks and lacing. When the patient is put upon the stretcher, his insteps take upon the lower bar, preventing his slipping downward. The slide to be used with this stretcher is made of ordinary boards, battened together, and may be placed in a hatchway, extending from the coaming to the deck below, over the ladder, or it can be used without the ladder. Upon this slide the stretcher is sent below.

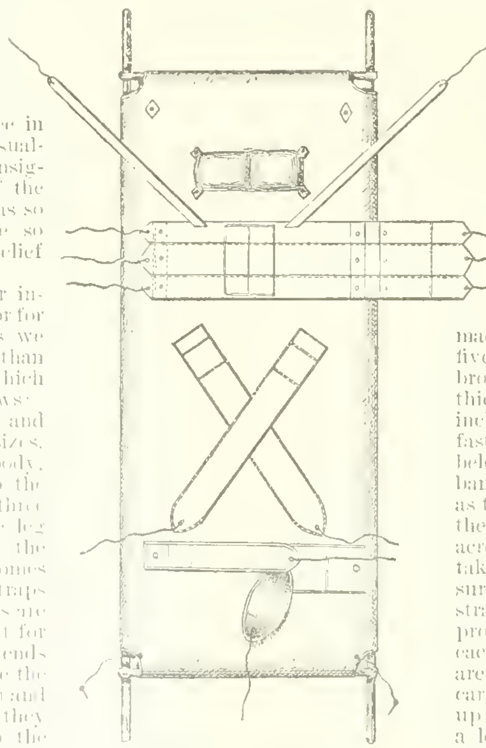

Fig. 3513.—Gihon's Stretcher.

The advantage of this stretcher is, that it does not involve suspension of the body; and it is immaterial whether or not a ladder is in place in a hatchway.

When not in use the bars are removed at one end, laid parallel with the poles, and the whole is neatly rolled. This form of stretcher is available for landing parties. Lieutenant-Commander Mahan has devised a stretcher which is described by Medical Director Gravatt, U. S. N., as follows (Fig. 3512): "This stretcher is made of light pine boards, six feet five inches long, fourteen inches broad, and one and one-half inches thick, with a wooden batten several inches in height and thickness, firmly fastened across each end and a little below the middle. Three canvas bands, four inches broad, are made so as to buckle just across the chest at the armpits, over the abdomen, and across the leg. The middle batten takes under the buttock, 'and gives surprising support.' A man so strapped can be put in any position, prone, upright, or at any angle. Near each end of the board, rope handles are made, by which it can easily be carried through narrow doors and up and down ladders. By means of a loop across the head-end it can be lowered through hatches or over the side."

The suspension of sick or wounded men on shipboard is a very unusual occurrence, and it will probably never be attempted in action. For bearers to carry a man down a ladder in a stretcher is a very awkward procedure; and a device like Mahan's, when sending below, will be most serviceable when used with a slide.

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Objections urged against this stretcher are, that it would be injurious in case of thigh fracture, and that it cannot be availed of for landing parties. Medical Inspector Gravatt, U. S. N., reports that he has used Mahan's device in cases of thigh fracture without detriment.

There are many other forms of stretcher available for the purpose under consideration. Wells' ambulance cot is in use in the United States naval service, but, as is true of other devices of this kind, men cannot be sent below upon it conveniently without the slide. This is an excellent form of stretcher for landing parties. "The improved cot" of Gorgas, or the "ambulance lift" of McDonald are seldom used. Gihon's "naval ambulance cot" is a secure and excellent device (Fig. 3513) and adapted to any ordinary need of transportation. Most of the stretchers devised for the old type of ship contemplate the suspension of the wounded, with hoisting or lowering; but, as hitherto remarked, this is a rare procedure. During an action at sea, if a hatchway is cleared, it will, as a rule, be used for militant purposes, and it is only where the ladder is taken away that suspension can be practised. If the ladder remain, one of the forms of stretcher already described, and with a slide, will be found the simplest and best procedure when hand-portage is not desirable.

For an improvised stretcher Lieutenant Mason, U. S. N., suggested the use of a ship's hammock, which is stretched and laced to a wooden frame, made of poles and cross-bars.

John C. Wise.

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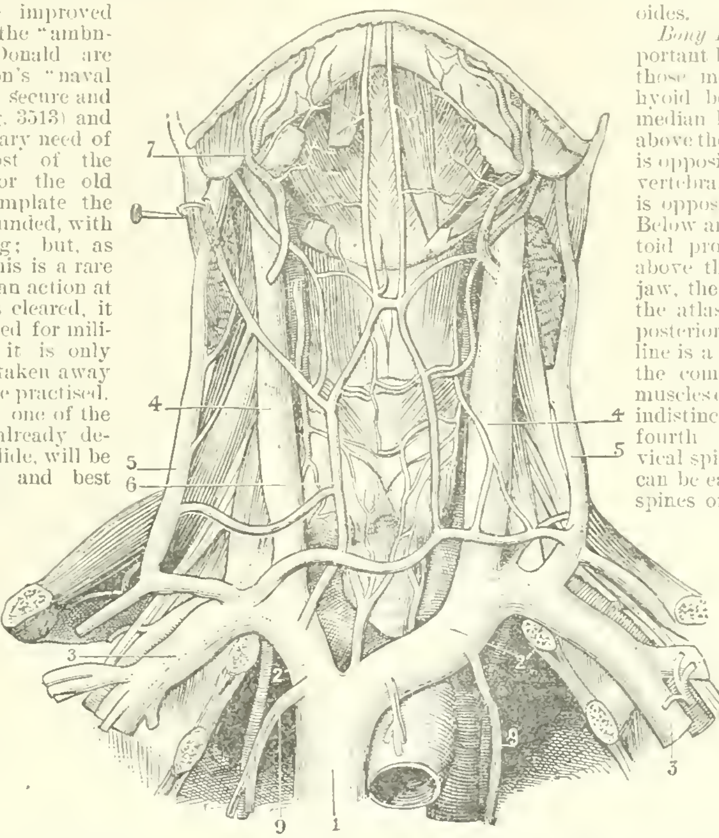

FIG. 3514.—Superior Vena Cava and Its Affluents. (From Testut.) 1, Superior vena cava; 2, trunk formed by the union of the brachial and cephalic veins on the right side; 2', the corresponding venous trunk on the left side; 3, 3, subclavian veins; 4, internal jugular vein; 5, external jugular vein; 6, anterior jugular vein; 7, facial vein; 8, thyroid veins; 9, internal mammary vein.

NECK, SURGICAL ANATOMY OF THE.—By the neck we usually mean the space between the occipital bone and lower jaw, above, and the upper aperture of the thorax, below. For convenience of description it is advisable to divide the neck into regions, viz., two lateral, an anterior median, and a posterior.

The *lateral* region represents a quadrilateral which is divided diagonally by the great sterno-mastoid muscle into two triangles, the anterior (carotid) and the posterior. Each of these is again subdivided into two by the omohyoid muscle. The anterior triangle is subdivided into a superior and an inferior carotid triangle, and the posterior into an occipital and a subclavian triangle.

The *anterior median* region is divided into two spaces by the hyoid bone, the upper being called the suprahyoid or submaxillary, and the lower the infrahyoid or hyosternal region.

The *submaxillary* region is bounded posteriorly by the posterior belly of the digastric and stylohyoid muscles, and contains the submaxillary gland.

The *posterior region* includes the portion commonly known as the nape of the neck.

SURFACE ANATOMY.—The outline of the neck varies much in different people; in stout individuals it is round and full, and the various landmarks are not easily distinguished; in thin people, on the other hand, every landmark stands out prominently, and can be made out by even the most inexperienced. The neck is, as a rule, fuller and rounder in women and children, and the *pomum Adami* is less marked. In muscular males the prominences are well seen; in old people who are thin the sterno-mastoid muscles and superficial veins stand out well, as does also the internal border of the platysma myoides.

Bony Points.—The most important bony point, and one of those most easily felt, is the hyoid bone, which is in the median line, a finger's breadth above the thyroid cartilage. It is opposite the fourth cervical vertebra. The cricoid cartilage is opposite the sixth cervical. Below and in front of the mastoid process, and behind and above the angle of the lower jaw, the transverse process of the atlas can be felt. In the posterior region in the middle line is a depression formed by the complexus and trapezius muscles of each side; here can be indistinctly made out the third, fourth, fifth, and sixth cervical spines, while the seventh can be easily felt, and also the spines of the first two dorsal vertebræ. These become more prominent when the head is bent forward; occasionally, when the spine of the sixth cervical vertebra is well developed, it is quite as prominent as the seventh. The transverse process of the sixth cervical vertebra can be felt on deep pressure opposite the cricoid cartilage, in the course of the carotid vessels. This is called the "carotid tubercle," and here the carotid may be easily compressed against it.

Anterior or Median Region.—In the receding angle below the chin is the hyoid bone, which can be easily felt in the fattest necks, it divides the anterior part of the neck into the suprahyoid and infrahyoid regions. In the median line of the suprahyoid region the anterior bellies and the digastric muscles cause a slight convexity; on the outer side of each anterior belly of the digastric muscle is felt the submaxillary gland lying on the mylohyoid muscle, which helps to form the floor of the mouth. This region is commonly cut into in self-inflicted wounds of the throat. About half an inch below the hyoid bone is the prominent thyroid cartilage (pomum Adami). This cartilage is prominent in deep-voiced men and people with thin necks, but in women and children it is not so distinctly seen; the notch at its upper border can be easily felt, and is commonly situated to one side of the median line. The superior cornua of the thyroid cartilage can be traced with the finger.

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The space between the thyroid cartilage and the hyoid bone is called the thyrohyoid space, a membrane connecting these two structures; this membrane is covered by the muscles going to the hyoid bone from below, and is pierced by the superior laryngeal nerve and artery of each side. A cut made through the thyrohyoidean space would sever the lower part of the epiglottis. The rima glottidis is opposite the middle of the thyroid cartilage. Below this cartilage the finger sinks into a slight depression, the cricothyroid space; this is the space in which the operation of laryngotomy is performed, the opening here being well below the vocal cords. Across this space ramify two small vessels, the cricothyroid branches of the superior thyroid arteries. The next landmark of interest is the cricoid cartilage; it is a guide to many operations on the neck and air passages, and can be distinguished in the youngest and fattest neck. The cricoid cartilage is opposite the sixth cervical vertebra, and the narrowest part of the gullet is behind it; at this point foreign bodies are most likely to be arrested. The omohyoid muscle crosses the carotid vessels on a line with the cricoid cartilage, immediately above which line is the point usually selected for tying the common carotid artery. The middle cervical ganglion of the sympathetic is also on a line with this cartilage, and a little below and outside of it is the point where the vertebral artery enters the transverse process of the sixth cervical vertebra.

Below the cricoid cartilage the finger passes on to the trachea, the separate rings of which cannot be easily felt, because they are covered by the isthmus of the thyroid gland above, and below the trachea recedes from the surface. At the upper border of the sternum the trachea is one inch and a half from the surface. The isthmus of the thyroid crosses the second and third rings of the trachea.

In front of the trachea, below the isthmus, lie the inferior thyroid veins, which give so much trouble in tracheotomy. Occasionally an artery is found lying upon

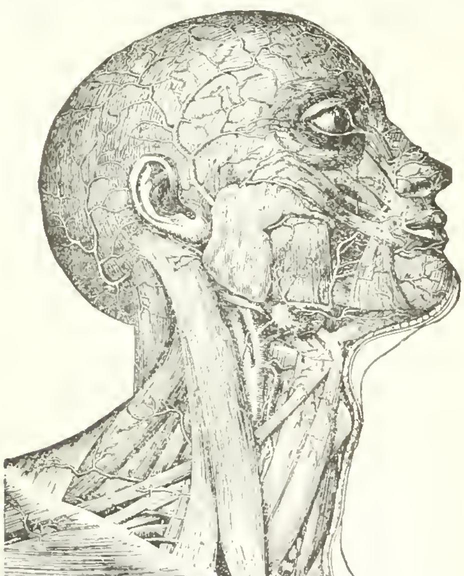

FIG. 3515.—Dissection of the Neck, showing the Triangles and their Contents. (Tiedemann.)

the trachea, on its way to the thyroid gland; it is called the thyroidea ima and generally arises from the innominate. The episternal notch is felt at the top of the sternum, and is opposite the second dorsal vertebra.

Lateral Region.—The sternomastoid muscle is the prominent landmark in this region; in thin subjects, especially, it is well seen, and stands out distinctly when the face is turned to the opposite shoulder. The inner border, which covers the carotid artery, is more strongly marked than the posterior, which is thin, only the lower portion

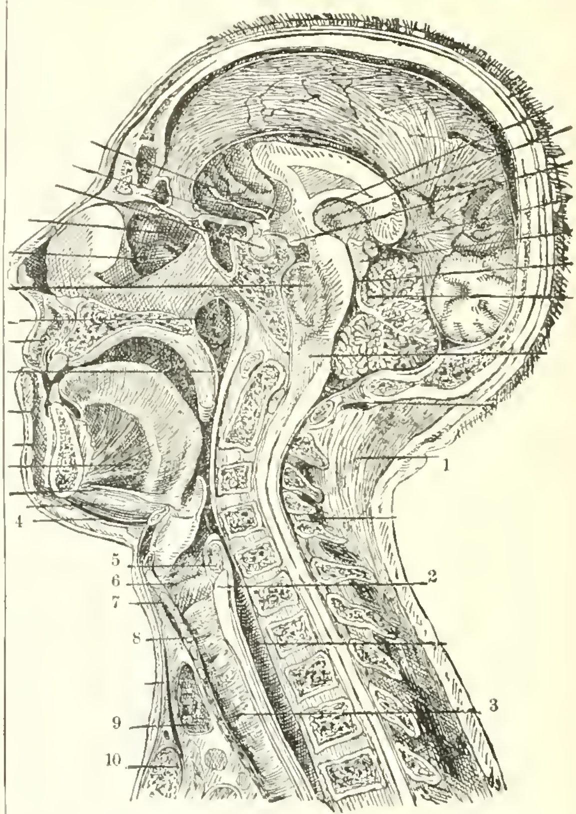

FIG. 3516.—Vertical Median Section of the Head and Neck. 1, Ligamentum nuchæ; 2, cricoid cartilage; 3, trachea; 4, hyoid bone; 5, musculus arytenoideus; 6, ventricle of larynx; 7, thyroid cartilage; 8, cricoid cartilage; 9, thyroid body; 10, sternum. (After Braune.)

showing through the skin. The sternal tendons are well seen in nearly everybody, the depression between them being named the suprasternal fossa. In some necks this fossa is absent, owing to the space being filled with fat. The space between the sternal and clavicular portions of the sternomastoid can usually be made out; in thin necks it is well marked. The internal jugular vein and carotid artery lie behind this space; deeper down still, we have the apex of the lung, which sometimes rises an inch and a half above the clavicle.

The sternoclavicular articulation is an important landmark; immediately behind it, on the left side, is the common carotid artery and the division of the innominate; on the right, it is opposite the point where the internal jugular joins the subclavian vein to form the innominate. The division of the innominate artery in children is higher up than the articulation; in some cases it divides in front of the trachea (see *Arteries, Anomalies of*).

The depression above the clavicle, between the trapezius and the clavicular origin of the sternomastoid, is called the supraclavicular fossa. In this fossa the external jugular vein terminates in the subclavian, after piercing the deep cervical fascia. Here also may be felt, in thin persons, the brachial plexus of nerves and the omohyoid muscle, and in the angle formed by the sternomastoid and clavicle the third part of the subclavian artery may be felt pulsating. At this point it can be compressed against the first rib. The central point of the greatest convexity of the clavicle is opposite the third portion of

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the subclavian artery. This is a more certain landmark than the muscle, the extent of attachment of which to the clavicle varies considerably.

The posterior border of the sternomastoid corresponds pretty closely to the outer border of the scalenus anticus muscle; this point should be borne in mind in tying the subclavian artery.

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Behind the sternomastoid the chain of lymphatic glands, when enlarged, can be easily felt.

The posterior belly of the digastric muscle corresponds to a line drawn from the mastoid process to the body of the hyoid bone. When the chin is extended a prominent fold of cervical fascia can be felt going from the angle of the lower jaw, downward and outward.

The position of the tonsil corresponds externally to the angle of the jaw.

Veins (Surface Marking of).—The most important of these is the *external jugular*, which can always be seen. Its course is marked out by a line drawn from the angle of the jaw to the middle of the clavicle, at which point it pierces the deep cervical fascia to join the subclavian vein. It is occasionally joined by a vein which runs over the clavicle (see *Veins, Anomalies of*). By pressing above the clavicle, the vein is distended, and its course is easily traced.

The *anterior jugular* vein lies on the sternohyoid muscle and in front of the inner border of the sternomastoid. When the external jugular is small this vein attains considerable size.

The surface marking of the *internal jugular* corresponds to a line drawn immediately external to the line of the artery. The *facial vein* runs from the anterior border of the masseter muscle downward and backward, and joins the internal jugular opposite the upper border of the thyroid cartilage.

The *middle thyroid vein* crosses the carotid artery opposite the cricoid cartilage.

Arteries (Surface Marking of).—The *carotid* artery corresponds to a line drawn from the sternoclavicular articulation to a point midway between the mastoid process and the angle of the jaw. The *common carotid* reaches as high as the upper border of the thyroid cartilage. It can be compressed against the sixth cervical transverse process ("carotid tubercle"), which is opposite the cricoid cartilage. The *superior thyroid* artery comes off from the external carotid a little above the upper border of the thyroid cartilage. The *lingual* artery runs forward from the external carotid to the upper border of the great cornu of the hyoid bone, to which it is parallel. The hypoglossal nerve lies above the artery. The course of the *facial* artery in the neck corresponds to a line drawn from the tip of the great cornu of the hyoid bone to the outer border of the masseter muscle.

The *occipital* arteries can be felt pulsating immediately below and a little in front of the tip of the mastoid process.

Nerves (Surface Marking of).—The *spinal accessory* nerve passes beneath the anterior border of the sternomastoid muscle an inch below the tip of the mastoid process, and emerges from the posterior border at a point on a level with the upper border of the thyroid cartilage; it then crosses the posterior triangle obliquely and enters the trapezius muscle on a level with the sixth or seventh cervical spines.

The *phrenic* nerve commences in the neck about the level of the hyoid bone, and runs obliquely downward over the scalenus anticus to its inner edge. In the neck the phrenic nerve is covered by the sternomastoid.

The *superficial cervical* nerves all emerge at a point corresponding to the middle of the posterior border of the sternomastoid. The *great auricular* crosses the sternomastoid on its way up to the ear; the *lesser occipital* runs along the posterior border of the sternomastoid; the *superficial cervical* crosses the sternomastoid at right angles and reaches the middle of the neck, and lines drawn from the point of emergence to the sternum, middle of the clavicle, and the acromion would mark the course of the *suprasternal, supraclavicular,* and *supra-acromial* nerves.

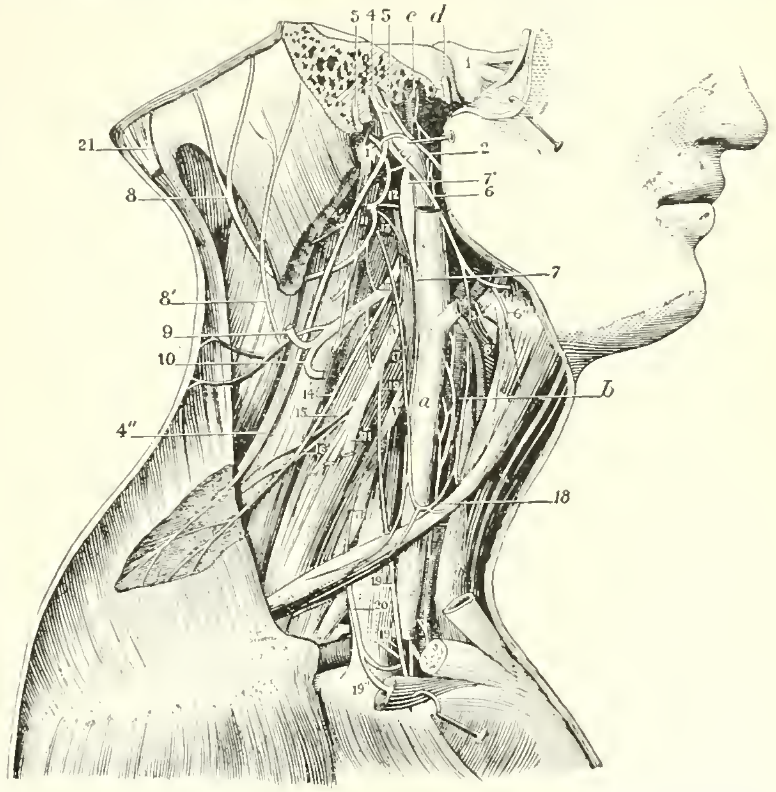

Fig. 3517.—Deep Cervical Plexus of Nerves. (From Testut.) *I, II, . . . VIII*, Anterior branches of the eight cervical nerves. 1, trigeminal nerve, with its three branches; 2, glossopharyngeal; 3, pneumogastric, with, 3', its branch, the superior laryngeal; 4, spinal accessory, with its two branches—4', that which supplies the sterno-cleido-mastoid muscle, and, 4", that which goes to the trapezius; 5, facial nerve; 6, the main trunk of the hypoglossal, with its two branches—6', the descending ramus, and, 6", that which supplies the thyrohyoid muscle; 7, the great sympathetic, with, 7', its superior cervical ganglion; 8, the larger mastoid branch of the cervical plexus; 8', the little mastoid branch; 9, the auricular branch; 10, the transverse cervical branch; 11, the subclavian and subacromial branches; 12, point of anastomosis with the great sympathetic; 13, nerve of the large anterior rectus muscle; 14, trapezian branch of the cervical plexus; 15, nerve of the levator ang. scap.; 16, nerve of the rhomboideus; 17, internal descending branch; 18, bend of the hypoglossal, with its efferent branches that supply the subhyoidean muscles; 19, phrenic nerve, with, 19', its anastomosis with the great sympathetic, and, 19", its anastomosis with the nerve that supplies the subclavius muscle; 20, the nerve of the subclavius muscle; 21, great occipital nerve.

a, Internal jugular vein; *b*, the common carotid artery; *c*, the internal carotid; *d*, the middle meningeal; *e*, the subclavian artery.

The cutaneous branches of the cervical plexus are widely distributed, supplying the ear, back of scalp, cheek, parotid gland, side and front of neck, and upper part of chest and shoulder.

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The facial nerve sends a branch to the neck, which supplies the platysma myoides muscle.

TOPOGRAPHICAL ANATOMY.—The skin over the anterior and lateral regions of the neck is thin and lax, and in

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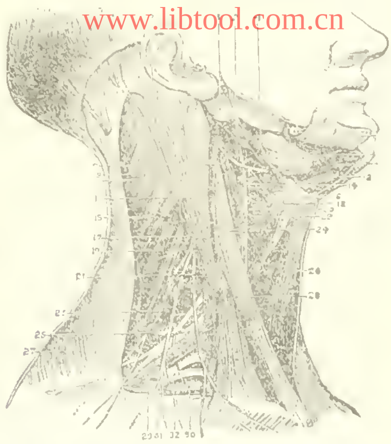

FIG. 3518.—Superficial Dissection of the Neck, showing the Distribution of the Branches of the Superficial Cervical Plexus of Nerves. (Heath.)

plastic operations is of great value in making flaps. The platysma is closely connected with the skin of this part of the neck. There is frequently some transverse wrinkling of the skin above the hyoid bone, and in this region in fat people there is much fat, giving rise to what is called a double chin; here also the sebaceous follicles are very abundant. In adult males this part is covered with beard.

The skin of the posterior region is very thick and adheres closely to the deeper structures; this is due to the large number of short fibrous connections between the skin and fascia. Carbuncles and boils frequently occur here and cause great pain, owing to the density of the parts and their free nerve supply.

The *nape* of the neck is often the seat of pustular and vesicular eruptions, which are due almost invariably, when localized in this part, to the presence of pediculi, these parasites finding a safe habitat in the thick hair under the prominent portion of the occipital bone. The glands in this region are frequently enlarged in sympathy with eruptions of the hairy scalp. The nape of the neck was the favorite site, in olden times, for the application of setons and issues.

Fatty tumors are often seen at the lower part of this region.

CERVICAL FASCIA.—It is the custom to divide the deep fascia of the neck into *superficial* and *deep* processes. The superficial fascia invests all the muscles, with the exception of the platysma; and some of the veins, as the external jugular, are also superficial to it. It is attached posteriorly to the spinous processes of the cervical vertebræ and ligamentum nuchæ; passing forward it splits to enclose the trapezius and then crosses the posterior triangle; at the posterior border of the sternomastoid the fascia divides into two layers which enclose that muscle, these layers unite at the anterior border of the muscle, and the fascia passes on to the middle line of the neck, where it is continuous with that of the opposite side. It covers the anterior triangle, being attached above to the lower jaw. In the posterior triangle the fascia is attached below to the clavicle and above to the mastoid process and the superior curved line of the occipital bone; in this triangle it is pierced by the external jugular vein and some of the superficial cervical nerves. In the anterior triangle the fascia is attached above to the body of the lower jaw, and continues backward and upward over the parotid gland to be attached to the zygoma. It sends a process (the stylomaxillary ligament) between the parotid and the submaxillary glands. In front the fascia is attached to the hyoid bone and covers the thyroid gland, below which it splits into two layers; the deeper covers the sternohyoid and sternothyroid muscles, and is attached below to the posterior edge of the first piece of the sternum, behind the sternoclavicular joint; the superficial and thinner layer passes down over the sternomastoid muscles, and is attached to the anterior edge of the manubrium and interclavicular ligament. The space between these two layers is filled with cellular tissue and fat, and sometimes a small gland is found here. In this compartment are also found the sternal head of the sternomastoid and the anterior jugular vein. In tenotomy of the sternomastoid this space must be opened, and the vein is avoided by keeping the knife close to the tendon of the muscle.

This space is also cut through in performing the operation of tracheotomy, and air is sometimes driven at every inspiration into the cellular tissue beneath the deep layer, an occurrence which complicates the operation exceedingly. The process of fascia covering the posterior belly of the omohyoid and binding it down to the clavicle and first rib, is continuous with the fascia covering the depressors of the hyoid bone.

The deeper processes of cervical fascia are important; one comes off from the anterior border of the sternomastoid and forms a sheath which encloses the carotid artery, jugular vein, and pneumogastric nerve. The vein is separated from the artery by a thin septum of fascia.

A process of fascia also invests the thyroid body, passes behind the depressors of the hyoid bone, and lies in front of the trachea and deep vessels of the neck; below, this layer is continuous with the fibrous pericardium.

The *prevertebral* fascia is a layer which descends on the prevertebral muscles, separating them from the pharynx and œsophagus; laterally it joins the carotid sheath and then proceeds outward covering the scalene muscles, brachial plexus of nerves, and subclavian vessels, becoming continuous with the axillary sheath. It is also connected with the costocoracoid membrane.

Although the cervical fascia influences to a certain extent the growth of tumors and collections of matter, this influence has been much exaggerated, and tumors grow and matter collects and distributes itself often quite irrespective of this fascia.

Pus in front of the trachea would tend to gravitate into the anterior mediastinum and on the side of the neck

FIG. 3519.—Transverse Section of the Neck through the Fifth Cervical Vertebra, showing Cervical Fascia. (Braune.)

might perforate the apex of the pleural sac. An abscess in front of the vertebræ would lie beneath the prevertebral fascia, and if it did not burst into the gullet, might extend laterally and present itself outside the sternomastoid, or descend to the posterior mediastinum. In some cases these collections of pus have been known, after reaching

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the posterior triangle of the neck, to follow the course of the brachial plexus and present themselves in the axilla. Pus pent up between the layers of the cervical fascia has destroyed portions of not only the jugular vein, but also the carotid artery, and when the abscess cavity was opened the patient has died of hemorrhage from these vessels. Dr. S. W. Gross (*American Journ. of the Medical Sciences*, April, 1871) has collected twelve cases of ulceration of the jugular veins, with hemorrhage into the sacs of closed abscesses, or into abscesses several days after their contents have been evacuated, or into acute or chronic ulcers. The majority of cases were in children who had cellulitis of the neck following scarlet fever—all the cases proved fatal.

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Dr. Erichsen (*St. Petersburg. med. Woch.*, December, 1877) reports a case of suppurative angina which broke of itself, and several days afterward a profuse and fatal hemorrhage occurred. The autopsy revealed ulceration of the internal carotid artery. In such cases the lesson to be learned is to prevent the destructive effects of diffuse cellulitis by early and free incision, and, if hemorrhage does occur, not to rely exclusively on packing, but to ligature the affected vessel.

In opening abscesses in the neck, there is some danger of wounding some of the great vessels if a too free incision be made with the knife, the vessels being pushed out of their normal position by the abscess; their exact course is difficult to determine. In such cases at first the skin only should be incised; after this the knife should be laid aside and a director should be pushed through the fascia; and when pus runs along the groove of the director, a pair of dressing forceps should be introduced, opened in the abscess cavity, and withdrawn open. This method has the advantage of being perfectly safe, and is especially adapted for opening deep-seated abscesses. It is known as Hilton's method.

ARTERIES OF THE NECK.—The two large arterial trunks which are seen in the neck are the *carotid*, which lies in the anterior triangle, and the *subclavian*, which lies in the lower part of the posterior triangle (subclavian triangle).

The *carotid* is included in a sheath of deep cervical fascia with the internal jugular vein and pneumogastric nerve. The vein lies to its outer side, and in the living subject overlaps the artery at the lower end and especially on the left side. To the inner side of the artery lie the trachea and œsophagus, larynx, and pharynx, and low down the recurrent laryngeal nerve. The thyroid gland also lies to its inner side. The vagus nerve lies to the outer side and posteriorly above, and rather more in front below.

Lying on or in the sheath of the vessels is the descendens noni nerve. The great sternomastoid muscle covers not only the common, but also the internal and external carotid arteries. In the undissected subject it is impossible to puncture the common carotid from the side of the neck without piercing the sternomastoid muscle (Richet). This fact is not sufficiently dwelt on in anatomical works, the descriptions given being applicable to dissected subjects only. The omohyoid muscle crosses the artery and vein obliquely and on a line with the cricoid cartilage. The most important structures behind the artery are the sympathetic trunk, the inferior thyroid artery, and the recurrent laryngeal nerve. The common carotid normally gives off no branches in its course. It divides into external and internal carotid opposite the upper border of the thyroid cartilage. The right and left common carotid arteries are so similar in their course in the neck that one description will answer for both. The left, however, it is well to bear in mind, arises from the arch of the aorta, and is somewhat longer than the right, which arises from the innominate opposite the right sternoclavicular articulation. The right common carotid is generally larger and not so deeply placed in the neck as the left; it is also farther away from the trachea.

As the vessels ascend the neck they become more superficial, and, having a direction somewhat backward, get farther apart as they reach their termination. The surface-marking of the carotid has already been described.

The artery may be easily compressed against the transverse process of the sixth cervical vertebra.

Ligature of the Common Carotid.—A ligature may be applied to any part of the artery, except near its origin or termination. The usual point of ligature is either im-

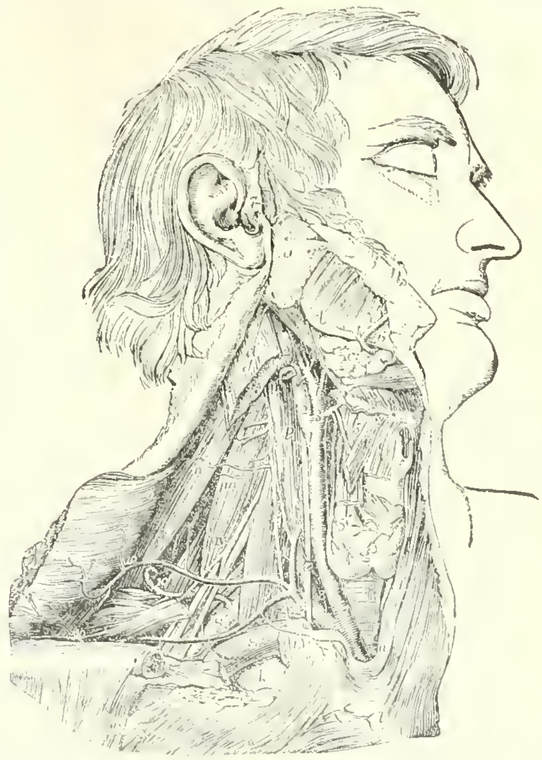

FIG. 3520.—View of the Common Carotid and Subclavian Arteries, with the Origin of their Branches and their Relations. (R. Quain.)

mediately above or below the omohyoid muscle. It is usually ligatured above the omohyoid, as here the artery is more superficial, and the operation is, in consequence, easier. An incision should be made along the inner border of the sternomastoid muscle, and the parts carefully divided until the sheath of the vessels is reached. The operation is much facilitated by drawing the sternomastoid outward and (if the superior operation be chosen) pulling inward the omohyoid. Should any veins or small branches of the superior thyroid artery come in the way, they should be divided between two ligatures. The sheath of the vessels should be opened on its inner side, so as to avoid the jugular vein, and the descendens noni nerve should be held aside to avoid injury. The aneurism needle with the ligature should be passed from without inward; in this way the vein and vagus nerve are most easily avoided.

The lower operation is the more difficult one, for, to expose the sheath of the vessels it is often necessary to divide some fibres of the muscles covering it. Again, the vein, if large, overlaps the artery; this renders the passing of the aneurism needle a proceeding of some difficulty. On the left side the internal jugular vein is much closer to the artery than on the right, and so the difficulty of passing a ligature around the artery is much increased. Ligature of the carotid is performed for wounds of the vessel or some of its branches, also for aneurism. It has been ligatured for pulsating orbital tumor. Mr. W. Rivington (*British Medical Journal*, October, 1885) records an interesting case of a boy, aged nine years, who swallowed a fish bone; this was followed

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by pyrexia, stiff neck, salivation, and a tender lump on the left side of the neck opposite the cricoid cartilage. Three days later, the boy had two severe attacks of hemorrhage from the mouth. Wound of the carotid was diagnosed, and the artery cut down upon and ligatured. The fish bone was found in the centre of a clot, and it had ulcerated in[illegible] www.libtool.com.cn [illegible]ent died of abscess of the brain ten days after the operation. A common site of carotid aneurism is at the bifurcation of the common carotid, and the treatment is ligature of the vessel below. In aneurism at the root of the neck the carotid has been ligatured with success above the tumor. Ligature at the distal side of an aneurism was first proposed by Brasdor, and practised by Warddrop. The treatment of aneurism of the arch of the aorta or innominate artery by simultaneous ligature of the carotid and subclavian arteries has been attended in a few cases with benefit.

Aneurism at the root of the neck frequently gives rise to "pressure symptoms." When the great venous trunks are compressed there is œdema and lividity, not only of the side of the face and neck, but also of the upper extremity of the same side. Not infrequently cough is produced by pressure on the recurrent laryngeal nerve, and if the pressure be great, then paralysis of the vocal cords of that side will ensue and cause a marked alteration of the voice. Dilatation of the pupil may also occur from pressure on the sympathetic trunk.

When the common carotid reaches the upper part of the larynx, it divides into two trunks, one of which, the

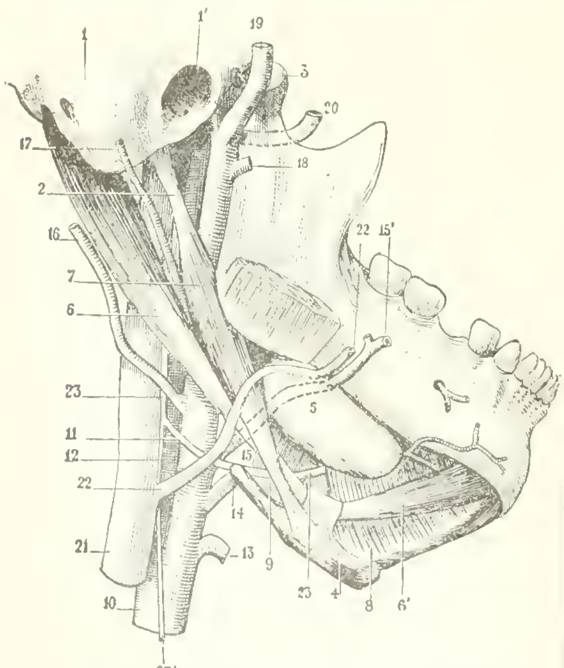

FIG. 3521.—Relations of the Two Carotids to the Styloid and Digastric Muscles. (From Testut.) 1, Mastoid process; 1′, orifice of the external auditory canal; 2, styloid process; 3, condyle of the inferior maxilla; 4, hyoid bone; 5, submaxillary gland; 6, 6′, the anterior and posterior bellies of the digastric muscle; 7, stylohyoid muscle; 8, mylohyoid muscle; 9, hyoglossus muscle; 10, common carotid; 11, internal carotid; 12, external carotid; 13, superior thyroid artery; 14, lingual artery; 15, 15′, facial artery; 16, occipital artery; 17, posterior auricular artery; 18, transverse artery of the face; 19, superficial temporal artery; 20, internal maxillary artery; 21, internal jugular vein; 22, facial vein; 23, great hypoglossal nerve, with, 23′, its descending branch.

external, gives off a number of branches, and is distributed to the superficial parts of the head and face and the tongue; the other, the *internal*, furnishes blood to the brain and eye. As a rule, the internal carotid has the deeper course, and lies behind the external, but not infrequently the two arteries lie side by side for some distance, the internal lying more posteriorly, and being recognized by the accompanying pneumogastric nerve. The two vessels are separated by the styloid process and stylohyoid ligament, also the styloglossus and stylopharyngeus muscles and glossopharyngeal nerve. The external trunk has two muscles and a nerve in relation to it anteriorly, viz., the digastric and stylohyoid muscles, and the hypoglossal nerve which hooks round one of its branches, the occipital. After passing behind the angle of the lower jaw the external carotid becomes embedded in the parotid gland.

Ligature of the external carotid is not a very easy operation owing to the number of branches given off from it, and the large venous trunks which lie over the lower portion may much increase the difficulties. The artery is reached by an incision in the line of the vessel, having its midpoint about the level of the hyoid bone. It is usually ligatured immediately below the digastric. It occasionally requires ligature in the course of operations for the removal of tumors about the angle of the jaw and neck.

Branches of External Carotid.—The most important branches in the neck are the superior thyroid, lingual, and the cervical portion of the occipital and facial.

The *superior thyroid* arises near the origin of the main vessel and curves downward, forward, and inward, beneath the depressors of the hyoid bone. It is distributed to the upper part of the thyroid gland, and can be readily exposed by an incision between the omohyoid and sterno-mastoid muscles. It sends a branch along the cricothyroid membrane which is sometimes wounded in the operation of laryngotomy. The superior thyroid artery has lately been tied with success for the purpose of arresting the growth of an enlarging thyroid body.

The *lingual* artery arises from the external carotid nearly opposite the great cornu of the hyoid bone (it may however, arise in common with the superior thyroid and cross the hyoid bone). It runs above and parallel to the great cornu and beneath the hyoglossus muscle. It is frequently necessary to ligature the lingual previous to extirpation of the tongue.

In ligaturing this vessel the one guide which the operator must rely on is the great cornu of the hyoid bone—it can always be felt and its relation to the artery is nearly always constant. The best place to expose the artery is immediately above the great cornu. Some authorities advise ligature of the artery near its origin from the carotid; but here, owing to the large veins which cover it, the operation is more difficult, and besides we have no absolute guide as to the exact point of origin of the artery, which frequently varies. On the other hand, the relation of the vessel to the great cornu of the hyoid bone is nearly always constant. The incision should be a curved one, and should extend from near the symphysis menti to near the angle of the lower jaw. The convexity of the curve should be downward, and its lowest point ought to reach the hyoid bone. After dividing the skin, platysma, and deep fascia, the tendon of the digastric muscle should be searched for, and in the angle which the tendon forms with the hyoid bone the artery will be found running beneath the hyoglossus muscle; the hypoglossal nerve is seen running over this muscle. If the submaxillary gland cover the parts, it should be held aside with hooks. After carefully dividing the hyoglossus muscle the artery will be felt pulsating at the bottom of the wound. If the incision be carried too far back the facial vein may be wounded.

When it is necessary to remove the submaxillary gland the facial artery must be ligatured. The operation presents no difficulties and requires no special description.

The *subclavian artery* is, surgically, a very important vessel. The left subclavian lies deeper than the right and arises directly from the arch of the aorta, while the right is one of the terminal branches of the innominate and commences opposite the right sternoclavicular articulation. Each artery curves upward into the neck

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under the anterior scalenus muscle, and then descends into the subclavian triangle under the clavicle and over the first rib. The subclavian vein lies in front and somewhat below the artery, from which it is separated by the anterior scalenus.

The artery is divided into three portions by the scalenus anticus muscle, viz., first, portion internal to the

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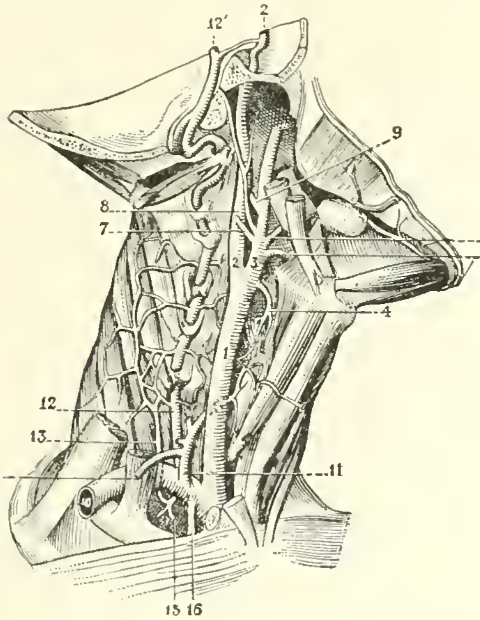

FIG. 3522.—Inferior Thyroid and Vertebral Arteries. (From Testut.) 1, Common carotid artery; 2, internal carotid artery; 3, external carotid artery and its branches; 4, superior thyroid artery; 5, lingual artery; 6, facial artery; 7, occipital artery; 8, inferior pharyngeal artery; 9, posterior auricular artery; 10, subclavian artery and its branches; 11, thyroid axis; 12, vertebral artery; 12', posterior cerebral artery; 13, deep cervical artery; 14, subscapular artery; 15, superior intercostal artery; 16, internal mammary artery.

muscle; second, portion beneath the muscle; and, third, portion external to the muscle reaching to the lower border of the first rib. Surgically, the third portion is most important. The external jugular vein crosses the artery, and the sternomastoid and the deep fascia which binds down the omohyoid muscle to the clavicle are in front of it; the brachial plexus of nerves lies above and to the outside of the third portion of the artery. Posteriorly the artery lies on the pleura and on the scalenus medius, and finally it rests on the first rib. The third portion of the artery can be felt pulsating above the clavicle, in the supraclavicular fossa, and here it may be readily compressed against the first rib with the thumb or the handle of an old-fashioned door-key wrapped in lint. The direction of the pressure should be vertical to the axis of the body; before attempting compression the shoulder should be lowered as much as possible. In compressing this vessel pain is sometimes caused by pressing on the lowest cord of the brachial plexus, which usually lies behind the artery; this may be easily avoided by rolling the nerve away from the artery, and then the proceeding is quite painless.

Some individuals (the writer among them) can arrest the pulse at the wrist by forcibly carrying the shoulder downward and backward. In this case the artery is compressed against the first rib by the subclavius muscle and clavicle.

Ligature of the subclavian is, as a rule, confined to the third portion, or that part lying in the supraclavicular space between the sternomastoid and trapezius muscles; the other portions are so deeply placed, so thickly studded with branches, and so closely connected with such important structures as the phrenic and vagus nerves, the junction of the internal jugular and subclavian veins, and, on the left side, with the thoracic duct, that ligature is rarely attempted. On the right side it is possible to ligature the vessel between the common carotid and the internal jugular vein.

The third portion of the vessel is comparatively superficial, being covered above the clavicle by no other soft parts than the skin, fascia, and fat. In at least fifty per cent. of subjects it is branchless, and when a branch is given off from the third portion it is almost invariably the posterior scapular.

To reach the artery an incision is made between the sternomastoid and the trapezius. The skin should be drawn down and the first incision should be made upon the clavicle to avoid wounding the external jugular, which pierces the deep fascia immediately above the clavicle. The vein should be held aside, or, better still, divided between two ligatures, and the deep fascia attached to the clavicle cut through; the finger should then be introduced and the scalene tubercle of the first rib searched for; this tubercle is usually found by following down the scalenus anticus muscle, which runs in the direction of the posterior edge of the sternomastoid. Having made out the scalene tubercle, the surgeon will feel the artery pulsating beneath the finger immediately outside the scalenus anticus muscle. The aneurism needle should be introduced from below upward to avoid the vein; it must hug the artery closely so that the lowest cord of the brachial plexus may not be included.

The operation is performed for aneurism of the axillary artery, and also of the innominate; also before amputating the whole upper extremity. In the latter case the common carotid is also tied. In axillary aneurism the operation is much complicated by the great distention of the veins and the great elevation of the clavicle.

Branches of the Subclavian.—The subclavian is rich in branches which are distributed in three different directions, viz., the vertebral and inferior thyroid, upward; the transversus colli and transversus humeri, outward; and the internal mammary and superior intercostal, downward. Most of the branches arise internal to the scalenus anticus; three of them, the transversus colli, transversus humeri, and inferior thyroid arise from a single trunk, the thyroid axis. The posterior scapular is frequently given off from the third part of the artery in place of from the transversus colli. The branches of the subclavian artery are subject to innumerable variations both as to their number and origin (see *Arteries, Anomalies of*). When the subclavian is ligatured, there being free anastomosis between its branches and those of the axillary artery, the nutrition of the arm is not interfered with.

The *vertebral artery*, which is the largest branch of the subclavian, arises from the upper and posterior part of

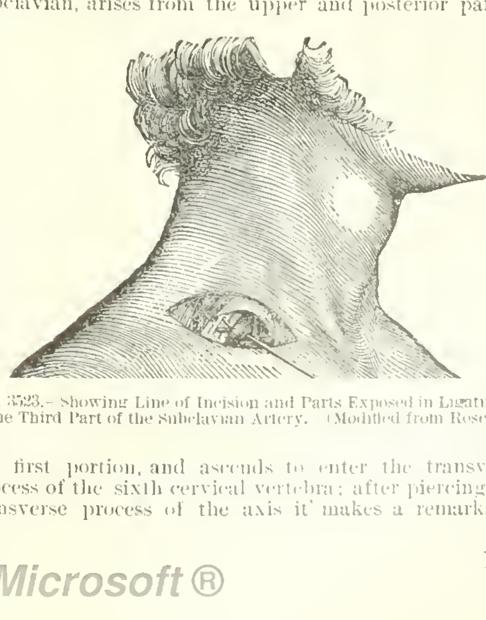

FIG. 3523.—Showing Line of Incision and Parts Exposed in Ligature of the Third Part of the Subclavian Artery. (Modified from Roser.)

the first portion, and ascends to enter the transverse process of the sixth cervical vertebra; after piercing the transverse process of the axis it makes a remarkable

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curve (Fig. 3524, 5) outward and upward to reach the foramen in the transvere process of the atlas, and bending backward, runs in the deep groove on the upper surface of the atlas.

Immediately above the clavicle this vessel lies very deeply between the scalenus anticus and longus colli muscles. It has frequently been ligatured here for the relief of epilepsy; the operation is a difficult one, owing to the many important structures in close relation with the vessel. An incision is made along the posterior border of the sternomastoid muscle immediately above the clavicle, the transverse process of the sixth cervical vertebra (carotid tubercle) is now searched for, and the artery is found lying between the scalene and longus colli muscles.

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Drs. Bright and Ramskill state that disease of the vertebral artery, immediately before it enters the skull, may lead to pain at the back of the head. The fact that the artery is here in close relation with the suboccipital nerve, which communicates with the great occipital nerve, may explain this symptom. (Treves.)

The vertebral artery is sometimes wounded by stabs in the neck; not a few cases are reported in which the artery was injured by stabs below the mastoid process. Dr. King (*Lancet*, November, 1885) records a case of injury of this artery in a young man, aged twenty-five, due to a deep wound below the left mastoid process; there was severe bleeding, so the wound was enlarged and the transverse process of a cervical vertebra was found broken; the finger placed between two transverse processes stopped the hemorrhage; the wound was plugged with strips of oiled lint, and in four weeks the patient had perfectly recovered. The plug was removed on the fourth day.

Hemorrhage from wounds of the vertebral artery between two transverse processes is difficult to arrest; wooden plugs have sometimes succeeded; occasionally the artery has been successfully tied by snipping away

Fig. 3524.—Deep Dissection of the Neck, showing the Course and Origin of the Vertebral Artery (5). (Tiedemann.)

the transverse process and applying a ligature. If this cannot be done the bleeding vessel may be secured by artery forceps, which should be left in the wound.

Traumatic aneurisms of the vertebral artery may occur after a stab in the neck; the writer on one occasion saw this follow a wound of the vessel between the second and third cervical transverse processes. These aneurisms are commonly mistaken for aneurism of one of the branches of the carotid—as, for instance, the occipital—and the common carotid has been tied on this supposition, without avail, of course. The mistake has arisen from the surgeon finding that pulsation in the aneurism ceased on compressing the carotid in the neck. Of course, if it is compressed below the "carotid tubercle," the circulation in the vertebral is arrested as well as in the carotid; and even if pressure is applied at this point, the vertebral may be compressed, for it frequently fails to enter the foramen in the transverse process of the sixth cervical vertebra.

The ligature placed on the carotid should be first tightened, and, if this arrests the pulsations in the aneurism, the ligation may be completed; but if pulsation is not arrested, then it is probable that the vertebral is the artery affected, and ligature of the carotid is a useless proceeding.

The treatment of such aneurisms is very unsatisfactory; cases of cure are reported from continuous compression with shot-bag, but if this fail operative measures are of little avail; it is useless to ligature the artery low down, as the anastomosis above is so free; and if the aneurism is cut down upon, ligature at the seat of the aneurism is rarely satisfactorily completed. The writer once saw the carotid tied for vertebral aneurism due to a stab with a knife below the mastoid, and afterward the sac of the aneurism cut down upon; but the hemorrhage could not be arrested by plugging, or otherwise, and the patient died. In this case pressure on the carotid against the sixth cervical transverse process arrested pulsations in the aneurism, and it was supposed that the affection was connected with the occipital artery.

The inferior thyroid artery is sometimes ligatured at the same time as the superior thyroid for enlarged thyroid in exophthalmic goitre (Graves' disease). Any of the arteries may be temporarily ligatured during an operation by tying the ligature over a piece of rubber tubing placed on the vessel. The writer has done this with both the carotid and the subclavian arteries with success.

Veins of the Neck.—The *anterior jugular* vein has already been mentioned as lying along the inner border of the sternomastoid. It varies somewhat as to its course, and is sometimes double. Occasionally, the veins of the two sides are connected by a large transverse branch, which is a source of trouble in the operation of tracheotomy. The anterior jugular, if large and placed nearer the median line than usual, is liable to be wounded in tracheotomy. It might also be wounded in tenotomy of the sternomastoid for wry-neck. The two anterior jugulars may be replaced by a single trunk.*

In front of the trachea and thyroid gland is a large vein, the *inferior thyroid* (vena thyroidea ima), which, when large, complicates operations on the trachea.

The *external jugular* vein corresponds to a line drawn from the angle of the jaw to the middle of the clavicle; it runs beneath the skin and platysma and over the sternomastoid muscle, and ends by piercing the deep fascia above the clavicle to join the subclavian vein. In the operation of tying the subclavian in its third part, it (the vein) must be held aside or ligatured.

The *internal jugular* vein lies to the outer side of the common carotid artery, and when distended partially overlaps it. In operations for the removal of tumors or enlarged glands of the neck, this vessel may be wounded; ligature in such accidents is the proper procedure, and is not attended by any evil after-effects. The writer has on three occasions ligatured the internal jugular with the most happy results.

The *subclavian vein* is a continuation of the axillary, and is in close relation with the clavicle; it lies in front of and below the subclavian artery, from which it is

* The anatomy of this region has been ably described by Dr. Pilcher in the Annals of Anatomy and Surgery, vol. iii., 1881.

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separated by the anterior scalenus muscle. On the left side the thoracic duct empties into it. The point of junction of the subclavian and internal jugular veins is opposite the sternoclavicular articulation. The wall of

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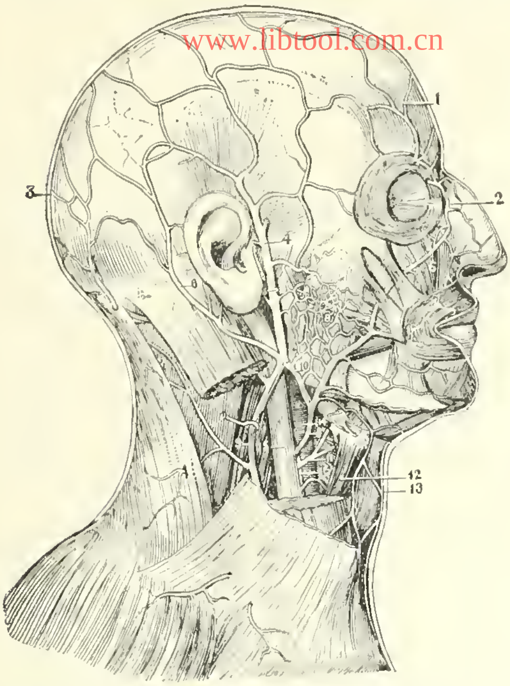

FIG. 3525.—Superficial Veins of the Face, Head, and Upper Part of the Neck. (From Testut.) 1, Frontal veins; 2, parietal veins; 3, occipital veins; 4, superficial temporal vein; 5, internal maxillary vein; 6, mastoid vein; 7, angular vein; 8, facial vein; 9, external jugular vein; 10, point where the latter anastomoses with the facial vein; 11, lingual vein; 12, superior thyroid vein; 13, anterior jugular vein; 14, carotid artery; 15, internal jugular vein; 16, pneumogastric nerve.

the subclavian vein adheres closely to the fascial sheath by which it is invested; this sheath is connected anteriorly with the costocoracoid membrane and the clavicle, and when the shoulder is carried forward the vessel becomes expanded. (Quain.) In operations at the root of the neck great care should be taken to avoid wounding the large veins, for air is very apt to be sucked in during inspiration. These veins are so firmly united to the bones and muscles, that when wounded they do not collapse, but, on the contrary, gape. It should be remembered that the risk of air entering is increased by movements of the upper limb, which still further open the wounded vein.

THYROID BODY.—This is a highly vascular organ consisting of two lateral lobes, one on each side of the larynx and trachea, connected by an isthmus which crosses the second and third rings of the trachea. The lobes are pear-shaped, and reach from the fifth and sixth rings of the trachea to the upper border of the thyroid cartilage; the lateral lobes are covered in front by the depressions of the hyoid bone, and posteriorly are in contact with the sheath of the great vessels of the neck. Each lateral lobe measures about two inches in length, one and one-fourth inch in breadth, and from three-fourths to one inch in thickness. The weight of the thyroid body is from one to two ounces, and is greater in females than in males. The isthmus is occasionally absent, the lateral lobes being connected by fibrous tissue only, as is the case in some animals, viz., the horse, donkey, etc.

Owing to the fact that the thyroid body lies over the great vessels of the neck, when enlarged it derives from them a visible pulsation, and a distinct thrill may be felt. Such pulsating tumors have been mistaken for aneurism, but as the thyroid body is closely connected with the larynx and trachea, it rises and falls in deglutition, and so is easily diagnosed from aneurismal or other tumors, which are not disturbed by deglutition. When hypertrophied the tumor resulting from an enlarged thyroid is called a "*bronchocele*" or *goitre*. When a goitre grows rapidly respiration is often interfered with, and operation has to be undertaken for its relief. It is not necessary to remove the whole gland to relieve the obstructed respiration, for division and removal of the isthmus only often gives very good results. Mr. Sidney Jones (*Lancet*, vol. ii., 1883) reports cases in which excision of the isthmus not only relieved the dyspnœa, but a month after the operation the lateral lobes had almost disappeared.

Since the advent of antiseptic surgery the extirpation of large bronchoceles by the knife has become most common, but the operation, owing to the very important structures in relation to it, is always a most formidable one. It is very important in this operation first to ligate the vessels supplying the gland, viz., the superior thyroid above, and the inferior thyroid below, and if present, the middle thyroid. In ligating the inferior thyroid artery, care must be taken not to injure the inferior laryngeal nerve, which winds among the branches of that artery. Simple cysts may be removed by enucleation. Owing to the conditions which follow complete removal of the thyroid, viz., myxœdema, and cachexia strumipriva, partial removal is the more common operation except in cases of malignant disease or when the growth becomes dangerous from pressure.

The ŒSOPHAGUS commences opposite the cricoid cartilage; it lies between the trachea and the vertebral column. At the lower end of the neck it inclines a little to the left, and for this reason œsophagotomy is performed on the left side. Strictures most commonly occur at its upper part, and foreign bodies are most apt to be arrested behind the larynx. Foreign bodies, such as fish bones, mutton or beef bones, have occasionally ulcerated through the œsophagus and perforated some of the large vessels with which it is in contact.

In performing *œsophagotomy* for the removal of an arrested foreign body, the incision is made between the sternomastoid and trachea, the middle point being opposite the cricoid cartilage. The inferior thyroid artery and recurrent laryngeal nerve must be carefully avoided. The carotid artery is in no danger of being wounded if proper care be taken.

In *œsophagostomy*, when a stricture exists high up, the incision into the œsophagus is made for the purpose of feeding the patient by a tube, and so avoiding gastrostomy. The fact that the operation is performed low down makes it much more dangerous than œsophagotomy, and nearly all the reported cases have ended in death within a short time of the operation from diffuse inflammation of the neck.

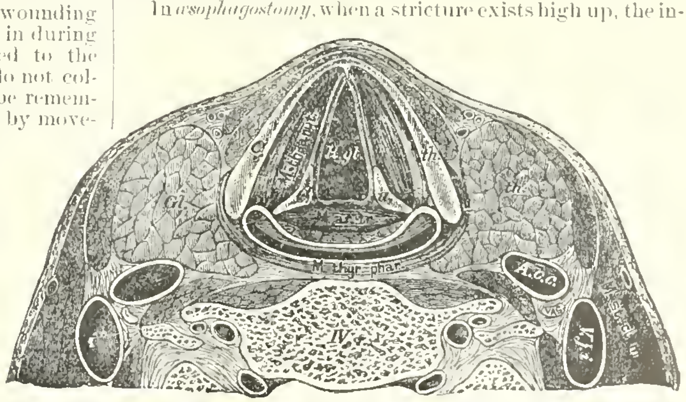

FIG. 3526.—Transverse Section of Neck, Opposite Fourth Cervical Vertebra, showing Thyroid Body (*Gl. th.*).

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HYOID BONE.—This is one of the most important landmarks in the neck, and one which can always be felt in the stoutest neck. It is the best guide for ligature of the lingual. In old age the different portions of the bone become ossified into one piece, and in consequence it is more easily broken by direct violence due to blows or throttling. Cases are reported of fracture of the hyoid from yawning and sudden extension backward of the head. The symptoms of fracture are pain, difficulty in speaking, in movements of the tongue, and in swallowing.

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LARYNX AND TRACHEA.—The *larynx* is connected above with the hyoid bone by means of the thyrohyoid membrane, and is continuous below with the trachea. Posteriorly it helps to form the wall of the pharynx. It consists of several parts, which are closely connected together by ligamentous structures, muscles, and mucous membrane; these parts are the thyroid cartilage, epiglottis, cricoid, and arytenoid cartilages. On the upper margin of the thyroid cartilage is a bursa which prevents friction as the larynx ascends beneath the hyoid bone in deglutition. This bursa is sometimes enlarged, and has to be incised. The larynx is occasionally wounded in cases of attempted suicide by cutting the throat. Between the lower border of the thyroid and cricoid cartilages is the cricothyroid membrane, where the operation of laryngotomy is performed. A small lymphatic gland is occasionally found here, which may become enlarged. (For description of interior of larynx see *Larynx*.)

Foreign Bodies.—Children not infrequently swallow articles which are sucked into the larynx during inspiration; these may be arrested by the cords at the rima, or may lodge in one of the ventricles. If they pass the rima they usually lodge in the right bronchus. These bodies can frequently be seen with a laryngoscope and extracted with forceps, but very often the operation of tracheotomy is necessary to remove them.

The TRACHEA extends from opposite the sixth cervical vertebra to its bifurcation opposite the third dorsal, where it is crossed by the arch of the aorta. It measures from four to five inches in length, and from three-fourths to one inch in breadth. It is covered by the depressors of the hyoid bone, and has on each side at its upper end the

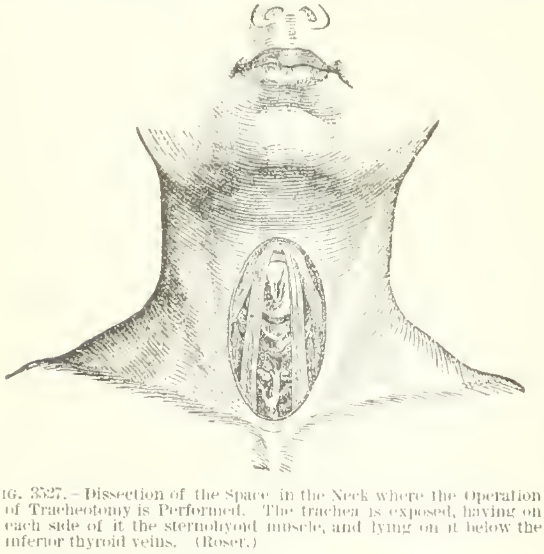

FIG. 3527.—Dissection of the Space in the Neck where the Operation of Tracheotomy is Performed. The trachea is exposed, having on each side of it the sternohyoid muscle, and lying on it below the inferior thyroid veins. (Roser.)

thyroid body. It is crossed by the isthmus of the thyroid gland opposite its second and third rings, and has also in front the inferior thyroid veins, and sometimes a transverse branch connecting the two anterior jugulars. When the middle thyroid artery is present it also lies upon the trachea in its course up to the isthmus of the thyroid. In children the thymus gland covers its lower portion. Laterally the trachea is in relation with the carotid artery and recurrent laryngeal nerve; posteriorly it is in contact with the œsophagus. The innominate artery crosses the lower end of the trachea; this occurs higher up in children than in adults.

The operation of *tracheotomy* is performed above or below the isthmus. It is required for the extraction of foreign bodies and for any obstruction to respiration having its seat in the larynx, as from diphtheritic membrane, new growths, etc. It is also performed as a preliminary to certain operations in the neck and mouth.

The distance between the cricoid cartilage and the upper border of the sternum, in ordinary individuals is about one inch and a half (4 cm.); when the head is thrown back three-fourths of an inch more is gained; so in performing tracheotomy the neck should be extended as much as possible by placing a hard round pillow under it, and the incision should be exactly in the middle line, so as to come between the two sternohyoid muscles and anterior jugular veins. In operating there is a choice as to where the trachea is to be opened, either above or below the isthmus. Above, the parts are more superficial and blood-vessels fewer, but the space is limited and the cricoid cartilage has often to be cut; below, although the trachea is deeper and the veins are more plentiful, still there is more room for incision, and we get farther away from the disease, which is an important point in diphtheria. With our present means of arresting hemorrhage the low operation is to be preferred.

Laryngotomy is performed in cases in which it is necessary rapidly to relieve suffocation, and in adults who have chronic affections of the larynx. It is performed by cutting the cricothyroid membrane transversely.

(For a more complete description of these operations see *Tracheotomy*.)

LYMPHATIC GLANDS OF THE NECK.—These are large and numerous. They frequently enlarge and become inflamed, and if not excised break down and suppurate, leaving unsightly scars. In scrofulous subjects the glands of the neck are the ones most frequently enlarged. The enlargement is always the result of some irritation, either of the mucous membrane of the throat, nose, ear, etc., or of the skin of the scalp, face, or neck. The glands are more liable to enlarge in persons of a scrofulous diathesis, and in them the amount of involvement of the glands is out of all proportion to the irritating cause; this may be an eczema of the scalp or a simple sore throat. In non-scrofulous individuals the glands are frequently enlarged from some special irritating cause, as a diseased tooth, tonsillitis, malignant disease of the tongue, lip, etc., but in these individuals the affection of the glands is not so widespread, nor is the enlargement so great, and the glands do not tend to suppurate.

In syphilitics the *glandulæ concatenatæ* in the posterior triangle of the neck are frequently enlarged and indurated, but they do not tend to suppurate. In tonsillitis an enlarged gland is always felt beneath the angle of the lower jaw; this is erroneously supposed by many to be the enlarged tonsil which cannot be felt from the outside.

In eczema of the scalp the glands of the neck are frequently enlarged, especially if the eczema be of the pustular variety. In delicate children pediculi not only often cause an eczema of the nape of the neck, but the irritation frequently causes enlargement of the glands in the suboccipital and mastoid regions.

Occasionally a single gland becomes enlarged over the carotid artery, and this has been mistaken for aneurism on account of the strong pulsation communicated to the tumor by the artery; these tumors, however, cannot be emptied by lateral pressure, and when lifted away from the artery all pulsation, of course, ceases.

When one or several glands of the neck have become enlarged and show no tendency to diminish, it is much better to remove them with the knife. This can be easily done before the gland breaks down and suppurates, and so forms inflammatory adhesions to the surrounding parts. In cases of "scrofulous necks," in which nearly all

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the glands are enlarged, their removal is advisable, for if left to themselves they break down and suppurate, and after months and perhaps years of discomfort, heal, leaving unsightly scars. An argument in favor of early excision is that foci of infection are removed, and the patient's chance of good health is much greater. Frequently thirty or forty glands have been removed at one operation, and the result is almost invariably good, the patient recovers rapidly, and the amount of scarring is very trifling. In dissecting out the glands in close relation to the large vessels, great care should be taken.

When the glands have suppurated and sinuses are left which will not heal, scraping the sinus and removal of the remains of the gland with a sharp spoon give very good results. Mr. Treves recommends puncture of softened caseous glands with a cautery; he also advises opening gland abscesses by the cautery highly heated.

The lymphatics of the neck are enlarged, with those of other parts of the body, in leukæmia and Hodgkin's disease, and care should be taken not to confound scrofulous glands with enlarged glands in these diseases. Removal of enlarged glands in Hodgkin's disease is, except for diagnostic purposes, of course, perfectly useless.

The lymphatic glands of the neck are arranged in the following groups: *Submaxillary* (ten to twelve in number), situated beneath the base of the inferior maxilla; these also include the *suprahyoid*, which are situated between the two anterior bellies of the digastric muscle in the middle line of the neck. *Superficial cervical* (four to six) situated along the external jugular vein beneath the platysma and deep fascia. *Deep cervical* (twenty to thirty). These are subdivided into *superior* and *inferior*. The *superior* are situated about the bifurcation of the common carotid, and reach to the base of the skull, lying along the internal jugular vein. The *inferior* are grouped around the lower part of the internal jugular vein, and extend outward into the supraclavicular fossa, becoming continuous below with the axillary and mediastinal glands.

The following table, from Sir F. Treves' book on "Scrofula and Its Gland Diseases," showing the relation certain glands bear to the periphery, will be found useful:

Scalp: Posterior part = suboccipital and mastoid glands; frontal and parietal portions = parotid glands; vessels from the scalp also enter the superficial cervical set of glands.

Skin of Face and Neck = Submaxillary, parotid, and superficial cervical glands.

External Ear = Superficial cervical glands.

Lower Lip = Submaxillary and suprahyoid glands.

Buccal Cavity = Submaxillary and deep superior cervical glands.

Gums of Lower Jaw = Submaxillary glands.

Tongue: Anterior portion = suprahyoid and submaxillary glands; posterior portion = deep cervical glands (superior).

Tonsils and Palate = Deep cervical glands (superior).

Pharynx: Upper part = parotid and retropharyngeal glands; lower part = deep cervical glands (superior).

Larynx, Orbit, and Roof of Mouth = deep cervical glands (superior set).

Nasal Fossa = Retropharyngeal glands and deep cervical (superior). Some lymphatics from the posterior part of the fossa enter the parotid gland.

PAROTID GLAND.—This gland lies on the face in front of the ear, and extends deeply into the space behind the lower jaw; its inferior portion is situated partly in the neck behind the angle of the jaw, lying on the digastric muscles in the submaxillary region. It is connected with very important structures, being pierced by the external carotid artery and facial nerve. This gland not infrequently becomes inflamed and suppurates after fevers (as typhoid) and operations on the abdominal viscera. Cases are reported in which it has become inflamed after ovariotomy, and the writer has twice seen abscess of the parotid follow severe blows on the abdomen. These abscesses are very painful, owing to the tension caused by the investing fibrous capsule. In opening abscesses here the incision should be transverse, to avoid cutting the facial nerve, and should be in front of the line of the carotid artery. Abscesses of the parotid gland frequently burst

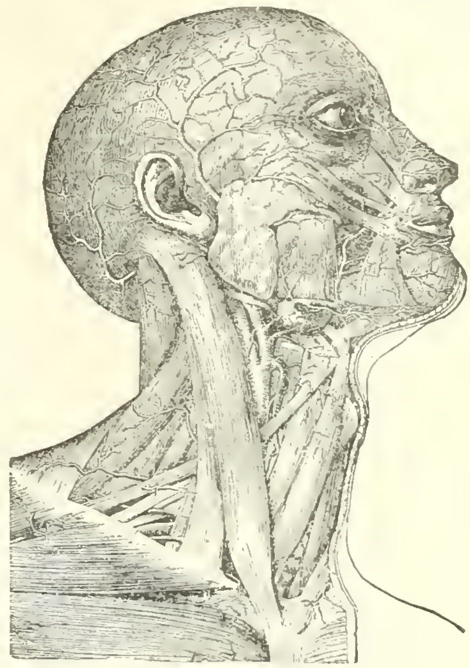

FIG. 3528.—Dissection of the Neck, showing the Triangles and their Contents. (Tiedemann.)

into the external auditory meatus. There are a number of lymphatic glands in relation with the parotid, which receive vessels from the scalp, pharynx, etc. Tumors are not infrequently found in this region, the extirpation of which gives rise to very severe hemorrhage. The facial nerve is frequently unavoidably injured in the removal of these tumors, and the external carotid artery sometimes requires ligature.

SUBMAXILLARY GLAND.—The submaxillary gland is situated in the submaxillary region, between the anterior and posterior bellies of the digastric muscle. It lies partly on the mylohyoid and partly beneath it. The facial artery grooves the back part and upper border of the gland. The gland is sometimes involved in malignant diseases affecting the mouth and tongue. It is separated from the parotid gland by a fold of deep cervical fascia, the stylomaxillary ligament.

NAPE OF THE NECK.—The superficial anatomy of this region has already been described. The most superficial muscle is the trapezius, which is covered by a layer of thick and tough fascia and is pierced by the great occipital nerve. To the outer side of the trapezius, and separated from it as it descends, is the sternomastoid muscle; crossing obliquely the interval between them are the splenius capitis and colli muscles. On removing the trapezius, which in this region is usually very thin, the complexus muscle comes into view, also pierced by the great occipital nerve; deeper down still are seen the muscles bounding the suboccipital triangle (rectus capitis anticus major, superior and inferior oblique), where are seen the suboccipital nerve and vertebral artery. In the central line is the ligamentum nuchæ. It extends from the seventh cervical spine to the external occipital protuberance. In some animals this ligament is a very powerful elastic band which suspends the head; to it are attached muscles and fascia. The occipital artery becomes superficial midway between the mastoid process and external occipital protuberance. It runs along the outer border of the superior oblique and is

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accompanied by the great occipital nerve. The lesser occipital nerve winds round the posterior border of the sternomastoid, and supplies the lateral region of the occiput; the suboccipital, being a purely motor nerve, rarely reaches the skin.

Spinal Cord and Vertebral Column.—The accompanying figure (3530) shows well the situation of the spinal cord in the neck vertebræ. It is not so well protected against injury as in other parts, for in the space between the several arches, any sharp instrument piercing the muscular tissue could easily wound the cord. The vertebral artery, as has already been mentioned, is also liable to injury on its way from one vertebra to another. From the great mobility of this part of the spine dislocation occasionally occurs and death is caused by pressure on the cord. In caries of the upper cervical vertebræ, sudden death has taken place from the destruction of the ligaments between the atlas and axis. When this occurs—the head with the atlas inclining forward and leaving the axis in its proper position—the medulla oblongata is crushed against the odontoid process, and so instant death is the result. (Hilton.)

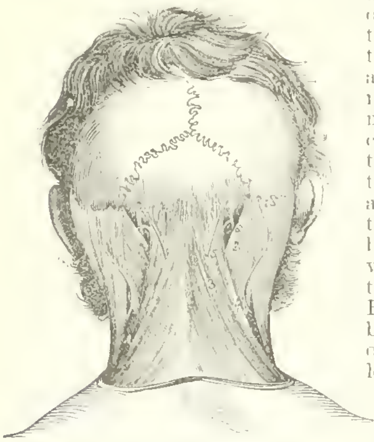

FIG. 3529. The Skin and Fascia have been Removed, and the Superficial Muscles Exposed. 1, Sternomastoid; 2, splenius capitis; 3, trapezius; 4, small occipital nerve; 5, great occipital nerve; 6, occipital artery. (After Roser.)

Caries of the spine in the cervical region is not uncommon. In its early stages the symptoms are somewhat obscure, the chief complaint being of pain in the course of the great occipital nerve, due to its implication in inflammatory exudation. The peculiar stiff way in which the patient carries his head, and the presence of a slight prominence which is excessively tender, enables the surgeon to recognize the disease. These cases occasionally result in a post-pharyngeal abscess, which has to be opened. This may easily and safely be done by an incision along the posterior border of the sternomastoid. Some advise tapping it with a trocar through the mouth.

BRANCHIAL FISTULÆ AND CYSTS.—In the mammalian embryo, at the fourth week, there are on each side of the head, behind the oral cavity, four fissures which communicate with the anterior part of the alimentary canal. These are the homologues of the clefts found in branchiate vertebrates. The third and fourth fissures in the human embryo disappear about the sixth week, and only the first remains at the end of the ninth week. This persists as the Eustachian tube, tympanic cavity, and external auditory meatus. The structures developed in the folds between the clefts (branchial arches) are as follows:

First Arch (*Mandibular*): Meckel's cartilage, the anterior portion of which is developed into the lower jaw, and the mandibular arch is completed by the malleus bone of the ear.

Second Arch (*Hyoid*): Incus, stapes (Parker), styloid process, stylohyoid ligament, and lesser cornu of the hyoid bone.

Third Arch: Great cornu and body of the hyoid bone.

Fourth Arch: No permanent remains.

Sometimes the clefts between these arches remain more or less open, and this fact explains the occurrence of congenital fistulæ of the neck, as well as that of cysts and diverticula from the œsophagus and larynx.

Paget says (Proc. Royal Med. Soc., 1877): "Cervical branchial fistulas occur as two or three minute orifices on one or both sides of the lower part of the neck, and they lead upward to the œsophagus and pharynx; the lowermost being near the sternal end of the clavicle in front of the sternomastoid muscle, the next opposite the thyroid cartilage, and the highest between the thyroid cartilage and hyoid bone." When two in number, they are often symmetrical; they vary in length from one-half to one and a half inches, and barely admit a probe. They have a smooth lining membrane, which secretes a clear mucous fluid. These fistulæ can be cured by cauterizing them with the galvanocautery. It is probable that many cysts and so-called hydroceles of the neck are due to imperfectly closed embryonal fissures.

Sanguineous cysts of the neck are probably originally branchial cysts, which have communicated with the internal jugular vien. Cases are on record in which, before removal of the cyst, the vein had to be ligatured (Glück: *Deutsche med. Woch.*, No. 5, 1886).

BRANCHIAL DERMOIDS.—These are occasionally seen in the neck, the most common situation being between the geniohyoglossi muscles, where the swelling projects into the submaxillary space and also into the mouth. They can usually be enucleated. A dermoid sometimes is seen under the deep fascia close to the carotid arteries.

THYROLINGUAL FISTULÆ AND CYSTS.—These are met with on the tongue, at the hyoid bone, and lower down over the thyroid cartilage, cricoid, and upper rings of the trachea. They grow slowly with the growth of the individual, and are very difficult to eradicate. The cyst wall is thin and lined with columnar epithelium, perhaps ciliated. Their contents are mucoid. They sometimes burst, leaving fistulous openings which are difficult to close. Unless the cyst be entirely removed, it will recur, for if any part of the epithelial lining be left it will secrete and cause a persistence of the trouble. Thyrolingual cysts and fistulæ are the remains of the thyrolingual duct, which passes up the neck to the tongue behind the hyoid bone. The lower part becomes the isthmus of the thyroid gland while the upper part persists as the foramen cæcum of the tongue.

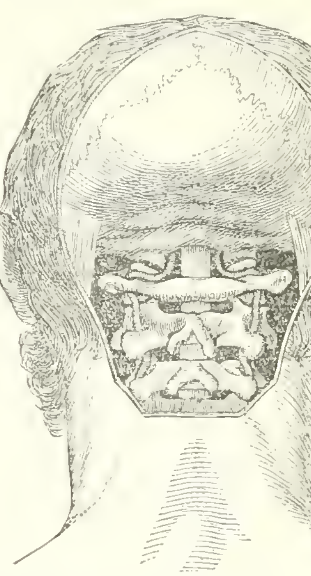

FIG. 3530. The Superficial Tissues have been Removed to show the Vertebral Artery Passing Through the Transverse Processes of the Vertebræ, and also the Relation of the Cord to the Spinal Canal. (Roser.)

TUMORS OF THE NECK.—The neck is a favorite site for tumors, fibrous, sarcomatous, and others. Sarcomatous tumors in the early stages can be removed, but they nearly always recur. Tumors of the neck, which are

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apparently so freely movable that their extirpation would seem to be an easy matter, are found, when cut down upon, to be intimately connected with the deep vessels and nerves. In these cases the tumor is freely movable laterally, the vessels going with them, but there is no freedom of movement in the vertical direction. It is remarkable with what impunity large tumors may be removed from the neck, especially if they are benign. It is not uncommon in these cases to ligature both the internal jugular vein and the carotid artery, and to cut through the sternomastoid muscle, and yet have the patient make a rapid recovery from the operation; the tumor, as mentioned above, if sarcomatous, almost invariably returns, for it is impossible in the neck in such cases to remove sufficient of the surrounding healthy structures.

Aneurismal tumors at the root of the neck are comparatively common, and although in many cases these tumors may have the appearance of being connected with the subclavian or innominate arteries, yet they almost invariably proceed from the aortic arch, and push their way upward under the clavicle into the neck. Fusiform aneurisms of the aorta frequently simulate aneurism of one of the great branches.

Tumors in connection with the thyroid gland have been alluded to in the description of that body.

Francis J. Shepherd.

NECROBIOSIS.—The gradual death of tissue due to slowly acting injurious agents is known as *necrobiosis* or *indirect necrosis*, in opposition to *direct necrosis* or *immediate death*. In necrobiosis the death of the cell is preceded by some other retrograde change, such as atrophy, cloudy swelling, mucous, hydropic or fatty degeneration, or by one of the pathological infiltrations. In the case of direct necrosis death of the tissue takes place rapidly without the occurrence of preceding abnormal changes in cellular structure. The preceding retrograde change in necrobiotic processes is by some writers regarded as constituting the necrobiosis; but a distinction should be made between the preceding atrophy, degeneration or infiltration, and the molecular disintegration which constitutes the essential feature of necrobiosis. The retrogressive changes preceding this disintegration usually occur so gradually, and in themselves present such definite characteristics, as to be classed by themselves. The use of the term necrobiosis is more theoretical than practical, inasmuch as a practical distinction between direct necrosis and necrobiosis is at times very difficult or impossible. Necrobiosis is, therefore, best conceived of as a slowly progressive or incomplete necrosis. The gross appearances of necrobiotic tissues vary according to the nature of the preceding retrograde change and the degree of necrosis present. Microscopically, in addition to the characteristic changes presented by the accompanying retrograde change, the nuclei of the affected tissue show karyorrhexis and a greater or less degree of karyolysis. The ultimate picture of necrobiosis is that of necrosis; if the necrobiotic process has been characterized by cloudy swelling, simple necrosis follows; if by fatty degeneration, soft caseation (fatty necrobiosis) occurs; if by hydropic degeneration, liquefaction necrosis results. The sequelæ of necrobiosis are essentially those of necrosis: regeneration, repair, cicatrization, calcification, and cyst formation. Likewise the causes producing necrobiosis are the same as those leading to direct necrosis: mechanical, thermal, chemical, infectious, and nutritional. The injurious agents may act separately or coincidently. As a general rule it may be stated that harmful agents of slight power but of long-continued action are more likely to produce necrobiosis than direct necrosis. Disturbances of blood supply, deficient nutrition and oxygenation, as in the case of chronic anæmia, are among the most important factors leading to necrobiotic processes. Chronic intoxications and infections also play a leading rôle in the production of necrobiosis. Clinically a neuropathic necrobiosis may be distinguished.

Aldred Scott Warthin.

NECROSIS, PATHOLOGY OF.—The condition of local death, the death of individual cells or groups of cells within the living body, is known as *necrosis*. If such local death occurs immediately or very quickly after the action of some injurious agent, it is termed *direct necrosis;* if, on the other hand, the death of tissue is of a slowly progressive nature preceded by other retrograde changes, the process is designated *necrobiosis* or *indirect necrosis*. The use of the word necrosis without modifying designation is usually taken as referring to direct necrosis.

Inasmuch as we have no definite knowledge, either chemical or histological, of the condition of cell life, the essential nature of cell death or necrosis is also unknown to us. The cellular change which marks the exact moment of the passage of life from the cell is at present beyond our knowledge; the slight histological changes taking place in cells at this moment do not permit us to determine with certainty the definite boundary between the states of cell life and cell death. Our conception of necrosis is, therefore, based upon the changes which follow necrosis rather than upon those taking place at the moment of cessation of life. The development of modern microscopical technique has, however, so perfected methods of tissue fixation that it is now possible to fix and preserve definitely the histological characteristics of the cells as they exist at the moment the tissue is placed in the fixing fluid. Our knowledge of the structure of normal living cells has been obtained from the study of cells killed and fixed by such means; and likewise our conceptions of pathological conditions are based upon the relative appearances of cells so treated.

As a result of such study certain pathological criteria have been created. Of these the condition of *necrosis* is that state of the cell which is characterized microscopically by the disappearance of the nucleus and certain molecular changes in the cytoplasm. The disappearance of the nucleus or its failure to respond to nuclear stains is to be taken as the most striking feature of necrosis, inasmuch as the nucleus is to be regarded as the most essential vital element of the cell. Cells may be dead and yet retain their nuclei, but necrosis becomes evident to us microscopically only when certain changes in cell structure have occurred to distinguish the dead cell from living ones. The loss of the nucleus may occur at the moment of death or subsequently; in either case it becomes the criterion of necrosis. To the disappearance of the nucleus and its loss of staining power the terms *karyolysis* and *chromatolysis* have been applied. These changes are very frequently preceded by fragmentation of the nuclear chromatin. This change is known as *karyorrhexis;* it has been shown to consist of regular and definite movements on the part of the chromatin elements. Small masses and granules of chromatin may leave the nucleus and pass into the cell body. With the disappearance of the cell membrane fine chromatin granules may be scattered throughout the cell detritus of the necrotic area. As a result of such diffusion of the chromatin areas of necrosis in the early stage may stain diffusely blue. In other cases the nucleus before its disappearance contracts and becomes smaller, at the same time staining more deeply than normal (*pyknosis.*) Very frequently the nucleus retains its normal form and size, but gradually loses its staining power and fades away, both nucleus and protoplasm being converted into a homogeneous hyaline mass.

Sooner or later, changes take place in the protoplasm of dead or dying cells. The normal granulation of the cytoplasm may disappear and the cell undergo a hyaline change. The cell membrane ultimately disappears and the outline of the cell becomes irregular or lost altogether. Often the cell protoplasm becomes coarsely granular, the cell ultimately breaking up into a granular débris. Vacuolation may take place and the cell become enlarged and swollen from the inbibition of fluid. As the result of such swelling, breaks in the continuity of the protoplasm may occur. On the other hand, the dead cells may under certain conditions become inspissated.

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Extrusion and constriction of portions of the protoplasm may occur during the process of dying. Ameboid cells usually assume a globular form. The disintegration of the protoplasm is termed *plasmoschisis*. The ultimate result of the necrotic process is the conversion of both nucleus and cytoplasm into a granular débris; when such appearances are found microscopically the condition is to be regarded as one of complete necrosis

Causes of Necrosis.—The causes which may lead to local death of tissue may be classed as follows: nutritional, mechanical, thermal, chemical, toxic, infectious, and neuropathic.

Disturbances of nutrition through interruption of the circulation are among the most frequent causes of necrosis. Local anemia due to arterial occlusion as a result of thrombosis, embolism, compression, ligature, or arteriosclerosis may be the direct cause of local tissue death (anæmic and hemorrhagic infarction). Likewise stasis due to mechanical, thermal, chemical, or trophic changes in the vessel walls or to weakened heart's action may be a primary or secondary factor of necrosis. Local asphyxia from any cause may result in cell death.

Traumatic violence may through crushing or tearing cause direct death of cells, or through damage to the blood-vessels it may cause necrosis through disturbed nutrition. Cells separated from their normal environment as a rule soon die.

Elevation of temperature from 54° to 68° C. for a short period of time causes the death of tissue; excessive cold produces the same result.

The prolonged action of *x*-rays may lead to necrotic changes. This has been explained as due to the destruction of nerves, but this point has not been definitely settled

Chemical and toxic substances of various kinds may act directly upon cells and cause their death. The poison may destroy the cells directly or, through chemical anion with the cell protoplasm or intercellular substance, render life impossible, or by producing changes in the blood-vessels give rise to necrosis secondarily. Most important of all as agents of necrosis are the bacterial toxins, particularly those of tuberculosis, typhoid, cholera, staphylococcus, and streptococcus infections. Chemical substances, originating within the body, may also give rise to necrosis under certain conditions.

The bile acids, uric acid, metabolic products in diabetes, pancreatic ferments, etc., may under certain pathological conditions give rise to necrotic processes. Fat necrosis is a striking example of necrosis arising from the action of a normal body product under abnormal conditions. The pancreatic juices are absorbed into the lymph and blood streams, the fat-splitting ferment, steapsin, causing necrosis of fat cells in the neighboring fat tissue, or even in such distant regions as the pericardium and fatty marrow.

The direct action of bacteria or other forms of vegetable and animal parasites may also produce necrosis of cells.

Primary lesions of the central nervous system and the peripheral nerves are considered by many writers to give rise to a trophic or neuropathic necrosis. The changes following such lesions are much more to be regarded as dependent upon circulatory disturbances than as trophic manifestations. As a result of lowered nutrition the normal resistance of the affected parts may be diminished and bacterial infection favored.

The causes mentioned above may act separately or coincidently. The degree of necrosis depends not only upon the nature and severity of the exciting cause, but also upon the condition of the tissue at the time of injury. Tissues of lowered vitality, in conditions of general anaemia, marasmus, and cachexia, die more easily than normal tissue; hence long-continued pressure of slight degree, which under normal conditions would produce no effect, may in such conditions as typhoid fever, chronic valvular disease, etc., bring about necrosis (*decubitus, marasmic necrosis*). Necrosis occurs also in the tissues of the aged as a result of slight injuries (*senile necrosis*).

Varieties of Necrosis.—Though the loss of the nucleus and a greater or less disorganization of the cytoplasm form the essential features of necrosis, these changes may be more or less modified, or so associated with other processes as to give rise to different varieties of necrosis, recognizable either by gross or by microscopical appearances. The kind of necrosis depends upon the location and nature of the affected cells, the character and severity of the destructive agent, and the nature of the surrounding tissue, particularly with reference to the absence or presence of fluids. If the dead cells are on a surface exposed to evaporation, inspissation may take place; on the other hand, if there is an abundant supply of fluid, the cells may become hydropic and ultimately liquefy; if the factors necessary for the formation of fibrin are present, coagulation may occur either in the cells or between them. The character of the necrosis may be further modified by infection with putrefactive bacteria. It becomes therefore possible to distinguish the following varieties of necrosis, each form presenting distinct macroscopical and microscopical characteristics when occurring alone. Between these different varieties there is, however, no distinct boundary line. They are very frequently combined or may follow each other in certain cases, so that the practical diagnosis as to the original form may be difficult.

Varieties of necrosis.	1. Simple.		Caseation.
	2. Coagulation.	Intercellular. Intracellular.	
	3. Liquefaction.		
	4. Mummification.		
	5. Moist gangrene.		

Simple Necrosis.—This form of necrosis is characterized microscopically by the disappearance of the nucleus and a hyaline or granular change in the cytoplasm, the original outlines of the tissue being preserved to a greater or less extent. Usually the dead cells are somewhat larger than normal, the protoplasm being more granular and staining heavily with eosin. Less frequently the cells are hyaline and homogeneous. By some writers this variety of necrosis is regarded as a form of coagulation necrosis, but it seems better to restrict the latter class to those forms

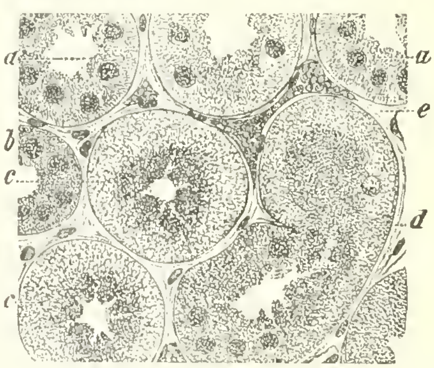

FIG. 3531.—Simple Necrosis of the Epithelium of the Uriniferous Tubes in a Case of Icterus Gravis. (From Ziegler.) *a*, Normal convoluted tubule; *b*, ascending loop tubule; *c*, convoluted tubule with necrotic epithelium; *d*, convoluted tubule with only a part of its epithelium necrotic; *e*, stroma and blood-vessels as yet unaltered. (Preparation hardened in Müller's Fluid, and stained with gentian violet.) Magnified 300 diameters.

of necrosis in which fibrin or fibrinoid substances are formed. Simple necrosis usually follows cloudy swelling; indeed, it may be regarded as a late stage of this degeneration advanced to such a degree that the nucleus has entirely disappeared Early stages of simple necrosis may often be recognized by the presence of diffuse chromatin. The gross appearances of simple necrosis

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are yellowish or grayish discoloration and lessened consistency. Simple necrosis is one of the most common forms of necrosis; it occurs very frequently in the epithelium of the kidneys and liver as the result of intoxica-

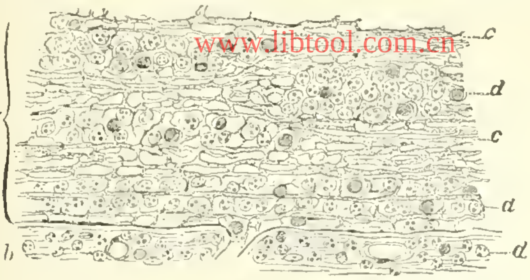

FIG. 3532.—Coagulation Necrosis. Croupous membrane from the trachea. (From Ziegler.) *a*, Transverse section of the membrane; *b*, uppermost layer of the mucous membrane with pus cells, *d*, scattered throughout its substance; *c*, fibrin threads and granules; *d*, pus cells. Magnified 250 diameters.

tions and infections, but may be found in any of the tissues. It is the most common form of necrosis found in anæmic and hemorrhagic infarcts, and in focal necroses due to various forms of intoxication and infection (typhoid, tuberculosis, diphtheria, scarlatina, etc.). A further change in tissues showing simple necrosis, so that all tissue outlines are lost and only a finely granular mass is left, results in the condition known as caseation.

Coagulation Necrosis.—This form of necrosis is characterized by the production, in the necrosed tissue, of fibrin or substances allied to fibrin, the so-called "*fibrinoid degeneration.*" The variety of necrosis described above as simple necrosis is by some writers regarded as a coagulation necrosis, but there is no positive evidence that it represents a coagulation process, and the resulting substance is not allied to fibrin. Coagulation necrosis occurs only in tissues rich in proteids and under conditions favorable for the production of the factors necessary for the formation of fibrin. Two forms are distinguished—*intercellular* and *intracellular*. In the intercellular form fibrin is formed between the dying or dead cells, the granular débris of the latter finally lying in a more or less dense network of fibrin threads. By the use of the Weigert's fibrin method this network of fibrin may be easily demonstrated. The fibrin may exist also in the granular, fibro-granular, or hyaline form. The chief source of the fibrin is most probably an exudate from the blood-vessels, but some of the factors necessary for the formation of fibrin may be supplied by the disintegration of tissue cells or leucocytes. The cells may become hyaline or granular, and ultimately completely disintegrate. This form of necrosis is most frequently seen in the fibrinous inflammations of mucous and serous membranes, and is hence also called *diphtheritic*, *croupous*, or *membranous* necrosis. The diphtheritic membrane may be taken as the typical example of this variety of necrosis. In all so-called diphtheritic inflammations there is more or less extensive necrosis of the mucosa with the formation of granular or fibro-granular fibrin between the granules of cell detritus. Intercellular coagulation necrosis may also occur in deeper tissues, as in the follicles of the spleen or lymph glands, in the liver, kidney, etc. It is of very common occurrence in the focal necroses of toxic and bacterial origin, and is almost constantly present to some degree in tubercles. It occurs much less frequently in anæmic and hemorrhagic infarction. Many chemicals cause coagulation by direct action. The toxæmia of superficial burns is associated with a form of coagulation necrosis in the splenic follicles and lymph glands similar to that seen in infectious processes. The coagulation of the blood and the process of thrombosis may be regarded as a form of coagulation necrosis. Tissues showing coagulation necrosis are firmer and paler than normal, more opaque, and show slight elevations above the cut surface. The source of the fibrin in the different instances of coagulation necrosis mentioned above is not entirely clear. A portion may result from the coagulation of vascular exudates and from escaped blood cells. In other cases it has been assumed that fibrinogenetic substances are derived from the necrosing cells or from bacterial products. The small quantity of fibrinogen found in the lymph may give rise to a portion of the fibrin produced during the necrotic process.

The intracellular form of coagulation necrosis is characterized by the coagulation of the cell protoplasm into a solid or semi-solid albuminous body more or less resembling fibrin. The most common example of this process is the so-called waxy or hyaline necrosis of striped muscle, commonly known as *Zenker's necrosis*. In this change the muscle loses its striations and becomes converted into a hyaline homogeneous substance which sometimes stains like fibrin, but often does not. To the naked eye such muscle appears pearly white or grayish, semitranslucent, resembling fish flesh. The condition occurs most commonly in cases of long-continued fevers as typhoid, and is found also in anæmic, thermal, and toxic necrosis of muscle. In the fevers the abdominal recti and the adductors of the femurs are most often affected. The exact chemical nature of the coagulated protoplasm is unknown. The simple necrosis which occurs in anæmic infarcts is regarded by some writers as being a similar form of intracellular necrosis (hyaline coagulation), but the process is of a very different nature from the change seen in striped muscle; and, as stated above, there is no definite proof that it is of the nature of a coagulation. Other writers look upon it as an inspissation process. In some instances intracellular coagulation may result from the imbibition of fibrinogen-containing fluids and their subsequent coagulation.

Liquefaction Necrosis.—In this variety of necrosis the dead cells undergo liquefaction; the dissolution may follow a hydropic degeneration or the necrotic cells may be dissolved in the tissue fluids. As a rule liquefaction necrosis occurs primarily in tissues freely bathed in lymph, but containing little of the fibrin-forming substances, as in the brain, cord, and skin. Burns of the second degree (blisters) are very common examples of this form of necrosis. Anæmic infarction of the brain, tissue suppurations, simple softening of thrombi, atheromatous softening in blood-vessel walls, and the digestion of necrotic areas of stomach and duodenum by the gastric juice are all processes characterized by softening and liquefaction. Liquefaction is also of frequent occurrence in certain tumors. In other cases liquefaction is a secondary process following simple or coagulation necrosis. The fibrinous exudates of inflammatory processes become liquefied during the later stages of the inflammation or during the process of healing, as in the case of the resolution of croupous pneumonia. Areas of caseation necrosis and moist gangrene may undergo a secondary liquefaction. On the other hand, coagulation may follow liquefaction, the fibrin-forming substances being produced from leucocytes. In the blebs which

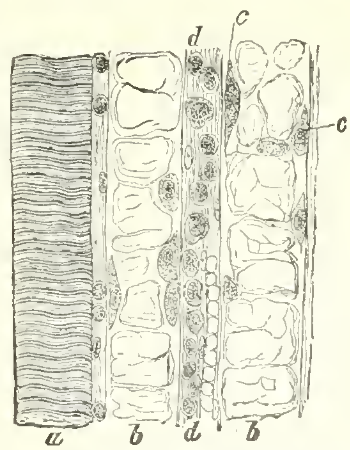

FIG. 3533.—Zenker's Necrosis of Striped Muscle Fibres, from a Case of Typhoid Fever. (From Ziegler.) *a*, Normal muscle fibre; *b*, *d*, degenerated fibres, which have broken down into separate masses; *c*, *c*, cells lying inside of the sarcolemma; *d*, connective tissue infiltrated with cells. Magnified 250 diameters.

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appear in gangrenous skin there may occur a coagulation of the fluid, and the coagula may later be dissolved. Macroscopically, liquefaction necrosis is characterized by the formation of blebs on free surfaces, or by cavities filled with softened tissue débris, varying in appearance from a thin watery fluid, as in the case of brain cysts, to thick creamy fluid in abscess cavities. The earlier stages are shown by softening and increase in the amount of tissue juices. Microscopically, the presence of fluid is shown by clear spaces or vacuoles, stringy disintegration, etc. Both gross and microscopical appearances may be altered by the presence of blood or blood pigments.

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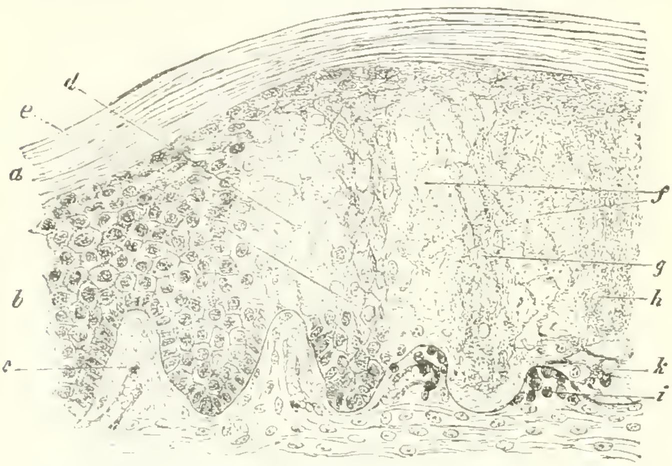

FIG. 3554.—Liquefaction Necrosis. Section through the epidermal and papillary portions of a cat's paw, a short time after it had been burned with fluid sealing-wax (alcohol; carmine). *a*, Horny layer of the epidermis; *b*, rete Malpighii; *c*, normal papilla of the skin; *d*, swollen epithelial cells, the nuclei of which are still visible at a few points, while at others they have entirely disappeared; *e*, epithelial cells lying between the papillæ, the upper ones being swollen and elongated, while the lower still remain in a normal condition; *f*, fibrinous network composed of epithelial cells broken down so as to be no longer recognizable as such) and exudate; *g*, an interpapillary mass of cells which have become swollen and have lost their nuclei; *h*, a part of a similar mass in which the cells have been entirely destroyed; *i*, a papilla that has been flattened by pressure and that is infiltrated with cells; *k*, solidified subepithelial exudate. Magnified 150 diameters. (Ziegler.)

Mummification Necrosis.—Necrotic tissues exposed to the air lose their fluids quickly through evaporation, and become leathery, dry, hard, shrivelled, brownish, or black, resembling mummy tissue. The condition is also known as dry gangrene; the amount of decomposition which takes place is, however, very slight, the dryness rendering the growth of saprophytic bacteria impossible. In the very early stages before the fluids are entirely removed there is some putrefaction usually present, as shown by the fact that there is almost always some odor about mummified tissue. The process may be regarded as a moist gangrene in which the processes of decomposition are cut short by the evaporation of fluid. Senile diabetic gangrene, gangrene of the extremities following freezing are examples of this form of necrosis. Microscopically, dry gangrene is characterized by the disappearance of the nuclei, the cells being flattened or contracted into hyaline masses. Cornification may be taken as a physiological example of this form of necrosis.

Moist Gangrene.—If necrotic tissues containing fluids become infected with saprophytic organisms with resulting decomposition, the condition is known as moist gangrene (*sphacelus, gangræna humida, gangræna putrida*). The formation of gas bubbles due to the presence of gas-forming bacteria gives rise to emphysematous gangrene (*gangræna emphysematosa*). The different forms of moist gangrene, though distinguished by various names, are in their essence identical, since bacteria develop only in moist tissues. As mentioned above, moist gangrene may be changed to the dry form through evaporation. Gangrenous tissues are black, greenish, or brownish in color, according to the amount of blood pigment present. If there was much blood in the tissue before death the gangrene may be *black*; if the tissues were anæmic the condition is sometimes designated *white gangrene*. Such forms are also distinguished clinically by the terms *hot* or *cold gangrene*. In hot gangrene the heat may come from an abundant blood supply in the neighboring tissues. The odor of putrefaction is always present in moist gangrene, and various gases may be formed. Ptomaïns and other poisonous substances are formed in the gangrenous area, and the absorption of these may lead to sapræmia. Softening and liquefaction are always present to a greater or less degree. Microscopically, moist gangrene, in addition to the essential features of necrosis, is characterized by the presence of products of decomposition in the form of fatty acid crystals, tyrosin, leucin, triple phosphate, blood pigment, etc. The general picture may be that of a simple coagulation or liquefaction necrosis, or a combination of these forms may be present. Liquefaction is always present in a greater or less degree according to the stage of the process; all elements of the tissues, even bone and fascia, ultimately becoming dissolved. Moist gangrene may be caused by external injuries, chemical action, freezing, burns, *x*-rays, pressure, disturbances of circulation with impaired nutrition, intoxications, and infections. Lesions of the central nervous system and peripheral nerves are also regarded as direct or indirect causes of gangrene (*neuropathic gangrene*). The tissues usually affected are those most likely to be infected with saprophytic organisms, viz., the extremities, skin, lungs, external genitals, uterus, and intestines. (See also *Gangrene*.)

Caseation Necrosis.—The term caseous is used as a gross descriptive designation for necrotic processes in which the dead areas bear more or less resemblance to cheese in color and consistency. Two forms may be distinguished, the *hard* or *firm* and *soft caseation*. Either simple or coagulation necrosis or moist gangrene may be followed by caseation; the latter condition is to be regarded as a post-necrotic change representing a more advanced stage of cellular disintegration. If coagulation necrosis is present, the caseation is usually of the firm variety; if there is much fluid in the part or if the necrosis had been preceded by fatty degeneration, soft caseation will result. Caseous areas are yellowish or grayish-white, more or less firm, dry, or viscid, and on section resemble cheese in consistency. Microscopically, the outlines of tissue elements are entirely lost, nuclei are absent, and the cells broken into fine granules. Fibrin threads may be shown by proper staining; fat droplets and vacuoles may be present. Early stages of caseation may stain diffusely blue from diffused chromatin; old caseation stains red with eosin, but shows no trace of chromatin. The chemical nature of caseous material is unknown; it probably includes many different substances derived from the breaking down of proteids. Caseation is a constant change in tubercles and gummata, and is of frequent occurrence in old infarcts, focal necroses, rapidly growing tumors, etc. Caseous areas not infrequently become liquefied. It is probable that diffusion processes take place between the area of caseation and the surrounding tissue; in this way the former may become infiltrated with fluid.

According to clinical or macroscopical characteristics the various forms of necrosis are also described as *focal, diffuse, spreading, central, circumscribed*, etc. Of these varieties *focal necrosis* deserves special mention. The term is applied to small necrotic foci, occurring very frequently in the course of various intoxications and infections, such as typhoid, diphtheria, scarlatina, smallpox,

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puerperal eclampsia, tuberculosis, toxæmia of burns, etc. The foci are found chiefly in the liver, spleen, lymph glands, and kidneys. The form of the necrosis is usually simple, but fibrin is often present in the necrotic material. The later stages present the appearance of caseation. Focal necroses may not be visible to the naked eye, or they may resemble miliary tubercles or abscesses, for which they may be mistaken. At other times they may appear as small pale yellow or grayish spots barely distinguishable from the surrounding normal tissue. Microscopically, small islands of simple coagulation or caseation necrosis are found. When the necrosis has been recent, diffuse or fragmented chromatin may be present and the areas may stain deep blue. About the necrotic areas there is often a leucocyte infiltration. Many of the leucocytes become involved in the necrotic process; their chromatin becomes diffuse, giving rise to a deeply staining periphery. In the liver focal necroses are often limited to the central zone of the lobule about the central vein; hence the designation *central necrosis*. The same term is also applied to central necroses of bone. Focal necroses are due to the direct action of bacilli or to poisons acting directly upon the cells or to local asphyxia. The changes in the small capillaries of the affected tissue play a very important part. Fibrin may be first formed in the capillaries and lymph vessels, and thus shutting off the supply of nutrition cause cell death. In other cases changes in the capillary walls may be first produced by the injurious agent; capillary thrombosis follows, and to this the cellular necrosis may be secondary. Transudation of serum through the injured capillary walls may also lead to necrosis of the surrounding cells. The sequelæ of focal necrosis are the same as those of necrosis in general.

Fat Necrosis.—The necrosis of the fat-containing cells of adipose tissue forms a condition so striking in its clinical and pathological aspects as to warrant special mention. The condition occurs most frequently in the abdominal fat in connection with pancreatitis. The necrotic areas appear in the fat as grayish or yellowish, or in some cases black, opaque areas, soft or gritty, slightly elevated and usually circular in outline. The appearance sometimes is such as to suggest that the fat had been seared by a hot iron. Microscopically, the fat cells are enlarged, the nuclei absent, the contents granular or presenting the appearance of fine needles radiating from the centre of the cell. Osmic acid has no effect upon the altered fat cells. With ordinary stains the necrotic fat cells react in a variety of ways. The granular detritus in the fat cells consists of a combination of lime salts and fatty acids. If the process is old, the amount of lime salts may be great. It has been definitely shown that fat necrosis is due to the fat-splitting ferment of the pancreas, which under certain inflammatory conditions of that organ gains access to the tissues through the blood or lymph. Experimentally, fat necrosis may be produced by injection of pancreatic extract, by ligature of the pancreatic vessels, by introduction of pieces of pancreas into adipose tissue or into the peritoneal cavity, and by the direct action of steapsin in fat tissue. Not only may the abdominal fat be affected in cases of pancreatitis associated with fat necrosis, but also the fat of the pericardium, liver cells, retroperitoneal region, and bone marrow. In the majority of cases the condition is fatal, but recovery has been noted, the dead fat cells becoming calcified.

Hæmolysis, the destruction of the red blood cells, and *leucolysis*, the disintegration of leucocytes, are discussed by some writers under the head of necrosis. The exact nature of these processes is not at present definitely determined. Bacterial products, various poisons, the blood sera of animals of different species, or of the same species under certain conditions, are the chief factors in the production of these conditions. Normal hæmolysis occurs in the spleen, lymph glands, hæmolymph glands, and bone marrow. In pernicious anæmia, sepsis, and many of the acute infections and intoxications hæmolysis occurs in these organs to a greatly increased extent. Pathological destruction of the red cells in the circulating blood occurs also in a variety of infections and intoxications. The term *hæmocytolysis* is more properly applied to this condition, but has been largely superseded by the word hæmolysis.

Sequelæ of Necrosis.—The course of the necrotic process depends upon the anatomical nature and location of the affected tissue, the course and manner of the injurious influence causing the necrosis, the condition and environment of the affected part, the amount of blood and lymph, the nature of preceding changes, the opportunity for the access of air and putrefactive agents to the part, etc. About the necrotic area there is always a more or less marked inflammatory reaction in the surrounding living tissue. As a result of such inflammation the necrotic area becomes isolated and sequestered. The process is called *sequestration*, and the area of necrotic tissue so shut off a *sequestrum*. The ultimate sequelæ will be: (1) *Regeneration* following the absorption or casting off of the dead tissue, new tissue resembling the normal being formed; (2) *cicatrization*; (3) *calcification*; (4) *cyst formation*, the dead tissue being liquefied and encapsulated; (5) *chronic abscess* or *ulcer*.

Aldred Scott Warthin.

NECROSIS OF BONE. See *Bone, Pathology of.*

NEMATODA.*—The class of the Nematoda or round worms constitutes a large, rather uniform, and clearly demarcated group, which by many recent authors has been regarded as of the rank even of a phylum, in which case the name Nemathelminthes has been applied. The group is characterized by a cylindrical body, often filiform even in its attenuation, and by the heavy cuticular investment which carries in some cases small bristles, hooks, or spines, but which is consistently without appendages and manifests at most surface striation, but never true segmentation. The body cavity is extensive, but unprovided with a peritoneal epithelium, and the sexual and excretory systems do not stand in any connection with it. Another striking feature is the entire absence of cilia in all stages of development.

An alimentary canal is present, at least in some stage of the life history of all forms. It is with rare exceptions a permanent structure in the members of the sub-class of true round worms, or Eunematoda; but in the sub-class of the hairsnakes or Gordiacea, the alimentary canal is greatly reduced in the adult, in that the mouth is closed and a delicate solid string of tissue is the only vestige of the anterior portion of the canal. The posterior region still retains its cavity and functions in connection with the reproductive organs of both sexes, which have with it a common outlet. In the Eunematoda, on the other hand, the male organs join the alimentary canal to form a common cloaca, but the female system is entirely unconnected with the alimentary system, and the vulva occupies a variable position in the midventral line. The sexes are separate, though in rare instances parthenogenesis or hermaphroditism modifies the usual balance.

By far the largest number of forms belongs to the Eunematoda, which will be considered first, while the Gordiacea and, as an appendix, the Acanthocephala will be discussed subsequently. Among the Eunematoda the better known forms are parasitic, though some are free living and an occasional species is capable of making use of both types of environment. The free living species are uniformly insignificant, but among parasitic forms one finds the microscopic blood parasites and the meter long guinea worm. In respect to location also there obtains great variety; and one finds these parasites in all regions of the alimentary, respiratory, circulatory, excretory, and muscular systems, and in connective tissue and serous cavities.

The greatly elongated cylindrical form tapers as a rule more or less toward both ends, though generally speak-

* A general discussion of parasitism and its effects will be found under the heading *Parasites*.

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ing the head is truncated and the tail acute. The chitinous cuticula invests the entire body, and is introverted a short distance at all orifices. It bears rarely unjointed spines and bristles and is marked often by delicate surface striations. In cross section (Fig. 3537) the body appears circular, and shows beneath the cuticula a thin hypoderma layer, which is prominently thickened at four points. Of these the lateral lines, fields, or areas, as they are called, are largest, and are visible in surface view as delicate longitudinal stripes (*c*, Fig. 3535). The dorsal and ventral median lines are much less prominent and are distinguishable ordinarily only in sectional views.

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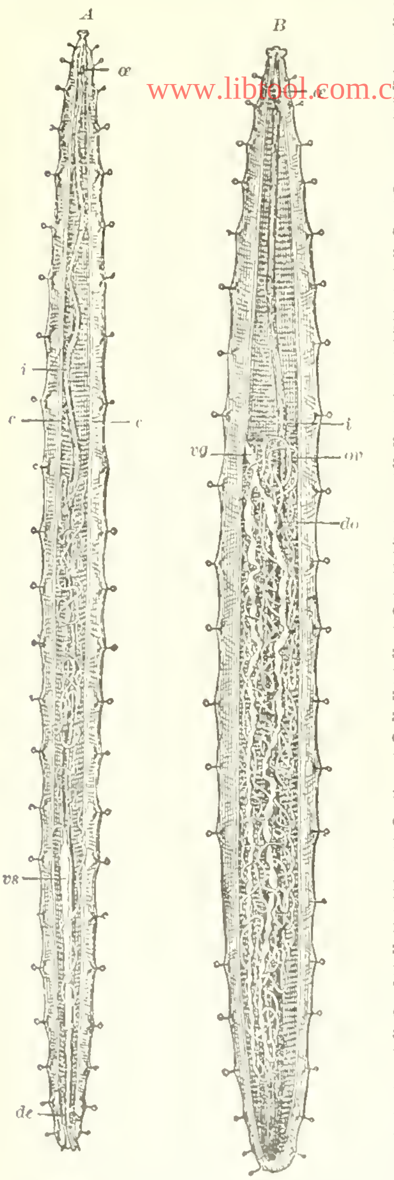

FIG. 3535.—Internal Anatomy of *Ascaris lumbricoides*, opened along dorsal line. *A*, Male; *B*, female; *c*, lateral line; *de*, ductus ejaculatorius; *do*, uterus; *i*, intestine; *oe*, œsophagus; *ov*, coiled ovary; *vg*, vagina; *vs*, seminal vesicle. (After Delafond.)

Directly below the hypodermis is the muscular layer which is interrupted by the lines already noted, and hence appears as four muscular fields. The muscle cells (*m*, Fig. 3536) are of a peculiar type in that a protoplasmic body is distinct from the contractile fibrillar portion. The main trunks of the nervous system occupy the dorsal and ventral areas, while the lateral areas contain each a delicate canal, which has been interpreted as part of the otherwise unexplained excretory system; with the latter are associated, however, certain stellate cells of peculiar character, which project from the lateral fields into the body cavity and are known as phagocytic organs.

The alimentary canal (*i*, Fig. 3535) is a straight simple tube extending from the mouth, which is always terminal, to the anus, which varies in location from the posterior end to a position on the ventral surface, some little distance removed from it. Various features connected with the canal are of great systematic importance. About the mouth are found a number of lips and papillæ characteristic of the genus or family. The buccal or pharyngeal cavity, an enlargement at the outset, the muscular œsophagus with a triangular lumen (Fig. 3537) and a terminal enlargement which may be indistinctly marked, or may partake of the form of a distinct bulb, or even two such, with a valvular apparatus, the intestine proper followed by the rectum and cloaca in the male—these constitute the distinct parts of the alimentary system.

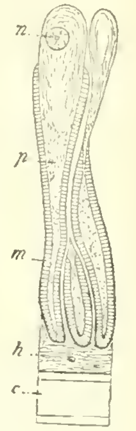

FIG. 3536.—Section of Body Wall. Highly magnified. *n*, Nucleus and *p*, protoplasmic body of muscle cell, *m*.

The sexual organs have the form of a long coiled tube, in the attenuated distal end of which the sexual cells are produced, while the proximal portions afford storage for the perfected germ cells before they are discharged from the body. In the female the system is regularly bifid, although one horn of the uterus may be undeveloped to a greater or less extent, while in the male only a single tube is present. The varied debouchment of the system in the two sexes has already been noted. About the vulva chitinous lips often of notable thickness are developed, and on the external surface near the male orifice numerous papillæ characteristic of the genus or species, and at times a sucker also are to be found; these function as accessory copulatory apparatus, while in the same category are included expanding folds of the body wall known as the bursa and awl-shaped chitinous structures called spicules. The bursa varies from a pair of simple folds lateral to the cloaca to a cup or bell surrounding it and the posterior end of the body. The spicules, either one or two in number, with an accessory guiding piece in some instances, are developed in a dorsal evagination from the cloacal wall and provided with special musculature for extrusion and retraction. Their form varies greatly in different species, and with the bursa and circumanal papillæ constitutes the means for determination of the species.

The Eunematoda are oviparous, but in some cases the eggs are retained long enough in the uterus to contain when laid a partly or fully developed embryo; and in a

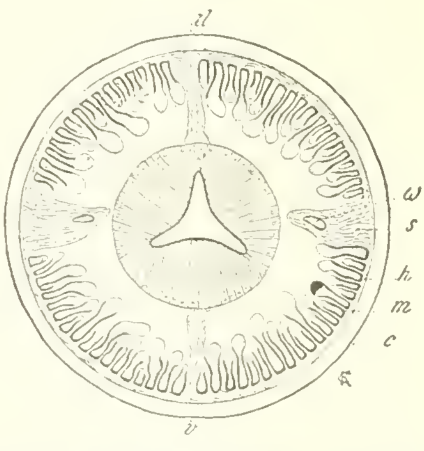

FIG. 3537.—Transsection of *Ascaris lumbricoides* at level of œsophagus. *c*, Cuticula; *h*, hypoderm; *i*, intestine; *m*, muscle layer; *d*, dorsal, *s*, lateral, *v*, ventral lines; *w*, excretory canal. (After Hertwig.)

few species the embryo deserts the shell before it is extruded from the body. All stages in the development of this ovoviviparous habit may be observed.

Ordinarily the eggs which undergo development exter-

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nal to the body of the host are provided with a heavy shell to resist the action of an unfavorable environment. In case the eggs undergo development while still in the uterus, the shell is thin. Some species develop directly, *i.e.*, without a change of host, though a certain stage in the life history at least is passed in the outer world; in other cases the immature worm lives in another animal, known as the intermediate host, than that which harbors the adult, or rarely in a different part of the body of the one host. In a few species a parasitic generation alternates with a free living generation of such different form as to have been regarded as another species; and the alternating generations differ radically in method of reproduction. In one case at least (*Trichinella*) the entire life history is passed within the host and transportation to a new host depends upon the carnivorous habit. In other cases also (blood filariæ) the life history is passed within two hosts and no part takes place externally; but in most instances there is a free living stage and infection is brought about primarily through the drinking-water. Some prominent exceptions to this general statement are noted later.

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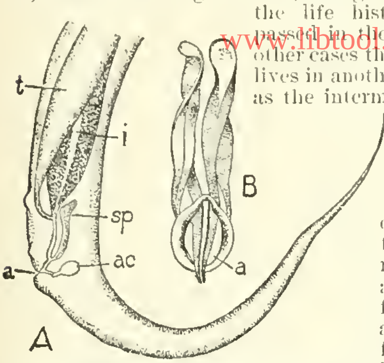

FIG. 3538.—*Anguillula aceti.* *A*, Tail of male; *ac*, accessory piece; *sp*, spicules; *B*, spicules partially protruded from anus. Magnified. (After Stiles.)

The family of the Anguillulidæ, which is difficult to characterize, contains mostly free nematodes of small size, transparent, filiform, and tapering to both ends. The œsophagus is inflated or has one or two bulbs at the posterior end. The female possesses double symmetrical uteri and short reflexed tubular ovaries, with vulva at or behind the centre of the body, with few, large ova, and with development rapid, often ovoviviparous. The male has two equal chitinous spicules, with or without one or more accessory pieces. The type genus is

Anguillula Ehrenberg 1826.—Buccal cavity very minute; œsophagus cylindrical with two bulbs, the posterior having a valve apparatus; vulva behind centre of body; male without bursa; accessory piece single, fan-shaped. The best-known species is the vinegar eel, which has recently been found as a parasite of man.

Anguillula aceti Müller (Fig. 3538).—Cuticula unstriated, body tapering slightly anteriad; tail greatly attenuated. Male 1.35 to 1.45 mm. long by 24–28 μ wide. Spicules 38 μ long, similar, twisted; accessory piece slightly caudad; no bursa; papillæ at least two preanal and one postanal. Female, 1 to 2.4 mm. long, by 40–72 μ in diameter, contains embryos 0.22 mm. long by 12 μ in diameter.

This worm, which is everywhere common in vinegar, has been recently studied by Stiles and Frankland in the rôle of a human parasite. The specimens were taken in great numbers from the urine of a female patient, and were present during a period of thirty-three days. The urine was always very acid and once had a marked odor of vinegar. In this sample the worms lived two months, and individuals then removed to vinegar became vigorous and bred rapidly.

Pathology.—The patient had chronic parenchymatous nephritis of a degenerative type, and the urine frequently contained albumin, but not while the parasites were present. No symptoms traceable to them were observed, and their presence in the bladder remained unexplained. The suspected use of vaginal douches acidulated with vinegar was denied by the patient, and no grounds existed for questioning the truth of the statement. Evidently this parasite might be present in the vagina if such a practice were followed. Billings and Miller have reported two other cases from the United States in which, however, the source of the parasite was not demonstrated beyond question.

Leptodera A. Schneider 1866.—Œsophagus with two bulbs, the posterior with or without valves. Male with or without bursa, often six to ten papillæ on the bursa or on the median line; two short spicules and a single accessory piece. Some species are hermaphroditic. A somewhat indistinct genus, difficult to separate from that last described, and perhaps identical with it.

Leptodera Niellyi R. Blanchard 1885.—(Syn.: *Anguillula leptodera* Nielly; *Rhabditis Niellyi* R. Bl. 1888.)

This species is known only in the larval form, in which it measures 333 μ in length and 13 μ in breadth. The alimentary canal was the only internal organ described; it displayed two enlargements in the pharynx, the second pharyngeal bulb having a dentate armature.

The worms were discovered by Nielly in 1882 in a young man, fourteen years of age, who was born near Brest, and had never been out of that region. A dermal eruption, much like craw-craw, of about five or six weeks' standing, affected chiefly the patient's limbs. In the fluid of each papule were found several worms, and the blood showed on microscopical examination at the outset of the malady many small nematoda, which, however, could not be found later; at no time were they found in fæces or urine.

The method of the introduction of the parasite was unknown; but it was remarked that the lad had been in the habit of drinking from brooks. It is easily surmised that the eggs of the worm were swallowed in drinking, and that the embryos, hatching out in the alimentary canal, bored their way into the circulation and thus reached the skin. Their presence both in the blood and in the papules is thus easily explained. They may have been, however, larvæ of some imported filaria, though dermatosis caused by larval nematoda has been observed in dog, fox and horse in Europe by many investigators.

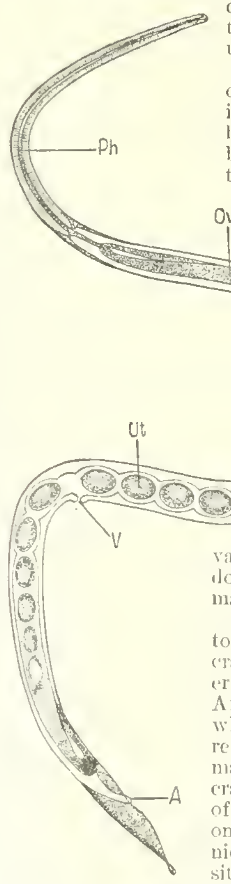

FIG. 3539.—*Strongyloides stercoralis* from Human Intestine. × 80. (After Braun.)

In this connection it is important to note the similarity of this case to craw-craw, a contagious vesicular eruption of the skin, observed in Africa and in South America, in which various investigators have reported the presence of larval nematoda. Manson regards craw-craw as a dermatosis characteristic of the "sleeping sickness," endemic on the west coast of Africa. Moniez has suggested that the parasites to which this case is due may have been imported by some sailor from Africa, and associates with it the case of elephantiasis, also observed in Brittany.

Leptodera pellio (A. Schneider 1866).—(Syn.: *Rhabditis pellio* A. Schneider 1866; *R. pellio* Bütschli 1873; *R. genitalis* Scheiber 1880.)

Male: Length, 0.8–1.5 mm.; bursa with seven to ten ribs on each side; spicules 27–33 μ in length, nearly alike. Female: Length, 0.9–1.5 mm., posterior extremity long

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and pointed, vulva a little in front of the middle; ovary not paired; eggs oval, 60 by 35 μ.

Scheiber found this species at Stuhlweissenburg, Hungary, in the urine of a native woman suffering from pyelonephritis, pneumonia, and acute intestinal catarrh. During the entire illness the worms were found in the vagina in all stages of development. Several other authors have found what is closely related, if not the same form, in the urine in cases of hæmaturia; but the parasitism is probably accidental, since Oerley has shown that *R. genitalis* Scheiber must be referred to *R. pellio*, a common free living form found in moist earth and putrefying substances, and also that worms of this species will multiply in the vagina of white rats. There is further to be noted both the habit of Hungarian peasants in employing moist earth for poultices and the record of Scheiber, that patient and clothing were earth-stained, rendering it altogether likely that such a poultice had been applied near the vulva, and that from it the free living worms had successfully colonized the vagina.

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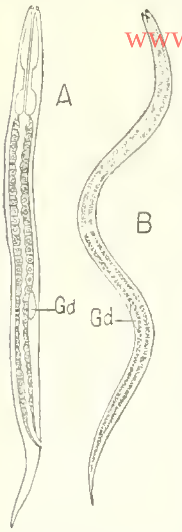

FIG. 3540. *Strongyloides stercoralis.* *A*, Rhabditiform larva from fresh fæces. × 145; *B*, filariform larva from culture; *Gd*, genital cell. 135. (After Braun.)

Leptodera terricola (Dujardin 1845.)—(Syn.: *Rhabditis terricola* Duj. 1845; *Pelodera teres* Schneider 1866; *P. setigera* Bastian 1879; *R. Cornwalli* Cobbold 1879.)

Mouth with six lips, anterior bulb of pharynx fusiform, posterior spherical. Male: Length, 1.3 mm.; tail attenuated, slightly longer than the bursa. Female: 2 mm. in length and over; posterior extremity sometimes regularly attenuated, sometimes sharply rounded and provided with a very fine tail; vulva about the middle of the body; ovoviviparous; eggs 60 by 40 μ.

This typical free living species should be listed as a pseudo-parasite of man by virtue of its occurrence in cadavers, and, in one case at least, its confusion with trichina. The facts in this celebrated case are as follows: The English schoolship *Cornwall* was visited in 1879 by an epidemic which affected many cadets and killed one. The symptoms of the disease were not incompatible with trichinosis, and microscopical examination of the exhumed cadaver, undertaken two months later, demonstrated in the muscles of the abdomen many nematoda, which, with the exception of the first one examined, were dead, but not one was encysted. The epidemic was pronounced therewith trichinosis, and attracted enough attention to be brought before Parliament. Cobbold and Bastian easily showed that the worms in question had nothing to do with *Trichinella*, and Oerley established their identity with *L. terricola*, which had undoubtedly penetrated the body after inhumation.

The family of the Angiostomidæ includes small rhabditis-like nematoda which manifest in development the alternation of two types of sexual generations of which the first is diœcious, free and very similar to Leptodera, while the second is parasitic, hermaphroditic, and of a different structure.

Strongyloides Grassi 1879.—Parasitic generation with simple mouth in which no armature is present; cylindrical pharynx very long. Free generation with small oral cavity; pharynx with two bulbs, the anterior fusiform, the posterior spherical and armed; male with two small spicules similar.

Strongyloides stercoralis Stiles and Hassall 1902.—(Syn.: *Anguillula intestinalis* and *A. stercoralis* Bavay 1877; *Leptodera intestinalis* and *L. stercoralis* Cobbold 1879; *Pseudorhabditis stercoralis* Perroncito 1881; *Rhabdonema strongyloides* Leuckart 1883; *Strongyloides intestinalis* Grassi 1883; *R. intestinale* Blanchard 1885.)

Free generation (Bavay's *A. stercoralis*) both sexes occur; body slender, tapering toward the ends; mouth with three or four indistinct papillæ; œsophagus 0.16 mm. long, with well-developed buccal cavity and two bulbs, the posterior of which is armed with three chitinous teeth; anus with protruding lips on right side of body. Male (Fig. 3541, B): 0.75–1 mm. long, 35 to 66 μ thick, with short recurved tail and two curved, conical spicules, 38 μ long. Female (Fig. 3541, A): 1–1.4 mm. long, 50–75 μ broad, with long slender pointed tail; vulva a little behind the middle of the body and on the right side; uterus double; eggs ellipsoidal, thin-shelled, 70 by 45 μ, segmentation advanced, embryo often hatched within body of mother; embryos at first with tapering tail, bulbous œsophagus, and chitinous teeth, soon changing to filariform stage.

Parasitic generation (Bavay's *A. intestinalis*) (Fig. 3539). Female only, hermaphroditic or parthenogenetic; length 2.1–2.2 mm., breadth 30–39 μ, body slightly tapering anteriorly, but terminated posteriorly by a short bluntly conical tail, with rounded and slightly dilated tip, mouth with three poorly developed lips (or none? Strong); œsophagus cylindrical, with no swellings, one-fourth the length of the body or more, distinguishable readily only in color from the intestine; vulva transverse in posterior third of the body; uterus with five to six (nine to twenty?) ellipsoidal eggs, 50–59, or 65–70 μ by 30–34, or 39 μ, and often joined in strings of two or three. The eggs are segmenting when laid, they develop rapidly and hatch before being ejected with the excrement. Embryos rhabditiform, 0.3–0.6 mm. long by 16–22 μ wide; first molt within twenty hours if in incubator.

Dr. Normand discovered the species in 1876, when examining microscopically the stools of soldiers returned from Cochin China, who were suffering from acute dysentery. Somewhat later he found at the necropsy of a soldier who had died from Cochin China diarrhœa, the other form of the species. Both of these forms were originally studied and described by Bavay. It was in 1883, before the connection of the two was established by Leuckart, who showed them to be phases in the life history of the same species. In life man harbors in the canal the one* form (*A. intestinalis* Bavay) and its young which, reaching the exterior with the fæces, may be transformed then into the other adult (*A. stercoralis* Bavay); the latter transformation may also take place in the intestine after death, as in cultures made in confirming these discoveries. Later authors have added many details, which may be summarized as follows:

The parasitic generation, which recalls a strongylid or a filaria in general appearance, produces eggs so abundantly that from an ordinary infection more than a million embryos may be evacuated in a single stool. The embryos (Fig. 3540, A) measure at hatching 0.2–0.24 mm. long by 12 μ broad, but develop so rapidly that those in the stools have attained a length of 0.30–0.60 mm. by a width of 16–23 μ. The embryos are characterized by a rhabditiform œsophagus, and under normal temperature they soon moult; and then, protected as if by a cyst in the larval skin, await more favorable conditions for further development. If kept, however, at a temperature of 25–35° C. they develop to sexual maturity in fifteen to eighteen hours; they copulate in thirty hours, and the females begin to lay at fifty to fifty-five hours.

After the first moult the structure of the embryos becomes more distinct, and one can see three or four oral papillæ and a buccal cavity, together with an anterior enlarged and median constricted region of the œsophagus, which is terminated by the œsophageal bulb, containing an apparatus for trituration composed of three chitinous teeth. The intestine which follows ends in a slightly protruding anus located on the right side. Also

* It is disputed whether the other form may rarely be found under the same circumstances.

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on the right, about one-third the distance from the bulb to the tail, is the whitish lenticular proton of the sexual system.

In most cases studied in temperate regions after a few days in culture, these embryos die or change form, becoming elongate and with more tapering tails, the œsophagus loses its teeth and enlargements and becomes a uniform cylinder; the embryos resemble young filariæ and have taken on the strongyloid form (Fig. 3540, B).

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Only thirty to forty eggs are deposited by each female of the free generation (Bavay's *A. stercoralis*), which develop so rapidly as to approach the ovoviviparous condition; they hatch out young worms about 0.22 mm. long, in which the œsophagus manifests a distinct rhabditiform character. After the first moult, which occurs when they are about 0.35 mm. long, they acquire in from thirty to thirty-six hours the strongyloid appearance, in that the mouth shows four lips, the œsophagus is cylindrical and has lost its dental armature, the tail is shortened, and bears near its end two small lateral wings. At the end of eight days the free form can no longer be found in the cultures, and all the young have become strongyloid larvæ. If introduced into the intestine, these larvæ develop into the parasitic female, with which the cycle begins anew.

A remarkable modification of this, the normal life cycle of the species, was discovered by Grassi, who found that the development might be abridged since the rhabditiform embryos may transform directly into the strongyloid larvæ without the intervention of any free sexual generation. This direct development has been confirmed by Leichtenstern, who has observed it for weeks in succession, while at other times alternation with the free rhabditiform generation comes in. The causes of this transformation are unknown as yet; it must, however, be regarded as an important etiological factor, since the infection of man may be due to the accidental introduction of either sort of larvæ, or of the adult parasitic form. Stiles has suggested that this abbreviation is a step toward perfect parasitism.

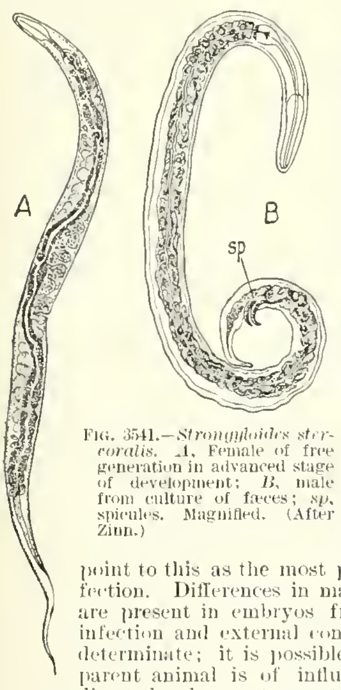

FIG. 3541.—*Strongyloides stercoralis*. *A*, Female of free generation in advanced stage of development; *B*, male from culture of fæces; *sp*, spicules. Magnified. (After Zinn.)

The method of introduction can only be inferred to be impure water or vegetables, salads, etc., which have been contaminated by human excrement. Although Normaud acquired the disease in Cochin China, while having refrained absolutely from drinking any but imported water, and was accordingly inclined to question the part played by water in its dispersal, yet in the absence of further evidence general considerations must point to this as the most probable source of infection. Differences in manner of development are present in embryos from a single original infection and external conditions seem to be indeterminate; it is possible that the age of the parent animal is of influence. Embryos with direct development are at least more resistant, and alone survive under unfavorable environment.

It has been claimed after culture experiments by Wilms that there are not two varieties of the parasite, one developing by the direct, the other by the indirect method, but that embryos from the same lot of eggs may develop in either fashion. Though the number of cases observed is probably too small for definite conclusions, it is striking that cases infected with the tropical strongyloids develop usually with the interpolation of the free sexual generation, while cases infected in temperate regions, both of Europe and America, manifest almost exclusively direct development. It should not be forgotten that there may be concerned here more than one species of closely related and heretofore confused forms, which would account for some of the apparently conflicting statements. Certain it is that the figures of the larvæ, given by various authors, do not agree in the form and proportions of the different regions in the œsophagus, which for individuals in the same moult are ordinarily regarded as constant, and an examination of the adult parasites, as figured by two most recent observers, Strong and Braun, shows numerous differences in detail, which can hardly be errors in observation.

The observations of Grassi, that the alternation of generations described above is not a necessary feature in the life cycle of this species, is still further of importance as explaining the enormous number of worms found in the intestine in some cases. Leuckart records an instance in which prodigious quantities of the worms were evacuated even a year and a half after leaving the locality of infection. Such evidence leaves little reasonable doubt of the multiplication of the parasite in the human alimentary canal, as in fact related species do so reproduce in other animals and as *Anguillula aceti* multiplies in the human bladder as noted above.

Distribution. — *Strongyloides stercoralis* occurs very widely. The entire tropical and subtropical zone of Africa, Asia, the Philippines, and the East Indies form apparently its original home, within which its occurrence is all but universal. It has also been recorded from Martinique, Brazil, Hawaii, and in Europe from Sicily, Italy, and Mount St. Gothard tunnel, Spain, Russia, and among brickworkers along the Rhine and in East Prussia. First reported in the United States by Strong, it has been observed and studied since then twice in Baltimore by Thayer, who showed its probable endemic character. For further data on its occurrence as well as for bibliography and discussion of previous cases consult the splendid paper by the latter author. Stiles has 5 further cases to be published soon.

Pathology.—At first the worm was regarded as the cause of the dysentery in which it was originally discovered and with which it is usually associated; more recent investigations have thrown some doubts upon this view. The rarity of the worm in the intestine at the outset of the disease, its abundance in stools of convalescents, its absence in cases which have freely bilious diarrhœa, and often in severe attacks of Cochin China diarrhœa, and finally its frequent presence in individuals enjoying normal health, all militate against the supposed pathogenic rôle of the species; and both Grassi and Leichtenstern go so far as to proclaim the species entirely innocuous, "innocent commensals of man."

On the other hand, its presence is not regarded by all authors as harmless, even though they do not regard it as the cause of the disease. Sonsino has found that in Italy excessive multiplication of the species may give rise to acute enteritis followed by dangerous anæmia. Golgi and others have observed epithelial lesions which they have attributed probably with justice to the action of this parasite. Its extraordinary multiplication in the human alimentary canal must contribute to the irritation of the mucosa and to the development of the lesions produced by the so-called Cochin China dysentery. Recent observations of Askanazy serve to demonstrate the pathological character of these worms, which he finds to be actual parasites of the intestinal wall in the duodenum and jejunum. Here they penetrate chiefly the mucosa, being often found in the epithelium of Lieberkühn's glands. They may penetrate to the muscular layer or rarely deeper than this. These migrations are in search of food, as the chyle-filled body of the worm shows; but no evidence was found to show that they ever suck the blood of their host.

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The female deposits eggs in the galleries of the mucosa, which give rise to embryos that wander out into the lumen of the intestine. In Teissier's case it was claimed that these embryos had taken a different route and had entered the circulation, perhaps by way of the chyle tubes; their presence here was accompanied by high temperature, which abated with their disappearance three days later. More probably this case represents a double infection of *Filaria* with *Strongyloides*. The limited number of *Strongyloides* eggs found in the fæces is to be explained perhaps on their deposition deep in the tissue. More recently Strong has confirmed the presence of adults, eggs and embryos in the epithelium and in the cavity of the crypts of Lieberkühn, in which cases the epithelium is often atrophied and less frequently entirely gone. Infiltrations of small round cells were observed in some cases, but no marked inflammatory changes. This author believes that the parasite is not harmless, though not particularly dangerous; and he finds it capable of producing an intermittent diarrhœa with intestinal disturbances. It certainly causes some mechanical injury from its rapid movements.

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FIG. 3542.—*Filaria medinensis*, Rolled on Split Stick. (After Fedtschenko.)

Prevention.—The use of filtered or boiled water and abstinence from eating uncooked vegetables of any sort, as well as the destruction of stools from patients afflicted with the parasite, are evident measures suggested by the life history. Special mention has been made by various observers of the general immunity of natives in Cochin China toward both the parasites and the endemic dysentery, and it has been explained on the basis of their universal use of water boiled or treated with alum sufficient to precipitate the organic matter.

The hydrotactic tendency of the embryos is useful in diagnosis in cases in which they are present in small numbers, since in the centre of a fecal layer spread on a culture plate a small cavity can be made and filled with water; here the embryos collect and are easily found. In pure water the embryos of the free generation are apt to perish, perhaps through lack of food materials. Leichtenstern has also pointed out that a differential diagnosis between this species and *Uncinaria* is not difficult, since in fresh fæces the latter form appears only as eggs, the former only as embryos. The *Uncinaria* embryo is also easily distinguished from that of *Strongyloides*, since the latter has a short thin-walled oral cavity, hardly chitinized at all, and a large spindle-shaped sexual rudiment, 33μ long, while the former possesses a long, heavily chitinized oral cavity and a minute circular sexual rudiment, only 3μ long. If eggs are taken from the canal at a necropsy, those of *Uncinaria* are distinguishable from those of *Strongyloides* by the smaller size and thicker shell.

Treatment.—Turpentine and male fern have no apparent effect. In mild cases thymol with general tonic treatment is successful generally, but in severe infections nothing yet reported is of any apparent value.

A genus which offers evident affinities to both Strongylidæ and Filaridæ, but which is usually included in a separate family, the Gnathostomidæ, is represented among human parasites by a single rare species:

Gnathostoma siamense (Levinsen 1889)—(Syn.: *Cheiracanthus siamensis* Lev. 1889.)

The genus is easily recognizable by the numerous spines which cover the entire body, or at least the anterior region. Several species occur in the Felidæ, and in swine and cattle. This form is known only by a single female specimen, length 9 mm., breadth 1 mm.; about the head eight circles of spines. The anterior third of the body alone is covered with spines, the anterior of which are three-pointed, and the posterior simple. The vulva lies behind the centre of the body.

The specimen was collected in Siam and came from a small tumor; when this disappeared there were found on the skin nodules the size of a pea, from one of which this worm emerged. The same symptoms were observed in two other cases, and in one of these five or six worms were expelled, but were not preserved.

Family of the Filaridæ.—Body greatly elongated, filiform; mouth variable, often papillate, sometimes with lips and even with a buccal capsule; œsophagus slender and without a bulb; male, with somewhat coiled tail and a single spicule or two unequal ones. Female, with double ovary and vulva near the anterior end of the body. Many species are ovoviviparous.

Filaria O. F. Müller 1787.—Very slender worms of nearly equal calibre throughout. Males notably smaller than the females, with coiled posterior end, which possesses in some cases alar appendages. Spicules ordinarily very different in size and form. Four preanal papillæ are almost constant; the number of postanal papillæ is, however, variable. Vulva always near the anterior end.

These forms are parasites of the serous cavities and subdermal connective tissue; in general the development, though not well known, appears to be indirect with an intermediate host from Crustacea or Insecta. Railliet justly remarks that for the physician this genus is a sort of "catchall" into which he throws all round worms, old or new, of which the structure is poorly known.

Filaria medinensis (Linnæus 1758)—(Syn.: *Gordius medinensis* Linn. 1758; *F. medinensis* Gmelin 1789; *F. dracunculus* Bremser 1819; *F. æthiopica* Valenciennes 1856; *Dracunculus medinensis* Cobbold 1864.)

Female: 30–100 cm. long (ordinarily 50–80), 0.5–2 mm. broad; body uniform in diameter, white or yellowish-brown; the anterior end smooth, rounded, with cephalic shield, and small mouth surrounded by six papillæ; alimentary canal atrophied in adult and with all other internal organs replaced by enormously developed uterus; vagina has disappeared. Uterus filled with larval filariæ, 0.5–0.75 mm. long and 15–25μ wide.

Male doubtfully observed, said to be much smaller than female, only 4–10 cm. long, found fixed to the female by its posterior extremity, about 14 cm. from the anterior end of the latter. If the observation is substantiated, the male follows the female into the tissues and perishes soon after copulation there. The vagina atrophies subsequently to this.

The so-called "guinea-worm" is the subject of the oldest records dealing with any parasite. Doubtless the fiery serpents which plagued the children of Israel in the wilderness were this species. The writings of the Egyptians and those of early classical times, as well as later authorities, make definite references to it. The Arabian physicians knew it well, and Rufus, of Ephesus, not only gives a good description of the disease and its cause, which he designates as a little snake, but recounts the commonly accepted opinion that "the Arabians suffer from it, and many strangers acquire the disease *if they drink the water*, for that is the chief cause."

Life History.—The adult female is met with in the connective tissue, particularly of the legs and feet. It appears here in eighty-five per cent. of all cases, and pierces the derma; a blister forms in the epidermis over this orifice, and on rupturing shows a small ulcer at the centre of which is a minute opening. If cold water is dashed on the surface here, a drop of a milky fluid exudes or a small tube (the uterus?) is protruded and bursts, setting free the opaque fluid. This fluid contains multitudes of embryos 0.5–0.75 mm. long and 15–25μ wide; they are flattened, terminate in a long pointed tail, and have a striated cuticula and a complete alimentary canal. They swim actively but intermittently, and live six days in pure water, but from two to three weeks in muddy water or moist earth.

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As may be followed experimentally they enter the body cavity of small aquatic animals (*Cyclops*, Fig. 3543) through the joints in the exoskeleton, and there with two or three moults, occupying five or six weeks, they metamorphose into a more cylindrical form with a tripartite posterior end. The further life history is unknown. Fedtschenko tried to infect cats and dogs with these infested *Cyclops*, but without result. Manson and Blanchard have successfully repeated these experiments. Some further changes may easily be necessary before the parasite is fitted for its final host, which may be cattle, horse, dog, wildcat, or jackal as well as man.

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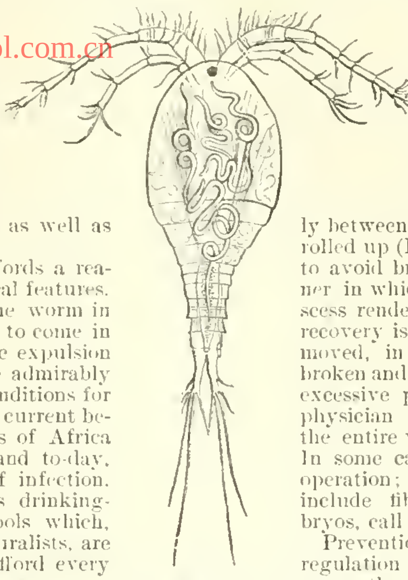

FIG. 3543.—Embryos of *Filaria medinensis* in body cavity of *Cyclops*. (After Fedtschenko.)

The life history, as given above, affords a reasonable explanation of some biological features. Both the preferential location of the worm in legs and feet which are most likely to come in contact with standing water and the expulsion of the embryos on such contact are admirably adjusted to secure for the young conditions for further development. It is a widely current belief among natives in different parts of Africa and Arabia, both in ancient times and to-day, that drinking-water is the source of infection. In the majority of infected districts drinking-water is obtained from surface pools which, according to the observations of naturalists, are swarming with *Cyclops*, and hence afford every opportunity for the spread of the disease.

Distribution. — The guinea-worm is rather widely distributed in tropical and subtropical countries. Most abundant in Deccan (India) and on the west coast of Africa, where in some seasons from one-half to nearly the entire population is affected, it is found more or less from India westward through Southern Asia and tropical Africa, and in a limited area of Brazil, where its introduction may probably be attributed to the slave trade. In Curaçoa and Surinam, where it was formerly endemic, and where it was no doubt introduced with negroes, it has now entirely disappeared. Records of its occurrence in Europe and North America are from natives of the infected area or visitors to it, and though frequently introduced it has never gained a footing in either place. Records of its occurrence in Africa and Arabia are found in historical and medical works of all ages. It is also known to occur in Persia, Turkestan, and Hindustan.

Pathology.—The seat of the adult females is the subcutaneous connective tissue, and they occur most com-

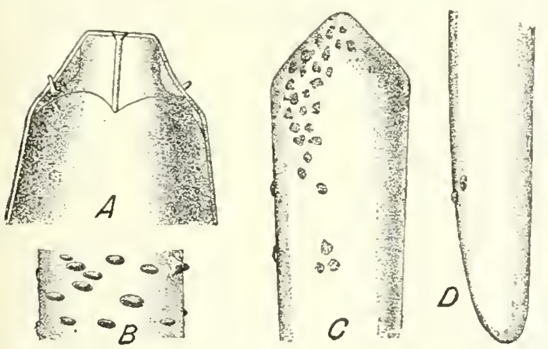

FIG. 3544.—*Filaria loa*. *A*, Head of male; *B*, mid body of male with cuticular bosses; *C*, head of female with bosses; *D*, posterior end of female with two bosses. Magnified. (After Blanchard.)

monly in the lower extremities, especially in the foot and ankle, but have been found in the arm, tongue, eyelid, scrotum, perineum, and trunk. As many as five or six in a single host is not uncommon. The presence of the worm is not detected ordinarily until it approaches the skin, where it produces a swelling, at first painless but later painful, and ultimately a running sore. Of itself the worm may be considered comparatively harmless, but the complications incident to a tropical climate often bring about excessive suppuration and gangrene, such as to necessitate amputation of the part infected, or even to be followed by death. The worm is sometimes expelled spontaneously, but in the majority of cases it is extracted by what is known as the Soudanese method. The end of the worm is seized firmly between two splints, on which it is gradually rolled up (Fig. 3542), great care being exercised to avoid breaking the slender body. The manner in which the worm is coiled up in the abscess renders the operation very slow, and while recovery is rapid when the entire worm is removed, in those cases in which it has been broken and a part left behind, the result has been excessive pain and often fatal gangrene. The physician finds it more satisfactory to remove the entire worm at once by a simple operation. In some cases complete cure follows a single operation; in others subsequent growths, which include fibrous tissue with numbers of embryos, call for further operative interference.

Prevention. — Apparently the satisfactory regulation of the supply of drinking-water will prove the means of stamping out the disease. Surface water is particularly suspicious on account of the large number of *Cyclops* likely to be present.

Filaria loa Guyot 1778.—(Syn.: *F. oculi* Gerv. et v. Ben. 1859 (nec. v. Nordm. 1852); *Dracunculus oculi* Diesing 1860; *Dr. loa* Cobbold 1864.)

Female 30–40 (rarely 70) mm. long, by 0.5 mm. broad, of cylindrical form (Fig. 3544) with anterior end blunt, posterior, straight, pointed; cuticula, transparent, yellowish, not striated but marked with minute, chitinous bosses irregularly distributed; uterus bifid, coiled; eggs 30–35 by 20–25 μ; when deposited containing embryos 210–250 μ in length.

Male: 20–30 mm. long, 0.3–0.45 broad; cuticula not striated, but with small papillæ except on first and last fifth; mouth without papillæ; tail (Fig. 3545) slightly incurved, with lateral wings and five ventral papillæ on each side, three being preanal and the first the largest; spicules two, short, unequal.

It was first observed in 1770, though a print of 1597 seems to show an operation for its removal. Nearly thirty cases are now on record; most of these are only notes, but recent descriptions of Ludwig and Blanchard have made its appearance and structure known. The earlier authors were inclined to regard it as identical with *F. medinensis*, but its specific distinctness maintained by others is now clearly demonstrated. Even if the immaturity of specimens eliminates the difference in size, the smooth striated cuticula of the guinea-worm will serve to separate it at once on careful examination from *F. loa* with its non-striated, embossed surface. The embryos differ also.

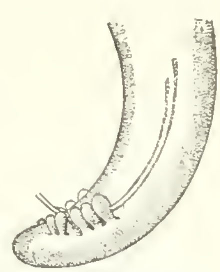

FIG. 3545. Tail of Male *Filaria loa* with Spicules and Papillæ. (Author's specimen.)

In distribution *F. loa* is limited to an area on the west coast of Africa (Guinea, Gold Coast, Gaboon), where it is not uncommon, and cases reported from other regions, which are largely among slaves of earlier days, have been those of persons who had come more or less recently from that region. Such are on rec-

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ord from Brazil, Trinidad, St. Domingo, France, England, and the United States.

Naturally the majority of records affect negroes, but physicians in Africa maintain that the parasite attacks blacks and whites alike, and the number of cases reported among missionaries supports this view. One of the latter has recently been reported in the United States by Ward and Milroy.

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Life History.—From the scattered facts on record Blanchard has outlined the course of development as follows: Introduced into man in the larval form with drinking-water, the form becomes adult in the alimentary canal. Either before or after copulation it penetrates the tissues where its development is slow, as shown by a residence of from four to ten years or more in the body. It appears beneath the conjunctiva of the eye or the skin at the last phase of its existence, but it may reach the surface of the body without having acquired its full development. That unlike *F. medinensis* it does not deposit eggs in dermal abscesses is clear from the entire absence of pus formation and of eruption in cases of its occurrence. It is a prisoner in the body, and the embryos must escape independently of the mother. They probably penetrate the blood, and are drawn from it by some blood-sucking parasite, from which in some unknown way they reach running water and in it a new host, or are inoculated directly when the intermediate host is feeding. Manson has conjectured that the well known *F. diurna* is the larva of *F. loa*, with which it agrees in geographical distribution. The opinion is generally accepted among inhabitants of the affected region that the source of infection is to be found in drinking-water.

Pathology.—The parasite is an active migrant through the connective tissue, but comes often into the region of the orbit. Its appearance in the tissue of the lid or beneath the conjunctiva is made known ordinarily by itching or even by slight pain which may disappear with the withdrawal of the worm, only to recur with its subsequent return at irregular intervals of days, weeks, or even months. An individual has been seen to pass rapidly from the one eye to the other over the bridge of the nose. In one case only has an immature specimen been found actually within the eye. In addition to itching, transient œdematous swellings accompany its appearance in various parts of the body. Fugitive tumefactions, known as Calabar swellings, are not uncommon in lower Nigeria. They are half the size of a goose egg, painless, sudden in appearance, disappearance, and recurrence, and may be found in any part of the body. They are thought to be produced by rubbing when a *F. loa* approaches the surface.

Treatment.—The negroes drive it from the eye by dropping a grain of salt into the conjunctival sac or by extracting the worm with a thorn. Deftness in operating is necessary, and if after cocainizing the eye the worm be grasped with a pair of forceps, a cut in conjunctiva or lid gives an opening through which it usually starts to escape, or may be withdrawn by a second forceps.

Filaria volvulus Leuckart 1893.—Body tapering uniformly, head rounded. Male 30–35 cm. long, 40–140μ in diameter, tail incurved; one postanal, two adanal, one preanal papilla on each side, two spicules 0.08 and 0.177 mm. long. Female 40–70 cm. in length. Embryos 250μ long, 5–6μ wide, resembling *F. nocturna* and *F. diurna*, but shorter and thicker and without sheath, head rounded, tail very sharp, clear spot in anterior fourth of body.

Leuckart received two dermal tumors from Gold Coast negroes containing several worms coiled in a ball and surrounded by a fluid containing embryos. A somewhat similar tumor excised from the arm of a French soldier, who had been in Dahomey, showed that the worm occupied a lymph vessel and was surrounded by a mass of connective tissue. Its identification as the same species has been questioned. Prout has recently described two other cases from Sierra Leone. Like *F. loa*, it is viviparous and found in subdermal tissue; but unlike that species it is sedentary and produces a circumscribed subcutaneous tumor.

F. conjunctivæ Addario 1885.—(Syn.: *F. palpebralis* Pace 1867, nec Wilson 1844; *F. peritonei hominis* Babesiu 1880; *Filaria inermis* Grassi 1887.)

Female: Length 10–16 cm., width 0.5 mm.; cuticula striated not embossed or papillate; mouth terminal, unarmed, vulva near anterior end; uterus double, with eggs and embryos measuring 350 by 5.5μ. Male unknown.

Dubini first found this species in Sicily in a tumor of the conjunctiva, and it has been recorded as a human parasite also in Italy and Hungary. The species is, according to Grassi, a normal parasite of the horse and ass, and is only occasional in man.

Filaria lentis Diesing 1851.—(Syn.: *Filaria oculi humani* von Nordmann 1832.)

With the case of von Nordmann, in which immature nematode worms were found in the lens, have been associated various poorly known and often doubtful cases of later observers, in several of which it is probable that the object was a vestige of a vessel or filament and not a filaria. In three cases the parasite was in the lens, in three also in the vitreous humor, and in two in the aqueous humor. The most recent, by Drake and Brockman, at Madras, has been assigned by Blanchard to *Filaria equina*, which is abundant in India. The character of other species is likely to remain permanently doubtful. Some of them are very likely young forms of the preceding species, *F. inermis*.

Filaria restiformis Leidy 1880. Length 66 cm., width at head 0.375 mm., at centre 1.5 mm.; anterior end pointed, posterior blunt; mouth without papillæ; œsophagus 1.125 mm. long.

Passed in West Virginia from the bladder of a man, fifty years of age. The patient had been suffering some days from hæmaturia. Raillict regards it as evidently a pseudoparasite. While it was not extracted by the attending physician, he maintained that no doubt existed as to the correctness of the patient's statements that the worm had actually been passed.

Filaria hominis oris Leidy 1850.—Length 14 cm., width at head 0.1 mm., at centre 0.38 mm. Mouth terminal, posterior end provided with an epidermal spine, 0.05 mm. long.

Leidy found the single specimen in the collection of the Philadelphia Academy labelled, "Obtained from the mouth of a child," and queried if it might be the young or the male of *F. medinensis*. Leuckart shared the opinion which has, however, been questioned by some later investigators.

F. labialis Pane 1864.—Length 30 mm.; pointed anteriorly; mouth with four papillæ, posterior end slightly inflated; vulva in posterior tenth; uterus double, but in posterior branch rudimentary.

A single specimen only from a pustule on the upper lip of a man in Naples, Italy. Not reported since 1864.

F. lymphatica Treutler 1793.—(Syn.: *Hamularia lymph.* Treutler 1793; *Filaria hominis bronchialis* Rud. 1819; *F. hominis* Dies. 1851; *F. lymph.* Moq.-Tandon 1860; *Strongylus bronchialis* Cobbold 1879.)

Length about 26 mm.; brownish spotted with white; transparent and pointed anteriorly; thickened and blunt posteriorly; two short spicules.

First found in 1790 in the hypertrophied bronchial ganglia of a man of twenty-eight years of age; it has been reported since then by Brera and by Zürn, who discovered another specimen at Geneva in 1879, under conditions like those of the first case. The view of Diesing and Weinland, that it was probably *Strongylus longevaginatus* (= *S. apri*) is improbable according to Railliet, who views it as a male of *F. inermis*. The view of Braun that it is *F. equina*, a common parasite of horse and ass in Europe, seems more probable.

Filaria immitis Leidy 1856.—Mouth with six papillæ. Male: 12–18 cm. long, 0.7–0.9 mm. wide; posterior end with low lateral wings and eight preanal as well as nine to ten postanal papillæ; posterior end rolled in several turns like a corkscrew, spicules unlike. Female: 25–30

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cm. long, 1–1.3 mm. wide, posterior end shortly blunt; vulva in posterior fourth; ovoviviparous embryos 0.28–0.30 mm. long and 5 μ wide, with a greatly attenuated posterior extremity.

Originally found by Leidy in the heart of a dog, it is now known to inhabit the entire venous system. The

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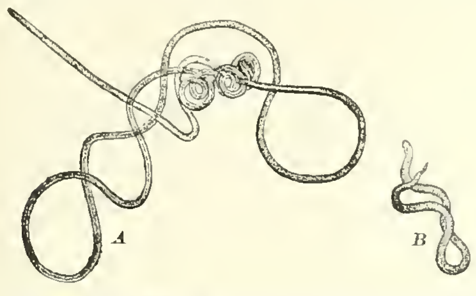

FIG. 3546.—*Filaria Bancrofti.* *A*, Adult male × 7.5. *B*, Embryo from hydrocele fluid × 200. (After Lothrop and Pratt.)

embryos are to be found in the peripheral circulation during the period of rest. With growth they retire to the larger vessels and escape from the kidneys or in excrement. Their normal method of exit is unknown. The parasite is most common in dogs living in the open.

The parasite is common in the United States, especially in the South and in South America. It seems to be very abundant in China and Japan, and is reported also from Italy, France, Germany, and Denmark.

As Moniez has shown, Braun was apparently in error in citing Bowlby as authority for the occurrence of this species in man; and Braun's own case is too uncertain in determination to be accepted as evidence in absence of other instances. If *F. immitis* is even occasionally a human parasite, it should be found as such in the United States, where it occurs commonly. No case has been found on record.

Filaria Bancrofti Cobbold 1877.—(Syn.: *Trichina cystica* Salisbury 1868, non Filaria cystica Rud. 1819; *F. sanguinis hominis* Lewis 1872; *F. sang.-hom. ægypt.* Sonsino 1874; *F. dermathemica* Da Silva Araujo; *F. Wuchereri* da Silva Lima 1877; *F. sanguinis hominis nocturna* Manson 1891; *F. nocturna* Manson 1891.)

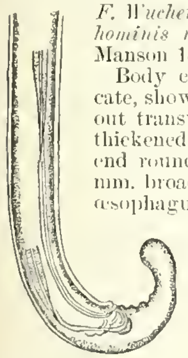

FIG. 3547.—Tail of Male *Filaria Bancrofti.* Magnified. (After von Linstow.)

Body elongated, white, opaque, very delicate, showing tendency to coil; cuticula without transverse striation, anterior end slightly thickened, without lips or papillæ, posterior end rounded. Male 35–40 mm. long; 0.1–0.12 mm. broad, head 51 μ, neck 43 μ, in diameter; œsophagus 0.13 mm. long; tail (Fig. 3547) slightly bent, 1 mm. long; papillæ undescribed; spicula 0.2 and 0.6 mm. long. Female 75–95 mm. long, 0.21–0.28 mm. broad, head 68 μ, neck 51 μ in diameter, vulva 0.72–1.27 mm. from head, anus 0.282 from tail. Eggs 25–28 μ or 35 (Lothrop and Pratt) by 15 μ. Embryos 0.127–0.2 mm. (or 0.2–0.33 mm.) long by 8–10 (7–11) μ broad, with unstriated cuticula, but enveloped in a delicate sheath (Fig. 3546, *B*).

Although first reported as early as 1863 by Demarquay, this form has been very generally confused with other species of the group, especially *F. Magalhaesi*, and even now only a little can be given beyond the data contained in the general characteristics which are taken from Maitland and Manson's account, and from that of Lothrop and Pratt. The discrepant measurements given by different authors are due, in part at least, to the fact that different species were under consideration.

The male (Fig. 3546, *A*) is much shorter than the female, and the posterior end exhibits a strong tendency to twist like a tendril. Both sexes manifest a proclivity to curl into a knot, and various observers note the difficulty of disentangling the individual worms from such a mass. In the female, which alone has been examined, the anterior end is traversed by four deep grooves, giving the transsection much the form of a maltese cross. The thick-walled vagina extends posteriorly a short distance from its external orifice, and splits into two thin-walled uterine tubes, which occupy the entire cavity of the body, forcing the intestine against the muscular wall at one side. These tubes are filled with ova and embryos in all stages of development. The smaller embryos are coiled within a thin structureless chorion. Preserved specimens may assume a brownish tint, owing to a change in the color of the uterine walls.

The embryonic filariæ in freshly drawn blood or in hydrocele fluid are rounded at the anterior end and pointed at the posterior. Though in constant motion, twisting and coiling, they never (?) exhibit a true progressive movement. In freshly drawn blood they are covered by a delicate sheath, which is indistinguishable normally except as a flagellum following the tail at some distance, 0.3–0.4 mm. (Fig. 3548); rarely, when the movement of the body is reversed, this disappears from the tail and becomes evident at the head (Fig. 3548, *A*). It is evidently the collapsed sheath, which Manson regards as a vitelline membrane, and in such specimens as have undergone endosmotic changes it appears like a distended sac enveloping the entire worm; such an appearance, though frequently figured, is entirely unnatural. The embryos of other species, *e.g.*, *F. immitis*, are without this sheath. These embryos may be kept alive five or more days in a cover-glass culture of blood, and after forty-eight hours many empty sheaths may be observed. Attached to the tip of the head is a minute spine, which at times is protruded in rapid succession with a peculiar "pouting" movement.

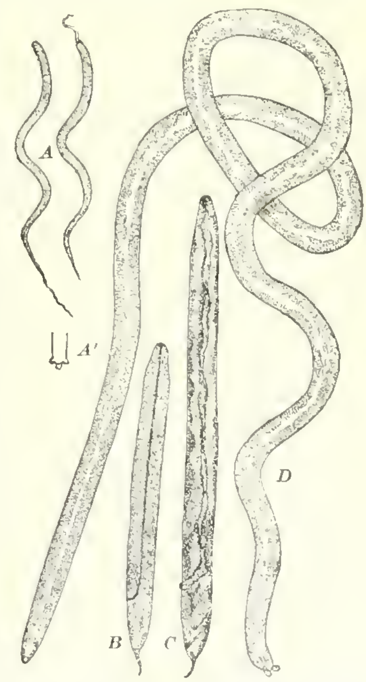

FIG. 3548.—Metamorphosis of *Filaria Bancrofti* in Thorax of Mosquito. *A*, Just ingested; *A'*, posterior end; *B*, five days old; *C*, ten days old; *D*, sixteen days old. (After T. L. Bancroft, except *A'* after Manson.)

Life History.—The female is viviparous, and the embryos, which are produced in enormous numbers, are evacuated into the lymph stream and ultimately pass from it into the blood current, where they are often found in extraordinary abundance. They measure 0.2–0.33 mm. by 7–11 μ (Lothrop and Pratt, 0.26–0.3 mm. by 6–8 μ). Twelve hours after being taken into the stomach of a mosquito one finds side by side free embryos and empty sheaths. By the next day the embryos have traversed the wall of the stomach and are in the thoracic muscle. At the end of eleven days they are 20–25 μ broad and more than 580 μ long. At seventeen to eighteen days they begin to leave the muscles and migrate into connective tissue in front of the prothorax. Such larvæ are

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more slender than before, 18–20 μ in diameter. These larvæ show an alimentary canal with œsophagus well differentiated and rudiments of the reproductive apparatus. While some remain in muscles even up to the fiftieth day, the most are gone. By even the twentieth day larvæ have penetrated the head and proboscis in sections of which they appear crowded into the cavity headed toward the point (Fig. 3549). Like the malarial organism they are inoculated directly. The last stage of development occurs in the skin; they become adult and copulate there; thus the variable position of lesions of elephantiasis are explained. In *Anopheles* James finds that the transformation requires only from twelve to fourteen days, and the activity of the embryos does not cease. According to the same author the broad inactive form measures 71–53 μ long and the slender active form 151–132 μ long and 2.6 μ broad; in this latter stage the œsophagus is two-fifths and the tail one-third of the entire length.

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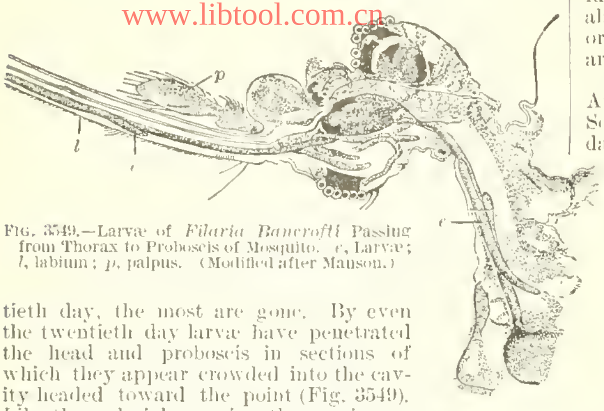

FIG. 3549.—Larvæ of *Filaria Bancrofti* Passing from Thorax to Proboscis of Mosquito. *c*, Larvæ; *l*, labium; *p*, palpus. (Modified after Manson.)

Bancroft and Manson suggested almost simultaneously that the mosquito might serve as a carrier of the embryonic filariæ in the blood. Manson, however, first observed the changes which these embryos undergo in the mosquito. He allowed mosquitoes to suck the blood of filarial subject, and found at first that the embryos are within a delicate sheath or membrane, apparently almost structureless; later, there becomes evident a marked transverse striation, and the sheath is ruptured by the worm forcing its cephalic end against it. Once free from the sheath, the embryo bores through the stomach wall of the insect and wanders into the thoracic muscles. The embryos which emigrate to the thoracic cavity do so as soon as they are withdrawn from the human host; those found some hours later in the mosquito's stomach are such as by immaturity or injury are not destined to metamorphose, and changes in such are retrogressive.

According to one view the worm escapes by boring its way out at the time the mosquito is depositing her eggs on the water, or by breaking out from dying mosquitoes which fall into a pool, and that the infection of the human host is brought about by drinking such water as contains well-developed embryos. It is further supposed that these young worms then bore their way through the human intestinal wall and attain maturity at some suitable point. Copulation here is followed by the production of swarms of embryos. In objection it may be urged that Bancroft has shown water to be fatal to the embryos in the course of three or four hours, and that hence it cannot be the medium by which they reach the human subject. He also says the embryos never escape naturally from the mosquito's body even if in water. The other hypothesis as to later development is that the infection takes place when the mosquito containing the fully developed embryos is sucking blood, and Bancroft has proved the migration of such embryos from the thoracic muscles into the labium, from which he believes they escape at a definite point at the tip to penetrate the body of the new host. Grassi believes that the larvæ escape from the bent labium in the act of biting by rupture of the cuticula. This part of the life history has not been cleared up as yet.

In the transmission of embryos certain species of mosquito only are culpable; among such are *Culex fatigans* in Australia, *Anopheles Rossii* in India, probably also *Anopheles musivus*; this genus James regards as the proper intermediate host, since in it the development is more rapid. In case the embryos are taken up by any unsuitable species of mosquito they are digested in the stomach; or if a few individuals succeed in wandering out, they are absorbed in the muscles.

Distribution.—Tropical Asia, Africa, America, and Australia are all infected. In Samoa and some other South Pacific Islands this parasite is particularly abundant, as much as fifty per cent. of the population being infected.

The first mention of this parasite in the United States was made by Salisbury in 1868, who found the ova in the urine. Some years later (1886) Guiteras called attention to the presence of the embryos in the South, reporting four cases from Key West and one from Charleston, S. C. Only a little later De Saussure published a clinical history of twenty-two cases, also from Charleston. Since then many cases have been reported in the Gulf and South Atlantic States, many of which have been undoubtedly imported, but indigenous cases are not wanting, and one concerns a woman who had always lived in Pennsylvania. The last account by Lothrop and Pratt gives a most extensive and valuable study of two cases in Boston imported from the Barbadoes, and includes important new data on the characteristics of the adult worms.

Pathology.—The adult worm was first found in 1876, by the elder Bancroft, in a lymphatic abscess of the arm and subsequently in a hydrocele. The two sexes are found coiled together, and probably live for some time. Since then this discovery has been abundantly confirmed. Manson has shown that the species normally occurs in the lymphatic vessels, and that the embryos, as well as the adults, rarely also gain the circulation by way of the thoracic duct. The embryonic blood filariæ were first observed by Demarquay, of Paris, in a man from Havana, who was suffering from chylocele. The name *F. sanguinis hominis*, first used for these embryos by Lewis in India, has been applied to several different embryos, which Manson has distinguished by appropriate names. Whether they belong to different species or are stages of development in one or two forms is still unsettled, though I am inclined to accept their specific independence. Such embryos have been reported from urine, tears (?), and secretion of the Meibomian glands as well as from the blood in cases of chyluria and elephantiasis, and also in apparently healthy individuals. In the Barbadoes nearly thirteen per cent. of the persons examined were infected, and yet two-thirds of the infected cases manifested no external sign of the disease.

Manson was also the first to establish the periodicity of the embryos, as those of this species appear in the blood toward evening, increase in numbers during the night, and disappear in the morning. Manson views the "filarial periodicity as an adaptation of the habits of the filaria to those of the mosquito, the intermediary host indispensable to the future life of the parasite." But since it has been shown that by reversing the period of sleep the habits of the embryo filariæ may be reversed also, the explanation of von Linstow appears more probable, namely, that the tonus of the capillaries is reduced during sleep; and thus the embryos, which are too large to enter them during the day, find entrance possible owing to the increased size of the vessels. Manson found the embryos massed in large arteries and irregularly scattered through the capillaries in the day time.

The presence of embryos in the blood is evidence of the parasitism of the adult in some part of the lymph system. The duration of life of both adult and larvæ is entirely unknown; for the former, however, it is certainly several years. So far as known the embryos do not bring about pathological changes, though leucocytosis with an increase of eosinophiles is noted in early stages, to disappear later. The adults occlude large lymphatics and produce lymph stasis with resulting dilatation of the lym-

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phatics. The clinical manifestations depend upon lymphatic obstructions and give rise to both general symptoms and local, which latter vary widely according to the part involved and to possible modification by infective processes.

An estimate has been made of from forty to fifty millions of embryos in the blood of a single man, and yet the individual suffered no apparent effect. It must be said, however, that the results of the parasite are brought about gradually; they are primarily a varicose condition of the lymphatics, giving rise to various conditions, such as chyluria, varicose inguinal glands, lymph scrotum, chylocele, lymphangitis, elephantiasis (*q. v.*). In the latter it is probable that the obstruction to the flow of the lymph produces mechanically the distention and excessive growth of such parts as arm, leg, scrotum, which is characteristic of the disease.

For examination Manson recommends a thick film of blood drawn at 8 to 9 P.M., when the embryos are most numerous. Fixing is unnecessary and the stain (fuchsin, gentian violet) is made by adding a few drops of an alcoholic solution of the dye to a watch glass of water. Overstaining is reducible by dilute acetic acid.

Prevention.—The protection of drinking-water from contamination by mosquitoes is strongly to be advised, and the case of the Friendly Islands is cited as evidence of the value of this measure. There forty per cent. of the males are affected by filariæ, all the people drinking from open pools; but the chiefs who have closed-water tanks rarely acquire the disease. It may, however, be urged in favor of mosquito inoculation that the chiefs are also least subject to mosquito bites. In any event, the protection of drinking-water and the destruction of useless pools will certainly reduce the number of mosquitoes, and consequently the extent of the disease, whether transmitted through drinking-water or by direct inoculation of a mosquito.

It must be noted that the presence of an infected individual is a distinct menace to the health of a community, since the widespread distribution of mosquitoes capable of acting as the intermediate host insures the possibility, and under some circumstances the certainty, of wider transmission of the disease. There is little doubt that the cases recorded from the Southern United States are primarily traceable to such introduction from the West Indies. The same explanation lies near at hand for those occasional cases which have been recorded in various localities, both here and abroad.

Filaria Magalhaesi R. Blanchard 1895.—(Syn.: *F. Bancrofti* Magalhaes 1892 *nec* Cobbold 1877.)

Body slender, elastic, resistant; cuticula heavy, cross striated. Female, 155 mm. long, 0.33 mm. broad at head, 0.285 mm. at neck, 0.7 mm. in maximum; vulva 2.56 mm. from cephalic extremity. Male, 83 mm. long, 0.407 mm. broad; tail with double spiral, on each side four preanal and four large postanal, papillæ of mulberry form (Fig. 3550); smaller (?) spicule 0.23 mm. long, longer unknown. Eggs 38 by 14 μ; embryos 0.3–0.35 mm. long and 5 μ broad with transversely striated cuticula.

Of this form Magalhaes discovered in Rio Janeiro two adults in the left cardiac ventricle of a man in whose blood embryonic filariæ were also present. It was at first wrongly assigned to *F. Bancrofti*, from which it is easily distinguished by the above characteristics. Like all Nematoda living in the heart the cuticula is tough to resist the powerful blood pressure, the body being like catgut, whereas *F. Bancrofti* is delicate and easily torn. The proportions of embryos and adults also differ materially.

The life history is unknown.

F. perstans Manson 1891.—(Syn.: *F. sanguinis hominis minor* Manson.)

The embryos, which have been known for some time, are found in the blood at all hours. They have no sheath, and measure only 0.18–0.23 mm. long by 4.5 μ broad, being thus much smaller than those previously described. Their continued presence in the capillaries may be due to this fact. The head is armed with a minute, exceedingly delicate filiform spine set on a papilla; this structure may be protruded and retracted rapidly. The embryo not only wriggles actively, but also travels about very rapidly. It is not numerous, but may be found in company with *F. nocturna* and *F. diurna*.

The adult was found by Daniels in a native of British Guiana, in whose blood both blunt- and sharp-tailed (*F. Ozzardi*) embryos were present. A male and a female lay in subperitoneal connective tissue. Manson also found an adult in one case of "sleeping sickness." Among the negroes on the west coast of Africa from one-third to one-half are infected, and most such show the earlier symptoms of this disease in nearly all cases of which *F. perstans* is present. Yet this parasite is found in apparently healthy individuals, so that its etiological relation to the disease mentioned is still a matter of doubt.

F. Ozzardi Manson 1897.—Male, 45 mm. long, 0.06 mm. broad; female, 70–80 mm. long by 0.12 mm. broad. Embryos in blood, without sheath, sharp-tailed, 0.173–0.240 mm. long by 4–5 μ broad.

The embryos were originally reported from the blood of Carib Indians from British Guiana, and were present in about fifty per cent. of the cases examined. At first both sharp- and blunt-tailed embryos were found together and were regarded as developmental stages of one species. Daniels found adults, chiefly females, in the mesentery, and in fat at various points in the peritoneal cavity; and in a later case two sets of adults, the one which is regarded here as belonging to this species, and the other, which was viewed by Manson as *F. perstans*, to which the blunt-tailed embryos are also assigned. The relation of the adults to these embryos is still a matter of considerable doubt.

In addition to the foregoing there are also several species of *Filaria*, known only by the embryonic form which inhabits the blood. While von Linstow regards them all as developmental phases of one species, I cannot concur in a conclusion so widely at variance with their differences in structure, habits, and distribution. They may be briefly noted as follows:

Filaria diurna Manson 1891.—Only free embryos of this species have been observed. They were found in the blood of negroes from the west coast of Africa. They appear in the peripheral circulation about 8 A.M., increase in numbers until noon, and decrease later, to disappear by 9 P.M. The periodicity was maintained for some weeks. As adults of *F. loa* were found in one of the cases, Manson regards it as likely that *F. diurna* is the larval form of that species.

Filaria Demarquayi Manson 1891.—The embryos of this species were found in the blood of apparently healthy natives of St. Vincent, and later also of St. Lucia, West Indies, and of New Guinea. They have also been reported very recently from other localities in the West Indies. They resemble the embryos of *F. Bancrofti* in general appearance; they are, however, only half so large (in dry smears) and they are without a sheath. Their presence in the superficial capillaries is constant day and night.

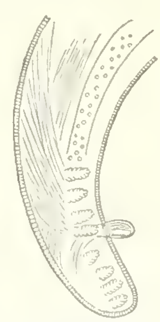

FIG. 3550.—Tail of Male *Filaria Magalhaesi*. Magnified. (After von Linstow.)

For convenient reference the characteristics of the blood filariæ may be given here in tabular form (p. 216) so far as they have been determined.

Filaria romanorum-orientalis Sarcani 1888 is a species observed in the blood of a Roumanian woman. The parasite measured 1 mm. long by 0.03 mm. broad, and had an alimentary canal and well developed sexual organs.

Family of the Trichocephalidæ. Body extremely elongated with two distinct regions, the longer anterior very slender and the shorter posterior more or less enlarged. Œsophagus very long, anus terminal. Males sometimes without a spicule, more often with a single simple one which possesses a sheath. Female with sim-

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CHARACTERISTICS OF BLOOD FILARIÆ.

Species	*F. diurna*	*F. nocturna*	*F. perstans*	*F. volvulus*	*F. Demarquayi*	*F. Ozzardi*
Length	0.300 mm.	0.300 mm.	0.230 mm.	0.250 mm.	0.205–0.210 mm.	0.17–0.24 mm.
Breadth	7.5 μ	7.5 μ	4.5 μ	5 μ	5 μ	4–5 μ.
Sheath	Present	Present	Absent	Absent	Absent	Absent.
Head	?	Six lipped armature	Papillated	Rounded	Retractile spine	
Tail	Sharp	One-fifth taper (sharp?).	Truncated.	Sharp, one-fifth taper.		Sharp.
Body	Central granular mass.	Indistinct central granular mass.	No central granular mass.	Central granular mass.		
"V" spot	Present.	Present	None	Clear spot	Present, 0.052 mm.	

ple ovary; vulva at junction of the two regions of the body; eggs with peculiar translucent plug in the shell at each pole. Development direct and without ecdysis.

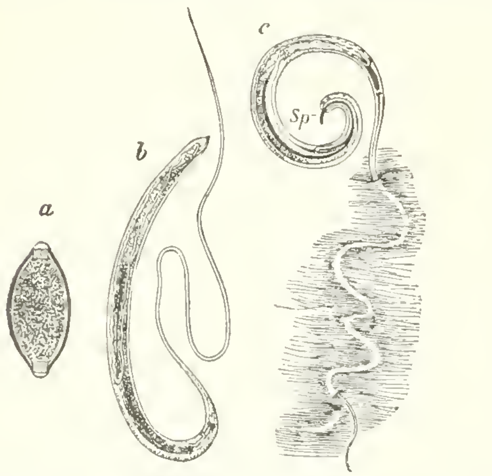

FIG. 3551.—*Trichocephalus trichiurus.* *a*, Egg; *b*, female; *c*, male with anterior end embedded in mucosa; *sp*, spicules. (After Claus.)

Of the half-dozen genera only two are important here, but they include two of the commonest and the most feared of human parasites.

Trichocephalus Goeze 1782.—Anterior region very long and filiform; posterior region, which contains the intestine and reproductive organs, short, sharply set off from anterior and markedly inflated. In the male it is rolled into a spiral; one spiculum with infundibuliform sheath. In the female the posterior regions are lightly bent, but not in a spiral. Parasitic in the large intestine and cæcum of mammals.

Trichocephalus trichiurus (L. 1771).—(Syn.: *Ascaris trichiura* L. 1771; *Trichocephalus* Goeze 1782; *T. hominis* Schrank 1788; *T. dispar* Rud. 1801; *Mastigodes hominis* Zeder, 1803.)

Male, 40–45 mm. long, with strongly attenuated anterior region comprising three-fifths of the total length. Spicule single, 2.5 mm. long, located in a spinous protractile sheath; posterior region in a flattened spiral. Female, 45–50 mm. long, with attenuated anterior region two-thirds of total length. Eggs, 51–53 μ long by 21–23 μ wide, brownish, thick-shelled, with polar knobs, and deposited before cleavage begins (Fig. 3551).

The striking appearance of this genus, a single species alone of which is parasitic in man, is due largely to the regions of the body. The filiform region contains only the œsophagus, leaving the remainder of the alimentary canal and all the reproductive organs for the greatly enlarged posterior region in which the transparency of the body wall permits one to recognize the various structures even in the living worm. The orifice of the vagina lies near the level of the transition from œsophagus to midgut.

Life History.—The eggs are produced in large numbers, four hundred thousand annually by a single female (Leuckart), and undergo no development until they have passed out of the human body. Cleavage takes place in water, but only at the end of some months or even more than a year. The eggs are well protected by the heavy shell from adverse circumstances, so that Davaine has kept embryos living within them for five years. The introduction of these embryos still within the shell is ordinarily brought about through drinking-water, though Blanchard suggests the evident possibility of their introduction on salads and uncooked vegetables. In the human stomach the shell is dissolved and the embryos are set at liberty to reach sexual maturity at the end of a few weeks, as has been definitely established by the experiments of Grassi.

Distribution.—This is one of the commonest parasites of man, being distributed over practically the entire earth, though more abundant in the warmer regions. Local variations in its frequency are noteworthy. Braun cites, as records of autopsies, its presence at Dresden as 2.5 per cent., at Erlangen 11.1 per cent., at Kiel 31.8 per cent., at Munich 9.3 per cent., at St. Petersburg 0.18 per cent., at Göttingen 46.1 per cent., at Basel 23.7 per cent., at Greenwich 68 per cent., at Dublin 89 per cent., at Paris 50 per cent., and in Southern Italy near 100 per cent. This species is growing rarer in Paris according to statistics available, and probably elsewhere also, owing to the disuse of surface water for drinking.

Pathology. — *Trichocephalus trichiurus* inhabits the human cæcum ordinarily, but rarely also the vermiform process and colon, and may be found in persons of all ages, even occurring in infants of a year old.

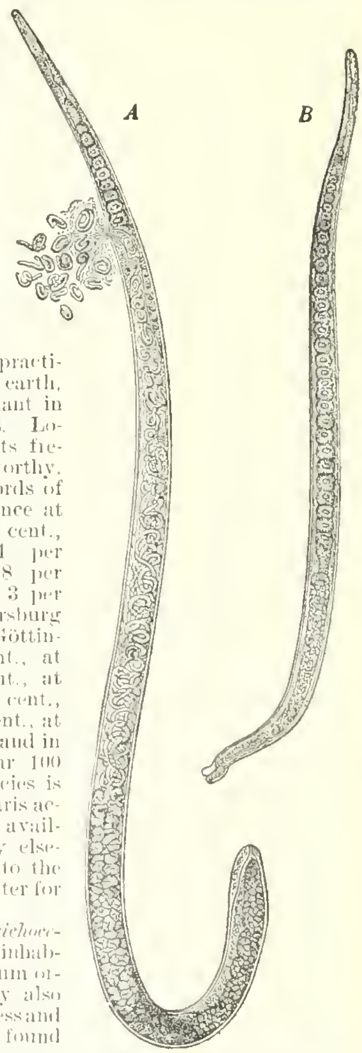

FIG. 3552.—Intestinal Trichina. *A*, Female with embryos; *B*, male, × 80. (After Heller.)

Usually only a few individuals are present in a single host, but in some cases as many as one thousand parasites have been found at

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once. Normally they occur with the filiform anterior region embedded in the mucosa, and recent investigation tends to demonstrate that such as are found free in the canal have been driven out by post-mortem changes.

This species has been regarded earlier as playing a pathogenic rôle in typhoid, cholera, and beri-beri, and more recently all pathogenic significance has been denied it. Though the presence of a few does not occasion pathogenic symptoms, yet since Askanazy has shown the occurrence of hæmoglobin in the alimentary canal of these worms, the fact that they nourish themselves on the blood of the host cannot be doubted. In occasional severe cases noteworthy depression, suppression of the urine, with fever, cardiac weakness, and often nervous symptoms, have been noted.

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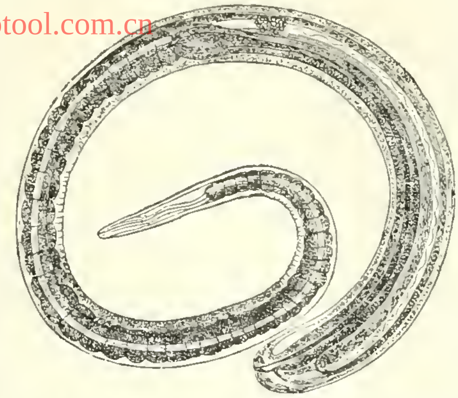

FIG. 3553.—Fully Developed Muscle Trichina with Alimentary Canal and Genital Primordium, Removed from Cyst. Magnified. (After Leuckart.)

Treatment is said to be difficult, and naphthalin, thymol, and pelletierine have been used with only moderate success. A later writer commends santonin as rapid and effective.

Prophylaxis.—Care in obtaining drinking-water and in selecting and cleansing uncooked vegetables will evidently limit the spread of the parasite.

Trichinella Railliet 1896. — (Syn.: *Trichina* Owen 1835.)

Very small, slender, without marked distinction of regions in body. Male without spicule, but with lateral appendages at posterior end, as if a poorly developed bursa were present. Female ovoviviparous; vulva at anterior fifth of body. Only a single species.

Trichinella spiralis Raill. 1896.—(Syn.: *Trichina spiralis* Owen 1835.)

Male (Fig. 3552, *B*), 1.4–1.6 mm. long by 0.04 mm. broad, without spicules, but with a short conical appendage on either side of the cloaca, behind which are two pairs of papillæ. Female (Fig. 3552, *A*), 3–4 mm. long, 0.06 mm. broad; vulva ventral near anterior fifth of body; anus terminal, viviparous. Fully developed larva, 0.8–1 mm. long by 0.04 mm. broad; cyst measures 0.4 by 0.25 mm.

The sexually mature parasite, sometimes called the intestinal trichina, inhabits the small intestine of man and various other mammals. The larval form, known as the muscle trichina, is found encysted in muscular tissue. Easily infected are man, pig, rat, mouse, guinea-pig, rabbit; less easily sheep, calf, horse; with difficulty cat, dog, badger. The intestinal form will develop also in birds, but the embryos are expelled with fæces and do not reach the muscles.

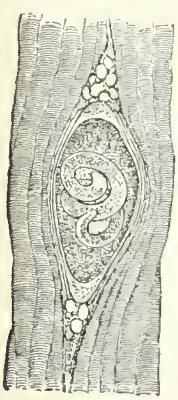

FIG. 3554.—Encapsulated trichina. (After Leuckart.)

History.—Encysted trichinæ were first noted by Peacock in London as early as 1828, but it was 1835 before their character as encapsulated entozoa was recognized by Paget and the parasite described by Richard Owen. The presence of encysted trichinæ in man was confirmed by a multitude of observations from various countries, and Joseph Leidy added a most important fact in the discovery of similar worms in pork. Feeding experiments by Leuckart, Virchow, and Küchenmeister, together with the observations of Zenker on a maid that had died of apparent typhoid, led to the elucidation of the life history and to proper estimation of the pathogenic character of the parasite which had heretofore been regarded as harmless or as the immature form of a *Trichocephalus* or *Strongylus*. Rapid accumulation of isolated cases and of epidemics of trichinosis, almost all from North Germany, placed beyond question the etiological significance and importance of the trichina.

Life History.—If a portion of flesh containing the larval worms is eaten by a suitable host, the larvæ are set free in the stomach and pass into the small intestine. They attain sexual maturity in about two and one-half days, copulate, and the male soon dies. Two opposed views as to the dispersal of the young have long been held. According to one the migration of the embryos is an active one in that they bore their own way out of the canal and through the connective tissues to their ultimate seat. The other view, however, of passive transport by the blood and lymph streams may be regarded as demonstrated by recent work, particularly that of Graham, whose account is followed in the main here. The gravid female bores into the intestinal wall as far as the lymph vessel. There the young are produced, being set free by the female into the lymph stream, which carries them ultimately into striated muscle tissue. At birth they measure 0.09–0.11 mm. in length by 5–6 μ in width, and at the close of this migration but little more, being then 0.12–0.16 mm. long. In eight days these embryos are in the intramuscular connective tissue and only a few days later in the muscle fibres themselves (Fig. 3555). The fibres lose their transverse striation and undergo granular and fatty degeneration. The embryo increases rapidly in size, and rolls into a loose spiral in an expansion of the completely degenerated fibre. By the action of the surrounding connective tissue, in which connective-tissue corpuscles and leucocytes are contained, a cyst of characteristic form is produced (Fig. 3554). It is thickened at the poles and measures about 0.4 mm. by 0.25 mm. in diameter. This process occupies several weeks, during which later broods of embryos are produced, since each female lives five to seven weeks and gives birth to from eight thousand to ten thousand young. Thus in the early stages of an infection one finds in the muscle embryos in various stages of development and encystment, side by side.

FIG. 3555.—Muscle Trichina Fifteen Days After Infection. × 165. (After Leuckart.)

Once encysted the larvæ remain quiescent; it may be for long periods. Thus encysted trichinæ have been found living in human muscle, twenty-five and even thirty-one years after the presumed infection. Not infrequently, though perhaps not always, one finds evidences of further change in the formation of a delicate calcareous layer about the cyst (Fig. 3556). In some cases this encroaches upon the larva so as to produce ultimately a calcareous nodule in which a remnant alone of the worm is contained. It is held by some that calcification does not ensue until after the death of the larva from unknown causes. Fatty degeneration of the encysted trichinæ can also be observed, and is likewise held to be a pathogenic process. Such larvæ as rarely occur in connective tissue are without the characteristic cyst, but appear to be smothered in a mass of proliferating connective tissue.

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While it has been determined experimentally that a considerable number of hosts furnish conditions favorable for the development of the trichinæ, the normal host is no doubt the rat, and evidence has been adduced to prove the introduction of this parasite into Europe from

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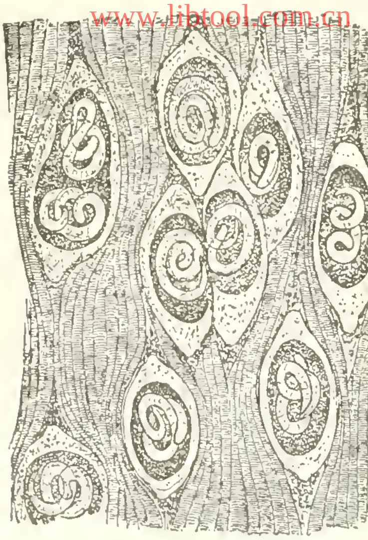

FIG. 3556.—Muscle with Encysted Trichinæ in Process of Calcification. (After Braun.)

the East with the brown or Norway rat. The method of transmission in this species is clear when one recalls that rats are cannibals and universally make way with aged or infirm members of the tribe. The well-known avidity with which pigs catch and eat rats explains the infection of swine, and it is from this source that man is infected.

Nearly all of the epidemics of trichinosis on record are confined to North Germany. In Saxony from 1860–75 there were 39 epidemics affecting 1,267 persons, of whom 19 died; at Hedersleben (1865), a town of about 2,000 inhabitants only, a total of 337 were sick and 101 died; at Emmersleben (1883) fully one-third died among those who ate the infected meat. Stiles has given a statistical review of trichinosis in Germany during recent years, from which is taken the following: 1860–1880—8,491 cases, 513 deaths, 6 per cent. mortality; 1881–1898—6,329 cases, 318 deaths, 5 per cent. mortality.

From the table of separate years it appears that there has been a general decrease in trichinosis in Germany during recent years, due probably to general education of the public on the dangers of eating raw pork as well as to meat inspection. The latter, which removes from consumption 1,500 to 2,000 trichinous hogs annually, is carried out in a most scientific manner by an army of some 30,000 inspectors and microscopists, at an annual cost (estimated) for the German Empire of $3,000,000, while for the city of Berlin alone the cost is $80,000. In spite of this system and expenditure security from trichinosis has not been attained *even for the meat examined*, as the following table shows, according to which more than half the cases of this disease are traceable to inspected meats.

During double the period given there have been recorded in the United States approximately 900 cases.

Of the 18 cases and 3 deaths alleged to have been due to American pork during 1881–83, neither Virchow nor others have accepted the evidence as tenable, and the careful examination made by Stiles renders it clear that the attacks upon American pork found in the German press are not supported by German health statistics. While the inspection doubtless diminishes chances of infection, it certainly gives rise to a false feeling of security

SUMMARY FOR THE GERMAN EMPIRE 1881–98 INCLUSIVE.

	Cases.	Deaths.
Meat inspected and passed as free	2,042	112
Meat condemned but used	142	13
Due to defects in inspection system	1,204	7
Total results of errors	3,388	132
Inspection uncertain	63	0
No inspection of meat used	874	84
Data obscure or wanting	1,968	98
Said to be due to American meats	18	3
Due to uninspected Russian meat	18	1
	6,329	318

For the years 1860–95 Stiles has collected records of about 900 cases from the United States. Undoubtedly during this time cases have been diagnosed as atypical typhoid or rheumatism which were in reality attacks of trichinosis, but in the opinion of various authors there were also unrecorded cases in Germany. Nevertheless it is clear that there is a much less prevalence of the disease here, and it is interesting to note the nationality of these cases so far as recorded.

TABLE OF TWO HUNDRED AND SEVENTY-FOUR AMERICAN CASES.

	Cases.	Per cent.		Cases.	Per cent.
German	208	76.0	American	4	1.5
"Foreign"	37	13.0	French Canadian	3	1.0
Negro	10	3.0	"French descent"	1	.4
Italian	4	1.5	Dane	1	.4
Irish	4	1.5	Swede	1	.4

Statistics as to the prevalence of trichinosis are given by numerous European authorities from examinations made at autopsies. The results vary from nothing in France, according to Blanchard, to about two per cent. in Germany, according to various authors. These figures are based upon macroscopic examinations in large part at least, and Leuckart with others has remarked that greater success would follow more rigid search. In the United States Williams has subjected five hundred and five cadavers to a careful microscopical study, with the result that twenty-seven cases were found to be infected, or five and a third per cent. One-third of them were classed as severe, and only two were evident on examination with the naked eye. The nationality of the cases is given in the following table, which is suggestive, though the number is too small to warrant the drawing of final conclusions:

	Positive.	Negative.	Total.	Per cent. of positive cases in each nationality.
United States, white	6	201	207	2.89
United States, colored	5	65	70	7.14
British and Irish	5	57	62	8.06
Canadian	2	10	12	16.66
German	6	43	49	12.24
Italian		10	12	16.66
Other nationalities	0	27	27	0.00
Unknown	1	65	66	1.51
	27	478	505	5.34

The infection of rats varies so widely in different localities that little dependence can be placed on figures heretofore given from the examination of small numbers of individuals. The examination of pigs shows in Boston 4–5.7 per cent. infected (Billings), in United States army 2.1 per cent. (Müller), in various German districts from 1.5 per cent. to 0.1 per cent. The records of Mark show distinctly that reasonable hygienic conditions reduce the percentage of infection among pigs enormously, even in a few years.

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Nematoda.

The trichinæ are found most abundantly in the muscles of the diaphragm, tongue, and neck, and are present at times in incredible numbers, estimated by Leuckart at from thirty to forty millions for a single host (man). Diagnosis of the disease may be positively confirmed by the discovery of embryos in bits of muscle removed from the patient by scalpel or special harpoon.

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The occurrence of other nematodes of somewhat similar size and appearance, the so-called false trichinæ, in the muscles and other organs of hare, rat, mouse, bird, fish, and even man (*cf.* case of Cobbold above, under *Leptodera terricola*) make it imperative that the determination be made with care in suspected cases of trichinosis. Of definite diagnostic value is the so-called "cell body" of the œsophagus, which is prominent in the anterior pointed region of the worm and which, though varying in length, is easily recognizable in all stages of growth and in both sexes (Fig. 3553).

Prophylaxis.—Man acquires the disease by the consumption of pork, in which are found living trichinæ. The chance of infection from all other animals is utterly inconsiderable, though a recent German author calls attention to the necessity of submitting dog meat to inspection on account of its rapidly increasing use as food. It has also been proved that salting, smoking, and other methods of curing ham do not afford a guarantee for the death of trichinæ which may be present. Two preventive methods have been suggested. The first is followed by Germany in her system of meat inspection; as already noted the system is expensive and does not afford absolute protection. Furthermore, unless the number of trichinæ present is enormous so that pathological changes have been induced in the flesh, the destruction of the meat constitutes an unnecessary loss of valuable food material. The second method of preventing the disease is the thorough cooking or curing of the meat so as to destroy the trichinæ. A temperature of 70° C. is sufficient to kill the encysted parasites, but in order that the centre of a piece of meat may reach this temperature cooking must be prolonged. One may determine the sufficiency of the cooking by the uniform clear gray color of a cut surface and the absence of red juice under pressure of the knife. This individual prophylaxis is both most reasonable and most effective; for the consumption of well-cooked pork is free from danger.

The old-fashioned slaughterhouse, at which the refuse was thrown to pigs and fell in part also to the rats infesting the place, was a serious menace to the health of the community, and offered the most admirable conditions for the rapid multiplication of parasites, especially these. On the other hand, the great modern packing establishments, in which all scraps are utilized under methods that destroy the life of any parasites present, are important agents in the limitation of this disease and in the general improvement of public health. Proper methods of slaughtering, curing, and preparing pork, and the abandonment of the unsanitary custom of eating the flesh of the pig uncooked are the true methods for the suppression of the disease.

Family of the Strongylidæ.—Body elongated, cylindrical, rarely filiform; alimentary canal complete; mouth provided with six papillæ, sometimes in the axis of the body, sometimes turned toward the dorsal or ventral surface, and frequently armed by chitinous teeth; œsophagus more or less enlarged at the posterior end, but not provided with a distinct bulb; sexes separate; male with caudal sac or bursa in shape like a saucer, or, if deeper, a bell encircling the end of the body. One or two spicules project from it, and the ribs or rays which mark its surface have characteristic arrangements in different species. The margin of this sac may be notched or deeply cut, so that it appears to consist of two separate parts; near the male orifice a small number of papillæ are often found. Female with one or two ovaries; female sexual opening very variable in position. The eggs when laid have undergone at least part of their development.

Strongylus apri (Gmelin 1789).—(Syn.: *Gordius pulmonalis apri* Ebel 1777; *Ascaris apri* Gmelin 1789; *Str. suis* Rud. 1809; *Str. paradoxus* Mehlis 1831; *Str. elongatus* Duj. 1845; *Str. longevaginatus* Dies. 1851; *Metastrongylus paradoxus* Molin 1860.)

Male, 12–25 mm. long, bursa bilobed, five ribs in each lobe, spicules very long and slender, measuring 2.5–4 mm. in length. Female, 20–50 mm. long, with short fish-hook tail at the base of which lies the anus and just in front of it the vulva on a rounded eminence. Eggs ellipsoid, 0.06–0.1 mm. long by 0.04–0.07 mm. broad; when laid they contain well-developed embryos.

The parasite inhabits commonly the bronchi and bronchioles of pig, sheep, and occasionally also man. Diesing reported it first from a six-year-old boy in Klausenburg; Chatin found some individuals, probably by accident, in the alimentary canal of a patient in France.

The observation of Rainey and Bristowe on nematode embryos from the larynx, which they called *Filaria trachealis*, points to this species even if an exact determination is impossible. Its abundant occurrence in the pig in Europe, and its extreme rarity in man point to some feature in the unknown life history, which renders human infection improbable.

Strongylus subtilis Looss 1895.—Body very slender and delicate, cuticula finely striated, oral papillæ inconspicuous; buccal cavity infundibuliform; œsophagus nearly one-sixth as long as the body. Male with inconspicuous alæ at anterior end, 4–5 mm. long, 90 μ in diameter at anterior end, 70 μ near bursa; two spicules, 0.15 mm. long, with accessory piece 0.05 mm. long (Fig. 3557). Bursa bilobed, with asymmetrical ribs. Female, 5.6–7 mm. long, 0.01 mm. in diameter at head, and 0.09 mm. in posterior third of body. Tail sharply pointed, anus near tip; vulva about one-fifth length from posterior end; uterus bilobed, with a few (three to six, or even eight or nine) eggs in each lobe; eggs oval, 63–70 by 41–36 μ, thin shelled, unsegmented, or partially segmented in uterus; development unknown. Infection by drinking-water.

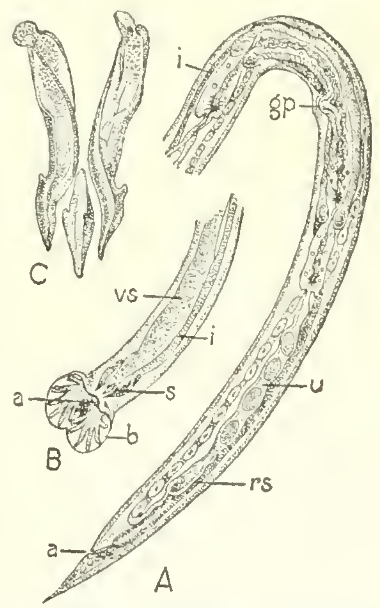

Fig. 3557.—*Strongylus subtilis.* *A*, Tail of female; *a*, anus; *gp*, genital pore; *i*, intestine; *rs*, seminal receptacle; *u*, uterus; *B*, tail of male; *b*, bursa; *s*, spicules; *vs*, seminal vesicle; *C*, spicules and accessory piece. Highly magnified. (After Looss.)

This parasite was described by Looss from specimens found at post-mortems in Egypt. It occurred in the stomach and duodenum of man and the camel. The infection was regularly light, and Looss doubted its pathogenic character on account of this as well as its small size and unarmed buccal cavity. Later Ijima reported a record made by Ogata of the discovery of as many as two hundred small nematodes in fluid taken from the stomach of a woman who died in Japan during the "Miura plague" of 1889. These parasites were identical with Looss' species, and while they were not regarded as the cause of the epidemic, it is clear that the presence of so large a number of parasites creates a presumption against their supposed harmlessness.

In view of its occurrence in such widely separated re-

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gions, its discovery in intermedial territory is probable, and its introduction into the United States by travellers from the Orient or by returning American troops is an evident possibility under present circumstances.

Dioctophyme renale (Goeze 1782.)—(Syn.: *Ascaris canis* et *martis* Schrank 1788; *A. visceralis* et *renalis* Gmelin 1789; *Strongylus gigas* Rud. 1802; *Eustrongylus gigas* Diesing 1851; *Strongylus renalis* Moq.-Tand. 1860; *Eu. visceralis* Raill. 1885.)

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Generally blood red, slightly tapering at both ends, especially the anterior; mouth triangular, bordered by six small papillæ. Male, 13–40 cm. long, 4–6 mm. broad. Caudal extremity obtuse, encircled by membranous pouch without rib lines, but with papillæ on margin. One slender spicule, 5–6 mm. long. Female, 20 cm. to 1 meter long; 5–12 mm. broad; tail obtuse and slightly curved; anus terminal; female sexual opening, 50–70 mm. from anterior end; eggs ovoid, thick-shelled, brown, 64–68 μ by 40–43 μ.

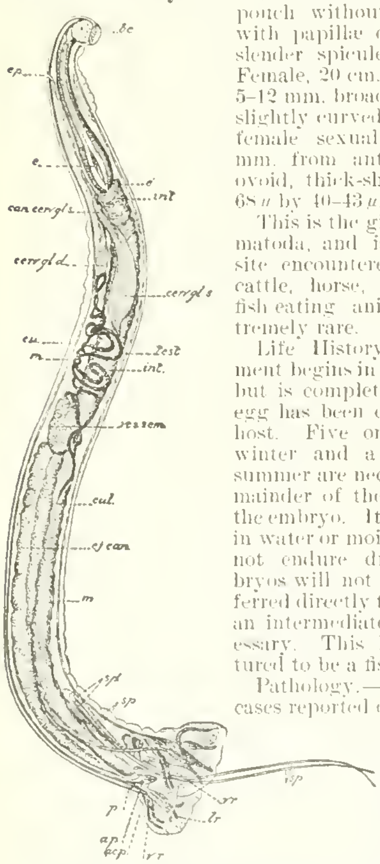

FIG. 3558. Male of *Uncinaria duodenalis*. Magnified. (After Schulthess.)

This is the giant of all the nematoda, and is a kidney parasite encountered in man, dog, cattle, horse, wolf, and many fish eating animals. It is extremely rare.

Life History.—The development begins in the female worm, but is completed only after the egg has been expelled from the host. Five or six months in winter and a shorter time in summer are necessary for the remainder of the development of the embryo. It lives a long time in water or moist earth, but cannot endure drying. The embryos will not develop if transferred directly to the dog, so that an intermediate host seems necessary. This has been conjectured to be a fish.

Pathology.—Of the numerous cases reported of the occurrence of this parasite in man, the majority are assignable to other parasites. Not more than ten are authentic. Trumbull's case (*New York Medical Record*, 1897) has been explained by Stiles as probably a *Filaria*.

Uncinaria Fröhlich 1789.—Anterior end curved dorsad; mouth opening obliquely from chitinous buccal capsule surrounded by transparent border; dorsal portion of capsule shorter than ventral, supported by conical structure sometimes projecting into cavity, at base of capsule two ventral teeth; near inner free border ventral wall bears on each side of the median line chitinous structures or teeth, often recurved like hooks (uncinate); inner dorsal wall also with teeth at times. Oviparous, eggs with thin transparent shell.

Of the species of this genus, which contains dangerous blood sucking intestinal parasites of the higher mammals, two occur in man, one an Old-World species long known and the other recently discovered on this continent. In medical writings the worm is more ordinarily called *Anchylostoma*, and the disease which it produces is spoken of as anchylostomiasis. As the recent important contribution of Stiles, to whom I am also indebted for valuable personal communications, shows clearly, the name of one at least of the species in question here is that given above, and the term uncinariasis or uncinariosis should be adopted as the correct designation of the disease which is known also as brickmakers' and miners' anæmia,

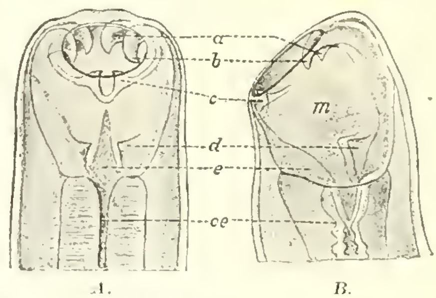

FIG. 3559.—Oral Capsule of *Uncinaria duodenalis* in (*A*) Dorsal and (*B*) Lateral Aspect. *a*, Inner; *b*, outer ventral tooth; *c*, dorsal tooth; *d*, stylet; *e*, dorsal rib; *m*, buccal cavity; *oc*, œsophagus. (After Hertwig.)

Egyptian chlorosis, tunnel disease, etc. Its chief symptoms are anæmia with the circulatory disturbances accompanying the pernicious type, colicky pains in the abdomen, great weakness, alternating constipation and diarrhœa with brownish or bloody stools, nausea, and œdema. Positive diagnosis is made by the discovery of the parasites and eggs in the fæces. In such cases care should be exercised not to confuse this with other species.

As the effects due to the two species are not distinguishable, a general discussion may be given for both together. By means of the powerful armature of the buccal capsule they pierce the intestinal mucosa and with the muscular œsophagus pump out blood. The intestinal epithelium is lost from the area taken into the capsule, and in addition to this the parasites move from spot to spot so that the host loses not only the blood taken by the parasite directly, but that lost through many minute hemorrhages at previous points of attack. The functional vitality of the intestinal wall is evidently reduced, and some are inclined to believe that the parasite also produces a poison which acts upon the host unfavorably.

Thymol and male fern are most frequently used for driving out these parasites, and Stiles quotes the following directions for thymol treatment:

Two grams of thymol at 8 A.M., repeated at 10 A.M., and castor oil or magnesia at noon. Diet of milk and soup. As some cases are obstinate, a re-examination of the fæces in a week is necessary, and the repetition of the treatment if eggs are still to be found. It should be noted that on the whole experiments are very unfavorable to the use of alcohol during the thymol treatment.

Rational prophylaxis must be based on better knowledge of the extent of the disease. When it is suspected microscopical examination of the fæces and treatment of all infected individuals are necessary preliminaries to its eradication. The construction of water-tight latrines in tunnels, brickyards, and other corporation properties where the disease is prevalent, together with the periodic disinfection of their contents by quicklime or by cremation, will largely prevent the spread of the disease. If, in addition, defecation in other places is forbidden and the regulation enforced, while on the other hand fresh pure drinking water is supplied and workmen are impressed with the necessity of personal cleanliness as a preventive for the disease,

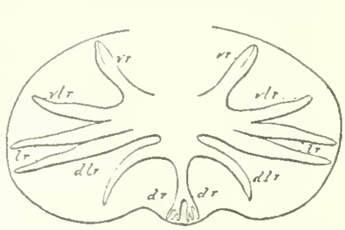

FIG. 3560.—Bursa of Male *Uncinaria duodenalis*. Magnified. (After Railliet.)

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the difficulty will be reduced to a minimum. It must be kept in mind that Looss has demonstrated the probability of infection from water with larvæ coming on to the skin, so that the presence of such larvæ in standing water is a real menace, even if none of it ever reaches the mouth.

The Old-World species has been known for some time, and its effects are clearly traceable back of the historic study of Perroncito, which showed it to be the cause of the severe miners' anæmia, which was associated with the construction of the Saint Gothard tunnel. It is only within the year 1902 that Stiles has called attention to the tremendous economic and hygienic importance of the New-World species in our Southern States, although the records of the presence of some species, probably this one, extend back for many years. In Central America uncinariasis has been for centuries the most important and dangerous general disease, involving twenty-three per cent. of the population; it appears in the old Indian traditions, and with the disease is associated "dirt-eating." The species has not been precisely determined. In Africa the infected negro does not seem to be subject to any resulting anæmia.

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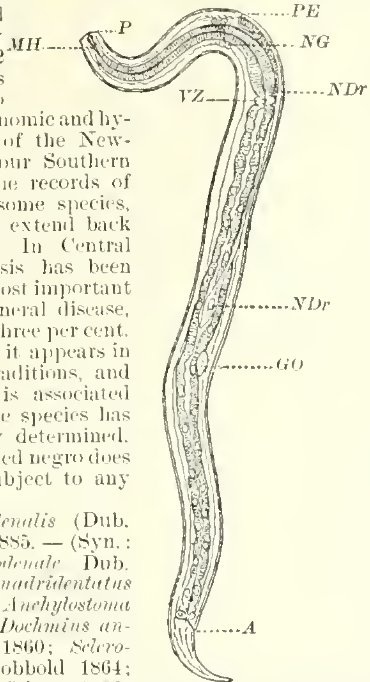

FIG. 3561.—Young *Uncinaria duodenalis* Four Days After Infection. *A*, Anus; *GO*, genital cell, *NDr*, œsophageal glands; *MH*, oral cavity. × 190 (After Looss.)

Uncinaria duodenalis (Dub. 1843) Railliet 1885.—(Syn.: *Agchylostoma duodenale* Dub. 1843; *Strongylus quadridentatus* v. Sieb. 1851; *Anchylostoma duod.* Dub. 1850; *Dochmius anchylostomum* Molin 1860; *Sclerostoma duodenale* Cobbold 1864; *Str. duodenalis* Schn. 1866; *Dochmius duodenalis* Leuck. 1876; *Ankylostoma* and *Ankylostomum duod.* auct.)

Body cylindrical; buccal cavity with two pairs of uncinate ventral teeth, and one pair of dorsal teeth, directed forward; dorsal rib not projecting into capsule. Female, 10–18 mm. long by 0.5–0.6 mm. wide; vulva at or near posterior third of body; eggs 52 by 32 μ, segmenting when deposited with direct development. Male (Fig. 3558), 8–11 mm. long by 0.4–0.5 mm. wide; caudal bursa (Fig. 3560) with dorso-medial lobe, dividing at two-thirds the distance from base, each branch being tridigitate, and with prominent lateral lobes united by a ventral lobe; spicules long, slender.

This species occurs in the upper region of the small intestine of man, and has been reported from Europe, Africa, Asia, the Philippines, and recently also from North America and the West Indies, where some regard it as of very recent introduction. A number of cases, including one fatal one, are on record in the United States within two years.

Structure.—One point in the structure deserves special attention—the so-called pharynx or buccal capsule (Fig. 3559). This is very nearly spherical, and is armed with four strong curved chitinous teeth. At the bottom of the capsule are two triangular lance-like organs, the function of which is the penetration of the tissue of the host. The body is curved dorsad at the anterior end on account of the shortness of the dorsal wall of the buccal capsule, so that the orifice actually points dorsad.

Life History.—The eggs are deposited in the alimentary canal of the host and must pass out of the body in order to undergo development, which will not take place in water, but proceeds rapidly in fæces or in slime, so that the rhabditiform embryo is hatched in twenty-four hours at 27° C. As 1° C. kills the eggs in from twenty-four to forty-eight hours, the climate of a large part of this country is an evident barrier to the spread of the parasite. At hatching the embryo measures 0.3 mm. in length, but grows rapidly, and after moulting once it enters upon a resting stage within the cast-off skin of the second moult. In this, the infecting stage of the parasite, the worms may live for a month or more in water without food, but if subjected to desiccation they perish. This naturally points to water as the probable means of infection, although the presence of such larvæ on moist salads and other vegetables, eaten uncooked, may well be a subsidiary means.

Recently Looss has brought forward the idea that these larvæ may enter the human body by way of the skin, which stands in perfect agreement with his earlier observations, that the larvæ which were fed to various animals in water did not settle down but were discharged per anum unchanged; yet part of them bored into the mucosa of the larynx and œsophagus and were active and growing two weeks later. When taken into the human body the worms undergo radical changes in structure. One may distinguish with Looss a third stage without buccal capsule (Fig. 3561), a fourth with provisional buccal capsule (Fig. 3562), and a fifth in which this organ corresponds to the adult form. From four to six weeks from the time of infection are required for the parasites to mature.

The view of Looss, that infection may take place through the skin, has been confirmed by a number of observations and experiments. Most striking was the infection of a limb about to be amputated and the subsequent discovery of many larvæ, which had forced a way in between hair and follicle and appeared in sections to have penetrated as far as the subdermal tissue. This method of infection, which Looss believes to be the most extensive, explains the susceptibility of Egyptian field laborers, and also epidemics among brickmakers as well as all cases in which the workmen are wont to work in moist earth with bare feet and hands. It explains the infection of children walking on damp ground, and gives, according to Bentley, the key to the "ground itch," or Pani-ghao, an affection of the skin of the lower extremities, endemic in Assam and in the West Indies. Its appearance is coincident with the advent of the rainy season, and is associated by this author with the presence of the larvæ of *Uncinaria duodenalis* in the soil of the infected areas. The typical lesion consists in a primary erythema followed by a vesicular eruption, which frequently becomes pustular, and in severe cases may result in obstinate ulceration or even in gangrene.

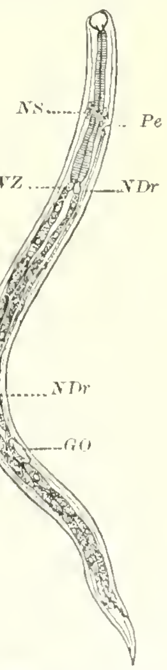

FIG. 3562.—*Uncinaria duodenalis* in Stage II. of Development. × 105 (After Looss.)

Uncinaria americana Stiles 1902.—Ventral recurved uncinate teeth absent from mouth, one pair prominent dorsal semilunar plates, and an inconspicuous ventral pair being present; dorsal median conical tooth projecting prominently into buccal capsule (Fig. 3565). Female, 9–11 mm. long by 0.31–0.35 mm. wide; vulva near middle of body but in front of it; eggs (Fig. 3564) 64–72 μ by 36–40 μ, segmenting or with well-developed embryos when deposited. Male, 7–9 mm. long by 0.29–0.31 mm. wide; dorsal ray of caudal bursa divided to the base, each

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branch bipartite to tip (Fig. 3563). Species otherwise similar to *U. duodenalis*.

This form has only just been differentiated by Stiles from the long known European *U. duodenalis*, from which in fact it differs radically. It has been obtained from cases of uncinariasis in man in Texas, Virginia, Florida, Porto Rico, and Cuba, and its wide occurrence goes to show that the parasite, though not recognized hitherto, is endemic in the Southern States, where it causes the most common disease on the farms and among the poor whites. The life history of the parasite is unknown, though the early stages correspond to those of *U. duodenalis*. The cases of the disease have been collected and abstracted by Stiles, who holds with evident right that it is not a recently imported disease, but has existed unrecognized for years. It has been traced from Virginia to Florida, and is most abundant in sandy areas. Guiteras has also an unpublished case from Brazil.

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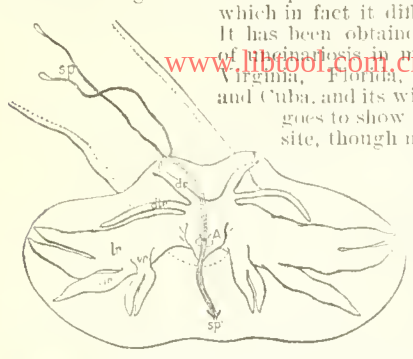

FIG. 3563.—Bursa of *Uncinaria americana*, Showing Ribs (*dr*, *lr*, etc.). *a*, Anus; *sp*, spicules. Magnified. (After Stiles.)

Physaloptera caucasica von Linstow 1902.—Cuticula heavy, non-striated, forming a projecting ring about the head, within which a pair of equilateral lips bear four papillæ in the submedian line and two conical teeth near the mouth opening. Œsophagus one-fifth the entire length; lateral lines strongly developed. Male, 14.22 mm. long by 0.71 mm. broad; bursa broad, rounded, tapering posteriad, with central longitudinal rows of small conical papillæ; spicules two unlike; lateral to the cloacal orifice two pairs of long stalked papillæ, in front one pair, behind two pairs, on the tail three pairs more. Female, 27 mm. long, 1.14 mm. broad, vulva at one-sixth the length from the anterior end; eggs heavy shelled, 57 by 39 μ.

The single account of this species by O. von Linstow is based on specimens, two males and nine females, in the collection of the museum at St. Petersburg, Russia. They are said to have been taken from the alimentary canal of man in the Caucasus. Further details are not given.

FIG. 3564. Eggs of *Uncinaria americana* from Fæces. × 235. (After Stiles.)

Family of the Ascaridæ.—Body relatively thick; mouth surrounded by three lips, one of which is dorsal, the others ventrolateral; œsophagus long, muscular, inflated at the end and often accompanied by an œsophageal bulb; male with one or two spicules; female with double ovary, oviparous; development direct. All are intestinal parasites.

Ascaris L. 1758.—Polymyaria, with very prominent lips; males with two equal spicules and many preanal and postanal papillæ; vulva in advance of centre of body. More than two hundred species are recorded; three have been reported from man.

Ascaris lumbricoides L. 1758.—Body reddish or grayish-yellow when living; spindle-shaped; lips (Fig. 3566) almost similar, approximately semicircular, with fine teeth on the edges, the dorsal possesses two papillæ, and each of the ventral ones only a single papilla. Male, 15–17 or even 25 cm. long and 3 mm. thick, with the posterior end curved toward the ventral face; spicules two, short, 2 mm. long; papillæ fifty-five to sixty preanal and seven pairs postanal. The female, 20–25 or even 40 cm. long and 5–5.5 mm. thick, with straight conical posterior end. The female sexual opening at the limit of the anterior third of the body, and situated in a ring-shaped depression. Fertilized eggs (Fig. 3567) elliptical, shell with transparent mammillated covering, 50–75 μ long by 40–58 μ wide, laid before cleavage begins. Unfertilized eggs, irregular, with scanty albumin covering, coarser granules, and thinner shell, measuring 81 by 45 μ.

This, the common round worm of children, is one of the most abundant and widely distributed of human parasites. It is distributed over the entire world, and though more abundant in the warmer regions, is recorded from Finland and Greenland. It is also more common in the country than in cities, which may be due to the presence of the same species in the pig and sheep. This parasite was well known to the ancients, both the Greeks and the Romans, although the ἀσκαρις of Greek authors is the form now known as *Oxyuris*.

Life History.—The development of the eggs does not begin until long after they have been expelled from the human intestine, and is dependent upon both moisture and warmth. Under mean temperature the embryo is completed in from thirty to forty days, and then lies in a spiral within a thin shell, which it does not seem to leave so long as the egg remains free, though it undergoes a moult here. The embryo may live long within the shell, even up to five years. The further development was believed by Leuckart to require the intervention of another host in which a larval stage is passed, but Davaine was successful in hatching the embryos in the intestine of the rat, and believes that the intervention of a second host is unnecessary. Subsequent experiments by various authors have strongly confirmed this view by raising experimentally adults in the human alimentary canal two months after the ingestion of eggs containing embryos. Accordingly the eggs are probably introduced into the human system with the embryo within by accident or by means of the drinking-water. The embryo is then set at liberty in the alimentary canal, and further development is merely growth. Of course the infection may be brought about by the means of contaminated vegetables, especially salads, which have been imperfectly cleaned.

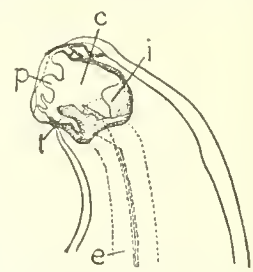

FIG. 3565.—Lateral View of Head of *Uncinaria americana*. *c*, Oral capsule; *e*, œsophagus; *i*, stylet; *p*, papilla; *t*, dorsal median tooth. (After Stiles.)

Pathology.—It has already been mentioned that the worms are most frequently found in children of medium growth, but this is due to the case of infection rather than to conditions for development, since the worm has been obtained from persons of all ages. Ordinarily one finds only a few specimens at once, but in some cases from five hundred to one thousand have been obtained from a single individual. It is noteworthy that hæmoglobin has been detected in the alimentary canal of the

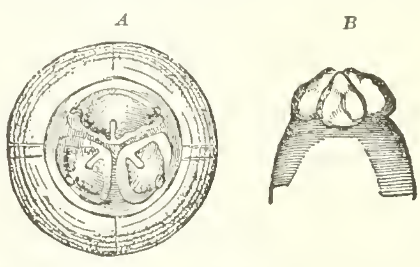

FIG. 3566.—Anterior End of *Ascaris lumbricoides*. *A*, Apical and *B*, Dorsal Aspect.

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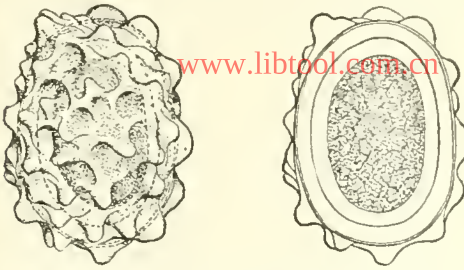
parasite, showing that its food consists in part of human blood. Their normal location is the small intestine, but specimens not infrequently wander into the stomach and are vomited. Rarely they have been known to make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A. B.

FIG. 3567.—Egg of *Ascaris lumbricoides* from Fæces. *A*, In surface view and *B* in optical section. (After Stiles.)

their way into the pharynx and choanæ, with the result of causing fatal suffocation both in children and in adults; also into the Eustachian tube or ductus choledochus, and they have even been found in abscesses of the liver.

Recently a number of unimpeachable cases have been brought forward in which the worm has bored its way through the uninjured wall of the intestine and has been found in the peritoneal cavity. Their presence here after having pierced abscesses of the wall is also known, and in some cases even, in which adhesion of the intestinal to the abdominal wall was present, the worm emerged from the body through an abscess at this point. In fevers the Ascaridæ will spontaneously desert the intestine.

It is evident that these wanderings are associated with great danger to the host. The presence also even of a few individuals in the intestine gives rise at times to marked nervous disturbances, hysteria, epileptic attacks, congestion of the brain, aphonia, etc., which are most easily explained on the basis of a poison excreted by the worms. In fact, recent investigators have been able to obtain such a toxic substance from the body of this species, and students in the laboratory handling specimens of *A. megalocephala* from the horse have been distinctly affected by poisonous emanations. The symptoms disappear with the removal of the worms. Moniez, however, is inclined to attribute the troubles in large part to the use of santonin for the expulsion of the worms, as this substance has an unfavorable effect upon the human organism. Guiart has called attention to the important fact that the parasites by their movements produce lesions of the wall so as to afford a point of attack for intestinal fevers, and thus become a source of great danger for the host. Knotted masses of this parasite have also been the cause of fatal intestinal obstruction.

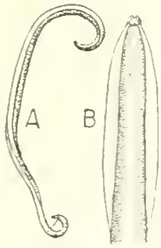

FIG. 3568.—*Ascaris canis*. *A*, Male. (Natural size.) *B*, Head showing papillæ and wings. Magnified. (Original.)

Treatment.—In general opinion santonin is the specific against *Ascaris*, and no one of the many other substances tried has achieved the same results. Moniez advises the use of centigrams equal to the number of years in a child's age, and for an adult 20–25 cgm. The drug kills the parasites, and the administration at the same time of a purgative is advantageous in bringing about their immediate expulsion. Careful watch should be kept for the violent symptoms which sometimes accompany the use of santonin and means taken at once to counteract them.

Ascaris canis Blanchard.—(Syn.: *Lumbricus canis* Werner 1782; *A. teres* Goeze 1782, *A. cati* and *caniculæ* Schrank 1788; *A. canis* and *felis* Gmelin 1789; *A. tricuspidata* and *felis* Bruguière 1791; *A. Werneri* Rud. 1793; *Fusaria mystax* Zeder 1800; *A. marginata* and *A. mystax* Rud. 1802; *A. alata* Bellingham 1839.)

Anterior end ordinarily curved and provided with two wing-like membranes which extend one along each side (Fig. 3568), lips almost equal, three- to six-cornered. Male, 40–90 mm. long, 1 mm. broad, with twenty-one preanal and five postanal papillæ. Female, 120–200 mm. long, vulva in the anterior fourth of the body, eggs almost spherical with thin shell, 0.068–0.072 mm. in diameter.

An abundant parasite in the small intestine of cats and dogs and also reported from various allied wild species, it has been found several times in man in England, Germany, Denmark, and the United States. Grassi doubts the accuracy of these determinations since experimental infection was not successful.

The development is direct and in general like that of the preceding species. The thin shell is highly impervious so that development continues in alcohol, turpentine, etc. It is probable that the embryo does not desert the shell until taken into the stomach of the host.

Ascaris maritima Leuckart 1876.—Known only from a single immature female, which was vomited by a child in North Greenland in 1865. The specimen was 43 mm. long and 1 mm. broad, and is regarded by some authors not as a normal parasite, but as one accidentally ingested with the viscera of some food animal. According to Leuckart it is very near *A. transfuga* of the bears.

Oxyuris Rudolphi 1803.—Three lips poorly developed or wanting; œsophagus long and provided with a distinct bulb. Male with only one spicule and with two pairs of preanal papillæ. Female with greatly elongated, pointed posterior end, two ovaries and vulva in anterior part of the body.

Oxyuris vermicularis Bremser 1819.—(Syn.: *Ascaris vermicularis* L. 1767; *Fusaria vermicularis* Zeder 1803. Œsophagus long and followed by a distinct bulb with teeth; body white, cuticula striated, forming wing-like projections from the dorsal and ventral surfaces near the head and also a low crest along the lateral lines of the body; three small retractile labial papillæ. Male, 3–5 mm. long, with spirally rolled tail; a single spicule and six pairs of papillæ. Female, 9–12 mm. long, 1 mm. broad, tail awl-shaped; vulva a little in front of the limit of the anterior fourth of the body, eggs elliptical, thin-shelled, 50–54 μ long by 20–27 μ wide, containing an embryo when deposited (Fig. 3569).

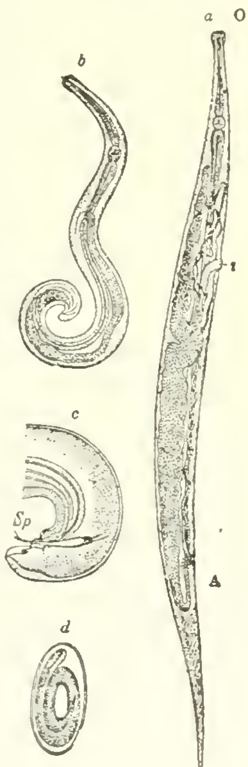

FIG. 3569.—*Oxyuris vermicularis*. *a*, Female; *b*, male; *c*, posterior end of latter; *d*, egg with embryo; *i*, vulva; *sp*, spicule. Magnified. (After Leuckart.)

This species, known from remote antiquity, is a cosmopolitan parasite of the human intestine. It has not been definitely recognized as a parasite of other animals, but Leidey's *O. compar* from the cat is very likely the same form. It is more abundant in cities than in the country, and occurs equally in cold and warm regions. These parasites are most abundant in infants, a fact which accords with the ease of auto-infection as shown by the development.

Life History.—The embryo develops within the egg shell while still contained in the uterus, and it was long thought that the further development could take place

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in the canal. In fact, however, the female at the time of oviposition lives in the lower part of the rectum and even attains the vicinity of the anus, although the earlier portion of the adult life history is passed in the small intestine, where the worms acquire sexual maturity and copulate. Evacuated from the body, the embryo undergoes transformation to the so-called embryonic stage while still within the egg shell, and now awaits ingestion by a new host. The primary infection is by drinking-water or contaminated fruit or vegetables, which are eaten uncooked; but self-infection and transference to other individuals are brought about by scratching and rubbing with the fingers to allay the intense itching caused by the daily migration of the females out from the anus on to the perineum and the surrounding parts. Perhaps in the distribution of *Oxyuris* eggs the flies play a part such as Grassi has demonstrated for *Trichocephalus* and eggs of *Tænia*. The direct development is very rapid, as Leuckart obtained experimentally *Oxyurides* 6–7 mm. long within fourteen days after ingestion of the eggs; Grassi and others have confirmed this by further experiments.

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Pathology.—The females are far more numerous than the males, and by their migrations determine unbearable pruritus, which recurs periodically on retiring. In a number of cases among young girls the worms have migrated into the vagina and have produced onanism, and even the inception of nymphomania. In many cases large numbers in the rectum have excited no untoward symptoms, but in others they have produced reflex nervous activities of all grades up to epileptic attacks, such as have been noted under *Ascaris*. Recent investigations in Egypt have demonstrated the responsibility of this parasite for nodules on the rectal wall, previously attributed to *Schistosoma*, which contain eggs of *Oxyuris vermicularis* in a calculus. *Oxyuris* has also been recorded in tuberculous nodules in the cavum Douglasii of a female, and Vuillemin has recently discovered them in a tumor near the anus of a boy. The latter case shows definitely the wandering of the worms through 2 cm. or more of solid tissue. This habit exhibits a new and evidently dangerous feature in the parasitism of this species through the disturbance of the tissues and the introduction into them of bacteria from the rectum.

Treatment.—It is difficult to remove these worms entirely. Vermifuges and purgatives with enemata, etc., are successful to a degree; but the case of auto-infection is an obstacle to a complete cure. Local application of mercurial ointment will alleviate the pruritus, and manual extraction, if prolonged, will reduce their numbers rapidly. But in any event treatment is prolonged.

The sub-class of the Gordiacea includes forms familiarly known as "hair snakes" or "hair worms." They are greatly elongated, slender worms, somewhat filaria-like in external appearance, but of radically different internal structure. Lateral fields are wanting, and the body musculation is of a different histological type from that of the Eunematoda. The mouth is occluded and the alimentary canal persists in the adult only as a functionless vestigial strand. In both sexes the reproductive organs open to the exterior with the alimentary canal at a terminal or subterminal cloaca. The reproductive system is constructed on a different plan, and the lateral canal system is wanting. The male has no spicules, but the posterior end of the body is forked and functions as grasping organ.

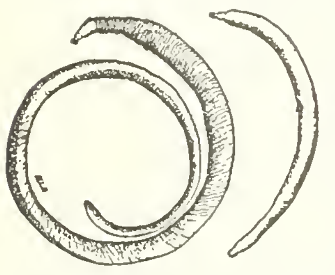

FIG. 3570.—*Gigantorhynchus gigas*. Male at right, female at left. Half natural size. (Original.)

The adult lives free in ponds, swamps, and other bodies of water, and the eggs are deposited on the stems of water plants. The larvæ possess a proboscis armed with hooks and bore into the body cavity of aquicolous insect larvæ, or rarely mollusks, where they encyst. According to Villot the second stage is passed in the intestine and body cavity of fishes. More commonly apparently the worms develop to maturity in the body cavity of insects, from which they emerge into the water for the adult free existence.

Several species have been reported from the human alimentary canal. They are pseudoparasites, having been swallowed, according to one view, in the adult condition with drinking-water; but their occurrence in fruit, especially apples, makes this even a more likely source of infection. Lockwood noted in 1876 the frequent presence, in fruit, of *Mermis*, another genus of Eunematoda, and suggested the probable occurrence of this form as a pseudoparasite of man under conditions; this has not been actually recorded so far as I find. But of Gordius as a pseudoparasite Parona has recently listed eleven cases, the first as early as 1638; of these Kirtland's (Ohio) is the only one from the United States. Two other unpublished cases have recently been communicated to me from Michigan and Maryland. It will be of no particular value to enter here upon a detailed description of the species found.

The Gordiacea are, however, emphasized by Cobbold as important for the medical practitioner, since they have been passed off as the guinea-worm and as having been evacuated with fecal matter by neurasthenic persons under treatment.

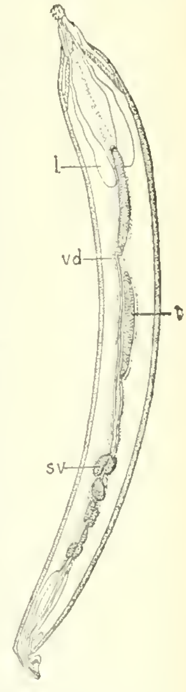

FIG. 3571.—*Gigantorhynchus gigas* Opened to Show Internal Anatomy. *l*, Lemniscus; *sv*, seminal vesicle; *t*, testis; *vd*, vas deferens. Modified. (Original.)

The Acanthocephala may best be discussed as an appendix to the class Nematoda, although they are regarded by many as a cognate class and by others are separated even more widely. The forms included here, though parasites of the most complete type, are not common in man. The group may be characterized as follows: Elongated, cylindrical body, often deeply corrugated, bearing at anterior end a retractile proboscis provided with many minute hooks in rows. No trace of alimentary canal. Reproductive organs open at posterior end; sexes separate. Male with campanulate bursa about the orifice. Mostly small forms, parasitic as adults in vertebrates only. The structure is uniform, and can be learned from the brief account which follows of the largest and commonest species.

Gigantorhynchus gigas Hamann 1892.—(Syn.: *Tænia hirudinacea* Pallas 1781; *Echinorhynchus gigas* Goeze 1782.)

Body milk white, sometimes slightly tinted, with transverse irregular ridges. Posterior end somewhat smaller; proboscis spherical, armed with five or six rows of hooks. The proboscis can be retracted into a neck-like region, which is much slimmer than the following portion of the body. Male, 60–90 mm. long by 3–5 mm. broad, with bell-shaped caudal pouch. Female, 230–350 mm. long by 4–9 mm. broad; tail blunt; eggs almost cylindrical, 0.087–0.1 mm. long with three embryonic envelopes.

The adult worm is found in the small intestine of the pig, ordinarily fixed to the wall by the proboscis, and is widely distributed.

Structure.—The elongated body (Fig. 3570) is largest near the head and tapers gradually toward the posterior end. At the anterior end a sharp constriction separates

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the body from the short neck portion, which is not more than one-fourth or one-fifth the diameter of the body close to it. From the apex of this region may be projected the proboscis which is contained within it, like the reversed finger of a glove. As the proboscis rolls out the hooks also turn www.libtool.com.cn the proboscis is completely extruded the shape of the organ is nearly that of a sphere on which are from five to six irregular rows of hooks. Behind these the proboscis is slightly smaller.

If the internal structure be examined, it will be seen that the proboscis is provided with retractor muscles, by means of which it may be withdrawn into the body. At the base of the proboscis is the small mass of nervous matter which represents the brain.

There is no trace of an alimentary canal, hence these forms, like the tapeworm, take nourishment by absorption. Two elongated sac-like organs hang down into the body cavity along the sides of the proboscis. These are the lemnisci (*l*, Fig. 3571); their function is uncertain.

The mass of the body is made up of the organs of the reproductive system. All these worms are diœcious. The male organs (Fig. 3571) consist of two large testes, together with the ducts and accessory glands connected with them. The tail of the male has a hemispherical expansion, something like the caudal bursa of other Nematoda; the male sexual opening in the centre of this sac at the tip of the body is provided with a small copulatory organ. The internal sexual organs of the female are much similar in general appearance; the ovaries lie toward the front of the body cavity, which is largely filled with eggs in various stages of development. These are discharged by the oviduct, which opens at the posterior end of the body.

Life History.—The eggs of *Gigantorynchus* are discharged from the alimentary canal of the host and distributed with fæces. When eaten by some insect they are hatched in its intestine. The embryo, which has a conical form armed at one end with four hooks like tapeworm hooks, and a number of smaller ones, penetrates into the abdominal cavity of the insect and encysts there. In this condition the embryos may even live through the metamorphoses of the insect until the host is eaten by some pig. In the alimentary canal of the pig the embryo is set free, attaches itself and acquires maturity. There is some dispute as to what insect is the intermediate host; the white worm-like larva of the May bug and the larva of the common rose chafer have been found to contain these worms in Europe, and Stiles has experimentally infected the larvæ of the June bug in this country. It is also maintained that various species of snail may function as the larval host. In all probability the larva is not confined to a single host, but may develop in many.

Leuckart accepts some reports of the occurrence of this species in man as trustworthy, and Lindemann says that it is not rare as a human parasite in Southern Russia. Schneider notes the consumption, as food, of the larvæ and adults of *Melolontha*, the May beetle, which acts as the intermediate host, so that infection is evidently possible.

Gigantorhynchus moniliformis (Bremser 1819).—Body attenuated anteriorly. Proboscis, 0.425–0.450 mm. long, 0.175–0.19 mm. broad, with hooks in fifteen transverse and twelve longitudinal rows. Male, 4–4.5 cm. long. Female, 7–8 cm. long, or even up to 27 cm. according to Westrumb. Eggs ellipsoidal, 85 μ long, 45 μ broad.

The normal hosts of this species are field mice, rats, etc., and the intermediate host in Italy has been determined as *Blaps mucronata*. Calandruccio in experimenting on the life history succeeded in infecting himself with the adult. The severe symptoms which manifested themselves were dispelled by the evacuation of the worms. In other cases of the occurrence of this species as a human parasite its identity was less definitely established.

Echinorhynchus hominis Lambl 1859.—Length, 5.6 mm.; width, 0.6 mm.; proboscis almost spherical with twelve transverse rows of eight hooks each. Large hooks, 103 μ long, small hooks, 77 μ.

An uncertain species of which Lambl found a single specimen at Prague in the small intestine of a boy who had died of leukæmia.

Echinorhynchus sp. Welch 1872.—In 1872 Welch described as *Echinorhynchus* a body which he found encysted in the mucosa of the jejunum of a soldier. According to Railliet it was evidently a Linguatulid (see *Arachnida*).

Echinorhynchus sp. Moniez 1896.—Kunstler and Pitres found certain peculiar bodies in the pleural cavity of a patient who had suffered two years from pleurisy, but without fever. They interpreted these structures as coccidia, but Moniez holds with greater probability to their likeness to eggs of *Echinorhynchus*. The case is entirely isolated under either explanation.

Henry B. Ward.

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NEOPLASMS. See *Tumors*.

NEPHRECTOMY; NEPHROTOMY. See *Kidneys, etc.*

NERVES, GENERAL PHYSIOLOGY OF.—HISTOLOGICAL AND GENERAL.—Nerves consist essentially of the long, slender processes of nerve cells. They are hence composed of protoplasm, and they possess the general chemical and physical properties of this substance; but they differ physiologically from other forms of protoplasm, in that they possess to a high degree the properties of conductivity and excitability, while the properties of growth, metabolism, respiration, and contractility are feebly developed or altogether absent. There is in these respects a marked physiological difference even between the nerve and the cell body from which it arises. Many of the reactions of the cells to external conditions are the opposite to the reactions of the nerve. The cell generates nerve impulses; it possesses spontaneity or automatism, absent in the fibre; it is closely dependent on a supply of oxygen, while the nerve is almost independent; it has an active metabolism, which the nerve lacks almost entirely; it respires, while the nerve respires little or not at all; it or some of its dendritic processes may be contractile, the nerve has lost this property altogether. The physiology of the nervous tissue, which includes nerve cells, differs therefore in many respects from that of the nerves proper, which we shall consider here. In short, the nerve cells possess pre-eminently the property of automatism or spontaneity; the nerve fibre, the property of conduction.

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This physiological differentiation of the conducting protoplasm of the nerve is accompanied, as might be expected, by an histological differentiation. The protoplasm of the nerve fibre, called the axis cylinder, or axon, differs in physical appearance from that of the rest of the cell body from which it arises in that the fibre is striated longitudinally as if composed of distinct fibrils, and is surrounded by a fatty sheath. These fibrils can be more easily seen in invertebrate than in vertebrate nerves, and particularly in the leeches, where they have been traced by Apathy[1] from one nerve cell into and even through other nerve cells. Some observers even go so far as to maintain that these fibrils are the true conducting portions of the fibre, but of this there is no physiological evidence. Besides this peculiar fibrillar structure of the axis cylinder, nerves are as a rule easily differentiated from other tissues even by the naked eye by their white, glistening, fatty sheaths. Nearly all nerve fibres which take their origin in the brain and spinal cord, and many having origin elsewhere, are surrounded by such a sheath, which is called the medulla, and such nerves are called medullated nerves. The nerves of invertebrates and those of the sympathetic system of vertebrates, on the other hand, often lack these sheaths, and are called non-medullated nerves. The function of this medullated sheath is not definitely ascertained, but it has been suggested that it prevents the spreading of the impulse from one fibre to another. It appears to influence the physiological behavior of the nerve, for medullated nerves are generally more easily excited than non-medullated, and they react differently to an exposure to a constant electrical current. A momentary exposure of a non-medullated nerve to a constant electrical current may block conduction in the region of the anode or positive electrode for several minutes or hours; whereas medullated nerves after such treatment recover their conductivity very quickly.[35] Waller[2] suggested that the medulla was reserve material which was used up by the metabolism of the nerve during conduction, and he explained in this way the indefatigability which medullated nerves possess; but Miss Sowton[3] has recently shown that the non-medullated olfactory nerve of fishes is almost or quite as inexhaustible as are medullated nerves, if we may judge from the undiminished size of the electrical response attending conduction after long stimulation. Nerve fibres differ from other protoplasm also in the quickness with which they stain blue when exposed to a solution of methylene blue. It is thus possible to stain them before the other tissues are colored, and an important method for tracing the course and distribution of nerves has been founded on this peculiarity.

The chemical composition of the axis-cylinder process is not definitely known. Other portions of gray nervous matter which it resembles consist largely of colloidal substances of proteid nature, and differ from most tissues in the unusually large amounts of lecithin and cholesterin present. Nothing can be said positively regarding the inorganic salts present in the axis-cylinder process. Ranke[4] believed its reaction to be slightly acid, but most observers have found the cut surface of the nerve alkaline to litmus; it is possible that like other protoplasm it is neutral to phenolphthalein. The medulla consists chiefly of cerebrin, lecithin, cephalin, cholesterin, and neurokeratin. The latter substance forms a horny supporting framework. Lecithin is a trimethyl cholin-distearyl phosphoric acid glycerin ester. Other fatty acids may be present in place of the stearic acid, and the lecithins from different animals vary in this respect. The kephalin or cephalin, according to Koch and Thudicum, is probably monomethyl cholin lecithin. The constitution of cerebrin is unknown, but in the brain of the sheep it contains the sugar galactose, two or four molecules of stearic or oleic acid containing nitrogen, possibly united to a hexatomic alcohol or to glycerin. The cerebrins obtained from the brains of different animals differ chemically. The high content of all nerve tissues in lecithin and cholesterin is probably of physiological importance, as will be shown farther on, and possibly determines their susceptibility to the anæsthetics.

As the conducting part of a nerve fibre consists of protoplasm, it cannot continue to exist for any length of time if cut off from the rest of the cell, but soon degenerates and disintegrates. Experiments on plant cells and infusoria have shown that portions of the cell cut away from the nucleus die and no longer grow, although they may continue movement and some other functions for some days.[5] The nerve fibre shows the same relationship, demonstrating that its maintenance in a normal condition depends on its connection with a nucleated part of the cell body. If a mammalian nerve is severed, the peripheral portion, whether sensory or motor, loses its power of conduction and excitability in from four to six days.[9] In frogs conduction may persist for from five to eight days, and, in nerves kept cool, even longer. These facts indicate that the nerve fibre, however close its connection with the peripheral cell which it innervates, is not nourished from it and does not enter into organic connection with it; and, further, that it is not nourished by the nuclei of the medullary sheath. No immediate functional reunion of the peripheral and the central ends of a severed nerve can be brought about by suturing, for whether sutured or not degeneration of the peripheral part always occurs. This is accompanied by the division of the nuclei of the medulla and the fragmentation and fatty degeneration of the axis cylinder and medullary sheath. Degeneration does not extend gradually downward from the cut end of the fibre, but takes place with the same rapidity in the whole of the cut-off portion. The restoral of function in the cut nerve is brought about by the growth downward of the central ends of the cut fibres—of those fibres, in other words, still in connection with the nerve cells.[6] These push down in the paths of the degenerating fibres and ultimately become medullated and re-establish union with the peripheral organs, although this may be prevented if the fibres meet in their course any obstacle which turns them aside. There appears to be no choice of termination on the part of the fibre—for example, of a motor fibre for a muscle cell or of a sensory fibre for a sensory end-organ—for if the central end of a sensory nerve is sutured to the peripheral end of a cut motor nerve, the sensory fibres will innervate the muscle fibres formerly supplied by the motor nerve, and vice versa.[7] Also if the vagus and sympathetic be cut and the central end of the vagus cross-sutured with the upper end of the sympathetic in the neck, the vagus fibres growing upward in the paths of the degenerating sympathetic innervate the submaxillary gland and cause secretion on stimulation, and thus take on a secretory function.[8] Similar facts have been established by Langley for the fibres innervating the pupil and those erecting the hairs on the cat's neck, and by Cunningham and other observers in other nerves. The time required for the restoration of the function of the nerve will depend in part on the distance the nerve has to grow to re-establish union, and in part on the nerve which is regenerating. The longer the distance which the regenerating fibre has to grow before reaching its destination, the longer will be the time required for regeneration. On the other hand, nerves differ somewhat in their speed of regeneration or growth, and no doubt constitutional differences of this sort exist among different individuals. The time required is as a rule from two weeks to four or more months. For some reason the nerve fibres within the cord appear in mammals to have little power of regeneration if the cord is severed. The reason for this peculiar reaction is not yet satisfactorily explained. The subject is badly in need of careful investigation, since even the possibility of regeneration in mammals is not definitely disproved.[10]

Excitability.—Nerves are excitable—that is, they will respond to stimulation, at any point in the course of the fibre. No variation in excitability at different points of the nerve has been detected in any one nerve as long as it remains uninjured in the body,[11] but if the nerve is injured by cutting it or its branches, an increase of ex

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citability is brought about in the immediate neighborhood of the injury.[12] This increase in irritability is probably due to the electrical disturbance set up in the nerve by the injury and called the current of rest. This apparent variation in excitability, really brought about by injury following the cutting of branches of the nerve, has been described by Grützner and others, and was at first interpreted as showing variations in irritability in the normal nerve. It is easily demonstrated in the frog's sciatic in the neighborhood of the branches given off to the thigh muscles. The region of increased excitability extends about 5-7 mm. along the nerve from the point of injury.[12] While there is no variation in excitability in the same nerve, there is a considerable variation between the different motor nerves of the same animals, those nerves most frequently used appearing as a rule to be the most easily excited. Thus the sciatic nerve of the frog is far more irritable than the brachial nerve to all kinds of stimuli,[13] and sympathetic fibres appear less excitable than motor.

The change in the nerve which gives rise to the nerve impulse, *i.e.*, the excitatory change, may be caused in any one of the following ways: (1) By mechanical shock; (2) by heat of 38° C. or above; (3) by lowering the temperature of the nerve to +3° or −2° C.; (4) by taking water from the nerve; (5) by the action of specific chemical substances; (6) by electrical currents; and (7) by ether vibrations.

Mechanical Stimulation.—Mechanical stimulation, first discovered by Swammerdam[14] about 1650, may be brought about either by suddenly stretching the nerve, by shaking it, or by a sharp blow. Pressure gradually increased does not excite the nerve, though it at first increases its excitability.[15] Mechanical stimulation is seldom used in experimentation, as the nerve is generally crushed or injured by repeated shocks; but special appliances have been developed to avoid this so far as possible. Among these are the tetanomotor of Heidenhain[17] and the apparatus of Uexküll,[16] the former instrument delivering a series of sharp blows; the latter shaking the nerve. The excitability of nerves to mechanical stimulation varies greatly, and may be artificially increased or diminished. Thus the extraction of water from the nerve may render the latter so sensitive to mechanical stimulation that the slightest jar, or the lightest touch of the nerve with a glass rod will cause the discharge of a series of nerve impulses, causing tetanus of the attached muscle. The time relations of the stimulus and the resulting contraction are the same with mechanical and electrical stimulation. After a few blows a nerve may become non-irritable to further stimulation, but if left undisturbed it slowly recovers.[11]

Heat Stimulation.—A moderate degree of warmth (10–25° C.) diminishes nerve excitability. To cause the generation of a nerve impulse by heat the nerve must be heated suddenly to a temperature of 38° C. or higher. Heating a nerve quickly from 3° C. to 20° C. does not generate a nerve impulse. These facts show that it is not a sudden increase in heat or change in temperature of the nerve which stimulates, but the exposure of the nerve to a certain critical temperature; and this suggests that probably heat stimulates by coagulating some of the proteids of the nerve. This conclusion is supported by the fact that if the nerve is kept at 40° C. for a short time it loses its irritability permanently, although if it is exposed for a few moments only, an impulse may be generated and excitability restored if it is again cooled; and by the further fact that the temperature at which a nerve is stimulated by heat is about the temperature of coagulation of a proteid isolated by Halliburton from brain tissues, *i.e.*, 35–40° C. The restoral of irritability on recooling sometimes observed after a short exposure to 40°–45° C., is apparently opposed to the hypothesis that heat stimulation is due to coagulation; but this restoral may be owing to the coagulation having been but partial.

Cold Stimulation.—If the sciatic nerve of the frog is exposed to a temperature of 3° C. or lower, tetanus of the attached gastrocnemius muscle generally follows.[18] Cooling the nerve from 20° to 3° C. increases the excitability of the nerve to all stimuli, but does not as a rule generate nerve impulses sufficiently strong to produce muscular contraction. The cooling tetanus resembles that produced by drying the nerve, and there is thus a similarity between the physiological effects produced by cooling and those produced by the extraction of water, resembling that emphasized by Greeley in connection with the production of spores in infusoria. Below 0° C. or −2° C. the frog's nerve loses its irritability, but may be restored by very cautious warming. Mammalian nerves, according to Howell and others, lose their conductivity at 5° C., or even at a higher temperature, without preliminary stimulation.[19] It has been suggested that the tetanus produced by cold is due to mechanical stimulation by the ice crystals formed; but this is not probable, since the nerve may be stimulated at a temperature above the freezing point of the nerve, and the gradual rise in excitability as temperature is lowered shows that the final stimulation is but a culmination of a process going on as temperature falls. The increase in excitability produced by cold is true also for mammalian nerves (Biedermann). Conductivity, on the other hand, is reduced by cold. Not only does cooling increase the excitability of the nerve fibre, but the whole central nervous system may in the frog be brought by this means into a condition of increased reflex excitability resembling that caused by strychnine.[57] The increase of excitability produced by cooling culminating in stimulation may be compared to the precipitation of moisture from the atmosphere, and, as will be discussed on page 232, may be brought into relation with the change in state of the colloids in the nerve.

Drying Stimulation.—If nerves are allowed to dry in the air they gradually increase in excitability, and finally nerve impulses are generated sufficient, in the case of motor nerves, to cause a prolonged tetanus or series of twitches of the attached muscle. The dried nerve, like the cooled nerve, becomes totally non-irritable and very stiff, but its excitability may be completely restored by placing it in water or physiological salt solution. A similar drying tetanus is produced by placing the nerve in solutions of sugar, urea, glycerin, or other non-electrolytes having an osmotic pressure of thirteen atmospheres or over, that is, in solutions containing something more than a half-gram molecule of the substance to the litre, or by placing it in solutions of neutral salts of the same osmotic strength. Even neutral salts which by their own action annihilate nerve irritability will stimulate if strong enough to extract water rapidly. The stimulating action of solutions of nearly all non-electrolytes and many electrolytes except sodium salts and a few other compounds to be discussed later, is to be explained by the indirect osmotic extraction of water. If the water is extracted very gradually the nerve may be dried without generating impulses strong enough to cause muscle contractions. It has been suggested (Grützner) that this stimulation is really mechanical, due to shock or compression of the nerve substance by the shrinking tissue, but this is probably not the case. A probable explanation of this stimulation will be found on page 232 and may be confidently ascribed to a change in the nerve similar to that produced by cold.

Chemical Stimulation.—The excitation of the nerve by chemicals was first observed by Swammerdam in the seventeenth century. It has been studied by von Humboldt, Eckhard, Kölliker, Kühne, Grützner[20] and many others. The earlier work established the general fact that the application of solutions of many non-electrolytes and electrolytes would stimulate motor and sensory nerves. The strong solutions which were used led to the conclusion that most chemicals stimulated indirectly by the withdrawal of water, a conclusion which was undoubtedly correct. The first careful work comparing solutions containing the same number of molecules in the litre was done by Grützner, who showed that some other factor entered into the stimulation besides the withdrawal of water. He was unable to discover what this was, but

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referred it to a specific stimulating action of the salts. Thus sodium fluoride and other sodium salts and some alkalies stimulated in solutions too weak to draw water from the nerve. Grützner found that with certain exceptions a relation existed between molecular weight and stimulating or poisonous action. In salts of the same series those of greater molecular weight stimulated more and poisoned more rapidly. Thus sodium iodide was stronger than the bromide, and this than the chloride. Barium chloride was more baneful than strontium chloride. Grützner believed that sensory nerves were more readily stimulated by potassium salts than by sodium, while motor nerves were not stimulated by potassium salts, but were by sodium. This conclusion is not correct. The author's observations[21] on a large number of salts, acids, and alkalies gave the following results: The frog's sciatic is stimulated by immersion in solutions of any salt, if this be sufficiently concentrated. This stimulation, as already stated, is brought about osmotically. If the solutions have an osmotic pressure no greater than that of the nerve—*i.e.*, approximately six atmospheres—only solutions of electrolytes will stimulate; the non-electrolytes are ineffective. Of these electrolytes all sodium salts of monovalent or bivalent acids, with one or two possible exceptions, will stimulate in isotonic solutions. The similar salts of other metals, such as potassium, lithium, calcium, strontium, magnesium, zinc, silver, mercury, aluminum, iron, and ammonium, will not stimulate, but gradually annihilate irritability. Of the sodium salts the monovalent salts, such as the chloride, bromide, iodide, nitrate, and acetate, are least powerful; the bivalent salts, such as the sulphate, oxalate, tartrate, and borate, are from two to three times as powerful as the monovalent; while the trivalent salts, such as the citrate, ferro- and ferricyanides, and the phosphate, are about six times as powerful as the monovalent salts. This shows that the stimulation is due to the anion and not to the cathions, and further, that it is dependent in part upon the number of electrical charges on the anion. In other words, chemical stimulation is really due to the negative electrical charges of the salt, and chemical stimulation is an electrical stimulation. The positive ions have an effect opposite to that of the anions, and tend to prevent stimulation and lower irritability, and this is due to the positive electrical charges which they bear. Thus potassium, lithium, ammonium, and hydrogen not only will not stimulate the nerve except in strong solutions or when united to still more powerful trivalent anions, but they annihilate nerve irritability very rapidly. All acids destroy nerve irritability rapidly unless applied in very dilute solutions. In some acid salts, however, such as copper sulphate, a nerve may remain highly irritable for several hours. In solutions having a strength of one-fifth normal or higher, acids will often stimulate (osmosis ?), but below this strength they annihilate irritability. Of the alkalies, sodium, potassium, and barium hydrates stimulate in dilutions not greater than one twentieth normal; ammonium hydrate will not stimulate the motor nerve, but destroys its irritability. This is in harmony with the small dissociation of the compound. Of the oxidizing salts the permanganates will stimulate both in the case of potassium and in that of sodium, in one twelfth or one-fourteenth molecular solutions. Of the monovalent sodium salts the fluoride, iodide, bromide, and chloride stimulate in the order named, the fluoride being the strongest. Something besides the number of charges is thus seen to be of importance. The author has suggested that this is the movement of the charges about the atom, but this is as yet hypothetical. The general result of this work is that positive and negative ions act as a rule in an opposite manner, and that chemical stimulation proper, as apart from stimulation by osmosis, is in reality an electrical stimulation and produces the same kind of a change in the nerve as does electrical stimulation.

Electrical Stimulation.—Nerves may be stimulated electrically in several ways, but the end result is a disturbance of the electric equilibrium, if we may so term it, within the nerve and a resulting change in the nerve itself which causes the nerve impulse. One way, as has just been shown, is to introduce the electrical charges into the nerve in the form of ions in solution, but the more usual method of stimulation is to change the distribution of charged particles already in the nerve and thus upset electrical equilibrium. The nerve may be stimulated by induction by bringing near the nerve a highly charged Leyden jar and suddenly discharging the jar, or, as in unipolar stimulation, by connecting the nerve with one pole of an induction coil, when on making and breaking the primary circuit stimulation may ensue.[22] In both these cases, at the moment of making or breaking the current, there is a sudden equalization of the charges which have been accumulated in the nerve by induction. In other words, the electrical equilibrium is upset by induction. Herz waves may stimulate a nerve which is near the induction machine, but the nerve quickly loses its irritability and conductivity under their influence.[23] The exact manner of action of the Herz waves has not been clearly determined. Induced currents from the inductorium and constant currents from the battery are the forms of electrical stimulation most generally used. Both these currents stimulate in the same way, the differences between them being due only to differences in intensity and duration of the current. The most probable explanation of their action, speaking in general terms, is that they alter the distribution of ions in the nerve, the negativity of the nerve being increased in the neighborhood of the cathode owing to the predominance here of negative ions and the positivity in the neighborhood of the anode. In this way a disturbance of electrical equilibrium within the nerve is produced. It appears that to bring about this disturbance of equilibrium with sufficient suddenness to cause a nerve impulse, polarization must take place in the nerve. This polarization is due to the fact that the membranes surrounding the axis-cylinder process do not permit free osmosis of the salt particles in the nerve through them. It thus happens that when a cathode is brought against a nerve, the negative ions which are repelled from it or are diffusing into the nerve from it accumulate against the outside of the membrane lining the axis-cylinder process. This accumulation of negative particles on the outside of the membrane holds bound to it on the inside the positively charged sodium particles or other positive ions in the nerve in that region. This disturbs the electrical equilibrium of that part of the nerve, as it leaves a surplus of unbound negative charges in the nerve at that point. It is this sudden surplus of negative charges which sets up in the nerve that change which causes the nerve impulse. What the nature of that change is we shall shortly discuss, but it may be said here that it consists possibly in a change in the nature of a precipitation taking place in the colloids of the nerve, strictly analogous to the changes produced by cold or by the extraction of water.

A study of the phenomena of electrical stimulation has led to the general law that that form of electrical stimulation is the most effective in which the intensity of current is greatest and reached in the shortest time.[22] In other words, stimulating power is a function of the intensity and of the reciprocal of the time. For this reason sharp shocks of great intensity, such as induction shocks, are more efficient than the galvanic current, and the break-induction shock is more powerful than the make, as in the latter the rise is more gradual owing to self-induction in the primary coil. Too rapidly repeated shocks will not stimulate, and at 15° C. a duration of 0.0015 to 0.02 second is necessary. Shocks more rapid than three thousand per second generally cause but a single initial muscle twitch.

It has been shown that the nerve impulse does not arise throughout that portion of the nerve which is traversed by the current, but only at its point of exit and entry. The point of entry of the current into the fibre is called the physiological anode, and that of exit is called the physiological cathode. The impulse is formed at the cathode on making the current and at the anode on breaking it.

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This may be easily demonstrated by ligaturing the nerve between the electrodes so as to interrupt the conduction of a nerve impulse at this point, when it will be found that the muscle will contract only at the making of the current when the cathode is on the muscle side of the ligature and at the break of the current when the anode is on the muscle side of the ligature. It is a curious fact that if either electrode is placed on a portion of the nerve which has been rendered non-irritable by ether or in any other way, the impulse which normally is produced by that electrode no longer appears. It looks as if the passage of the current from a non-irritable to an irritable portion of the nerve will not stimulate. The reason for this fact of polar failure is still obscure. Electrical stimulation taking place at the cathode at the make of the current is thus shown to correspond to chemical stimulation. It is always an increase in the number or efficiency of the negative ions or a diminution in the number or efficiency of positive ions which stimulates. The positive electrode, as we shall see, diminishes excitability like the positive ions. It makes no difference whether the charges are applied to the nerve on atoms in the form of ions, or from a battery, the effect on the nerve is the same. Electrical stimulation quickly exhausts the excitability of the nerve at the point stimulated, unless the current is frequently reversed. This exhaustion is frequently attributed to electrolysis; but as it occurs also with non-polarizable electrodes, it is due not to electrolysis but to changes brought about in the condition of the nerve, or, more properly speaking, its colloidal particles, by the changed distribution of ions in the nerve. In using the induction shocks where reversal of the current occurs with every make and break shock, exhaustion is far less apt to happen than when a constant current is used.

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The action of electrical currents on the nerve does not end with the initial stimulation but continues during their passage, and will be discussed later under the heading of electrotonus. Suffice it to say here that under ordinary circumstances, and unless the excitability of the nerve has been artificially increased by local cooling in the neighborhood of one electrode, or by drying, or by the chemical action of sodium chloride or other substances, the current generates a nerve impulse large enough to cause muscle contraction only at the moment of opening and closing the circuit. If, however, the local excitability of the nerve is increased in the neighborhood of one of the electrodes in any of the above ways, a series of nerve impulses causing tetanus may be produced, lasting throughout the passage of the current or occurring after its close.

Modification of Excitability.—The excitability of a nerve at any point may be artificially increased or diminished. The local application of cold increases excitability down to about +2° C. for the frog's nerve and somewhat higher for the mammalian. Below this point excitability rapidly falls. Local warming diminishes excitability until a temperature of about 35° C. is reached, when excitability again increases. The excitability of the nerve is increased by local injury such as section, or mechanical pressure, or heat action. For about 5 mm. from the cut end of a nerve this increase in excitability is well marked. This increase may be due to the electrical disturbance or current of injury in the neighborhood of the injured part, a condition of catelectrotonus prevailing at this point. In all electrical stimulation the disturbing influence of this nerve current has to be considered. The local application of alcohol, ether, carbon dioxide, or chloroform is said to increase excitability at first (Waller) before anæsthetization takes place. Waller observed an increase in the size of the negative variation when these agents were used. It is not impossible, however, that it is the conductivity which is altered, the general analogy between the effects of these agencies and moderate warmth elsewhere strengthening this supposition. Excitability is enormously increased by drying the nerve, or by taking water from it by osmosis. It is increased further, temporarily at least, by allowing the nerve to lie in one-seventh normal sodium-chloride solution, or by a brief exposure to the sulphate, citrate, or other stimulating sodium salts, and it is diminished by hydrogen, potassium, lithium, ammonium, calcium, and other positive ions. Distilled water at first increases excitability and then diminishes it. Excitability is also powerfully influenced by the passage of a constant current through the nerve, being greatly reduced in the region of the anode and increased in the neighborhood of the cathode while a current of moderate intensity flows through the nerve. Excitability increases in the neighborhood of the anode on breaking the current. The changes in excitability thus produced will be discussed under the heading of Electrotonus.

SUMMARY.—*Excitability.*—The facts concerning excitability just stated are most readily interpreted by assuming that all the agencies which stimulate or increase excitability do so by producing the same sort of a change in the nerve protoplasm. What that change is we are not yet in a position to state definitely; but the many striking resemblances of the process to the reactions shown by colloidal solutions strongly indicate something more than a passing similarity between the two processes. The facts may be conveniently interpreted if we assume the nerve to consist of electropositive colloidal particles and stimulation to consist in the coalescence or gelation of these particles. The action of cold, of mechanical shock, of negative ions, and of the negative electrode in stimulating may on this hypothesis be easily reconciled, all of these agencies acting in the way specified to produce gelation. This matter will be considered at the end of the article more in detail. The various agencies which diminish excitability diminish the tendency of the particles to coalesce.

Conductivity.—The principal function of a nerve is the conduction of a nerve impulse. Conductivity is not something peculiar to the nerve, but is found in all protoplasm. In the sensitive plants, for example, in the absence of nerves an impulse is propagated from place to place through the cells at a fairly rapid speed. This observation allows us to disregard at once such elements as the medullary sheath or longitudinal fibrillæ of the nerve as unessential in the matter of conduction. As protoplasm without these structures still conducts, it is clear that whatever rôle they may play in determining other factors of conduction, for example speed, they are not essential to conduction itself. Conduction takes place in any nerve in either direction with the same ease. Thus if a nerve is stimulated in the middle the impulse passes both downward and upward and may be detected by the negative variation or electrical disturbance which the nerve undergoes. The effect of this impulse passing downward in a motor nerve is apparent in the muscle contraction; what effect the impulse passing upward to the motor cell may have is not yet determined. The rate of conduction varies in different nerves. It is highest in mammalian nerves and in the frog's sciatic, *i.e.*, 25 to 40 metres per second. In the lobster it travels 6 metres per second; in the mollusc, Anodon, only 1 cm. per second; in the mantel of Eledone 1 mm.; and in the electric nerves of the Torpedo at 5° C. 9 metres per second. At a higher temperature Schönlein found a rate of from 12 to 27 metres per second.[34] In the plant Dionæ, conduction, according to Burdon Sanderson, occurs at the rate of about 200 mm. per second at 30°–32° C. No optical changes have been observed in the nerve accompanying the passage of the impulse, but in the insectivorous plant Drosera and in other plants Darwin observed that the passage of the impulse was accompanied by the appearance of a cloudy precipitate in the cell protoplasm, this precipitate shortly dissolving. This precipitation he called aggregation and compared it to the nerve impulse.

Influence of Temperature.—The speed and character of the nerve impulse are influenced by temperature. Bernstein observed an increase in the height of the muscle contraction if the impulse passed through a warmed area. Howell and Budgett secured similar results in the vaso-constrictor mammalian nerves. Waller found that

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a temperature of 10° C. abolished the negative variation and conduction. In the frog's sciatic a temperature of 0° C. does not block the action current and the impulse, but at −2° to −7° C. both are blocked. Between 8° and 35° C. little effect of changes in temperature can be seen. Herrick[25] found that between 10° and 35° C. there was no change in the negative variation, but below 10° C. the negative variation diminishes. In general a low temperature slows and prolongs the negative variation, and a high temperature causes an increase in height and a diminution in duration. In mammals a temperature of 2° or 6° C. blocks conductivity, but conduction returns on warming. The fibres going to the abductors of the larynx are blocked by cold before the adductors.

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The Electrical Phenomena of Nerves.—The electrical phenomena of nerves were first studied accurately by Du Bois-Reymond in 1843–45. Like all protoplasm a nerve shows a difference of potential between the uninjured and the injured portions. This difference is of such a character that the injured part appears negative to the uninjured. Thus Du Bois-Reymond found that if two electrodes connected with a galvanometer be placed one on the cut end of a nerve, the other at some point on its surface, a current flows in the circuit from the uninjured surface toward the cut end and may be detected by the deflection of the galvanometer. This current is called the current of rest, or of injury, or the demarcation current of the nerve, and it may amount to 0.0035 to 0.02 volt. The amount of this current is about the same in warm- and cold-blooded animals. Besides this current, which is at its maximum between the equator and the cut end of the piece of nerve, there is a difference of potential between the two ends of a nerve, so that if the two cut surfaces of a motor nerve or a sensory nerve be connected with an electrometer there is a small axial current. In a motor nerve this axial current flows in the nerve from the peripheral to the central end, and in the sensory roots in an opposite direction.[26] The amount of this axial current is not great, but the current is constantly present, and is greater in the posterior than in the anterior roots. In the anterior it amounts to about 0.0006 of a Daniel, in the posterior roots to 0.0015 of a Daniel. The electromotive force of the nerve current of injury is said to be greater in a nerve used constantly, like the pneumogastric, than in other motor nerves. In non-medullated nerves the current is greater than in medullated. This current of rest or of injury persists for some time, becoming constantly weaker, but may be still detected several days after section when the excitability is entirely lost. Although the direction of the nerve current is ordinarily in the sense already mentioned, it may be reversed by high temperature and by desiccation. By appropriate means a nerve may be prepared which shows no current of injury. Thus if a frog's sciatic is removed from the body and placed in frog's blood containing a little calcium, the nerve after several hours is said to show no injury current whatever.[27]

It is probable that the current of injury may be increased or diminished in many different ways, but this subject has not yet been sufficiently investigated to allow us to classify the facts in any general group. Ether diminishes the current as do acids; alkalies increase the current.

The cause of the current of injury is, as its name implies, probably to be attributed to chemical or physical changes taking place in the nerve at the point of injury more rapidly than elsewhere. There are several explanations of this change. Du Bois-Reymond, who supposed the nerve to be made up of bipolar electric particles, of which the two ends were negative and the middle positive, believed it to be due to the exposure of the negative ends of the particles by the section. Hermann[28] refers it, as do most authors, to the alterations in the state or composition of the protoplasm at the injured point. The author has suggested that this change consists in the increase in size or the coagulation of the positively charged colloidal particles of the nerve brought about by the injury, thus causing a change of their surface of separation from the fluid leading to the liberation of formerly bound negative charges. It is impossible, however, at the present time to state positively what the real explanation is.

Negative Variation.—Du Bois-Reymond[22] discovered about 1843 that if one electrode from a galvanometer be placed on the cut end of a nerve and the other on its longitudinal surface, on stimulation of the nerve the needle of the galvanometer, which had been deflected by the current of injury, receded momentarily toward zero. This electrical disturbance he called the negative variation or current of action. It has since been shown that this electrical disturbance generally or invariably accompanies the nerve impulse and is a convenient way of detecting the passing of such an impulse. The variation follows mechanical, heat, or chemical stimulation as well as electrical. It occurs in plants and muscles and secreting epithelia as well as in nerves. The variation is of such a nature that the first electrode reached by the impulse becomes negative to the other. The negative variation is biphasic, that is, a positive phase follows the negative. The negative variation travels at the same rate as the nerve impulse, and shows other parallelisms which clearly indicate its close connection with the phenomenon of conduction. Thus exposure of the nerve to carbon dioxide, ether, or chloroform is said to cause a preliminary rise in excitability and an increase in height of the negative variation, both conduction and the negative variation being later abolished;[29] a ligature abolishes both the variation and the conduction; cold lengthens the duration of the negative variation, but diminishes its height, and warmth increases the height and shortens the duration. These facts so clearly establish the parallelism between the negative variation or action current and the nerve impulse that by most physiologists the electrical disturbance is regarded as an invariable concomitant of the nerve impulse. Others hold a different opinion, however. Cases are on record in which the cooled muscle of a frog has contracted, following a stimulus not accompanied by a negative variation; and in other instances the negative variation may be detected without muscle contraction. Steinach found in warmed frogs tetanus produced with the secondary coil 43 cm. from the primary, while the negative variation first appeared when the secondary coil was at a distance of 39 cm. Boruttau believes that in the one case the muscle is a little more sensitive than the electrometer, and in the other the latter is more sensitive than the muscle. The size of the negative variation is proportional, as a rule, to that of the current of injury, and up to a certain point a larger stimulus causes a larger negative variation and a larger muscle contraction. The negative variation is increased by catelectrotonus and diminished by anelectrotonus. A negative variation occurs also in the tetanus due to natural stimulation of the nerves of strychnine frogs. The cause of the negative variation and its relation to conduction will be discussed on page 232.

Electrotonus.—If two electrodes from a battery are placed upon a nerve, a nerve impulse is generated at the cathode or negative electrode when the current is made, and at the anode or positive electrode when the current is broken, provided the current be fairly strong. While the current flows through the nerve no impulses are as a rule generated, but nevertheless a change in irritability is brought about in the nerve. This change of irritability and conductivity in the region of the electrodes has been carefully investigated by Pflüger and is called electrotonus.[30] The irritability of the nerve is increased in the neighborhood of the cathode during the passage of the current and diminished in the neighborhood of the anode; after the current is broken the anodic region undergoes a rise in irritability and the cathodic region a fall. These changes may be demonstrated by stimulating the nerve in the region of the cathode or anode with stimuli just strong enough in the normal nerve to cause muscle contraction, when if applied to the cathodic region an increased muscle contraction is obtained; if ap-

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plied to the anodic region no response follows. If the current is strong and continued for some time the cathodic region also becomes less irritable. The strength of current necessary to produce electrotonic effects is very small, 0.0001–0.00001 milliampère may suffice. Sensory nerves show the same phenomena of electrotonus as motor, although Zirhelle thought that both the anode and the cathode diminished excitability in the former. Exceptions to the general statement that irritability is increased by the cathode and diminished by the anode have been noted by several observers, *i.e.*, Budge, Schiff, Valentine, and others. Irritability may increase (though very rarely) in anelectrotonus, and Nasse has observed several cases of the total reversal of the law. The cause of these rare exceptions is not yet clear.

Although the constant current only changes excitability but does not ordinarily excite during the passage of the current, yet in some cases a tetanus of the muscle is observed during the passage of the current, or after it is broken.[39] This tetanus, called Ritter's tetanus, arises from the cathode if it occurs during the passage of the current, and from the anode if it occurs after the current is broken. This tetanus may be artificially produced at will if the excitability of the nerve is increased by cooling, by drying, or by the osmotic extraction of water. This tetanus demonstrates the fact that the changes going on in the nerve during the passing of the current are of the same nature as those which produce the impulse. The current really stimulates throughout its passing, only the changes produced after the current is once applied are too gradual to cause a muscle contraction. If, however, the excitability of the nerve is already artificially raised (that is, if the instability of the nerve substance is artificially increased), the change is sufficiently abrupt to generate nerve impulses so that a number of muscle contractions take place during the passage of the current. It is necessary to bear these facts in mind, since the law of electrical excitation is ordinarily stated in the way mentioned—*i.e.*, that excitation occurs only at the make and break of the current.

The explanation of these electrotonic changes of irritability is not difficult on the colloidal hypothesis already sketched. The primary effect of the current is to cause a disturbance in the even distribution of the ions in the nerve. Positive ions predominate in numbers near the anode, negative ions near the cathode. These ions bring about a change in the state of the colloids. Near the anode the positive ions increase the stabililty of the protoplasmic hydrosol, the colloidal particles are here increasing in numbers and increasing their total surface; near the cathode, on the other hand, the colloidal particles, owing to the presence of negative ions, are diminishing in numbers, increasing in size, and diminishing the surface of contact. The stability of the hydrosol is being reduced near the cathode, and, in accordance with the general law stated farther on, excitability varies inversely with the stability of the protoplasmic hydrosol. If this change is abrupt, so great a contraction of surface of the particles takes place that an impulse is generated strong enough to reach the muscle and cause muscle contraction. If the change is gradual, as it is after the first application, the change is not strong enough at any moment to cause an impulse large enough to reach the muscle. Stimulation takes place at the anode on opening, and excitability is increased here owing to the fact that on breaking the current the positive ions accumulated here in excess diffuse into the region formerly occupied by the cathode, and the negative ions from the cathodic region by diffusion reach the anode. There is thus produced in the neighborhood of the anode a diminished positivity or an increased negativity. The equilibrium of the solution is at once upset, the positive colloidal particles suddenly diminish in numbers and surface and increase in size owing to this diminution of positive ions, and this generates, as always, a nerve impulse which may continue, causing tetanus. Thus the rise in irritability near the anode is explained. Similarly in the region of the cathode, on breaking the current there is a sudden diminution of the negativity of this region and an increase in positivity due to the diffusion into this region of the positive ions from the anode. The result is that a sudden increase in number and surface of the particles results and conductivity and irritability are accordingly reduced. In other words, a process of solution is occurring near the anode and of gelation near the cathode during the passing of the current; after breaking the current the reverse of these processes occurs. It may be stated that these changes, although not visible in nerves, may be readily seen in infusoria and other forms of protoplasm, and the change in state of the protoplasm is of an opposite character at the two poles, liquefaction generally occurring on the anodic side.

Besides the changes in irritability of the nerve produced by the current, there are changes in its electrical behavior at the same time. Polarization takes place, so that on breaking the current a reverse current in the opposite direction may be observed. This polarizing current often reverses itself, running first in one direction and then in the other. This reversal is less pronounced in nerve than in muscle and is absent in dead muscle. These facts show that the polarization current is due not only to a physical polarization taking place at the limiting membranes of the nerve, but also to a change in state of the protoplasm. The polarization current may take place in the same direction as the original current, particularly after heavy currents of very brief duration.

While a constant current passes through a nerve electrical disturbances may be seen on both sides of the electrodes. If electrodes connected with a galvanometer are applied on the anodic side, it will be found that each point nearer the electrode is positive to that farther away, and if on the cathodic side negative to that farther away. We thus get physical electrotonic currents. These currents are due in large part, if not altogether, to the polarization taking place at the boundary of the axis-cylinder process, causing a spread of the current along the nerve.[31] They are, however, not altogether explicable on this hypothesis, for they disappear in dead and disintegrating nerves; they are greatly reduced by etherizing the nerve; and they are suppressed if the nerve be ligatured between the polarization current and the galvanometer electrodes. The currents are more powerful near the electrodes and their intensity is greater on the side of the anode than on that of the cathode. The anelectrotonic current may have an electromotive force of 0.5 of a Daniell, while the catalectrotonic current has but 0.05 Daniell. These currents are sufficiently strong to stimulate other nerves in contact with those stimulated. They exist in non-medulated as well as medullated nerves. They may be reproduced on artificial nerve models called core-conductors, consisting of a wire surrounded by a solution of an electrolyte. The suppression of the current by ether may be due to a diminution of polarization owing to an alteration of permeability of the axis-cylinder wall.

Indefatigability of Nerve.—Nerves are not supposed to be fatigued by the act of conduction. Bowditch[32] curarized frogs, thus blocking the nerve impulse and protecting the muscle from fatigue. The nerve was then stimulated by induction shocks continuously for six hours; at the end of that time the curare was excreted and the muscles began to contract. A similar experiment was tried by Maschek, who blocked the impulse by ether, and by Bernstein,[33] who blocked the impulse by the anode and with the same results. These facts indicate that nerve conduction is not accompanied by metabolic changes.

Metabolism of Nerve.—The only evidences of metabolism in nerve are the changes produced in it by cutting it off from its nerve-cell connection and Waller's observations on carbon-dioxide formation. No heat is produced by nerve conduction. Electrothermic contacts sensitive to 0.001° C. show no indication of heat production.[34] Similarly all attempts to show that carbon dioxide or acid are produced have been fruitless. Waller says that after exposures for a brief interval to carbonic anhydride

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nerve irritability is increased and the size of negative variation is increased. The same result is obtained if the nerve is tetanized; so Waller concludes that carbonic anhydride is produced during tetanization. As many other factors affect the negative variation in the same way, we cannot conclude from this observation that the conduction of the nerve impulse is accompanied by a metabolic change, leading to carbonic-anhydride formation.

The Action of Anæsthetics.—The anæsthetics, chloroform, ether, carbon dioxide, and alcohol all temporarily annihilate nerve conduction, although some observers state that a preliminary rise in excitability is their first effect. If not exposed too long to the action of the anæsthetic the nerve will recover; but if too large an amount is used, or if the exposure is too long, irritability and conductivity appear to be permanently lost. Chloroform is much more active than ether and the nerve recovers from it with much greater slowness. This may be due to its being less volatile than ether and hence escaping less readily from the nerve or to its having a more powerful action. The most probable explanation of the action of the anæsthetics is that they dissolve the lecithoproteids or colloids of the nerve. Mayer[55] and Overton[56] have pointed out the parallelism of the anæsthetic action to the fat-dissolving powers of the anæsthetics. The nerve is particularly rich in lecithin compounds, and it is not improbable that the anæsthetics act upon them. The dissolving action of these substances may be easily seen in blood corpuscles, the eggs of many marine forms and other organisms, so that it is probable that they act on nerve protoplasm in the same manner. There is, hence, nothing peculiar about the action of the anæsthetics. They produce the same kind of a change in protoplasm as do positive ions, the positive electrode, or warmth. They put the nerve in a condition of anelectrotonus. They are particularly valuable because they are so soluble in protoplasm, so volatile, and effective in such small amounts.

General Summary.—We are now in a position to see how far the foregoing facts enable us to understand the processes in the nerve which are represented in the nerve impulse. There have been several hypotheses thus far proposed to explain these phenomena. One of the earliest was that of Du Bois-Reymond. In this theory the nerve substance is supposed to be composed of bipolar electrical particles negative at each end and positive in the middle. The current of rest is obtained by connecting the middle or positive surface with the cut end or negative surface. As each portion of a magnet shows the polarity of the whole magnet, so each portion of a nerve shows the polarity of the whole nerve. The nerve impulse is simply a turning of these particles on their axes, so that the negative ends turn toward the surface. This will explain the action current.

Hermann believed that these particles did not pre-exist, but that the current of injury was due to catabolic changes taking place at the cut surface. This became negative to the rest in consequence of these chemical changes. A similar change occurred during conduction, and this change in each part of the nerve caused the part just following it to be put in a position of catelectrotonus. On this theory the negative variation stimulated each part of the nerve in turn and was itself regenerated by the change which it brought about.

Becquerel supposed that there were numerous electrocapillary couples in the nerve which gave rise to electric currents, each couple, consisting of two different liquids, being separated by a capillary opening or by an organic membrane. D'Arsonval, who has developed this theory, supposed the electrical phenomena to be due to modification of the surface of separation of the two liquids similar to the electrical phenomena shown by the capillary electrometer.

Loeb has suggested that conduction is due to a change in state of the colloids, but has furnished no evidence in support of this view. The author believes that the facts indicate the truth of this hypothesis and suggests the following more specific theory:

The protoplasm of the nerve is essentially a colloidal solution. The colloidal particles are proteid in nature and in all likelihood are lecithin proteids resembling the sheaths of the red blood corpuscles, as is indicated by the especial richness of the nerves in lecithin. These particles are of different sizes and are electropositive. They continually change their state of aggregation, being easily precipitated or brought into solution and easily coalescing with their neighbors or breaking up into a large number of smaller particles. Through these changes the surface separating each particle from the surrounding fluid augments or diminishes. When two particles coalesce the total surface is reduced; when one particle separates into two the total surface of separation is increased. Around each particle there are induced in the water electrical changes of an opposite sign. It will be seen that any change in the surface of separation must necessarily produce an electrical disturbance exactly in the same manner as do the movements of the capillary electrometer, and in this respect my suggestion harmonizes entirely with that of D'Arsonval.

Stimulation, whatever its character, whether mechanical, chemical, thermal, or electrical, brings about a change in the state of division of these colloidal particles. It produces either one of two effects, *i.e.*, a coalescence of the particles (gelation), or an increase in number of the particles (solution). According as a stimulus produces one or the other of these effects we say that it excites the nerve or anæsthetizes it. It may fairly be questioned which effect is the excitation and which the anæsthetization. This question may be answered, I believe, by the exciting action of drying the nerve and of applying cold. Both of these processes excite or generate nerve impulses. Since they can hardly be supposed to increase the solubility of the colloids, we may confidently assume that they congeal or precipitate the colloids, and hence that excitation is due to a diminution in the number of colloidal particles and a reduction in their total surfaces; and conversely, anæsthetization or inhibition is due to the reverse process. All the exciting agencies may be interpreted in this way. Thus mechanical shock which disturbs the hydrosol brings about such a condition of temporary coagulation or rigidity of the nerve protoplasm throwing the particles together. This interpretation is strengthened by Mrs. Andrews' observations on the effect of shock on the choano-flagellates, where the rigidity of the previously fluid protoplasm can be easily demonstrated, and by my own observations on other forms of protoplasm, notably eggs. Cold, as will be seen, diminishes the stability of the protoplasmic solution or hydrosol, while warmth increases it; negative ions precipitate positive colloidal solutions and they excite the nerve; excitation takes place at the cathode or negative electrode, where positive colloidal particles will be precipitated; the extraction of water acts in the same manner as cold. In fact all the phenomena of excitation are readily understood on this hypothesis. Similarly the action of all anæsthetizing agents becomes clear. Positive colloidal solutions are rendered more permanent by positive ions, and these annihilate nerve excitability; warmth of moderate amount increases the stability of nearly all solutions, and this diminishes excitability; ether and the anæsthetics dissolve the protoplasm of eggs and other cells and destroy irritability; the anode, which holds positive colloids in solution, abolishes excitability. We may sum up our conclusions in the general law that nerve excitability varies inversely with the stability of the protoplasmic hydrosol. The less stable the hydrosol, the more irritable the nerve. Irritability will be lost when the nerve is stable, either in the condition of solution or in that of total gelation. The rise in irritability at the anode on opening the current is due to the fact that, as already explained, by the action of the current the particles are greatly divided; and after the current is broken the diffusion outward of the positive ions reduces the stability of the hydrosol here and it returns back toward the normal. The electrotonic effects are due to the solution being made more stable near the anode and less stable near the cathode.

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As readily as the facts of excitation are understood on this hypothesis, so many of the facts of the electrical phenomena of nerves may be explained. The electrical disturbances are the result of the alterations in the surface of separation of particles and liquid. Whenever these particles coalesce, a portion of the negative charges, formerly induced about each particle, are set free. The portion of the nerve where this is occurring becomes temporarily electronegative to the rest of the nerve. Thus the current of injury is due to the coalescence of particles at the injured end. This is always negative to the uninjured part.

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If this is true, the exposure of the end of the nerve to acids or anæsthetics should diminish the current of injury, whereas alkalies should increase it. Such I have found to be the case. The current of action is the result of the progressive precipitation of the colloids and a progressive setting free of negative charges. It is, however, impossible within the limits of this article to discuss the bearing of this hypothesis on all the numerous electrical phenomena of nerves. It may be stated, however, that a warmed or etherized portion of a nerve is electropositive; a cooled portion electronegative to the normal nerve.

The conduction of the nerve impulse may be understood on this hypothesis as follows: Each precipitation of colloidal particles sets free by the accompanying reduction in surface negative charges formerly induced in the water about each particle: these charges at once precipitate the next layer of particles, and so on. Thus the negative variation successively stimulates each following segment of the nerve, as Hermann supposed, and it is regenerated by the change which it itself has produced. The sheath and peculiar structure of the nerve probably, as Boruttau supposes, plays an important part in the electrical phenomena of polarization and stimulation, and possibly in determining the speed of transmission, but the change in the protoplasm itself is the most important factor in conduction. Finally, it should in all fairness be stated that among the difficulties or exceptions to this hypothesis are the statements that the anæsthetics bring about a preliminary rise in irritability, and that conductivity and excitability may vary somewhat independently of each other. Whether these facts can be harmonized with the explanation already offered remains for the present unknown.

Albert P. Mathews.

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NERVES, PATHOLOGICAL CHANGES IN. See *Neurone, etc.*

NERVE TISSUE, HISTOLOGY OF.—According to the fundamental conception of neurology the entire nervous system, central as well as peripheral, has been regarded as composed of morphological units, the neurones, held together by the supporting tissues, the neuroglia. The term neurone was suggested by Waldeyer in 1891, and was accorded almost universally an international acceptance by anatomists, physiologists, pathologists, and clinicians. The term neura, proposed by Rauber, and neurodendron by Kölliker, to designate the same unit, have not met with similar favor. More recent investigations, however (Apàthy, Betha), have thrown some doubt upon the neurone doctrine as formerly held. The neurone consists of a cell body, dendritic processes, and an axis-cylinder process (axone with its terminal ramifications). As the neurone does not consist only of the cell body, but also has processes, some of which are of extreme length, it is impossible to see the entire neurone in the majority of cases. As a matter of convenience, therefore, the description of the neurone may fall under two headings—the nerve cells or nerve-cell bodies, and the nerve fibres.

The Nerve Cell.—The essential part of a neurone originating the nerve impulse is the cell body. Nerve cells or ganglion cells, as they are generally called, occur in groups known as ganglia in the cerebrospinal system, the sympathetic system, and in the organs of special sense. While variable in size, they are among the largest cells in the body, often, as in some of the ganglion cells in the anterior horns of the spinal cord, reaching a size of from 90 to 135 μ, the cells of Betz in the paracentral lobule being especially large. Many nerve cells, however, are much smaller in size, the cells of the granular layer of the cerebellum being only from 4 to 8 μ in diameter.

Study of the morphology of the neurones requires the consideration of their external peculiarities as well as of their internal architecture. The former are best revealed by the methods of Golgi and Ehrlich, and the latter by the methods of Nissl and Held.

Morphology of the Nerve Cells.—Nerve cells vary greatly in shape. Starting originally as spherical cells, some may retain this shape as in the spinal, Gasserian, or other ganglia; others may become ellipsoidal, as in the spinal cord, pyriform as the cells of Purkinje in the cerebellum, pyramidal as the cells in the gray matter of the cerebrum, or stellated as the multipolar ganglion cells of the spinal cord. The most conspicuous peculiarity of the nerve cells is the branching. This may take place only on one side leading to a prolongation of the protoplasm into a single pole, such cells being known as unipolar nerve cells; when the protoplasm is prolonged into two, usually opposite, poles, the cells are appropriately designated as bipolar; when the protoplasm extends in several directions multipolar cells are formed. Each polar prolongation is continued to form a nerve-cell process. Of such processes two kinds are recognized, the branched *protoplasmic processes* and the *axis-cylinder process.*

The branched protoplasmic processes, now usually called the *dendrites*, form prolongations of the protoplasm from the cell body, hence the old name of protoplasmic process. They are always broader and thicker at their origin, becoming gradually narrower as they divide,

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Nerve Tissue.

splitting up and subdividing in an antler-like fashion until a rich twig-work or arborization results. The group of terminal end-branches of the dendrites is known as the *telodendrion*. The character of the dendrites, which result from the branching of the protoplasmic processes, varies much in different parts of the central nervous system. In some cells the branching commences a short distance from the origin of the process, while in other cells the process continues for some distance from the cell body before undergoing division, and then suddenly breaks up into a large number of dendritic branches.

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The cerebellar cells of Purkinje are instances of the former type, the apical dendrites of the pyramidal cells of the cerebral cortex of the latter. The extent and complexity of arborization is also variable, being comparatively simple and with little branching in some cells,

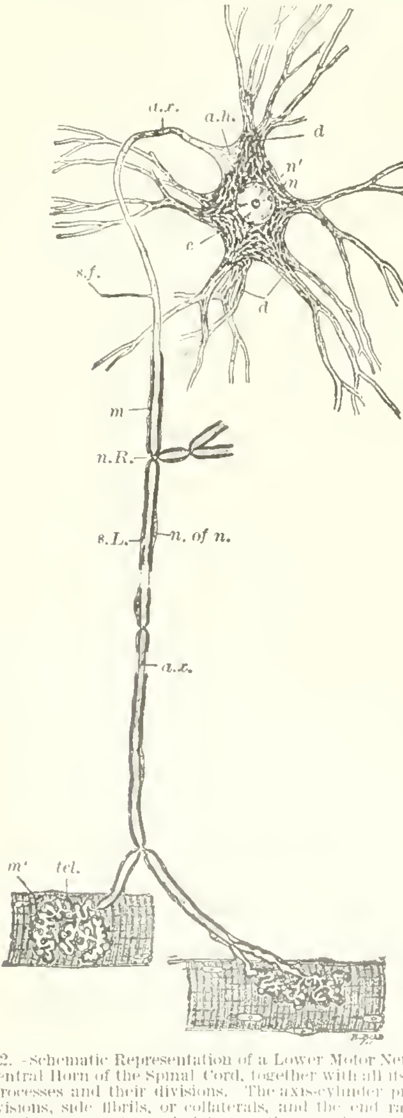

FIG. 3572.—Schematic Representation of a Lower Motor Neurone from the Ventral Horn of the Spinal Cord, together with all its protoplasmic processes and their divisions. The axis-cylinder process with its divisions, side fibrils, or collaterals, and the end ramifications (telodendrions or motor end-plates) in the muscle, represent parts of a single cell or neurone. *a.h.*, Axone hillock devoid of Nissl bodies, and showing a tendency to fibrillation; *a.x.*, axis-cylinder or axone, also indistinctly fibrillated. This process, at a short distance from the cell body, becomes surrounded by a myelin sheath, *m*, and a cellular sheath, the neurilemma, the latter not being an integral part of the neurone; *c*, cytoplasm showing the dark-colored Nissl bodies, separated from one another by the lighter ground substance; *d*, protoplasmic processes (dendrites) containing Nissl bodies; *n*, nucleus; *n'*, nucleolus; *n.R.*, nodes of Ranvier; *s.f.*, side fibril; *n. of n*, nucleus of neurilemma; *tel.*, motor end-plate or telodendrion; *m'*, striped muscle fibre; *s.L.*, segmentation of Schmidt-Lantermann. (From "The Nervous System and Its Constituent Neurones," by Lewellys F. Barker. D. Appleton & Co., New York, 1899.)

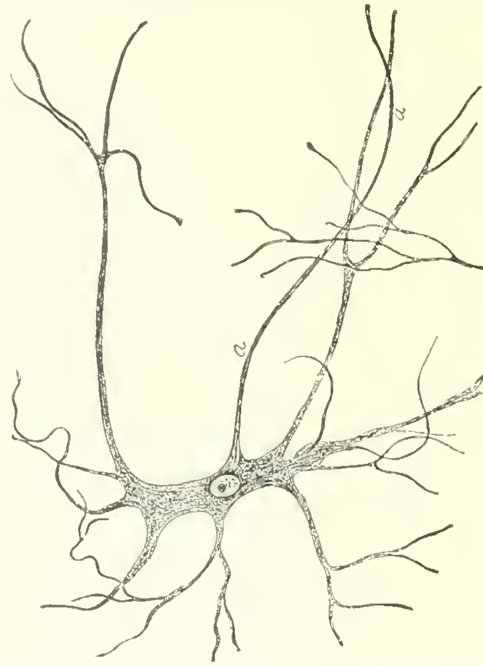

FIG. 3573.—Multipolar Ganglion Cell from the Anterior Horns of the Spinal Cord, Isolated by Maceration and Teasing, showing that the numerous branched protoplasmic processes are somewhat displaced and distorted, owing to manipulation. *a*, Axis-cylinder process; cytoplasm granular; nucleus large, distinct; nucleolus darker than nucleus. (Piersol.)

while in others a complete arborization exists, forming a dense forest which extends over a wide territory. Besides the degree of complexity of arborization the relation of the dendrites to the surface of the cells is of interest, since this branching may arise from only one or two dendritic processes as in the cells of the hippocampus, or it may originate from all sides of the cell like

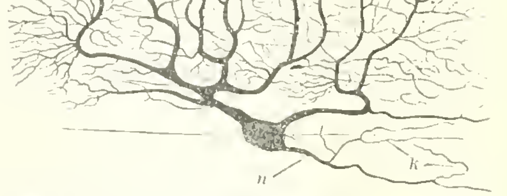

FIG. 3574.—Cell of Purkinje from the Cerebellum of Man. Showing pyriform cell body, large arborescent protoplasmic process with gemmules forming the typical telodendria of the dendrite. *n*, Axis-cylinder process; *k*, collateral fibrils. (Kölliker.)

a radiation as in the ventral horns of the spinal cord. Rarely neurones are characterized by entire absence of dendrites; such *adendritic* elements have been observed in the nervous system of invertebrates and also in the

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Nerve Tissue.

spinal ganglia of man. The contours of many lateral dendrites exhibit the presence of small buds known under the name of *gemmules*. *The axis-cylinder process, neu-*

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FIG. 3575.—Golgi's Cell of the First Type from the Corpus Geniculatum of a Cat. Showing numerous richly branched dendrites, and the very fine axone with its collateral branches. (Kölliker.)

rite or *axone*, unlike the dendrite, is thin, slender, inconspicuous, straighter in its course and smooth in outline. It was formerly described as an unbranching single process, and was supposed to be always the continuation of the axis cylinder of a nerve fibre. Golgi's investiga-

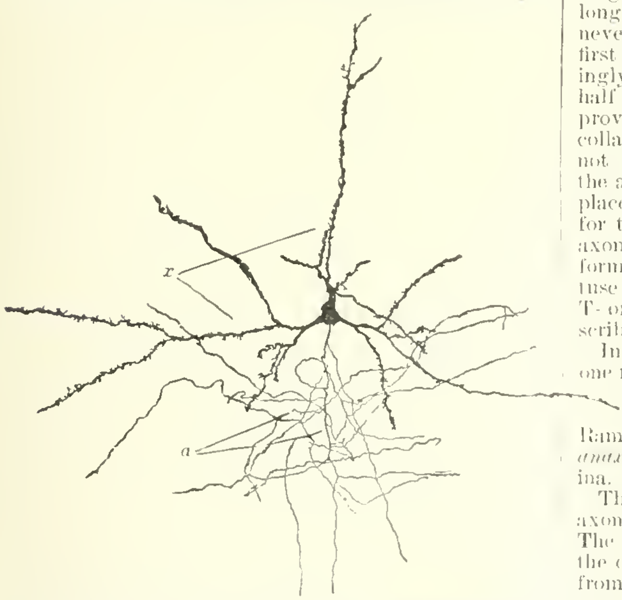

FIG. 3576.—Golgi's Cell of the Second Type from the Cerebrum of a Cat. Showing *x*, the coarse protoplasmic processes easily distinguishable from the more delicate axis-cylinder process *a*, forming the rich telodendrion of the axone. (Kölliker.)

tions have shown, on the contrary, the existence of nerve cells in which the axone is branched and does not become the axis cylinder of a nerve fibre. Hence nerve cells are arranged into two types—cells of the *first type*, in which the single non-branching axone becomes the axis cylinder of a medullated nerve fibre, and those of the *second type* in which the axone does not become the axis-cylinder process of a nerve fibre but undergoes branching, forming a telodendrion of the axone to which the name of

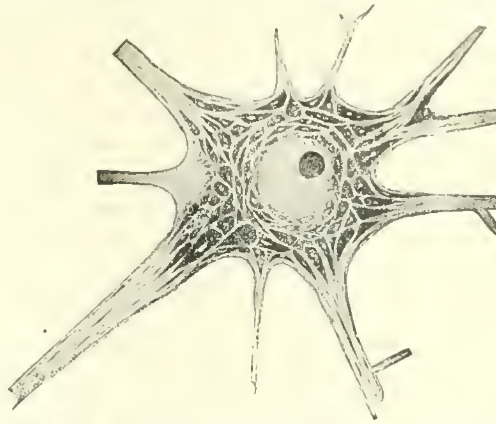

FIG. 3577.—Motor Nerve Cell from Ventral Horn of Gray Matter of Spinal Cord of Rabbit. Of the three lower processes, the middle one represents the axone; all the other processes are dendrites. The margin of the cells and of the masses of stainable substance appear too sharp in the reproduction. At the angle of division of the large dendrite at the left superior angle of the cell is shown one of the wedges of division. The spindle-shaped Nissl bodies are well shown, especially in the dendrites. (From "The Nervous System and Its Constituent Neurones," by Lewellys F. Barker. D. Appleton & Co., New York, 1899.)

dendraxone or neuropodion (Kölliker) is applied. The termination of the dendraxone usually takes place by exhaustion of repeated division. Very rarely and only in exceptional cases the terminal branches are interwoven to form a basket-like meshwork surrounding the cell body of a second neurone. Axones vary greatly in length, being very short, often only a few millimetres long; in nerve cells of the second type the dendraxone never leaves the gray substance. In nerve cells of the first type, on the contrary, the monaxone may be exceedingly long, some extending, as spinal nerve fibres, fully half the length of the body. Monaxones are frequently provided with collateral branches or *paraxones*. These collateral branches should not be mistaken either for the arborization which takes place in the dendraxone or for the true division of the axone into two branches, forming a right or an obtuse angle resulting in the T- or Y-shaped branches described by Ranvier.

In addition to the monaxone neurones, *diaxone* as well as *polyaxone* neurones have been observed. Ramòn y Cajal describes also *anaxone* neurones in the retina.

The mode of origin of the axone also claims attention. The axone may arise from the cell body directly or else from the dendrite; in this case the origin is usually near the cell body, while more rarely it is situated at some distance from the cell body. At its origin the axone is wedge-shaped and hence is called the *implantation cone*. It possesses certain characteristics in its internal structure and will be referred to later. The axone may have protecting coverings or a sheath. When

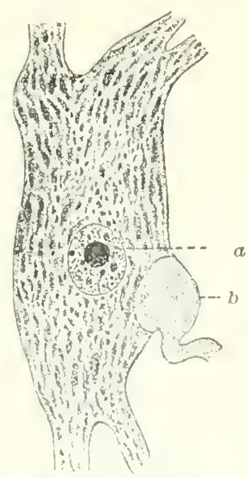

FIG. 3578. Nerve Cell from the Anterior Horn of the Spinal Cord of an Ox. Showing coarse chromatophile flakes, nucleus (*a*), nucleolus, and the implantation cone or axone hillock (*b*), devoid of chromatophile granules. (Böhm-Davidoff.)

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no envelope is present it is customary to speak of *naked axones*. The coverings are the *neurilemma* or the *sheath of Schwann*, and the *medullary substance* or the *white substance of Schwann*. One or both may invest the axone for a portion or its entire length. In the case of a nerve cell of the second type, where the dendraxone is limited to the gray substance, no sheath is present. In nerve cells of the second type there are stretches in which the axone is naked, those in which it is enveloped only by the neurilemma, and finally tracts in which both neurilemma and medullary substance are present. In the latter case the medullary substance is the inner sheath, while the neurilemma is the outer one. At times ill-defined fibrous tissue, called Henle's sheath, is present outside of the neurilemma.

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FIG. 3579. Portions of Two Medullated Nerve Fibres Stained with Osmic Acid. (From a young rabbit.) × 425 diameters. *R*, *R*, Nodes of Ranvier, with axis cylinder passing through; *a*, primitive sheath of the nerve or neurilemma; *c*, opposite the middle of the segment, indicates the nucleus and protoplasm lying between the neurilemma and the medullary substance. In *A* the nodes are wider and the intersegmented substance is more apparent than in *B*. (Quain.)

Structure of the Nerve Cell.—Nerve cells like all other cells consist of protoplasm, to which the name of *neuroplasm* has been applied by Kölliker. They contain an attraction sphere, within which one or more centrosomes are situated; a nucleus, which is larger than in most other cells of the body; usually a single nucleolus, more rarely several nucleoli; an implantation cone; several nuclear caps, and sometimes several spindles. A variable amount of pigment granules is also present, depending upon the age of the cell. Not every nerve cell, however, contains the above-enumerated parts. In fresh preparations, without the use of reagents, the protoplasm appears more or less homogeneous. With the use of reagents and different methods of fixation the protoplasm varies in appearance, being fibrillar, granular, or vacuolated. The latter two conditions at least may be regarded as probably artefacts, produced by reagents. The granules have a special affinity for certain aniline stains. They appear very distinctly when stained by the Nissl method and are generally known as *Nissl bodies*, *chromatophile* or *tigroid* granules (Fig. 3577). The granules are variable in size, regular or irregular in shape, and are arranged in groups, rows, or irregularly; sometimes simulating rods of variable thickness and constituting the so-called "*stainable substance*" of Nissl. That portion of the protoplasm which has no affinity for stains is known as the "*unstainable substance*" of Nissl.

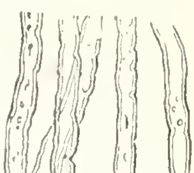

FIG. 3580.—White or Medullated Nerve Fibres (shortly after death), showing the sinuous outlines and double contours. (Quain.)

The granules are more concentrated in the inner portion (or the *entoplasm*) of the cell, while in the outer portion (or the *ectoplasm*) they are more rod-shaped. The rod-shaped elements are present in the dendrite, but are not found in the axone. Nissl suggested an elaborate classification of nerve cells, depending upon the amount, the arrangement, and the proportion of the granular substance to that of the cytoplasm and the relation of the granules to the nucleus. This classification is, however, not generally adopted by neurologists.

The spindles, as their name indicates, are spindle-shaped aggregations of chromatophile granules in the stainable substance of the nerve cells.

The "*unstainable substance*" of the cell body constitutes the ground substance, regarded by Nissl as homogeneous; but the investigations of Held (by a different staining method) have not only shown this substance to become stained of a deep red color in contrast to the blue color of the stainable substance, but also the presence of longitudinal threads not demonstrable by the Nissl method. Within the axone these threads or fibres appear to form a honeycomb network (the *axospongium*), in the meshes of which granules of variable size (the *neurosomes*) are present (Fig. 3578).

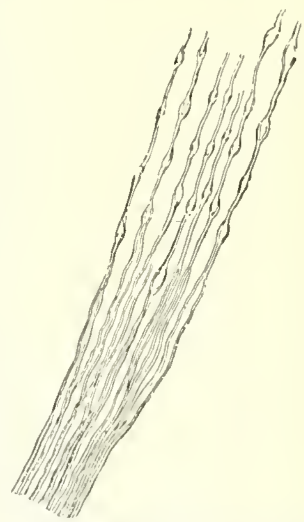

FIG. 3581. — Medullated Nerve Fibres from the Root of a Spinal Nerve near its Termination, showing the varicose appearance of the fibres. (Quain.)

The *implantation cone* or *axone hillock* is free from chromatophile granules, and stands out in marked contrast to the rest of the protoplasm of the cell body on account of the mottled appearance of the latter.

The *nucleus* is relatively large, round, usually centrally situated, surrounded by a delicate nuclear membrane, is single in adult man, and contains numerous granules which have little affinity for stain, whereas the neucleolus, situated in the interior of the nucleus, takes the staining deeply. Lenhossek has described the presence of several nucleoli. The nuclear caps are dense aggregations of chromatophile granules situated outside of the nucleus, but in close contact with it.

NERVE FIBRES.—It is evident from the foregoing consideration that the nerve fibres are the axones of the neurones. The nerve fibres form the chief constituents of all nerve trunks and enter largely into the composition of the cerebrospinal axis, forming not only the whole of the white substance, but constituting also a considerable portion of the gray matter. Depending upon the character of the coverings or sheath surrounding the fibres, the latter are divided into two varieties, the *medullated* and the *non-medullated* fibres. Although this distinction, for purposes of description, is convenient, it must be remembered that the same fibre may be medullated in one part of its course, and later, in a different part, lose its medullary substance before reaching its final termination.

Medullated Nerve Fibres.—A typical medullated nerve fibre consists of the *axis cylinder*, the inner or axial portion of the fibre, the *medullary substance*, or the white substance of Schwann, surrounding the axis cylinder, the *neurilemma* or *sheath of Schwann*, the outer covering surrounding the medullary substance, and the nerve corpuscles or nuclei. The axis cylinder is the most important part of the nerve fibre, conveying as it does the nerve impulse and constituting the only part which is never absent in the nerve fibre. The axis cylinder originates in the cell body of the neurone as its axone and terminates in the tissue to be controlled by that element.

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It appears as a thread, running through the centre of the fibre, but consists of a bundle of very delicate nerve


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FIG. 3582.—Small Branch of a Muscular Nerve of the Frog, Near its Termination. Showing the well-marked nodes of Ranvier, the axis cylinder, and the division of the fibres at the nodes. (Kölliker.)

fibrillæ, called the ultimate nerve fibrillæ, held together by a homogeneous cement substance and surrounded by a delicate and closely adherent membrane, the *axilemma*.

Surrounding the axilemma is the medullary substance, much thicker than the axilemma, of soft fatty consistency, and acting as a protecting medium to the delicate axis cylinder. In the fresh state the medullary substance does not lie in actual contact with the axilemma, but is separated from it by a lymphatic space. The medullary substance itself is not homogeneous, but consists of a network of neurokeratin, in the meshes of which the soft semifluid substance, the myelin, is held. The myelin is of an albumino-fatty composition, containing protagon, and capable of powerfully refracting light. At regular intervals, along the course of the fibre, symmetrical constrictions of the medullary substance occur, known as the *nodes of Ranvier*. These nodes are constrictions of the neurilemma and complete interruptions of the continuity of the medullary substance, but not affecting the axis cylinder, which at these points is in contact with the neurilemma. That portion of the nerve fibre which is situated between two adjacent nodes is known as the *internode*. In fine nerve fibres the internodes are shorter than in those of greater diameter, and in fibres of the same thickness they are shorter in warm-blooded than in cold-blooded animals. Near the termination of the fibre the internodes are also shorter. At the constrictions the axis cylinder is accessible to various reagents which cannot reach it at other points, as they cannot penetrate the medullary substance. Actual breaks in the medullary substance are artificial markings—the Schmidt-Lantermann segments as they are called,—resulting from the use of reagents. These interruptions may be distinguished from the true nodes by their irregular character, their asymmetry, and by the fact that no constrictions of the neurilemma take place in these locations. Nerve fibres are not uniform in diameter, but vary greatly; according to Kölliker, the finest fibres measure from 2 to 4 μ, those of medium size from 4 to 9 μ, while the largest possess a diameter from 9 to 20 μ. *The neurilemma* or *sheath of Schwann* is the outermost covering of the nerve fibre, and consists of a structureless or hyaline membrane, surrounding the medullary substance. Oval *nerve nuclei*, or nerve corpuscles, lie just beneath the neurilemma in depressions on the outer surface of the medullary substance. Only one such corpuscle is present in each internode and is usually placed in the middle of the internode. The medullated nerve fibres in the central nervous system have *no* neurilemma, nodes of Ranvier, or corpuscles. In the fresh state the medullated nerve fibre has a glistening, homogeneous appearance. After death the fibre appears to have a double contour, but later becomes mottled, as the result of rapid disintegration. Osmic acid stains the medullary substance black.

FIG. 3583.—Portion of the Network of the Fibres of Remak from the Pneumogastric of a Dog. Showing *n*, nucleus; *p*, protoplasm surrounding it and the faint striation caused by the fibrils. (Quain.)

Non-Medullated Nerve Fibres.—The *non-medullated* nerve fibres or the *fibres of Remak* are nothing more than axones or axis-cylinder processes of neurones devoid of medullary substance and neurilemma. The latter, however, is replaced by a delicate sheath, beneath which the small nerve nuclei are located. The nuclei are more numerous in these than they are in

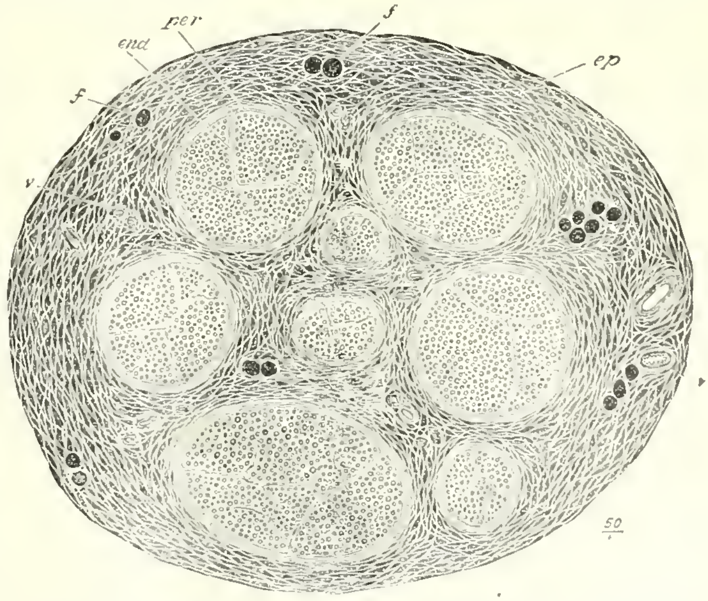

FIG. 3584.—Transverse Section of the Internal Saphenous Nerve of Man, made after being stained in osmic acid and subsequently hardened in alcohol. Drawn as seen under very low magnifying power. Showing *ep*, epineurium or the general sheath of the nerve, consisting of connective-tissue bundles of variable size separated by cleft-like areolæ, which appear as a network of clear lines with here and there fat cells, *f*, and blood-vessels, *v*; *per*, perineurium, the lamellated connective tissue, enclosing the funiculus; *end*, interior of the funiculus, showing the cut ends of the medullated nerve fibres which are embedded in the connective tissue within the funiculus (endoneurium). The fat cells and the nerve fibres are darkly stained, but the connective tissue of the nerve is only slightly stained. (Quain.)

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the medullated nerve fibres. Non-medullated nerves often appear varicose and exhibit a marked tendency to branch and form plexuses. Their ultimate fibrillæ are more widely separated than are those of the medullated fibres, protoplasm in the former taking the place of the cement substance in the latter. As independent fibres they occur principally in the sympathetic system, but not infrequently they are associated with medullated fibres in nerve trunks, as in the vagus.

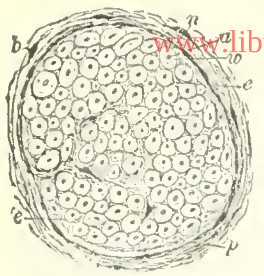
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FIG. 3585.—A Simple Funiculus More Highly Magnified. The apparent small nucleated cells are sections of the nerve fibres and their axis cylinders. *a*, Axis cylinder; *w*, white substance of Schwann or medullary substance; *n*, neurilemma; *e*, endoneurium; *p*, perineurium; *b*, connective-tissue cells of the same. (Piersol.)

Nerve Trunks.—The nerve fibres are usually collected in bundles or funiculi, several of which constitute the nerve trunk. The individual fibres are held together by a delicate connective tissue, the *endoneurium*. A certain number of the fibres are grouped to form a funiculus, the latter being surrounded by a more dense connective-tissue envelope, the *perineurium*. The funiculi in turn are grouped together to form a nerve trunk, and are surrounded by a larger amount of loosely arranged connective tissue, the *epineurium*. This tissue supports the blood-vessels and the lymphatics, which invariably are present in the interior of the nerve trunk, as well as the adipose tissue often present in the larger nerve trunks.

The Neuroglia.—The supporting substance in the white matter of the brain and cord, as well as a considerable portion of the matrix of the gray substance, is made up of a network of exceedingly delicate fibres, the *neuroglia* fibres, and the neuroglia cells, two varieties of which are distinguished—the *spider cells* and the *mossy cells*. The cell body of the spider cell is smaller, while their processes are long, thin, rigid, with very little branching. They occur chiefly in the white substance of the brain and cord. The mossy cells have a larger cell body, short, richly branched processes, and are principally found in the gray substance, where they are often in intimate relation with the walls of blood-vessels.

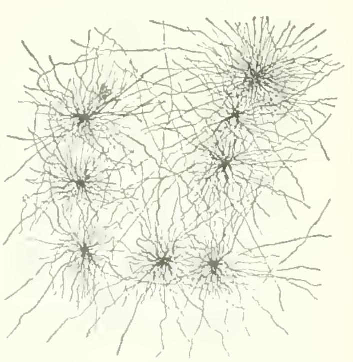

FIG. 3586.—A Group of Spider Cells from the White Substance of the Brain of Man, stained by Golgi's method. Drawn as seen under high magnifying power. (Kölliker.)

Robert Formad.

NERVOUS SYSTEM, TRAUMATIC AFFECTIONS OF.—It is not purposed here to attempt a detailed description of all the affections of the nervous system which are caused by trauma. Within the limits of the present article nothing further can be attempted than a brief analysis of the causal relations in which trauma stands to nervous diseases, with especial consideration of the place which nervous diseases, when caused in this manner, occupy at law. What is to be said, therefore, will be chiefly interesting to the medical man who is brought in contact with injuries to the nervous system and their legal complications. Personal-injury claims form a very important feature of modern life. Not only transportation companies, but private individuals as well, fully expect to pay for injuries which are received through actionable negligence for which they are responsible. Similarly, few receive injuries traceable to the negligence of others without promptly demanding compensation. In our mechanical times the frequency of accidents is enormous. Consequently, the evaluation of injuries received and the compensation to which the injured person is entitled are matters of prime importance. Greater interests are involved than in any other medico-legal question. This becomes plain as soon as we reflect upon the large sums which are annually paid out in such cases. From the report of the Brooklyn Rapid Transit Company for the year 1901 it appears that in that year more than one million dollars was paid for personal injuries and expenses incident thereto. This sum represented nearly ten per cent. of the gross receipts of the company for the year named. Individual verdicts are also often very high. As much as thirty-five thousand dollars has been paid for a personal injury, and for a death claim resulting from the Tunnel accident of the New York Central and Hudson River Railroad of February 8th, 1902, a verdict of $60,000 was returned by the jury. Verdicts varying from $10,000 to $20,000 are not at all unusual, and anything under $1,000 is considered virtually a victory for the defendant. Court calendars are overcrowded with these cases, which form the bulk of jury trials to-day. But the calendar is not a complete index of the degree of activity in this branch of law, as for every case that comes to trial it is safe to estimate that ten are settled by mutual agreement out of court. If the magnitude of the interests at stake are taken into consideration, it is not surprising that trial lawyers should be on the alert, or that there should be great competition for plaintiff's cases. As a result, "runners" or "ambulance chasers," representing legal firms which specialize in accident cases, are constantly stationed about centres of traffic; they rush to the scene of accident, and make their appearance at the hospital door almost simultaneously with the injured person. Thenceforth the claim is prosecuted on the contingent fee plan. The system has doubtless been much abused, and has been made the object of much attack and ridicule. It is made possible solely through the poverty of the plaintiff, who is generally unable himself to carry on the great expense of trial at law, and who consequently is forced to accept professional services which are to be paid for, on a percentage basis, out of the damages awarded. It has many very objectionable features. By such a system the lawyer is made more than an advocate, and the expert medical witness more than a mouthpiece of science. But no practical and better substitute has yet been suggested. The question will probably resolve itself eventually by fewer claims being litigated, and more being settled by mutual agreement. Mr. Herbert W. Page, whose book, "Injuries of the Spine," published in 1882, marked a distinct epoch in the history of this subject, told me a year or two ago that litigation of personal-injury claims in England was becoming more and more infrequent. Erichsen's book, which appeared in 1866, and which furnished the original description of the peculiar symptoms resulting from railway and allied injuries, gave the first effective impetus to litigation of this character. For years afterward personal-injury claims were prominent in the English courts. But now, according to the statement of Mr. Page, they are so infrequent that, in his position as consulting surgeon to the London and Northwestern Railway, he is called upon to go to court only three or four times a year. It has seemed to me that the willingness for compromise is growing in this country also. Among the litigated cases those hardest to compromise are the ones in which injury to the nervous system is alleged. In purely surgical injuries, such as the loss of a limb or of an eye, the cause is definite, and the question quickly resolves itself into one of liability and the appraisal of the value, as far as such an appraisal is possible, of the injured or missing member. But in nervous affections, and especially in the functional af-

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fections, with their obscure causation, their indefinite and often bizarre symptomatology, agreement is much more difficult. The contending parties are often at variance in regard to every particular. Neither is inclined to give in, and the case, if it is a case, goes to the jury.

Nervous diseases are divided into two great classes, organic and functional. A functional, as opposed to an organic disease, is one in which the anatomical integrity of nervous structure remains unimpaired. Functional diseases doubtless have a material pathology. But such a pathology remains inaccessible by any methods of investigation at present at our disposal, and we are therefore obliged to retain this classification, artificial as we know it to be. Of the organic nervous affections caused by trauma, the vast majority are definite surgical injuries to the central or peripheral nervous system. Thus, injuries of all kinds to the head, with injury of the brain; to the back, with injury to the spinal cord; or to the peripheral nerves, are causes. When, in addition to the cause, we can demonstrate certain cardinal abrogations of function of these organs, which we have learned to rely upon as indications of structural alterations in them, the diagnosis of organic injury is justifiable. Thus, after head injuries, paralysis of one or more cranial nerves, or of the extremities, together with other general symptoms, speaks for injury to the brain; paralysis, with anæsthesia in characteristic areas, and loss of control of the sphincters, speaks for injury to the spinal cord; paralysis, with degenerative electrical reactions, speaks for injury to a peripheral nerve. Injuries of this character are ordinarily easy to recognize, and the prognosis in regard to them can usually be formulated with considerable precision. Consequently, in common with other surgical injuries, when they are seen in court, which they rarely are, the questions for the jury to decide concern the legal aspects of the accident rather than its surgical results.

There is a group of chronic organic diseases, with uncertain and indefinite causation, which are not infrequently the subjects of litigation. The most important of these are locomotor ataxia and general paralysis of the insane, or general paresis. Others of this class are ataxic paraplegia, progressive muscular atrophy, paralysis agitans, syringomyelia, multiple sclerosis, etc. These latter are, however, much rarer diseases than the two first mentioned, and consequently of much less importance. Both locomotor ataxia and general paresis are comparatively common (the latter chiefly in cities). As has been said, their causes are obscure and undetermined. It is possible, and indeed probable, that injury can act as a contributing cause in their development. But the weight of scientific evidence is against their ever occurring solely as the result of trauma. Both diseases are often latent for a long time, and both may undergo a sudden outbreak of symptoms as the result of disease or injury. Both diseases, by their symptoms, expose the victims of them to accidents. It is consequently not surprising that both are frequently made the subjects of personal-injury claims. Juries often award verdicts in such cases, in view of the fact that sworn experts, who frequently do not at all understand the condition about which they testify, affirm that the injury was the sole cause of the trouble.

Epilepsy is another disease, which in this connection can be considered organic, and about which legal interest frequently centres. That typical epileptic convulsions follow head injuries, even when there is no discoverable injury to the brain, is an incontestable fact. In order to establish a reasonable support for such a contention in any given case, it is necessary to prove that the patient had not had epilepsy before the accident, and that the accident, in character and severity, was of a nature to produce such a result.

While the three diseases named above not infrequently figure in litigated cases, the chief interest, both legal and scientific, in traumatic affections of the nervous system, centres about the functional disorders known, since the appearance in 1889 of Oppenheim's monograph, as the traumatic neuroses. In the earlier treatises, and especially in Erichsen's, these neuroses were totally misunderstood and were classified with organic injuries. Progress throughout the whole field of neurology has now made it possible, in most cases at least, to distinguish these two great classes. As originally described by Oppenheim, the traumatic neuroses present chiefly the symptoms of neurasthenia and hysteria, but also some which indicate structural lesions. The term was a taking one and has attained a rather different meaning from that which Oppenheim intended. To-day, by a traumatic neurosis is understood a simple neurosis, without known organic basis, plus such characteristics as its traumatic origin has added to it. Thus considered, the traumatic neuroses are composed of symptom groups which can, in nearly all cases, be brought under the rubric of neurasthenia or hysteria. In causation, they have many points in common. They have both attained their prominence through railway accidents. This is partly due to railway accidents so often being due to actionable negligence, and partly to the fact that in such accidents physical injury and mental shock are conspicuously combined. Both mental and physical elements are present in nearly all accidents. In most cases of neurasthenia the bruising and shaking up have been considerable, although severe surgical injuries are usually absent. Hysteria, on the other hand, is a fright neurosis above all else, and the history of injury in its causation is often very inconspicuous. It is well to observe in this connection that in the State of New York there can be no recovery of damages unless there has been a definite physical injury. Injuries resulting from fright alone do not constitute a cause of action.

Much has been written and much said about litigation as a cause of functional nervous diseases following trauma. If one were to be guided by the fluent generalizations of some railway claim agents, one would have to believe that any real injury to the nervous system could not occur on a railway; that all persons who allege such injuries either deceive themselves or wish to defraud the company. Certain experts, on the other hand, who are especially prominent in plaintiff's cases, are not inclined to accord much importance to the financial side of the question. Leaving aside actual simulators and impostors, who are very rare, I may say that my experience has taught me that the question of damages has a great influence on both neurasthenia and hysteria, and that in neither disease is restoration of health probable while litigation is pending. This baneful effect is due to the difficulty of carrying out proper treatment so long as legal questions are pending. Were the treatment for such cases simply medicinal, such a statement would naturally appear absurd. Medicines, however, play a very insignificant rôle in the treatment. They are of some indirect service, but far more important is the psychological direction of the patient. The diversion of the patient's thoughts away from morbid channels, the arousing of his interest in matters not connected with himself or his troubles, the exclusion from his consciousness of suggestions which may magnify or create symptoms,—these are the keys to the successful treatment of the traumatic neuroses. They are rendered powerless by the damage claim. The frequent examinations by experts (in some cases as many as five or six doctors examine a plaintiff), the law's delays, the legal inadvisability of the patient's returning to work, and the thousand and one annoyances inevitable to litigation, render futile any attempt to control the patient psychologically. These factors, in my opinion, are much more responsible for the continuance of symptoms than is any desire which the patient may possess to profit by his misfortune. This is especially true for traumatic hysteria, in which disease, aside from its being an agent in suggestion, the money question has little or no influence. The question of litigation as a cause of the traumatic neuroses must be kept separate from the question of voluntary exaggeration of symptoms actually present, and of simulation or fraud pure and simple. As far as actual simulation is concerned it is very rare, and should not pass undetected by a phy-

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sician who is skilful and reasonably resourceful in his methods of examination. Voluntary exaggeration of symptoms actually present is more difficult to detect. It is not often encountered in hysteria. But in neurasthenia, the making the most of symptoms is an integral part of the disease and inseparable from it. It is, therefore, not an easy matter to determine when it reaches the point where the patient exaggerates in spite of himself and involuntarily, or when it is intentional, voluntary, and purposeful. There is no rule to guide us in determining how this question may be satisfactorily answered in any given case. Some help may be derived from information obtained from outside sources. But as a general rule the physician's conclusion must be based on his own examination, and the soundness of it is usually directly proportional to his experience and acumen, both professional and worldly.

In what has now been said, it has been plainly hinted that the traumatic neuroses are the results of mental impressions, rather than of physical injuries. The different ways in which these impressions act and in which their effects are elaborated constitute the two main symptom groups of neurasthenia and hysteria. Each group has some characteristics in common with the other. But each has also its own individuality, which stamps it as a definite clinical entity. Neurasthenia represents irritability, fatigue, and exhaustion. Such perversion of mental function as exists is in the line of exaggeration of tendencies common to all mankind. Hysteria, on the other hand, is absolute delusion. The premises of the neurasthenic's reasoning may be sound, but the deductions which he draws from them are too general. The hysteric, on the other hand, is wrong in his premises, and the deductions which he draws are insane delusions. The former is within the boundary line of mental alienation, the latter way beyond it. The characteristics of a case of traumatic neurasthenia are usually somewhat as follows:

A man, whose previous life has, according to the evidence, been healthy, is in an accident in which he is considerably shaken up and badly frightened. He is astonished to find that he has escaped without severe physical injury. He is able to walk, and in general accidents he can often render assistance to those more severely injured than he. That night he does not sleep well. He is disturbed by dreams; or thoughts recalling the catastrophe thrust themselves into his consciousness. From then on he finds himself becoming more nervous, more easily fatigued, and more irritable than formerly. His sleep is regularly disturbed, and trifles upset him. He has lost his nerve. In short, he develops the ordinary symptoms of neurasthenia (*q. v.*), with which every practitioner is only too familiar. He differs in some respects from the ordinary neurasthenic. Pain in the back, only occasionally complained of in non-traumatic neurasthenia, is very prominent in the traumatic variety. It may exist as a dull constant pain, or be in the form of lumbago, increased by all movement. The mental state also is dominated by the recurring thoughts of the accident, and by a dread of its repetition. With such slight variations the picture is the same as in ordinary neurasthenia. The mental state varies from that of the irritable, querulous, self-centred, introspective semi-invalid, to that of the pronounced hypochondriac. Depression is a dominant feature, and may entirely do away with working capacity.

Neurasthenic complaints, in addition to those of fatigue, fear, depression, etc., may refer to nearly all parts of the body. Some of them have objective substantiation. There is no true paralysis, but the muscles are quickly fatigued as has been shown by the ergograph. There is often tremor of the face, and with it there is generally associated a fine tremor of the fingers. In addition to subjective pain in the back, there are usually one or more vertebral spines which are extremely sensitive to touch. These spots are often shifting, they are not always in the same places. Headache is another common symptom. It is referred, most frequently, to "the base of the brain." Feelings of numbness and tingling are regularly complained of, but there is never any objective anæsthesia. The vascular disturbances are particularly important. All neurasthenics have unstable sympathetic nervous systems. This condition is shown by the sudden changes in color of the face, by the cold hands and feet, and by the fact that sensations of heat and cold pass over the whole body. The heart is also irritable and often constantly over-active. Attacks of palpitation are common, and are induced by trivial causes. There is also a more or less persistent tachycardia.

Digestive disturbances are almost constant. They, in common with the mental state, are responsible for the poor nutrition of many of these patients. Complaints regarding the genital apparatus are frequent. Women notice disturbances of menstrual function. In men these complaints are chiefly in regard to seminal losses, to prostatorrhœa, etc. In a certain proportion of cases there is loss of sexual desire. The patients worry and reason about this, and fear that they are becoming impotent. As a result they approach the sexual act with timidity and often with great excitement. As a result of their fears there may fail to be an erection, or the excitement under which they labor may cause ejaculation. These failures become more pronounced with succeeding attempts, until finally, in despair, the patient is convinced that his virility is gone permanently. In some litigated cases impotency is the chief item in the complaint. In a recent case a young Swede, a superb specimen physically, brought suit for $25,000 for such a cause. He had fallen with some wooden structure into a river, and in rising to the surface had been struck across the thighs by a wooden beam. He was bruised, but the testicles were not directly injured. Active sexually before, he alleged that after the accident he experienced great loss in sexual power. Experts in his behalf testified that he was sterile and incurable. The jury, however, apparently adopted the view of neurasthenia, for they awarded a verdict of only $2,000, which sum the judge promptly cut in two.

In hysteria, the mental state often has many neurasthenic features, but in its salient characteristics it is totally different. The striking symptoms of hysteria—namely the palsies, the blindness, and the anæsthesias—although they constitute physical manifestations, are of purely psychic origin, dependent upon delusional beliefs or on fixed ideas. That they do not result from structural alterations is proved by their inconstancy and sudden fluctuations. Their occurrence in all peoples and in all times, and their conformity to definite and consistent symptomatic behavior in all classes of people, render absurd the position of those who contend that hysteria is voluntary simulation and not a disease. It seems to me very important that it be more generally recognized that hysteria is a distinct affection of the mind, and that its symptoms, while varied, are none the less characteristic and distinct. Contrary to the popular impression, and to the etymology of the name, it is not rare in men. Traumatic hysteria, in my personal experience, has been more frequent in men than in women. Present conceptions regarding mental diseases lead us to assume that they occur chiefly if not exclusively in persons who are hereditarily predisposed. In most of the cases which I have seen it has been impossible to prove the existence of an hereditary predisposition. I should add, however, that most of these cases were litigated; consequently too great scientific value should not to be given them.

The symptoms of traumatic hysteria are striking and varied. They may appear immediately after the accident, or they may be delayed until the morning after, or even for several days. This interval has been called by Charcot the "period of meditation." During it the patient is reflecting on the accident, is reasoning about it, subconsciously, and then he finally develops the symptoms. These may be referred to every organ and every system of the body. They may very closely resemble symptoms due to organic disease. But in the imitation there is always a flaw. The reproduction is never perfect. Thus, in hysterical paralysis, there are not the

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degenerative electrical reactions which are characteristic of peripheral palsies, or the changes of reflexes, rigidity, etc., which are characteristic of cerebral paralysis. In hysterical anæsthesia, also, the loss of sensibility is too transitory, or its association with other symptoms too contradictory, or its distribution too irregular, to warrant the belief that it rests upon an organic basis. It would be impossible, within the limits of the present article, to go into the symptoms of traumatic hysteria in detail. The reader is referred to the article *Hysteria* in THE HANDBOOK, or to the chapter on Traumatic Hysteria in my work on "Accident and Injury in their Relations to Diseases of the Nervous System." The following brief summary of the more important symptoms may be useful here. Paralysis is usually in the form of hemiplegia, without involvement of the face. In an overwhelming majority of cases it affects the left side. Monoplegia usually affects the arm and is generally the sequence of some slight injury to that member. Paraplegia is rare in traumatic cases. It is not accompanied by involvement of the sphincters. Polyplegia is most unusual. The paralysis of hysteria is of a flaccid type, and usually affects the limb in its entirety. It gets better and worse, according to changes in environment. It is not accompanied by electrical degenerative reactions nor by changes in the deep reflexes. Anæsthesia varies in distribution with the paralysis. Sometimes it affects the whole body. In hemiplegia, there is hemianæsthesia on the paralyzed side; in monoplegia, the sensory loss may affect the whole side, or only the paralyzed member. In paraplegia the genitals retain their sensibility. The anæsthesia of hysteria is profound and affects all forms of cutaneous sensibility. It may change its situation and extent as a result of mental impressions. Sight, hearing, taste, and smell are also commonly affected. The visual disturbances consist in concentric limitations in the visual fields, changes in the color fields, or amblyopia. Spasm of the orbicularis sometimes prevents the patient from opening the eyes. Hysterical deafness is a common symptom. If there is paralysis, at the same time, the deafness is unilateral and on the side of the paralysis. Deaf-mutism is rare; it occurred in one case in my experience. The deafness, which was complicated by hemiplegia, led to mutism, and at last report, one year and a half after the litigation had ceased, this condition still persisted. The hysterical attack is very important in litigated hysteria, as the patient is almost certain to have an attack in court. At a recent trial the plaintiff was in convulsions for two hours and a half in the courtroom. Such demonstrations appeal very strongly to the sympathies of the jury, though in the case referred to the jury disagreed on the first trial, and returned a verdict for the defendant on the second. These attacks are commonly called hystero-epilepsy—clearly a misnomer, as they are not in any way allied to epilepsy. They differ from epileptic attacks in the character of the aura, the quality and duration of the convulsive phenomena, and the absence of biting of the tongue and of the involuntary passage of urine. Epileptic attacks are not precipitated by excitements and crowds. Hysterical attacks have a predilection for dramatic surroundings. The lack of conformity to organic types makes the distinction of hysteria from the diseases which it simulates nearly always possible. Juries, however, fail to recognize this fact and consequently the medico-legal relations of traumatic hysteria are very peculiar. Under existing conditions it is almost impossible for a jury, composed of laymen, to decide justly with regard to traumatic hysteria. The plaintiff is generally brought before them, and he is almost sure to present the acme of all the symptoms which he has had. If some of these symptoms had previously disappeared, they are quite sure to return during the progress of the trial. The psychosis is nourished upon suggestion and introspection, facilities for which are so profusely furnished by the excitement and observation attendant upon court proceedings. It is entirely consistent with the nature of this malady that existing symptoms should become worse or vanished ones return on such occasions. It is not necessary to assume, in explanation, any voluntary exaggeration or simulation on the part of the patient. The effect of this clinical idiosyncrasy on a jury, however, is disastrous to the cause of the defendant. The twelve jurors have heard from the medical experts of the two sides testimony too often directly conflicting. On the one side the opinion has been expressed that the patient's condition is due simply to nervousness aggravated, if not caused by the suit, and that the symptoms will soon subside when the legal proceedings are at an end; on the other side, the belief has been sworn to that the injury is of organic and irreparable character, or, if perchance its functional nature is admitted, that the nervous system has sustained a shock from which it can never recover.

The jurors may be convinced of the honesty of all the views which they have heard expressed, and yet they are unable to determine, from the character of the testimony, which of the opposing opinions is the more likely to be correct. They are, therefore, obliged to rely upon the impression made upon them by the injured person himself. They see before them an individual in an even worse condition, perhaps, than his doctors had depicted. They see an alleged paralyzed limb absolutely motionless; they become witnesses of an emotional outburst more harrowing than any related in the evidence. And they see these things one or two years after the accident has occurred. Their natural inference is that the injuries are permanent. They find it hard to believe that the outlook for a malady which has so long defied the resources of medical skill is anything but hopeless. They are unwilling, if not unable, to believe in the unreality of physical symptoms. They cannot comprehend a part being the seat of paralysis or insensibility, unless there is some grave physical defect behind it; they do not know that a limb which is immobile to-day may be in wonted activity to-morrow. Thrown on their own resources by the contradiction in medical testimony, they render a verdict in accordance with their own impressions as to the plaintiff's injury. These impressions indicate a person severely and probably incurably injured; and the verdict, rendered accordingly, is generally in excess of anything to which the plaintiff is entitled.

The two types, hysteria and neurasthenia, as above sketched out, are in most cases distinct and unmistakable. In some cases the type of mental state is neurasthenic, with enough of the hysterical added to cause a hemianæsthesia or other permanent stigma of hysteria. To this type has been given the name of hystero-neurasthenia. In other cases, coupled with the symptoms of functional disease, are certain signs indicative of material destruction in the nervous system. These latter cases are difficult to classify. It is not to be denied that some of them are the direct outcome of severe traumatic physical injuries. Most of them, however, can better be explained on the assumption that some pre-existing organic disease, such as general arteriosclerosis, syphilis, or alcoholism, has been made worse, or has first been called into prominence, by traumatic agencies.

The prognosis of hysteria and neurasthenia provoked by trauma is a subject on which very diverse views are held. Reliable statistics bearing on the question are few. Certain facts, however, are in our possession. Neither disease is fatal. Some writers maintain that the vascular disturbances of neurasthenia lead to serious degeneration in the heart and arteries and so to premature death. Some few instances also are on record in which death during the convulsive phenomena of hysteria has occurred. Such cases are, however, so rare and so poorly substantiated by reliable evidence that we are safe in asserting that these diseases do not kill. It is not to be denied, however, that some patients have the same symptoms for years and years, and, as far as is known, never get well. On the other hand, there is nothing about either disease which makes recovery impossible. Organic diseases, such as locomotor ataxia or progressive muscular atrophy, are manifestly incurable. But in the neuroses a cure, in the widest sense of that term, is possible.

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The vital question concerns working capacity: What are the chances for a return of working capacity, provided that had been lost? To this question the answer is, that under reasonably favorable conditions these chances are very good. They are the best in patients who try to return to work as soon as possible after the accident, who are young, previously healthy, and of good family history.

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The prognosis which can be given in a case of neurasthenia is not always permissible for a case of hysteria. A person suffering from traumatic neurasthenia can often be brought to a condition in which he can safely return to work soon after the accident. The subjective disturbances, however, of which he complains may persist for months or years afterward. Indeed, it is very difficult to tell when they stop, and the patient may never himself admit that he is the same as he was before the accident. In hysteria, on the other hand, recovery may be longer delayed, but when it comes it is generally more complete. Few if any hysterical persons can undertake any work before the question of litigation is settled. But when that is once out of the way, a period of a few months generally, though not always, is sufficient for a fairly complete return of working capacity.

Pearce Bailey.

NEURALGIA.—Definition and Nature.—The term neuralgia in its strict sense signifies pain along the course of a nerve. The word has been used, however, to indicate conditions in which such pain exists purely as a neurosis, to distinguish it from the cases in which inflammatory and degenerative changes are present in the nerve, to which class the name "neuritis" is applied.

Probably the majority of the neuralgias are due in part only to any primary or essential neurosal disorder of the nervous centres, and indicate, in addition, some irritation of the sensory nerves from without.

This is eminently true of most of the typical neuralgias of the superficial nerves, and as our knowledge of the course and pathology of these diseases advances, many of the conditions formerly classed under the neuralgias are shown to be cases of neuritis. For instance, the gradual onset and decline of certain forms of sciatica and brachial neuralgia, their protracted course, the limitation of the pain to the tract and distribution of single nerves, and the fact that the pain is apt to be remittent rather than intermittent, together with the presence of tenderness along the nerve trunk, persistent alterations in the sensibility of the skin, and even muscular atrophy and trophic changes in the skin, all tend to point to the neuralgia being secondary to a neuritis, while examination of the nerve shows characteristic changes of inflammation and degeneration.

Then there are cases, such as some of the facial neuralgias, in which the character of the pain is that of neuralgia, persistent, intermittent, and frequently in neurotic individuals; and here examination of the nerve, after the affection has existed some time, often shows degenerative changes. The question then arises, Are these changes primary or secondary—*i.e.*, is the case a slow progressive neuritis from the start, or are these changes in the nerve secondary to the long persistent disorder of function which underlies the pain? The recent ion theory of Loeb, that the transmission of nerve stimuli is due to chemical change in the nerve substance, might well account for a permanent change resulting from constant severe pain persisting in the nerve.

Finally, there is the class of neuralgias in which the character, situation, severity, and duration of the pain are wholly determined by processes acting on healthy sensory nerves, and may be called reflex or symptomatic neuralgias. These irritative causes, however, if long continued, may induce a permanent neuralgic habit of the nervous centres.

The group of habit pains might also be classed as neuralgias, and both these and other forms may often be relieved by mental influences.

It is uncertain whether there are special nerves and nerve centres intended for the conveyance and perception of painful impressions, but the results of experimentation and the difference in the behavior in disease of this function—if so it may be called—from the other sensory functions, lead to the belief that such may be the case.

Again, it may be that the nerves of pain are the same with the nerves for the general feelings (*Gemeingefuhle*) of satisfaction or discomfort, which accompany, and yet are distinct from, the special sensations of relation, such as touch, temperature, and the like.

If there are special nerves and nerve centres for pain, it is probable that they are the seat of the disease in neuralgia.

It is common to hear the neuralgias of the superficial nerves spoken of as the only affections really deserving the name, and as belonging in a different category from the visceralgias and the periodical headaches, as well as from the pains of intermittent recurrence, but of ill-defined seat, to which children and feebly nourished persons, and especially neurotic persons, are liable.

In so far, however, as these painful disorders occur under similar conditions with typical neuralgias of the superficial nerves, and are themselves of unknown origin, there is much gained in treating of them both as kindred affections, and contrasting them with each other.

General Etiology and Pathology.—An *inherited neuropathic tendency* is the most important cause of neuralgia, and it is often impossible, in a given case, to measure the degree to which its influence is felt. It is, however, a far more important element in the migraines and the visceralgias than in the superficial neuralgias, and among the latter its effect is most strongly felt in the neuralgias of the fifth pair, and of the intercostal nerves.

The exact pathological state of the nervous centres in neuralgia is not known, any more than it is in the case of the other neuroses. Some of the conditions that give rise to it are, however, better understood.

Chief among these are: *Anæmia*, which acts both by impoverishment of the blood, and by overcharging the blood with carbonic acid; the *presence of abnormal substances in the blood*, as in gout, diabetes, malaria, chronic nephritis, and metallic poisoning; *absorption of the products of imperfect digestion or metabolism*; *the impairment of the vascular tonicity*, as in fatigue; *peripheral irritations*, such as disease of the teeth, eyes, respiratory and digestive tracts, uterus, and ovaries; chronic inflammation of the nerve sheath; *localized anæmia or congestion of nerves or nerve centres.*

Anæmia and states of *nervous debility* or *chronic fatigue* are common underlying causes of neuralgia, even though not the whole cause, and it is almost always best to suspect them and to fortify the patient against them by ample nourishment and tonic treatment. Although anæmic and debilitated patients are more prone than healthy persons to neuralgias of every sort, this is especially true with regard to the superficial neuralgias, the sufferers from migraine and the visceralgias being often in good, even robust, health so far as any anæmic tendency is concerned.

Anæmic neuralgias are, as a rule, protracted, like their cause, but may in the end pass away rapidly under appropriate treatment.

Diabetes sometimes causes intractable and often symmetrical neuralgias, especially sciatica, even though the symptoms of the underlying disease are not marked.

Gout and kindred disorders (lithæmia) may cause neuralgia, partly by alteration of the blood, or by direct irritation of the nervous centres, and partly by inducing neuritis. These neuralgias are sometimes bilateral and fugitive, sometimes lasting, according to their origin. Visceralgias are also common in the gouty, but it is an open question whether this may not be, in part, because of the neuropathic tendency which is intimately connected with gout.

Chronic nephritis, and the vascular and nutritive disorders associated with it, may cause various neuralgias, both superficial and visceral.

Syphilis likewise causes neuralgias both in its early and

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in its late stages, and here also the manner of its action may be either direct or indirect. It is also worthy of reflection, in a given case of this kind, whether the cause of the neuralgia may not be the antisyphilitic treatment which has been used, and not the disease itself.

The neuralgias due to *mineral poisoning* are apt to be bilateral, or to attack different parts successively. The arthralgias and visceralgias of lead poisoning belong in this category, but will be treated of with the other symptoms of the same origin.

Peripheral irritations cause neuralgia which is sometimes confined to the region irritated, sometimes located in distant parts, and are always to be carefully sought for and eliminated, since, even when they constitute only partial causes, they may be practically responsible for the seizures. Carious teeth may excite neuralgia in other branches of the fifth pair besides that directly irritated.

Injuries, such as *severe jars*, as in railroad accidents, or *blows*, even when they do not apparently injure any particular nerve, may excite severe neuralgias, and the same is true of *emotional excitement or mental overstrain, acute or chronic*.

The pains due to the pressure of *cancerous growths*, or other *tumors*, and *aneurisms*, though often classed as non-neuralgic, are really not always to be distinguished from neuralgia by any intrinsic characteristic. The diagnosis is often established by other indications of the presence of morbid growths, and, so far as the nervous system is concerned, is rendered probable by unusual persistence and severity of the pain, the occurrence of signs of neuritis, such as marked atrophy, contracture, anæsthesia, etc. A *bilateral distribution* of the pain is also suggestive of such a cause, pointing either to pressure upon symmetrical nerve trunks at their exit from the spinal canal, or, in the case of the brachial nerves, to a symmetrical enlargement of lymphatic glands. Neuralgia of the fifth pair has occasionally been traced to aneurism of the internal carotid.

Cold and damp weather and the atmospheric changes preceding and accompanying storms are fruitful causes of neuralgic attacks, acting no doubt in part by depressing the general nervous tone, and in part by causing congestion or anæmia of the sensitive cutaneous nerve fibres, and even increasing any neuritis that may be present.

It is proper to speak here of the relation to neuralgia of such general influences as *age* and *sex*.

Childhood is usually considered nearly free from neuralgia, but this is only true of the typical, peripheral neuralgias of protracted course. The so-called "growing pains" of childhood may fairly be called neuralgic, and children suffer from visceral neuralgias, and sometimes from typical migraine or periodical headache.

Puberty brings an increased tendency to migraine and headache, which then usually lasts until the age of forty-five or fifty. The neuralgias of acute anæmia and chlorosis occur also largely at this period, though anæmia is probably also a cause of some of the pains of childhood.

All neuralgias are most common in *middle life*, mainly because it is then that the nervous strains incident upon increased cares and exposures of all kinds make themselves most strongly felt, and act both directly and indirectly by increasing neuropathic tendencies.

Neuralgias *rarely begin in old age*, and when they do they are very intractable, perhaps because they depend upon tissue degenerations in the nervous and vascular systems. It is, however, a noticeable fact to which the writers can bear testimony that, in spite of their severity and persistency, the neuralgias of old age sometimes unexpectedly disappear for longer or shorter periods, or even permanently.

The *female sex* shows a relatively great liability to the neuralgias of neuropathic origin; the *male sex* to neuralgias of peripheral origin.

General Symptomatology.—All neuralgias have in common a greater or less tendency to *periodic* and apparently spontaneous *recurrence*, but the degree to which this periodicity is seen varies greatly.

The most regular and spontaneous periodicity is met with in the malarial neuralgias and in those of mainly neurosal origin, especially migraine and the periodic headaches. The visceralgias recur less regularly, but their outbreaks also are frequently, to all appearance, spontaneous, that is, due to cyclic changes within the nervous centres themselves, and not to irritation from without. In both cases this tendency to cyclic outbreaks may be interrupted, and attacks precipitated, by various causes.

Besides these neuralgias of regular recurrence, persons of neuropathic constitution are often liable in some degree to spontaneous attacks of pain, of relatively short duration; but the typical superficial neuralgias of protracted course, as a rule, show but little of this tendency to periodical and spontaneous recurrence, so characteristic of the more distinctly neurosal neuralgias. They may recur, it is true, but this is either from a recurrence of their underlying cause, or because the neuritis, which is usually present as an important complication, if not a cause, does not entirely pass away and excites the neuralgia to fresh outbreak.

Almost all neuralgias have in common a tendency to excite *vaso-motor* and *trophic changes*. The *vaso-motor* phenomena are most marked in cases of the migraines, which are often characterized by a marked pallor or redness, or both in turn, of one side of the head. These vascular changes have, in fact, been widely believed to be the essential feature of migraine, and to be directly responsible for the pain: but this is, in the writers' judgment, a mistaken opinion. Similar symptoms are seen in the other neuralgias, especially those of the neighborhood of the eye, and probably attend, if they do not cause, the changes in the glandular secretions (tears, urine, mucus, gastro-intestinal fluids), which are also very common near the seat of any severe neuralgia, and even at a distance from it. The writers have seen a sharp attack of intercostal neuralgia, for instance, of short duration and due to acute fatigue and exposure, pass entirely away with a copious discharge of limpid urine, such as often attends the close of a migrainoid attack. Finally, migraine is often unattended by any noticeable vascular changes.

The *trophic* phenomena are most marked in the case of the superficial neuralgias, and range from such changes as are obviously due to neuritis (herpes zoster and other cutaneous eruptions, muscular atrophy, and the like), to the more temporary alterations which are partly of vaso-motor origin, or due to irritation of trophic or glandular nerves, and partly of unknown origin (œdema of the skin, changes of color and increased brittleness of the hair, temporary muscular enfeeblement, impairment of the eyesight, possibly even glaucoma, etc.). The cases associated with herpes are occasionally accompanied by palsy of the muscles innervated by the affected or related nerves. The trophic changes in migraine are but slight.

It is often included in the definition of neuralgia, that the pain is confined to the *region of distribution of one or more nerve branches*, but this applies only to the neuralgias of the superficial nerves.

It is common to most neuralgic attacks that the pain is *intermittent or remittent* in severity. When a continuous dull aching is present, it may be suspected that the neuralgia is complicated by a material degree of neuritis.

For further examination of their symptomatology, neuralgias may be divided into:

1. Superficial neuralgias.
2. Migraine and the periodical headaches.
3. Visceralgias.
4. Unclassified neuralgias of irregular distribution.

1. The *superficial neuralgias* are limited to the course and areas of distribution of one or more nerves or parts of nerves supplying the skin and adjacent structures.

The principal varieties are: (1) The neuralgia of the fifth nerve, of which there are several subdivisions; (2) the neuralgia of the occipital nerve; (3) the neuralgia of the cervico-brachial nerves; (4) the neuralgia of the abdominal nerves; (5) the neuralgia of the anterior crural nerves; (6) the neuralgia of the sciatic nerves.

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All these neuralgias have the following peculiarities in common: The attacks are sometimes brief, often of relatively long duration.

The *brief attacks* generally occur in persons of neuralgic habit, and under these circumstances are more likely to attack the facial, intercostal, or abdominal nerves than the brachial or the sciatic. They may occur spontaneously, or from some special cause, as fatigue, excitement, or exposure, and may pass away after a night's sleep, like an attack of migraine, the disappearance being sometimes attended with a copious secretion of urine. Gouty persons are also subject to brief neuralgic attacks; and there are other obscure disorders of the nutrition (so-called lithæmia, and the like), of which the same is true, though it is by no means easy to say whether the neuralgia is really secondary to the nutritive disorder, or both are symptoms of an underlying nervous affection. Vaso-motor changes are common in acute attacks of brief duration, leading to pallor or redness of the skin. Such attacks are often attended also by increase, preceded at times by diminution, in the secretion of neighboring glandular organs, and occasionally by œdema of the skin. These phenomena are perhaps of vaso-motor origin. Hyperæsthesia of the skin is often present.

The *attacks of relatively long duration* usually come on gradually and are recovered from gradually. The pain is not felt over the whole area of distribution of the nerve, but has its points of election, and from these points the pain spreads or darts farther. Sometimes, and especially in the case of sciatica, the course of the nerve itself is the painful region, and it is believed that it is the sensitive nervi nervorum ramifying in the main nerve trunk that are mainly or even alone concerned in the neuralgic process in such cases. General tenderness along the nerve points to neuritis, but the localized tenderness which has just been referred to, and which is confined to certain definite spots (*points douloureux* of Valleix), probably do not necessarily have this significance. These spots of tenderness are apt to coincide with the foci of pain, but do not always do so. They are usually found where the nerve emerges from a bony or fibrous canal, or where it begins to ramify in the skin. The pain is often accompanied by subjective and objective *disorders of the sensibility.* The former consist in sensations of prickling and numbness, or of heat or coldness.

These sensations often precede or follow as well as attend an attack. When they overlast the attack a long time, and especially if they are sharply localized, they usually indicate that the nerve has been the seat of the inflammation. The *objective* disorders are of the nature either of hyperæsthesia or of anæsthesia. The former is usually seen at the beginning or at the height of an attack, and the latter usually later. A persistent impairment of sensibility points to destruction of some of the sensitive nerve fibres from neuritis.

Trophic changes in the skin and its appendages, or in the muscles, are common and usually point to neuritis. The muscles near an acutely painful region are sometimes temporarily paralyzed without apparent cause. The hair of the eyebrow and scalp has been known to become blanched during a neuralgic attack of the fifth nerve, recovering its color later. This change of color is probably due to the penetration of air into the hair shafts.

TREATMENT OF SUPERFICIAL NEURALGIAS (*vide* also sections on Neuralgia of the Fifth Pair, Sciatica, etc.).—*Causal Treatment.*—The importance of removing the causes of the neuralgia is evident to every one, but it is not equally recognized that it is necessary to remove partial causes, no matter how many there may be. Such causes are principally: (1) Exposure to alterations of temperature and weather, to be met by suitable clothing, change of occupation, temporary removal to a drier, or, it may be, to a more relaxing climate; (2) peripheral irritations, either near or remote from the seat of pain; (3) neuritis, primary or induced (*vide* below under Electricity and Surgical Operations); (4) dyscrasias, such as gout, syphilis, diabetes; (5) fatigue, anæmia, lack of proper nourishment. It should be remembered in this connection that a state of health sufficient for ordinary purposes may not be sufficient as counteractive of neuralgia. What would seem excessive nourishment (see under Neurasthenia), combined, if necessary, with massage and rest and cod-liver oil, arsenic, and large doses of iron, if well borne, is useful in a large number of cases.

Symptomatic Treatment.—This comprises the means used to relieve pain and to counteract the neuralgic condition and the irritability of the nervous centres. The important remedies of this class are: Quinine, aconitine, (*vide* under Neuralgias of the Fifth Pair), salicylate of sodium, opium, the coal-tar products, croton chloral, electricity, hydriatic treatment, counter-irritation, vibration, and local manipulation in the affected region, and surgical operations. The method of use of these remedies is too familiar to need comment, except that of the last five.

Electricity is mainly useful in the form of galvanism, which is usually applied with one pole of the battery near the nerve centres, and the other near the nerve trunks of the affected part. Its special indications are for the temporary relief of pain and in the treatment of neuritis. It is probably indifferent which pole is used in the painful area, but, on the other hand, it is of great importance, in acute neuralgias, that the current should flow without interruptions and that the strength should not be suddenly increased or diminished. The electrodes should be large and well nourished with warm water. The strength of the current should not be so great as to irritate the skin, and thereby excite, instead of soothe, the patient. Moderate variations of the current strength, as made by sliding the electrodes slowly over the skin, sometimes increase the effect. In chronic cases strong currents are sometimes useful, and it is not necessary to observe the same caution as to interruptions of the circuit.

Static electricity is of value in some cases of neuralgia given either in the form of sparks or in the unipolar method of charging and discharging described by Dr. Morton.

Hydriatic (or *Thermic*) *Applications* (so far as they can be used outside of special institutions) consist in the use of the local and prolonged wet-pack (*vide* under Sciatica); local bathing and showering, or, in chronic cases, the filiform douche; prolonged general warm baths (useful as a general sedative); prolonged application of ice (*vide* under Sciatica); or the application of dry warmth in the form of hot sand or salt bags.

Counter-irritation may be applied in the form of stimulating liniments and ointments, mustard, blisters, the actual cautery, or spray of ether, or of chloride of methyl.

The best liniments are those containing aconite and laudanum combined with alcohol and chloroform, or strong solutions of menthol (ʒ i. to fl. ℥ i.). A strong aconitine ointment (one part to eight) is said to be useful, but must be employed with great caution. These agents act not only by the irritation which they set up, but probably by lessening the sensitiveness of the skin as well. In the same way cocaine, instilled into the eye, will sometimes relieve pain in the globe and in the supra-orbital region.

Prolonged and rhythmical vibration or manipulation over an affected nerve, best done by an instrument designed for that purpose (Granville's hammer), is said to be of service, and similarly some forms of headache can often be relieved by prolonged manipulation or vibrations with the finger tips.

Surgical Operations comprise deep injections of irritants, such as water or chloroform; removal of a portion of the nerve (neurectomy); stretching of the nerve; and extirpation of the nerve roots or of the Gasserian ganglion.

Injections of chloroform have been followed by alarming results, probably by its introduction into a vein, though this is a rare event. The best way to avoid it is first to introduce the needle alone until its point comes

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near the nerve, and not to inject the chloroform if any blood appears. The dose is from ten to twenty minims.

Nerve-stretching is appropriate for mixed nerves, and has been applied to almost all the superficial nerves of the body, including the intercostals. Its effect is partly to diminish the conducting power of the sensitive fibres, and thereby diminish the irritations reaching the nerve centres, partly to alter the condition of nutrition in the nerve trunks, and partly, no doubt, to exert a so-called inhibitory action with regard to the neuralgic condition of the nerve centres. The operation is not often followed by serious results if done under proper antiseptic precautions, but when large nerves are treated in this way morbid changes are occasionally set up in the spinal cord. This operation has found its greatest sphere of usefulness in sciatica, to which heading (p. 247) the reader is referred.

Neurectomy and *extirpation of ganglia* are considered under facial neuralgia (p. 246).

Special Forms of Superficial Neuralgia.

Trifacial Neuralgia.—The fifth pair is more frequently affected in neuralgia than any other nerves. Conrad's statistics of seven hundred and seventeen cases of neuralgia showed thirty-three per cent. to be trigeminal. This frequency is due, in part, to the exposed position and extensive distribution, many attacks being induced by disease of parts supplied by its different branches, as the teeth, nose, eyes, etc.

The forms of trigeminal neuralgia may be clinically divided into three types:

1. Supraorbital neuralgia.
2. Reflex neuralgia.
3. Tic douloureux.

This division may not in a way be absolute, since many attacks of supra-orbital neuralgia, though implying a neuropathic constitution as a *sine qua non*, may be brought on by peripheral irritations, and thus in a way be reflex.

Furthermore, supra-orbital neuralgia may exist as a type by itself, or the nerve may be involved in either of the other two forms.

1. *Supra-orbital Neuralgia* may be divided into: A. Those manifested by constant pain. B. Those in which the attacks are intermittent. C. The periodic attacks.

A. The pain in supra-orbital neuralgia may be *constant* and persist for several weeks or more. In this case its character is generally described by the sufferer as twisting or boring, and radiates from above the eye to the vertex. During the attack there is generally tenderness over the supra-orbital foramen. Such attacks are frequently found with diseases of the eye, especially iritis and glaucoma, and may be benefited by treatment of these conditions. The supra-orbital neuralgias associated with herpes are apt to be very persistent.

B. The *intermittent* type is generally characterized by making its appearance in the early morning and continuing with great severity till two or three o'clock in the afternoon, when the pain subsides, only to recur on the following day. This type, from its intermittent character, was once thought to be always due to malaria; and the fact that large doses of quinine, given three or four hours before the paroxysm is due, has generally proved beneficial seemed to corroborate this view.

In this locality, at least, it is usually a sequel of a coryza which extends upward, causing a catarrhal inflammation of the frontal sinuses, to which the ophthalmic division sends sensory fibres, and free drainage of these sinuses is essential to recovery. This intermittent type, however, may persist as a neurosis or habit neuralgia long after its original cause has gone.

C. The supra-orbital neuralgias which come *periodically* at more or less regular intervals form a group by themselves, the attacks often being foreshadowed by marked gloom and depression of spirits.

These attacks may be accompanied by eye symptoms and vomiting, and after lasting a definite period of time disappear. This migrainoid type derives its name not only from the character and periodicity of the attacks, but from the fact that it sometimes alternates in the same patient with typical attacks of migraine. Moreover, there are patients who suffer from migraine from childhood till adult life, when the character of the attacks changes and the migrainoid neuralgia takes the place of the old headache.

2. *Reflex Neuralgias.*—The characteristic of the reflex neuralgias is that they stay until the cause is removed. The most common form is that due to diseases of the teeth, especially where cavities have led to exposure or disease of the pulp. They may also be due to changes in the alveolar processes, or to swelling and thickening of the periosteum of the bony canals through which the nerve passes. More rarely they are caused by aural disease.

The pain in this group of neuralgias is usually constant or jumping, though it may be paroxysmal, simulating tic douloureux. It is possible that in some cases true "tic douloureux" begins as a reflex (tooth) neuralgia. Against this, however, is the fact that the teeth have so often been drawn without benefit. Moreover, these reflex neuralgias often occur before the middle period of life.

3. The third type of trifacial neuralgia, *Tic Douloureux*, is to be sharply distinguished from the other forms. It begins in middle or advanced life and runs a characteristic course. The pain is located in the area of distribution of the second, or the second and third divisions of the fifth nerve, more rarely involving the first or all three branches. It generally starts in the upper lip or at the side of the nose, and is described at times as flashing upward along the nerve, at times as radiating outward like a pinwheel. It is paroxysmal in character, the attack being lightning-like in onset, of extreme severity, and lasts about a minute, disappearing as abruptly as it came. During the attack there is flushing of the affected side of the face, with twitching of the muscles, and often there are lachrymation or salivation and a serous discharge from the nose. The lightest touch or draught of air will precipitate an attack, while the patient dare not speak and refuses to eat solid food, so great is his dread of the pain.

These paroxysms come from several to many times a day, for periods of a few weeks or months, after which the patient may be free from them for an interval of several months. It is oftentimes a striking feature in these attacks that the pains occur with great frequency during the day, while the sufferer may go to bed at night and sleep unmolested.

The rule is for these alternations between periods of pain and periods of relief to persist over long intervals of time. It is not uncommon to see patients who have suffered for fifteen or twenty years.

Pathology.—Tic douloureux has been considered due to degenerative changes in the Gasserian ganglion, as described by many investigators. Coenen, however, maintains in a recent article that these changes are secondary to peripheral operations previously done for relief of the pain.

Degenerative changes of varying intensity have been shown to exist in the nerves by many investigators. Whether these are the original cause of the pain, or whether they result from the continued severe paroxysms cannot be decided with certainty.

Some investigations have demonstrated an endarteritis in the vessels supplying the affected nerves, at times resulting in marked diminution in the lumen of the vessel. This may be a factor in many cases by giving rise to nutritional disturbance.

The *treatment* of tic douloureux is medical and surgical, and the former should be given a thorough trial before the latter is undertaken. If the medical treatment is successful, the immediate attack is prematurely terminated, but permanent cure is rarely experienced. This, however, is often all that is accomplished through the peripheral operations, though the results of the latter are more constant.

Besides the so-called "overfeeding," and the observa-

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tion of general hygienic rules, the following drugs, out of the large number recommended, give the best results:

Aconitine (the crystallized alkaloid) is best given at first in doses of gr. $\frac{1}{100}$ to gr. $\frac{1}{300}$ every two to three hours, in pill form or solution; then if no unusual susceptibility shows itself, in doses of gr. $\frac{1}{200}$ to gr. $\frac{1}{100}$ or even more, though this amount is rarely reached without the patient's complaining of severe tingling and numbness of the extremities and sometimes of a sense of coldness and faintness. A moderate degree of these symptoms does not contraindicate the continuance of the treatment for some days, or even weeks, if the patient is otherwise in good health and is constantly under observation. Tincture of aconite root can be substituted if necessary, but is less certain in its action.

Gelsemium may be given in any reliable preparation until the signs of physiological action appear, the most characteristic being a drooping of the eyelids.

Castor oil certainly does good in some cases, if given every morning on rising, in half-ounce doses, increased to one ounce as he patient becomes accustomed to the drug. Purgative effects often fail to appear after the first few doses, hough the remedial action persists.

Iodide of potassium has many advocates and certainly does seem to do good in some cases, especially if given in moderately large doses.

Strychnine in massive doses is recommended by Dana, in cases of not over four or five years' standing. He keeps the patient quiet in bed and administers the strychnine subcutaneouly, starting with gr. $\frac{1}{30}$ once a day, and gradually increasing until gr. $\frac{1}{6}$ or gr. $\frac{1}{5}$ is reached. This should be given for four or five days, and then the dose gradually diminished. This should be followed, he says, by an iodide-of-potassium treatment.

Opium given in gradually increasing doses till the pain is controlled is advocated by La Tourette, who claims very satisfactory results from it.

Surgical treatment consists in the *peripheral operations*, which may be regarded as palliative, and the extirpation of the Gasserian ganglion, which gives permanent relief in most cases.

The peripheral operations generally consist in cutting down on the offending nerve—the customary points being at the dental canal, infra- or supra-orbital foramen, or sphenomaxillary fossa—and in twisting and pulling out as much of the nerve as possible. This procedure usually gives freedom from pain lasting from a few months to two years. Occasionally a patient will be relieved for three or four years, and some cases of cure have been reported. The average relief from forty-three such operations, recently collected by the writers, was ten months. Three or four peripheral operations had often been performed on the same patient. The *Gasserian-ganglion operation*, first done by Rose, ten years ago, is regarded as the only means of affording permanent relief, though it is attended with considerable danger, owing to the location of the ganglion and the liability to hemorrhage. Horsley has performed this difficult operation twenty-one times, with only two deaths. The reports of two hundred and one operations, collected by Türk, show that in seventeen per cent. of the cases the patients died as a direct result of the operation; ninety three per cent. of those who recovered were considered to have been permanently cured. This percentage of cures is, however, open to some criticism, for sufficient time had not elapsed after some of the operations to make it sure that a cure had been effected. On the other hand, the recurrence of pain after some of the earlier operations may have been due to the incompleteness of the operation.

Spiller and Frazier have recently brought forward the question of division of the sensory root of the ganglion as a radical operation. This was tried twelve years ago by Horsley and resulted fatally. It has never been attempted since then until last year, when it was recommended as being a simpler operation, and as attended with less danger of hemorrhage than the extirpation operations. It is an important recommendation of this procedure that it leaves the motor root intact. The only uncertainty is that regeneration of the sensory root may later take place with return of the pain. How great this danger is can be shown only by time.

Occipital neuralgia is generally an affection of the occipitalis major and minor and the great auricular nerves. It approaches the neuralgias of the fifth nerve in severity and in its tendency to assume the epileptiform type, and often superadds itself to them, especially to the supra-orbital variety, by extension. In its typical form it is commonly unilateral, and this, together with its history and the character of the pain, usually serves to distinguish it from the occipital headache met with in neurasthenia, chronic nephritis, intracranial tumor, and eye strain.

In the *treatment* a diligent search should be made for organic disease of the vertebræ and surrounding tissues. This failing, salicylates or coal-tar products or the above-named antineuralgic remedies may be employed for relief of the pain. Galvanism often acts favorably in this form of neuralgia. If, however, the pain proves intractable and relief cannot be obtained from medicine, surgical interference may be resorted to and resection of the nerve may be done. Intradural resection of the posterior root has recently been performed with successful results.

Brachial and Cervico-brachial Neuralgia has the distribution which its name implies, and the characteristics of a typical superficial neuralgia. Like the rest, it is often due to injury or neuritis, the latter sometimes being secondary to affections of the shoulder-joint, but it may occur simply as a sign of debility or a neuropathic diathesis, or from concussion accidents and the like.

The pain usually centres in foci, such as the point of the shoulder blade, the insertions of the deltoid, the neighborhood of the supinator longus muscle, the wrist, and more rarely the fingers, and radiates upward or downward from these points. The hand and even the whole arm are often the seat of sensations of numbness and tingling due perhaps to congestion of the nerve, or to disorders of the circulation of vaso-motor origin, or to neuritis, and these sensations sometimes substitute themselves for the neuralgic pain.

The *pathological diagnosis* should take into account the possible presence of cancerous cervical glands, pachymeningitis cervicalis, spondylitis deformans, and Pott's disease (bilateral pain, muscular atrophy, rigidity of the neck), or of angina pectoris.

Occupations and professions requiring constant use of certain groups of muscles of the arm often give rise to extremely obstinate and troublesome pain, which, however, does not follow the course of any particular nerves, but is generally increased by motions involving the much-used muscles. It is not a muscular affection, but probably comes best under Oppenheim's head of psychalgia brachii.

The chief point in *treatment* of this form is rest of the affected member, but recovery is accelerated by general tonics and static electricity. The treatment of brachial neuralgias in general is that of the other superficial neuralgias. Surgical treatment by nerve-stretching is possible at any point, even as high as the cervical plexus.

Intercostal Neuralgia is one of the commonest neuralgias of debilitated subjects, especially women, and of persons of nervous temperament. The intercostal nerves are surrounded at their origin by large venous plexuses, and are thus liable to suffer from any sluggishness of venous circulation. Neuralgia from this cause is more frequent on the left side, since there is greater obstacle to the emptying of these vessels. It is also met with in connection with brachial neuralgia, or with neuralgia of the thoracic or abdominal viscera. It is often associated with herpes ("shingles"), and then the pain may occur two or three days before the appearance of the rash. It may pass off with the healing of the vesicles or may persist for weeks or months. In many cases of intercostal neuralgia there are tender points at the seat of the pain, which is usually greatest over the side of the chest at the exit of the lateral nerve branches. Often a tender point is also felt at the exit of the dorsal or anterior branches. The path-

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ological diagnosis should consider intrathoracic cancer, Pott's disease, aneurism (all of which would be likely, but not certain, to cause bilateral pain), and pleurodynia. In all cases the heart, pleura, stomach, and gall bladder should be carefully examined for disorders. The treatment should be at first directed toward improving the debilitated and anæmic condition so often present. Blisters are often useful in cases not associated with herpes. Iodide of potassium, salicylates, or quinine in large doses may be given with benefit.

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Ilio-lumbar Neuralgia needs no separate notice except to remark that it is often found in connection with affections of the uterus and ovaries.

Anterior Crural Neuralgia is not very common and needs no separate notice. The pathological diagnosis should consider the possibilities of hip disease, osteo-arthritis of the spine, and pelvic tumor.

Meralgia Paræsthetica.—The symptoms of this condition, as the name implies, consist of paræsthesia and pain, and these are located over the area supplied by the external cutaneous nerve of the thigh. The surface involved usually extends from the crest of the ilium to the knee, on the outer aspect of the thigh, though only part of this may be affected. There is frequently a tender pressure point just below the anterior superior spine of the ilium. This disease may result from trauma, but is commonly seen in people with a rheumatic or lithæmic tendency. The treatment consists in hydrotherapeutic measures, massage, and remedies directed against the constitutional tendencies. The disease is not a very serious one, but often resists treatment almost indefinitely.

SCIATICA is one of the commonest and severest varieties of superficial neuralgia, both on account of the exposed position of the nerve, which renders it liable to injury both within and without the pelvis, and also from causes which are more subtle and less well understood.

The causes of sciatica are: local injuries; primary neuritis, as in herpes zoster; exposure to sudden alterations of heat and cold; intrapelvic diseases, even when they do not directly involve the nerve itself, as uterine disease for example; gout, diabetes, and the various constitutional affections which impair the quality of the blood or the general nutrition. Cancerous disease within the pelvis may, by pressure, give rise to pain which is hardly to be distinguished at first from sciatica, and this cause should be suspected if the symptoms are bilateral, unusually persistent, or attended with marked signs of neuritis, such as anæsthesia, localized numbness, and pricking, muscular wasting, and especially if other nerves are involved at the same time. Chronic inflammation of the tissues around the hip may also give rise to pains which could be readily mistaken for sciatica. It is very important, and usually perfectly easy to distinguish the pains of locomotor ataxia from those of sciatica. The former are bilateral, not confined to the distribution of the sciatic nerve, momentary in duration, and usually affect, by preference, small spots in the fleshy parts of the limb, the knee, or the heel, or dart down the leg and disappear again.

Osteo-arthritis of the spine is commonly mistaken for sciatica, the pain in this affection being caused by involvement of the nerve roots in the inflammatory exudation along the vertebræ. This gives rise to pain which is often distributed in patches, along the areas of distribution of these roots, over the front and side of the thighs and legs. Many of the curvatures described as sciatic scoliosis by many authors are really signs of osteo-arthritis, and are due to muscular spasm on the unaffected side of the spine, in attempts to relieve the involved nerve roots from pressure. This condition is recognized by the marked muscular rigidity on the unaffected side of the spine. The motion of the vertebral joints is quite free when the patient bends toward that side, while the lumbar spine remains perfectly rigid on any attempt to bend forward or toward the affected side.

Symptoms.—The distribution of the pain in sciatica may be coextensive with the distribution of the whole nerve, but oftener it centres in certain regions which may vary as the attack goes on. Such are the sacral region, the neighborhood of the sciatic notch, the back of the thigh, the popliteal space, the calf, the outer side of the leg, or the outer side and dorsum of the foot. Sometimes the course of the nerve itself is marked out by darts of pain. "Tender points" are found at the sacro-iliac synchondrosis, the sciatic notch, the popliteal space behind the head of the fibula, behind the outer malleolus, and often at other places as well. Some cases of sciatica are of short duration and seem to be of purely functional origin, while in others neuritis plays a large part in the production of the symptoms, causing persistent pain, loss of sensibility, cutaneous eruptions, coldness, and wasting, and increased pain on motion, voluntary or passive. Even where these symptoms are absent, and where the pain is fully intermittent, the absence of neuritis cannot be confidently asserted in cases of long standing.

The *prognosis* of sciatica depends upon its cause. Except when it is dependent upon some temporary irritation, however, it lasts usually for weeks or months, or even longer, and is liable to relapses and recurrences. The sciatica of diabetes is said to be peculiarly obstinate, even if the usual symptoms of the disease are not severe.

The *treatment* of sciatica varies with its causation and its stage (*vide* also under General Treatment). The removal of diathetic taints, absolute rest, superficial blistering, counter-irritation by a spray, of ether or of chloride of methyl, the local wet-pack followed by vigorous rubbing with cold water and by warm applications. If access is obtainable to a hydrotherapeutic institution, the Scotch douche may be used with benefit. Galvanism with long-continued mild currents, cutaneous faradization, are always in place, and turpentine, quinine, iodide of potassium, or salicylate of sodium in full doses, may be given in fresh cases for limited periods with some hope of relief.

In chronic cases the remedies may be proportionately vigorous. The galvanic applications may be as strong as the patient can bear, and special pains taken to localize the current on the nerve, at the sciatic notch, and in the popliteal space, by pressing the electrode inward, and seeking to excite referred sensations at the periphery. It probably makes no difference whether the anode or the cathode is employed over the nerve, or whether the current is occasionally interrupted. Indeed, a series of sudden reversals of the current are often of service. Static electricity in the forms previously mentioned (*vide* General Treatment) is of value in these cases. Deep massage along the nerve, even if painful at the time, may be of great value, probably by removing inflammatory exudations. Ice-bags may be applied continuously along the course of the nerve, and deep injections (*vide* under General Treatment) are serviceable, though not without danger. When other means fail, "nerve-stretching" may be used, and, indeed, under proper antiseptic precautions, it is not a dangerous operation in itself. It has, however, been shown that the effects of the traction are felt in the spinal canal, and myelitis has in a few instances been excited. A substitute operation is the so-called "bloodless stretching," in which, the patient being under ether, the thigh is forcibly flexed on the pelvis and the leg extended at the knee, and this position maintained for some minutes. That the nerve can be stretched in this way is beyond question; but it may be doubted whether the method is really safer as regards its secondary effects than that of the exposure of the nerve by a single incision, and the use of a measured amount of direct traction, upward and downward in turn.

Coccygodynia.—This is a severe neuralgic pain in the region of the coccyx, occurring almost exclusively in women. The pain is marked on sitting or during defecation and micturition, and the end of the coccyx is exquisitely tender to moderate pressure. The condition occurs almost always in neurotic individuals, but may be brought on by trauma or difficult labor. It frequently runs an obstinate course and is best treated by tonics, counter-irritation, hydrotherapy, or galvanism. Excis-

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ion of the coccyx may be performed, but often fails to give relief.

It might be well to speak here of the importance of examining the feet in all cases of vague and obscure pains in the legs, knees, thighs, and hips, for the greatest variety of sensations, from constant dull aching or burning to sharp neuralgic twinges, may have their origin in weak or broken-down arches, and immediate relief may be obtained from proper treatment. Metatarsalgia is but one instance of this sequence.

Migraine—*vide* the article on *Headache*.

VISCERAL NEURALGIAS.—The visceral neuralgias are of great importance, both on account of the suffering which they cause, and because of their constitutional significance. They occur, like the other neuralgias, partly from general nervous causes, such as fatigue, gout, and other constitutional diseases of the nutrition, and especially the neuropathic tendency, and partly as a result of functional and organic disorders of the viscera. To what extent actual neuritis occurs as a cause is not yet known, but it is certain that chronic inflammation of the nerves is often set up by organic affections of the organs, such as the heart, to the neighborhood of which the pain is referred.

The pain of the visceral neuralgias is usually deep-seated, vaguely located, and dull, but at the same time intense and prostrating, and sometimes attended with faintness, nausea, sweating, and often disorders of the circulation and secretions. Though not sharply localized visceral neuralgias take their name from the organ in the neighborhood of which they seem to be situated, as the pharynx, the œsophagus, the heart, stomach, liver, bowels, ovaries, uterus, rectum, testis, etc.

Angina Pectoris (see Vol. I., p. 227), though a true visceral neuralgia, is so often a symptom of heart disease that it is usually described in that connection. It may, however, be mentioned here that it occurs not infrequently, though hardly in its severest forms, entirely independently of organic disease. In a case known to the writers, for instance, it occurred during a considerable period on the slightest exertion, such as rapid walking, in a lady suffering from temporary debility from overwork, and was each time attended with breathlessness, and with pain and numbness in the left arm, yet eventually passed entirely away. Various other such cases are on record.

Dull pain felt during the intervals of the attacks is looked upon as perhaps indicating neuritis of the cardiac nerves, but in such cases cardiac disease probably exists as well.

It is an interesting question whether nitrite of amyl, which acts so well in angina pectoris of organic origin, would be beneficial also in the functional cases.

The *treatment* should be, in the first instance, tonic, and in the attacks itself diffusible stimulants and analgesics would be in place. Besides the outspoken diseases of the heart, increased vascular tension should be sought for, and signs of Bright's disease, as well as functional irritability of the nervous cardiac apparatus, such as result from physical overstrain and from abuse of tobacco and other cardiac stimulants. Under these circumstances digitalis or other heart tonics might be indicated.

When the attacks are of frequent occurrence electricity, either by the superficial use of the wire brush and faradic current or in the form of galvanism, is said to be of service, as is also counter irritation over the chest.

Gastralgia (gastrodynia, cardialgia, gastric colic) is perhaps the most common form of visceral neuralgia, and in its widest sense covers a variety of sensory symptoms, ranging from sensitiveness and pain accompanying the act of digestion, and perhaps accompanied with signs of delayed or imperfect digestion, yet not due to gastritis or ulcer, to severe paroxysms of pain entirely unconnected with the digestive process.

The *etiology* is similar to that of the other visceral neuralgias, but it is met with in young children oftener than the rest. It is especially common in gouty subjects and in persons of nervous, mobile temperament, and the writers have several times seen slight symptoms of this general character at the time of the menopause.

The pain in gastralgia is felt primarily at the epigastrium, and radiates thence upward in the direction of the œsophagus, and through toward the back, besides laterally through the abdomen. Allbutt ("Visceral Neuroses") says that it may be associated with anginiform attacks, and it may be attended likewise with superficial neuralgia of the abdominal walls and other parts of the body, as the face.

The relation of gastralgia, as well as of the other sensory visceralgias, to the functional affections of the viscera is very important and calls for further study. There is no question that many digestive disorders which attend gastritis, or even cancer, may also occur as pure neuroses, and it is likewise evident that there is a whole range of nervous disorders, sensory and motor, of which these purely painful affections form only one division.

Treatment (*vide* also under General Treatment).—The vices of nutrition and assimilation should be corrected, such as are seen in gout, and evinced also by a variety of nervous symptoms often described under the head of lithæmia, and sometimes attended with the presence of free uric acid or oxalate of lime in the urine. Constipation should be corrected and the diet regulated, but not necesarily reduced to a very small amount, even if digestion is attended with pain. Sometimes it will be found that one kind of food will agree better than another without apparent reason, and, when the gastralgia is associated with serious disorders of the digestion, it may be that a patient who does very badly at home will get on very well if removed from home and placed under the care of a nurse. Indeed, the most significant fact to bear in mind is that, as a rule, it is a general nervous condition which needs treatment, rather than the special symptoms.

Belladonna and the antispasmodics, such as asafœtida and valerian, besides the gastric stimulants, are of more service in gastralgia and the other visceral neuralgias than their anæsthetizing influence would suggest. Morphine must be resorted to if necessary. Deep pressure sometimes gives temporary relief.

It is not necessary to review in detail the neuralgias of the other abdominal viscera and of the genital organs. Attention has already been called to the fact that affections of the *uterus and ovaries* may give rise to neuralgiform affections in distant parts of the body, or in the distribution of the lumbo-abdominal nerves; but besides this the uterine and ovarian nerves themselves are sometimes the seat of neuralgia, not to speak of the pain of dysmenorrhœa, which is, doubtless, in part, of that character.

Neuralgia of the liver is said to be sometimes attended by swelling of the liver and by jaundice; but here, as frequently in the case of the abdominal neuralgias, it is difficult to guard carefully enough against mistaking an organic disease for one of the concomitants of a neuralgic attack.

Neuralgia of the anus and rectum is a well-marked and painful affection, and the tendency to it may be hereditary. The seizures may come on spontaneously, especially after fatigue, or may be excited by slight irritations, such as the passage of hardened fæces, or may follow sexual intercourse or seminal emissions. The pain may be accompanied by clonic spasms of the perineal muscles. The rapid injection of hot water into the rectum, or hard and deep pressure with some smooth object will often stop the attack, which otherwise is liable to last for one or two hours.

Besides the more or less typical neuralgias there are a number of other painful affections, of spontaneous origin or provoked by trifling irritations, and of unknown pathology, which occur usually in persons of neuralgic or neuropathic tendency, and are therefore fairly to be classed as neuralgic, although they do not follow the distribution of a special nerve. Such are pains referred to the skin, the muscles, or the joints, not attended by signs

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of local inflammation or by any appearance of local congestion or anæmia, and capable of coming and going with greater or less rapidity. The "growing pains" of anæmic children are of this order, together with a similar affection sometimes met with in adults; also the "general neuralgia" of anæmic patients, and those dermatalgias which are not due to the organic irritation of sensitive nerve fibres, such as occur in locomotor ataxia and neuritis. The arthralgic pains of false (hysterical) joint disease might perhaps be included.

The therapeutic indications are, primarily, to improve the constitutional and nutritive condition, and to relieve the pain by local or general baths or liniments, or by anodynes.

James J. Putnam.
George A. Waterman.

NEURASTHENIA.—The term *neurasthenia* ("*nervousness*," or *nervous weakness or prostration*) has come into general use to indicate certain states of the nervous system of which the anatomical basis is unknown, but which are characterized, on the one hand, by a lack of vigor, efficiency, and enduran , affecting usually a large number of the nervous functions, and, on the other hand, by signs of active derangement, which in part seem to occur as positive symptoms, and in part are due to a failure of the mutual support and control which the different parts of the nervous system aff rd each other in health.

In its widest sense the term neurasthenia is used as covering the groups of symptoms usually indicated by such names as *nervous prostration, spinal irritation, neuropathic or neurotic diathesis.* Even abnormal mental states, such as mild degrees of melancholia and "morbid fears," are often classed as neurasthenia, but their relation to a more serious malady should not be forgotten.

Sometimes neurasthenic symptoms are secondary to localized pathological affections in one or another part of the body, and this fact has led some observers to recognize in neurasthenia only a symptom of errors of refraction, lithæmia, uterine disease, organic disease of the brain or cord, and the like. It would, however, be easy to push this attempt too far, and the writers certainly believe that neurasthenia is a useful term to indicate states of nervous weakness which are often primary, and which even when secondary usually imply a pre-existing basis of functional disease.

Since a sense of fatigue is generally one of the chief symptoms in the neurasthenic individual, it is possible that an actual pathological change in the nervous system is the cause of this condition. Hodge has shown that fatigued animals show degenerative changes in the protoplasm and nuclei of their ganglion cells, and some such process may be the underlying cause of certain types of neurasthenia. On the other hand, the tired feeling may be a purely psychological symptom or the result of an inharmonious working of a brain of which the several parts may be structurally normal.

It has been said with some truth that hysterical and hypochondriacal persons are always neurasthenic, but that neurasthenic persons are not always hysterical or hypochondriacal; and hysteria has also been spoken of as "nervousness" crystallized into the form of a definite disease. Although typical cases of neurasthenia and of hysteria differ widely, yet the two affections run into each other, and the same patient may, at the same moment or at different periods, show symptoms of both diseases.

While it is true that neurasthenia should be looked upon—relatively to hysteria and insanity—less as a distinct disease than as a departure from health, and as an expression of the mode in which degeneration of the nervous powers first shows itself, still it must not be forgotten that neurasthenics present certain symptoms which are almost as characteristic as those of any other of the neuroses.

SYMPTOMATOLOGY.—The symptoms called neurasthenic are conveniently divided into those which arise as a sign that the patient is unequal to the ordinary tasks of a fairly healthy person, and those which are manifestations of a morbid action on the part of the nervous system over and above the indications of simple inefficiency. These can be called, for convenience' sake, *negative* and *positive* symptoms, respectively. Thus, the *negative* symptoms are those of fatigue or pain arising without sufficient cause, but still due to effort, and, within certain limits, proportionate to the effort made; while the *positive* symptoms are nervous outbreaks or signs of excessive weakness of special kinds, occurring almost independently of effort, and at least out of proportion to it. The negative and positive symptoms may run into each other, as, for example, when, in the place of an oversensitiveness or self-distrust, we find an ever-present sense of anxiety or "morbid fear"; or, when a simple incapacity of the eyes to bear a prolonged strain passes into a high degree of photophobia or asthenopia; or when instead of a simple feebleness of the digestion we have an active nervous dyspepsia, and so on through the whole range of nervous functions. Usually the symptoms of special nervous derangement appear on a background of general nervous weakness. It sometimes happens, however, that some one symptom is so prominent that it seems to stand almost alone. In like manner some cases present almost exclusively mental symptoms, and cannot bear a slight emotional strain without great suffering and yet may show more than ordinary physical strength and endurance; while with others by far the most prominent symptoms affect the muscular and vegetative functions.

The late Dr. George M. Beard, to whom we owe many valuable observations on this subject, attempted to base upon this fact a division of neurasthenic symptoms into cerebral and spinal, but this is premature and is not based upon sufficiently well-grounded reasoning.

Individual cases of neurasthenia vary so greatly in the grouping of their symptoms that it will be better to study the symptoms themselves one by one rather than to attempt to describe different types of the disease. It is, however, worth while to bear in mind that the term "irritable weakness" aptly indicates the character of many of the conditions met with.

Special Symptomatology.—The *temperament* of neurasthenics is essentially mobile. They are usually quick, versatile, and sensitive, and may be talented and intellectual, though they rarely have the robustness and endurance necessary for great success. Often a sense of nervous weakness and effort is present, which gives rise to self-consciousness and self-distrust, and finally to a suspiciousness toward others, and to a vague feeling of isolation and dread.

A healthy organism should respond to calls upon it with an elasticity like that with which the cushion of a billiard-table responds to the blow of the ball.

With neurasthenic patients this is usually not the case. A trifling impression arouses an exaggerated *inward reaction* in the form of egotistic or self-distrustful ideas, while the *outward reaction* is correspondingly feeble or unduly delayed. Slight obstacles seem mountains, and some patients can hardly persuade themselves into a decision or an exertion, although under the influence of some slight excitement they may act with energy and intelligence. A similar undue inward reaction is shown in other departments of nervous energy besides the strictly mental. Thus, even with patients who seem well-balanced and of good self-control, trifling causes may excite or maintain neuralgia or dyspepsia, disorders of the sleep, collapse of strength and the like, with provoking and inexplicable readiness.

Instead of the vague sense of anxiety and dread, special "morbid fears" are often present. The variety of these fears is endless. Among the most common is the fear of large open spaces, fear of crowds, of walking alone, or riding in railway trains, fear of contamination from touch, fear of taking food and the like, fear of becoming insane.

In many cases, of course, these symptoms mean something more serious than neurasthenia; but often, on the other hand, they represent the natural or "reasonable"

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fears of healthy persons acting upon a morbidly sensitive temperament. Such persons begin by being vaguely timorous and distrustful and end by having special "fears."

Sometimes the neurasthenic temperament approaches the hysterical temperament, in exhibiting gross selfishness and fondness for making a display and attracting attention; but, as a rule, neurasthenic patients are docile, patient, self-sacrificing, and intelligent, or if they are selfish, it is because of a life of semi-invalidism, or of habits of painful introspection, and is not due to a lack of moral sense, which is rather characteristic of the hysterical temperament.

On the other hand, it is not uncommon to see neurasthenic patients exhibiting some of the special disorders which are usually considered as peculiar to hysteria, such as hemiplegic disorders of sensation or motion, alteration of the deep reflexes, photophobia, etc.

The *digestive disorders* of neurasthenia may vary from simple feebleness of the digestion, or digestion perhaps sufficiently well performed but attended with pain, to disturbances almost or quite indistinguishable from true catarrhal affections. Such patients are also very subject to visceral neuralgias, which, when they affect the nerves of the digestive tract, are often attended with marked signs of functional disorder of the corresponding organs.

Other symptoms are likewise met with, which are hardly to be called digestive, though affecting the digestive organs. Such are attacks of nausea, not due to the taking of food; attacks of diarrhœa, or, more strictly, discharges of watery fluid, coming on suddenly as a result of slight nervous fatigue or excitement, and passing away as quickly, or perhaps permanently yielding to an improvement in the patient's general condition; or discharges of large quantities of mucus, in masses or strips, with or without fæces.

These nervous disorders of the digestion are of so much practical importance and interest that they have of late years attracted much attention.

Often the only conclusive diagnostic sign to distinguish them from organic affections is the fact that they do not improve under the usual treatment of gastro-intestinal catarrh, chronic ulcer, etc., which they simulate, while they are greatly influenced by improvement in the patient's general condition and surroundings. Thus, a removal of the patient from home, or his subjection to the "rest cure" (see under Treatment), may effect what the most careful dietetic and medicinal treatment had failed in years to accomplish.

Finally, it is not to be forgotten that in any given case the symptoms may be in part of organic, in part only of functional origin.

In some cases the neurotic dyspepsias are so severe that, what with the nausea and vomiting and general distress and pain, the patient's strength is greatly reduced, and his life may even be threatened. In two cases under the care of one of us these symptoms were attended with symptoms of insanity of the melancholic type, and with suicidal tendency.

Sensory Disorders.—The most important type and instance of the disorders of special sense is simple *asthenopia*, which is often so severe that some patients, who may have otherwise no more serious trouble than a certain delicacy of health, are, for years together, almost totally unable to use their eyes for any fine work. This may be due in part, or wholly, to weakness of the muscles of convergence and accommodation, and is sometimes remarkably relieved by a systematic method of exercise, combined, if necessary, with suitable glasses. Other patients are much annoyed by sparks of light floating in the field of vision, or by glimmering sensations similar to those which often precede sick headache. Tinnitus aurium is sometimes found, but this is less likely to be a prominent symptom in simple neurasthenia than to occur as a sign of irritation of the nervous centres, such as may imply toxic conditions of some sorts.

Neurasthenic patients are subject to *neuralgia*, or to neuralgiform attacks, both superficial and visceral, and usually shifting and fugitive in character (see under Neuralgia), and to periodical headaches.

Backache, sometimes with excessive sensitiveness to light pressure over the spine, is very common, and may be associated with some slight uterine disorder, though it may also occur alone. It is usually increased by exercise, and especially by using the arms above the height of the shoulders, and by anything which causes general fatigue.

The pain of the neurasthenic backache may be along the vertebral column, or farther outward, especially about the sacral and iliac attachment of the large muscles of the back. It is often provokingly obstinate under local treatment, and disappears the soonest under such treatment as best agrees with the patient's general condition. Sometimes, in the class of cases to which the name of "spinal irritation" was formerly given, the sensitiveness of the back to slight pressure, combined with the local pain, is the most prominent symptom present. In such cases, besides the local sensitiveness, the pressure gives rise to special peripheral sensations, thoracic, pulmonary, abdominal, etc., according to the level at which it is made.

Pain in the muscles and joints is not uncommon, without it being possible to discover any sign of typical rheumatism, gout, or neuralgia, and this symptom, like so many others, is capable of attaining a prominence out of proportion to the rest. Thus, in the case of a gentleman of whom one of us has had the care, intense muscular pain in the legs, beginning after an interval of quiescence of half an hour and rising steadily in severity, is brought on so easily by the least exertion that the patient has been obliged for many years to give up walking almost altogether.

Another very common variety of pain, not precisely neuralgic, is a distressing *sense of pressure at the vertex or occiput*, often combined with tenderness and stiffness of the muscles of the neck. This is usually a sign of some special fatigue or strain, but some patients suffer from it almost continuously, and find in it a source of serious distress.

Paræsthesia ("prickling and numbness") in the extremities, or assuming the hemiplegic distribution, is likewise often complained of, but it is to be remembered that the same symptom is met with in debilitated women who are not especially neurasthenic, in cases of chronic lead poisoning and in other conditions.

Palpitation and *cardiac irregularity* are not uncommon, and we have seen one or two patients with peculiar *disorders of the respiratory rhythm*. One of these was cured by systematic exercises of the respiratory muscles.

The writers have noticed that *cardio-respiratory murmurs* occur with great frequency in young male neurasthenics of the thin, poorly nourished type. Sometimes this murmur is very transitory.

Nervous cough is sometimes a marked and obstinate symptom, and may last for months, without any (local) cause whatever, and then pass quickly away. These coughs, like many other of the neurasthenic symptoms, are associated at times with slight irritation in the nose, or pharynx, or ears, or in the genital tract. Sometimes, instead of the cough, we find a veritable *asthmatic seizure*, and in this connection the semineurotic origin of hay-cold is to be remembered.

It is not uncommon to see in patients who cannot be called other than neurasthenic an almost *periodical recurrence of symptoms*, such as migrainoid headaches, attacks of exhaustion, sleeplessness, and the like. Usually some slight overexertion or fatigue seems to act as the immediate cause of these outbreaks, but the cause and the effect are out of proportion to each other.

Neurasthenic patients are, as a rule, very easily affected by *stimulants* of every kind, and at the same time they often feel rather a desire for them. In spite of this, they are by no means always inclined to be immoderate in indulgence, and need not necessarily be advised to abstain altogether from their use.

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Insomnia, in one or another form, is almost always present at one time or another, and forms one of the most important symptoms of neurasthenia, on account of its indirect effects as well as for the suffering that it occasions. The early morning period of wakefulness is a time when the depression of spirits, from which neurasthenics often suffer, makes itself most prominently felt.

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It is also true, however, that such patients usually sleep more than they themselves believe, and that they do not suffer from an amount of real fatigue at all in proportion to their sensations in the morning after a night of restlessness and unpleasant dreams. Excessive *drowsiness* is a less common symptom than insomnia, and, though annoying, less serious in its results.

Vaso-motor Symptoms.—Besides the fact that nervous patients are prone to blush easily, a fact which usually indicates only a general emotional excitability, they often show symptoms which are fairly attributable to a morbid action of the vaso-motor nervous system. Such are the vascular spasms of *digiti mortui*, chilliness, and urticaria, and the vascular dilatation which causes erythematous patches, burning, and swelling of the hands and feet, and even chilblains.

The general sensation of heat, which leads certain patients to go about with light clothing in the coldest weather, is probably not really of vaso-motor origin, nor have we a right to attribute to this cause the attacks of profuse sweating on the slightest exertion from which neurasthenics occasionally suffer, or the watery discharges from the bowels already alluded to. It is more probable that these are neuroses of the glandular nerves themselves.

The "hot flashes," which are often such a serious annoyance, are sometimes attended with visible flushing of the face, hands, etc., and with distressing sensations of fulness and pulsation in the head—symptoms which are probably vaso-motor in character; but sometimes they are unattended by any such phenomena, and, so far as we know, are neuroses of sensation only, and analogous to the many other morbid feelings with which such patients are liable to be attacked.

The *sexual functions* are apt to be disordered in various ways. Impotence, premature ejaculation, sense of prostration after sexual intercourse, and similar symptoms, are much oftener met with among neurasthenic than among healthy persons; and it is with persons of this class, both male and female, that irritations in the genital tract produce, indirectly, their most serious results. The sexual instincts in neurasthenics are usually active and practically normal, the grave perversion of desire belonging rather to the category of insanity.

The *general nutritive condition* of neurasthenic patients may be good and their muscular strength quite up to the normal. They are, however, usually spare in flesh, and if, as often happens, their appetite, digestion, and power of assimilation are disturbed, they may become greatly reduced in health. On the other hand, many of these patients, and some of the worst cases, are over-fat, and often at the same time anæmic.

The *metabolic functions* are apt to be at fault, and indeed, strictly speaking, it is often impossible to say whether the nervous or the nutritive disorder comes first. Free uric acid, urates, or oxalate of lime are often found in the urine; the phosphates are liable to be increased, and the quantity of the urine may be increased or diminished, or both in turn.

Where such conditions as these are traceable to functional diseases of the liver, or to a gouty inheritance, or to the absorption of products of imperfect digestion, the nervous symptoms which occur may fairly be considered to be secondary.

On the other hand, there is little or no doubt that the nervous weakness may be the primary affection, and, even in many cases of gouty parentage, it is probable that the impaired nervous system is often a direct inheritance.

The *pupils* are apt to be unusually large in moderate light, and very mobile.

The *voice* sometimes shows signs of the universal tendency to irritability and weakness, and lacks the normal firm, sonorous quality.

The *hair, teeth*, and *skin* of neurasthenics are said by Beard to suffer from premature denutrition; but this is difficult to prove with certainty, though it may be admitted as possible that a lack of nervous vigor should show itself in this direction as well as in so many others.

The following sketch by Dr. Clifford Allbutt may be quoted as giving an excellent picture of one variety of neurasthenic patients.

After speaking of the contrast between the neurotic and the hysteric types, and the absence in the former of the exaggerated selfishness and feebleness of purpose, which are characteristics of the latter, he says: "He enters your room with a brisk step and a quick, observant eye. You see a slightly built, meagre man, of sallow complexion, or, if colored, with the color painted high upon the cheek-bone. The cheeks and temples are hollow, and the temporal arteries are visible under the lean skin, which often shows tanned markings, deepened during attacks of pain; the hair is straight, fine, and sparse upon the scalp; the features are sharp, often prominent; the lips thin, and the skin dry; and some remnants of eczema may be seen about the chin or ears. The bodily frame is lightly and often finely built, the bony fingers and wrists and the visible sinews and radials betraying the absence of fat. Here and there, in later life, a knotty knuckle may tell of gouty parentage. The pulse, when most tranquil, usually ranges between 70 and 80, and accelerates on the least excitement. The clavicles and ribs in like manner are prominent, and the heart's apex may be seen to beat sharply before the eye; its systole to the ear is likewise short and sharp, and the second sound very audible over a wide area. The limbs are small, but often very sinewy; such persons are as active as birds, and the absence of fat in their muscles often gives to these, in states of health, the quality of hardness under the hand. Their conversation, again, is lively and voluble, often keen and brilliant, but impressionable rather than imaginative; you may generally notice in them, too, some little blinking, twitching, or tattooing trick which quickens as thoughts and cords come faster. His companions will tell you that he is subject to great fluctuations of the animal spirits; gay even fascinating, in society; brisk, orderly, and thorough in business; but at home dejected or fretful. He is a small eater, a light sleeper, and a worn worker. These persons are the heirs of every true neurosis, from insanity to toothache; and, on the whole, when we consider the infinite perturbations of intermarriage, it is surprising how true they run, or how clearly you may detect the neurotic strain in mixed descendants. Of their visceral neuroses I shall have to speak hereafter, and would only say now that in both sexes of them migraine, stomachache, and windy colic are frequent and eminent, and receive the name of dyspepsia; and in the women are added to these uterine and ovarian neuralgias and hyperæsthesias. To call these suffering women of the neurotic type hysterical is to confuse all due acceptance of names, and, what is worse still, is to confuse the real relations of things. The neurotic woman is sensitive, zealous, managing, self-forgetful, wearing herself for others; the hysteric, whether languid or impusive, is purposeless, introspective, and selfish. In the one is the defect of endurance, but in the other defect of the higher gifts and dominion of mind."

Besides this, which might be called the intellectual type of neurasthenia, there is another, in which the element of feebleness, mental and physical, is the predominating characteristic. Many of the "fat anæmics" belong to this class, and in them, in lieu of excitability and misdirected force, the nervous symptoms suggest those of hysteria, of a mild type, in their exaggerated response to slight irritations.

Influence of Age and Sex.—Neurasthenia, unlike hysteria, is almost as common among men as among women. In its full development it is a disease of pu-

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berty and middle life, but signs of the neurasthenic tendency are to be found in early youth, consisting in a general mobility of temperament, oversensitiveness, and precociousness, and the occurrence of special nervous symptoms, such as insomnia, somnambulism, chorea, night-terrors, etc.

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Still later, especially in young women from sixteen to twenty years of age, various other signs of nervous weakness may make their appearance, such as headache, backache, extreme and causeless lassitude; and these years constitute in fact a critical period, during which many persons are nervous invalids, who may later reacquire good health. Very often these periods of prostration are attributed to special causes, such as falls, overexertion, and the like, but these events are rarely more than exciting causes, and are not necessary to the result. Such attacks are often diagnosticated as anæmia, or chlorosis, or as "spinal concussion," but their failure to respond to ordinary tonic or local treatment, and the fact that they are often relieved by means addressed to the general nervous condition, point to their true origin. Of course, true anæmia may complicate this condition of nervous prostration, or even act as its cause, and may require its own special treatment; but the important point is that the nervous element in the case is not to be overlooked.

Course and Prognosis.—Neurasthenia is not likely to shorten life to any marked degree, unless it causes severe disorders of the nutrition. It does, however, occasionally happen that a patient dies from no other apparent cause than a prostration of the nervous functions.

On the other hand, neurasthenia is not, as a rule, an acquired disease, but an inherited weakness of the nervous system, and in this sense is not, strictly speaking, curable. It is, however, often possible to remove the patient from the circumstances which call out the manifestations of this weakness and thus practically to effect a cure. Sometimes even with the best of treatment partial improvement and frequent relapses are the rule. Constant watchfulness and good judgment rarely fail to bring some amelioration. Acquired neurasthenia may pass away with the cessation of its cause, or may overlast this for many years, as in some cases of railway accidents, or similar injuries, and in the case of neurasthenia of the menopause.

Neurasthenic symptoms sometimes constitute the first stage of outspoken mental disease, but, on the other hand, patients may be severely neurasthenic all their lives long without suffering from more serious mental trouble.

The relation of neurasthenia to organic disease is obscure, but very important.

The fact that neurasthenia is so often associated with disordered metabolism, and with impaired nutritive vitality of many tissues of the body, and that its course is often marked by the frequent occurrence of functional disturbance of the heart and vaso-motor system, makes the inference natural that the nervous disorder must sometimes pave the way, or, more strictly perhaps, mark the commencement of more or less serious organic affections.

Our opinion in the matter, as regards chronic neurasthenia, is at present limited to this inference. We do, however, know that *acute* mental strain may be the starting-point of such affections as chronic nephritis, diabetes, and probably many other disorders.

Diagnosis.—This has been sufficiently covered by the foregoing sections. It cannot, however, be amiss to recall again that the presence of neurasthenic symptoms only shows that the efficiency of the nervous system has received a blow of some kind, and leaves still before us the task of seeking the real source of mischief. It is especially important to recognize that some organic diseases, such as disseminated sclerosis or cerebral tumor, may cause neurasthenic or hysterical symptoms, and perhaps for a time no others.

Etiology.—Neurasthenia must be distinctly counted as belonging to the great family of neuroses, and is inheritable from parents suffering from any one of this group of affections. It stands also in a similar relationship to various constitutional diseases, such as gout, phthisis, anæmia, and other less well-marked disorders of the nutrition (lithæmia), as well as to all of the many influences which impair the vigor of the nervous system, including even organic disease of the nervous centres.

Chief among the causes that tend to develop and maintain the neurasthenic tendency may be mentioned an irregular, unhealthy, and overstimulating life, especially at the time of childhood and puberty, when the emotional nature is so active; and, at a later time, exposure to responsibility and worry greater than the patient is fitted to bear.

Some patients are, in fact, neurasthenic only in relation to their surroundings, and appear healthy when under conditions more suited to their powers and character.

One-sided, or unsystematic education in youth, or in early professional life, which makes success in later years possible only at the cost of undue strain, is a fruitful source of mischief.

It has been said that neurasthenia is more common in America than elsewhere, and that the cause of this consists partly in the peculiarities of the climate, partly in the fact that we have been brought rather rapidly under the influence of an overstimulating state of civilization. These statements and arguments are suggestive, but cannot be asserted positively without further proof.

Among the special causes of neurasthenia may be mentioned disease of the uterus and ovaries in women, and of the prostate gland in men; also concussion accidents, fright, grief, or mental strain. A condition of nervous exhaustion, which may be called acute neurasthenia, may be due to excessive overwork, as has been already alluded to.

Some of the more local neurasthenic symptoms may also be excited by irritations in the sensitive mucous tract, especially of the nose, and by errors of refraction in the eye.

Treatment.—The first indication for treatment is, of course, to remove special causes of the neurasthenic state, such as disorders of metabolism, anæmia, errors of refraction, disease of the uterus and prostate, chronic fatigue, etc. It is often found, however, that this attempt is less successful than had been anticipated, because the true relation between the symptoms and their causes had not been made out.

It is also noticeable that the neurasthenic condition can be largely relieved by appropriate general treatment, even while the irritation that caused or maintains it still persists.

The treatment of uterine disorders especially may, on this ground, often be postponed to advantage until the general health has been partially restored by other means, or at least until the confidence of the patient has been fully gained; for, except under these conditions, the local treatment may do more harm than good.

It is certain that benefit often follows gynæcological operations on neurasthenic subjects, but it is often difficult to say why this happens, and equally difficult to obtain reliable statistics for estimating the relative number of good and of poor results.

One powerful factor with some patients is the sense that now, at last, the real cause of the long illness has been found. This cause can be counted on the most in cases in which many other treatments have been tried in vain.

It would, however, be unreasonable to deny that pelvic disorders, even when painless, may act as foci of morbid excitation, so that where operations are not likely to do harm they may be advised. The fact should never be forgotten, however, that no surgeon should operate in this class of cases without the advice of a judicious physician or without having made a careful study of neurasthenia.

It should be noted that the statement made above as to the effect of operations as the starting-point of new encouragement, or hope, applies equally to operations

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on other organs, as the nose, or eyes, or to the overcoming of morbid mental habits and analogous influences. It is a dangerous practice, however, to undertake operations with encouragement as the sole excuse.

The next indication is to secure that perfection of nutrition for the nervous system which will enable it to work at its best; and to place the patient in surroundings suited to his individual powers and needs. Where this is distinctly impossible, the aim should be to enable him to bear the strain imposed upon him with as little cost as possible.

As has been said, many persons are neurasthenic only in relation to their surroundings, and enjoy good health when leading a simple life, or while in the country, though they cannot stand the excitements and responsibilities of the town. Many persons break down under the strain of emulation and competition, who can do good and active work if freed from these influences. They must learn to estimate their endurance justly, and not to be misled by their excitable temperament into attempting too much.

When the needed change cannot be secured, the time of labor should be shortened by an hour of recreation and rest in the middle of the day, or by early bed hours. Patients who do not sleep well should not work later than the early evening hours.

If exercise can be taken freely, this furnishes an immense resource, where rightly used, and even when vigorous exercise is not well borne, as is very often the case, especially if the patient is at the same time exposed to other sources of fatigue, neurasthenics almost always gain by being a great deal in the open air. The subject of exercise is so important that it must be worked out in detail for each case. Where horseback-riding, rowing, tennis, etc., are to be had, the problem is relatively simple; but for ladies, and in winter, recourse must be had to such amusements as battledore, some thorough system of calisthenics, frequent short walks, and the like, and to rubbing with a wire or hair flesh-brush, either dry or moistened with water, or salt and water.

Neurasthenic patients are, from the want of confidence in their strength, apt to fall into unsystematic habits of life, or to be without a regular occupation, and both these wants should be carefully met. Frequent short intervals of recreation, and frequent change of scene are useful, unless incompatible with proper regularity of life. Almost any change is apt to work well at first.

The strict observance of regular hours of work, rest, and exercise often saves much wear and tear, and makes the difference between an efficient and a useless person. Even a very feeble person can have some real interest, and take some real part in the work of life.

Patients with feeble nervous systems are usually better when taking as much food as their digestions allow, and that is commonly more than their appetites would suggest.

In spite of "delicate stomachs," if the nervous strength is withdrawn from other directions and turned to the service of the digestion, such persons can usually greatly increase their food without much difficulty. As a rule, the most suitable kind of food is that which agrees best with the digestion, but in certain cases great benefit is obtained from special diets. (See article on *Gout.*) In some cases of sick headache I have found a distinct advantage in alternating between the albuminous and the vegetable diets.

Thoroughly cooked and strained oatmeal, or Mellin's food, with warm milk, can be taken as a matter of routine, in the forenoon and afternoon (not always well borne at this latter time) and at bedtime, or one or two eggs, boiled or raw, or scraped meat mixed with bread-crumbs and slightly broiled, may be substituted.

The *medicinal* treatment of neurasthenia is mainly useful in correcting the disorders of nutrition with which the nervous symptoms are associated. Of the drugs that are thought to improve, directly or indirectly, the vigor of the nervous system, only arsenic, cod-liver oil, nux vomica, and perhaps the glycerophosphates, are of much value.

The temptation is strong to exaggerate the anæmic element in neurasthenia and to give iron largely, but this is not advisable, unless distinctly indicated.

Neurasthenia may be the indirect result of conditions which are susceptible of benefit through the so-called *organotherapy*, and the range of this mode of treatment is still *sub judice*. Here, too, in many cases, the physician who believes in the specific treatment cures through the encouragement which his conviction carries.

Electricity, in the form of galvanization of the head, general faradization, the static breeze, and electric baths are sometimes of distinct service. The simplest method of using electricity is to pass the faradic current from the neck to the feet and hands alternately, for fifteen minutes or half an hour, daily.

For the more complicated methods, the special text-books must be consulted.

A judicious *hydrotherapeutic treatment* is after all the very best method of exciting the vaso-motor activity of the nervous system and thus setting better nutritive processes on foot. Its success depends upon the choice of methods by which a good "reaction" will be brought on and maintained. Usually some warm application (blankets, hot cabinet, hot bath) is used to warm the skin and then the stimulus of cooler water follows. At this stage friction, or some other form of mechanical stimulation, is very useful.

A "powerful reaction" is a good thing, but it is a very easy matter to fatigue a very delicate patient, and so one must often be content with a moderate reaction. A good system of graduated baths might embrace:

1. The blanket pack followed by hard friction with cool or cold water.
2. Hot baths followed by quick, strong affusions.
3. The dripping sheet, preceded or not by the wet pack.

For some cases of neurasthenia, where the patient is able to go about and take part in active duties, the above treatment is sufficient; for others, further means are needed to meet special symptoms, or to overcome an amount of prostration such as confines the patient to the bed or house, or totally unfits him for any active employment.

In order to treat successfully the *mental symptoms* of neurasthenia, the physician must thoroughly win the confidence of his patient by attention, kindness, and by showing self-confidence and authority, and must provide suitable employment for his thoughts, as a basis for special advice.

The *nervous indigestion* is in most cases best treated by a careful attention to the general condition, including, if necessary, removal from home, etc.

The food should be simple and digestible, but it is striking how little these cases, in spite of the violence of the symptoms, are benefited by attention to the digestive functions, such as is required in true catarrhal gastritis.

A similar statement may be made with regard to the other special symptoms of neurasthenia. They may all be helped somewhat by such symptomatic treatment as would naturally suggest itself, but as a rule they are to be taken as a sign of general nervous weakness, and require general treatment.

It has been said, with truth, that neurasthenic patients are cured, not by physic, but by the physician.

Nervous indigestion is often benefited by electricity (faradic or galvanic current, or both combined in one circuit) used as a general tonic, or applied directly to the epigastrium, with one pole at the back of the neck.

Such patients should also abstain from active exercise after eating.

The cases of pronounced invalidism require a special consideration. Although they need to be treated on the lines which have been already laid down, it is for them that the so-called "rest-cure," elaborated and practically invented by Dr. S. Weir Mitchell, is so pre-eminently useful. For patients who are so reduced in strength,

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and nervous vigor and self-confidence that they become more deeply implicated the more they struggle to free themselves, the rejuvenation often secured through this means is remarkable. For some of them, it is the moral element in the "cure" which is the most important, for others the opportunity for nutritive improvement.

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The "rest-cure" consists of several parts—seclusion, generally with removal from home and complete rest in bed, during six or eight weeks; forced feeding, massage, and electricity. This system may be modified or simplified to suit special needs, but in severe cases there is no part of it that can be safely omitted. The complete removal from responsibility and care, from unhealthy and familiar surroundings, the anxiety of friends, and most of all, from a vague sense of responsibility as regards themselves, which the enforced rest involves, gives a feeling of mental repose, like that afforded by a long sea voyage to a person simply fatigued by overwork.

The *food* consists at first of skimmed milk,* given in small quantities every two hours, and rapidly increased until the patient takes two quarts daily. Solid meals are then gradually added, so that soon the patient is taking a very large quantity of nourishment, and in the absence of all other calls upon his nervous strength, digests it perfectly well.

Massage† is given once, or even twice, daily, taking the place of voluntary exercise. The latter is absolutely forbidden, even to the extent of feeding one's self, with the result that the patient, having no excuse for feeling tired, soon loses even the apprehension of fatigue. After a time muscular exercises are added to the massage, and eventually substituted for it, and the patient is gradually allowed to walk.

As the patient is obliged to lie constantly in bed, it is important that her time should be sufficiently occupied, and this is not difficult, especially if she has a private nurse of the proper temperament and experience.

The following was the daily schedule of a patient of the writer's, and may be taken as a typical specimen: 7 A.M., small cup of black coffee; patient allowed to brush her teeth. 7:45—Hands and face washed, fire made by nurse. 8—Breakfast, which at this time consisted mainly of a pint of gruel (taken slowly, and kept warm when desired, by table-lamp). 8:30—Sponge bath; bed made. 9:30—Windows open for half an hour (the weather being cold the patient was warmly covered except for the face. 10—Breathing exercises; food. 10:30—Hands and feet exercise, following by reading aloud for fifteen minutes. 11:30—Temperature of body taken, and patient rolled in blankets. 12—Food. 12:30 Bath given. 1 P.M.—Massage and rest. 3—Hair brushed, reading aloud. 4—Food; breathing exercises. 7—Hands and feet exercise; patient arranged for the night. 8—Food. 10—Food.

In some cases we have given patients breathing exercises to carry out every hour or two; and, as a commencement of more vigorous exertion, have had them roll over from one side of the bed to the other a certain number of times. These hints from personal experience are offered, not as constituting material modifications of the treatment as laid down by Dr. Mitchell, but as likely to prove useful where the full treatment cannot be carried out, which so often happens.

The cases which are the most benefited by the rest-cure are those in which the nervous symptoms are caused or maintained mainly by simple anæmia or impaired nutrition. Even in the purely "nervous" cases, however, an occasional treatment of this kind often gives a chance to start fresh once more, which is invaluable.

Some cases are not helped at all in this way. This may often be suspected beforehand, but sometimes a fortnight's trial must be given them (Playfair), and if this is explained to them in advance, they are usually stimulated to do their best.

Perhaps the most indispensable condition for success is that the physician should gain and keep the fullest confidence of his patient. How he will best accomplish this must depend, in the end, upon his own character and temperament. If he never allows himself to be discouraged, and insists on the systematic brushing aside of morbid thoughts on the part of his patients, he will often be agreeably surprised at the results which he initiates.

James J. Putnam.
George A. Waterman.

NEURINE.—Neurine is a ptomaïn which is frequently found in meat and other articles of food which have undergone a certain amount of decomposition. Chemically, it is a derivative of ammonium hydroxide; is, in fact, trimethyl-vinyl-ammonium hydroxide, $N(CH_3)_3CHCH_2OH$. It is often confused with choline; the latter, however, is trimethyl-oxyethyl-ammonium hydroxide, $N(CH_3)_3C_2H_4OHOH$. Neurine was first prepared synthetically in 1858 by Hoffmann by treating trimethylamine and ethylene bromide with silver oxide or potassium hydroxide. The name neurine is due to Liebreich,[1] who is usually credited with having obtained the substance by boiling protagon for twenty-four hours with concentrated barium hydroxide. According to later investigators, however, it seems very probable that Liebreich was dealing not with the vinyl base (neurine) but with an impure preparation of the oxyethyl base (choline).[2] More recently neurine has been obtained by Brieger[3] from putrefying horse, beef, and human flesh. Brieger also obtained it from human brains by boiling with barium hydroxide; it appears probable, however, that neurine occurs in the brain only as a result of putrefactive changes, for Gulewitsch could find no trace of it in perfectly fresh ox brains.[4] It has also been obtained from decomposing mushrooms; such mushrooms are very poisonous.

The genesis of neurine in the above cases is very obscure; it may be that it is formed from the cholin which is a part of the lecithin and protagon molecule (see articles on *Cholin* and *Lecithin*). Bayer showed that choline chloride could be transformed into neurine by chemical processes; this was done by heating the choline chloride with concentrated hydriodic acid and red phosphorus and then treating the iodine compound so formed with silver oxide. On the other hand, neurine may be converted into choline by first making the iodine compound and then heating this with silver nitrate.[5] Schmidt and Weiss,[6] moreover, found that choline and its salts could be converted into neurine by the action of micro-organisms. It is a significant fact that neurine is almost always accompanied by choline; hence it is probable that the latter is, as a rule, derived from the former by the loss of a molecule of water.[7]

Neurine is a colorless syrup soluble in water and alcohol; it has a strongly alkaline reaction and forms easily soluble salts. When heated, either dry or in concentrated solution, it decomposes with the formation of trimethylamine ($N[CH_3]_3$). With platinum chloride neurine forms a double compound $(C_5H_{12}NCl)_2.PtCl_4$, which is insoluble in alcohol; this compound is soluble with difficulty in hot water, from which it crystallizes in small octahedra. These crystals melt, with decomposition, at 195.5–198° C. and contain 33.6 per cent. platinum. A similar double salt is formed with gold chloride. A substance isomeric with muscarine may be obtained by treating neurine with hypochlorous acid and then decomposing the resulting compound with silver oxide.

Neurine may be isolated from organic liquids containing it by the method of Brieger. The method is essentially as follows: To an alcoholic extract of the material is added a saturated solution of mercuric chloride in alcohol. The precipitate (which contains most of the neurine) is washed with alcohol and water and then decomposed by hydrogen sulphide; the mercury sulphide is filtered off and the filtrate concentrated and taken up in alcohol

* Milk mixed with half its bulk of oatmeal jelly answers an admirable purpose.

† The writer has found the application of the wet pack or blanket-pack for an hour or less, as recommended by Dr. Mary Putnam-Jacobi ("Massage and the Wet Pack in the Treatment of Anæmia"), a useful adjunct to the massage.

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The neurine is precipitated by an alcoholic solution of platinum chloride; the precipitate is washed on the filter with a little cold water (which dissolves the choline salt of platinum chloride) and the neurine salt is recrystallized several times from hot water.

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Neurine is a very poisonous substance. 40 mgm. (injected subcutaneously) per kilogram body weight is fatal to rabbits. The symptoms are very similar to those caused by muscarine. A few milligrams of the hydrochloride injected into a frog causes within a short time complete paralysis of the extremities with, a little later, a diminution of reflex excitability. The heart is greatly slowed and finally stops in diastole, as in muscarine poisoning; atropine will cause the heart to begin beating again. As small a quantity as two milligrams is fatal for most frogs. After the administration of neurine to mammals there are profuse salivation, dyspnœa, diarrhœa (due to increased peristalsis), great slowing of the heart and a fall of blood pressure, and finally convulsions and death from failure of the respiration. Before the depression of the heart and respiration there is often a brief period of stimulation, due probably to the sensation of nausea. Cats seem to be much more sensitive to neurine than are rabbits or guinea-pigs; when a cat is poisoned with this substance there is, in addition to the symptoms noted above, a marked secretion of alkaline sweat from the ball of the foot. Many of the symptoms of neurine poisoning are antagonized by atropine, but even after the administration of this drug there remains a condition of general paralysis. The fatal dose for animals is ten times as great when the poison is given by the mouth as when injected subcutaneously.

Under the name of "neurine" a weak solution of choline was formerly occasionally used as a solvent for diphtheritic membranes. *Reid Hunt.*

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NEURITIS.—Neuritis is inflammation of a nerve trunk or its branches. As a localized affection involving a single nerve it generally attacks certain nerves, such as the branches of the brachial plexus in the upper extremities, or of the lumbar or sacral plexus in the lower extremities. The cranial nerves may also be attacked by neuritis. When only one nerve trunk is affected, the condition is usually spoken of as "isolated," "localized," or "mononeuritis." When many of the peripheral nerves are involved at the same time, it is characterized as multiple neuritis, or polyneuritis, a condition meriting special description, and which will be discussed later. Neuritis may be either acute or chronic, or the symptoms of acute neuritis may persist for a long time and then become chronic.

The causes of neuritis are numerous. It may be due to traumatism such as direct wounding or contusion of the nerve, or to compression of the nerve by sudden and forcible muscular contraction; to dislocation of joints; to injury to the nerve from fragments of bone resulting from fracture; to compression of the nerve from the formation of callus; to pressure of growths; or, finally, to pressure upon the nerve trunks in the axilla during the use of crutches. Neuritis may also be caused by chemical agents such as ether, osmic acid, or alcohol, coming in direct contact with the nerve through subcutaneous injection. It may also develop from refrigeration through exposure to cold, and as a complication or sequel of various infectious diseases. It may also arise by extension from adjacent inflammation.

Patients who are addicted to the excessive use of alcohol, or those suffering from chronic toxic disorders such as gout, rheumatism, diabetes, chronic nephritis, or syphilis, are more predisposed to the development of localized neuritis after slight traumatism or exposure to cold. Arteritis obliterans and arteriosclerosis may also be considered to be predisposing causes.

Pathologically, there are various types and degrees of neuritis. We thus have: 1. Perineuritis, in which the inflammation originates in the perineurium to which it may be limited. 2. Interstitial neuritis, in which the inflammatory process is located principally in the interstitial structure of the nerve. 3. Parenchymatous neuritis, in which the nerve fibres undergo inflammation and degeneration. The first two forms represent a true inflammatory process. In the third form, the same changes often occur which usually arise as a consequence of complete division of the nerve. As these different processes vary in degree and are frequently found in combination, their clinical differentiation cannot always be accomplished.

Isolated neuritis is generally a perineuritis or interstitial neuritis. There are redness and swelling of the connective tissue enveloping the nerve, the blood-vessels of the nerve sheath are distended with blood, and there may be minute hemorrhages. Sero-fibrinous exudation and migration of leucocytes follow the hyperæmia. These changes may be limited to the sheath (perineuritis), or may extend into the substance of the nerve (interstitial neuritis). When the process is severe or of long standing, the nerve fibres may also become involved. In the parenchymatous form the inflammation begins in the nerve fibres, resulting in their degeneration and atrophy.

Symptoms.—Pain in the course and distribution of the nerve is the principal symptom. Its degree varies with the extent and intensity of the inflammatory process. The nerve trunk is sometimes swollen and extremely sensitive to pressure, the pain often radiating to the ultimate distribution of the nerve. The pain sometimes affects the entire extremity, which may become extremely hyperæsthetic. It is variously described by patients as darting, boring, burning, and occasionally shooting through the course of the nerve. It is increased by movement and is usually worse at night. Numbness and tingling may also be present. This may be attended by some constitutional disturbance as increased pulse rate and rise of temperature. Should the nerve fibres become involved, objective sensory disturbances may arise, such as varying degrees of anæsthesia in the area of the distribution of the affected nerve, with weakness or muscular paralysis. Herpetic eruption or glossy skin may also be present. In severe cases anæsthesia, paralysis, and atrophy usually take place. The faradic irritability of the nerve and muscles is at first increased, but gradually it diminishes, and is finally lost when the nerve fibres undergo degeneration.

The neuritis may ascend a nerve ("ascending neuritis"), reaching the plexus from which the nerve arises, and thus extend to several or all of the nerves of the limb. The inflammation has also been known in rare instances to extend to the spinal cord, causing subacute or chronic myelitis.

Prognosis.—Acute neuritis may disappear in a few weeks if the cause can be successfully removed. The most favorable cases are those due to slight traumatism. More commonly the affection persists in a chronic stage for many weeks or even months. The most protracted forms arise in patients with gout or rheumatism, or in such toxic cases in which the toxin cannot be removed at once. When the axis-cylinder processes are involved, as in degenerative neuritis, the condition may last for many months, paralysis and atrophy becoming permanent if the nerve fibres do not undergo regeneration. An opinion as to the prognosis often depends upon the changes in the electrical irritability of the nerves and muscles.

Treatment.—When a nerve is divided by a wound, the separated edges should at once be approximated and sutured. In compression or injuries of nerves from luxation, fracture, callus, tumors, inflammation of soft parts, abscesses, etc., it is the first duty of the physician to insist upon immediate surgical measures to free the injured nerve if possible.

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A cure is not always accomplished by this method alone, inasmuch as any accompanying muscular paralysis calls for subsequent treatment. Under such circumstances surgical intervention must be the first step, otherwise all other treatment will prove futile. The general constitutional condition of the patient must not be overlooked. In acute cases absolute rest of the affected limb is essential, either by keeping the patient in bed, or by immobilization of the limb by a suitable supporting bandage. The relief of pain is an important feature. In acute traumatic cases a Chapman's ice bag applied along the course of the nerve, or cold compresses often prove valuable. The application of hot-water cloths ameliorates the pain in many cases. When anaesthetic areas are present, extreme care should be observed when hot-water cloths are applied, in order to avoid burning the skin. Blistering or superficial linear cauterization over the affected nerve trunk often effectually relieves the pain.

At times it is necessary to administer some of the coal-tar derivatives such as phenacetin, acetanilid, or salipyrin. When the pain is persistent and severe, and is not relieved by other means, we must resort to the use of opium, morphine, or codeine. Local injection of a solution of cocaine at the seat of the greatest pain often gives relief. The continuous galvanic current is also of great value in diminishing the pain. The anode should be placed over the affected nerve, the current strength being from six to eight milliampères, the application lasting five or six minutes daily. For the paralysis accompanying degenerative neuritis after the acute symptoms have subsided, the application of the labile or interrupted galvanic current to the affected muscles seems to hasten the recovery of motility by improving the nutrition of the muscles and accelerating the regeneration of the nerve. Massage is generally contraindicated during the early period of the inflammation, but it can be favorably utilized later. Small doses of mercury have been recommended by Gowers for the purpose of influencing the neuritic process.

Multiple Neuritis or Polyneuritis.—This is a disease in which many nerves are inflamed simultaneously or in rapid succession. It usually affects symmetrically the nerve trunks in the extremities, particularly in their peripheral distribution. In this form of neuritis the pathological process originates in the nerve fibres, the adventitial structures generally being involved secondarily. In mononeuritis the nerve sheaths and the connective tissue, as a rule, are primarily affected. As early as 1828 Graves described the condition as "a form of generalized paralysis probably depending upon disease of the peripheral nerves." The first authentic case with post mortem verification was published by Dumesnil, of Rouen, in 1864, but it was not until further observations were reported by Lancereaux in 1871, Eichhorst in 1875, Joffroy in 1879, Leyden in 1880, and Grainger Stewart in 1881 that the doctrine of multiple neuritis was placed upon a sound pathological basis. During the last twenty years many observations and monographs relating to this subject have been published, the literature now being quite abundant.

Etiology.—Multiple neuritis is invariably the result of some toxic substance circulating in the blood. A very large number of different causes are active in its production.

(*a*) *Poisonous substances introduced into the system* (these being mentioned in the order of their importance): Alcohol, lead, arsenic, copper, silver, phosphorus, mercury, carbonic oxide gas, bisulphide of carbon, and nitrobenzol.

(*b*) *Poisons originating within the body* (autotoxic): Dyscrasic conditions such as gout, diabetes, tuberculosis, carcinomatosis, syphilis.

(*c*) *As a sequel or complication of various infectious diseases:* Diphtheria, influenza, typhoid fever, smallpox, scarlet fever, measles, pneumonia, whooping cough, epidemic cerebrospinal meningitis, erysipelas, gonorrhœa, malarial toxæmia, acute articular rheumatism, leprosy, and all forms of septicæmia.

The majority of cases of multiple neuritis are traceable to alcoholic excesses. It is hardly necessary to mention that the vulnerability of the peripheral nerves to the effect of alcohol varies in different individuals. One person may indulge in large quantities daily for years without developing neuritis, while many others who probably possess less resistance in the peripheral neurons are attacked by the disease after the continued daily use of a comparatively small amount of alcohol. The writer has seen several cases resulting from the daily use of about two ounces of whiskey continued for three or four months. Multiple neuritis as a sequel of acute alcoholic intoxication is almost unknown.

According to the preponderance of one set of symptoms over another, multiple neuritis has been classified into various clinical types, such as:

1. *A motor or paralytic type* (alcohol, arsenic, diphtheria, Landry's paralysis).

2. *A sensory type*, an ataxic form which is often described as "pseudotabes" or "neurotabes peripherica," and is most commonly due to arsenic or alcohol.

3. *A vaso-motor type* (erythromelalgia, Raynaud's disease).

4. *An endemic form* (beri-beri or kakki, particularly prevalent in Japan and the Dutch East Indies).

Multiple neuritis occurs most frequently, however, in transitional forms, and may then be characterized as a common or mixed type in which motor, sensory, and vaso-motor phenomena arise in various combinations.

Polyneuritis usually occurs between the ages of twenty-five and fifty years. Aside from the form due to diphtheria, it is rare in children, although it has been occasionally observed between two and six years of age. A number of cases of multiple neuritis in children as a result of alcoholic poisoning are now on record. In one of the writer's cases the child, who was five years old, had been given whiskey and beer daily for several months by its ignorant mother, for the purpose of strengthening it after an attack of diarrhœa. The disease rarely occurs after the sixtieth year.

Symptoms.—It is now well established that in multiple neuritis no set of symptoms is exclusively related to a single cause. A description of the symptomatology of the alcoholic form will convey a knowledge of the general features of the affection.

Multiple neuritis may be either acute or subacute in its onset, and may follow or accompany an attack of delirium tremens. The temperature may be slightly elevated in the beginning, and some fever may continue throughout the acute period of the disease. Normal temperature is not unusual. At first there is often tingling, or a sensation of "pins and needles" or numbness in the extremities, with vague sharp pains or aches, which gradually become more acute. The paræsthesiæ and pain are soon followed by muscular weakness, or paralysis, or inco-ordination. Either the upper or lower limbs or both may be involved, first and chiefly the hands or the feet. The feet are affected more frequently than the hands; motor symptoms may exist in the legs, and only sensory symptoms in the hands. This is accompanied by tenderness along the nerve trunks and in the muscles, the muscular tenderness usually increasing to an extreme degree. The co-ordinating power may be affected at the same time. Tremor is often conspicuous. Most frequently the knee jerks are absent, this depending directly on the involvement of the anterior crural nerves. The knee jerk is present or even exaggerated in some cases of slight degree, and this invariably indicates that the anterior crural nerves are intact.

In the lower extremities the nerves most commonly affected are the peronei and the posterior tibial and their branches. Occasionally the anterior crural nerves are also involved. Thus, the paralysis usually affects symmetrically the corresponding tibial group of muscles producing "foot drop." In severe cases nearly all of the nerves of the extremities may gradually become involved, and a more or less complete paraplegia develops.

The upper extremities may escape entirely, or the

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paralysis is almost always of lesser degree and extent than in the lower extremities. The musculospiral nerve and its branches are most commonly affected, thus producing paralysis of the extensors of the wrist and hand and "wrist-drop." It often happens that other nerves are also involved. A peculiar feature in these cases is the implication of the nerves in their peripheral distribution, the paralysis usually being more pronounced in the distal portions of the extremity. This is also indicated by the fact that at times when the supinators and the long abductor of the thumb in the upper extremity and the tibialis anticus in the lower extremity remain intact, there may be paralysis of the other muscles which receive their supply through the same nerve trunks. Sometimes the muscles above the knees and elbows are also affected. In the more severe cases the diaphragm and the muscles of the abdomen also become involved. In rare instances several of the cranial nerves may be implicated, the facial muscles, those of the tongue, or the ocular muscles thus becoming affected. The paretic or paralyzed muscles soon become flaccid and undergo atrophy and present the reaction of degeneration. Sensory disturbances are often associated with the loss of motor power. They may be altogether absent or exist alone. In addition to the subjective sensations already mentioned, extreme hyperæsthesia may exist over the affected parts, or tactile, pain, or muscular senses may be affected in various degrees. In the ataxic form inco-ordination is the chief symptom. It is usually accompanied by muscular tenderness, and exists with or without the affection of cutaneous sensibility just described. The inco-ordination in these cases resembles closely that of tabes, hence the form in which this symptom is predominant has been called "pseudo-tabes." Its most frequent cause is alcohol, but it has also resulted from arsenical poisoning and from infectious processes.

Trophic changes occur in prolonged cases in the nails, skin, and hairs, and are similar to those of ordinary neuritis. In uncomplicated cases the sphincters of the bladder and rectum are not involved.

In some severe cases in which the neuritis is widely distributed, the pneumogastric nerve or some of its branches may become affected, causing interference with the action of the heart, the muscles of respiration, and the vocal cords.

All of the symptoms vary according to the acuteness and intensity of the disease, and they also differ according to the cause. In lead poisoning the paralysis is usually confined to the upper extremities. In alcoholism all four extremities are often affected, the arms escaping more often than the legs.

Mental Symptoms.—A somewhat characteristic disturbance of memory often takes place. In general, it may be described as a peculiar form of forgetfulness with delusions of recollection. The memory for recent events is generally confused but not always entirely lost. Occurrences of some days, weeks, or months previously are misinterpreted by the patient as of quite recent occurrence, or as having just taken place. Although he may be confined to bed and unable to move, he may assert that he has just returned from a long journey, or has been out for a ride, or has just visited friends, etc. In some cases there are insomnia, delirium, talkativeness, or incoherence, or other more pronounced manifestations of acute alcoholic insanity or confusional insanity. All of these mental symptoms are essentially due to toxæmia, and bear no direct relation to the degree or form of the neuritis. Although more commonly observed in alcoholic subjects, they are known to occur in the course of multiple neuritis due to other poisons and also from infection.

Diagnosis.—In acute cases, when all of the characteristic symptoms are present, and the patient is unable to move from the bed, the diagnosis is very simple. It is the subacute forms that often present some difficulty in their diagnosis. On account of the presence of inco-ordination, pains in the legs, and loss of knee jerks, and some objective disturbances of sensibility, it has sometimes been mistaken for tabes. It is easily differentiated from tabes, however, on account of the presence (in multiple neuritis) of tenderness of the muscles and nerves, the neural character of the pains, the symmetrical diminution or loss of muscular power, the absence of bladder symptoms, and the presence of the pupillary light reflex.

Multiple neuritis has also at times been confounded with atypical cases of poliomyelitis, but poliomyelitis is most frequent in children; its onset is abrupt, the paralysis is rarely symmetrical in its distribution, and there is generally an absence of all sensory symptoms.

The history of some form of toxæmia known to cause polyneuritis is a potent element in the differential diagnosis.

The Diagnosis of the Toxic Cause, and the Differentiation of the Various Types.—It is not always easy to determine from the clinical symptoms alone whether a certain case of multiple neuritis is caused by alcohol, arsenic, lead, or some infectious process. However, there are certain elements in the history, a peculiarity in the distribution of the paralysis, and well-defined indications associated with some special forms of toxæmia or infection, which often conclusively prove the cause of the neuritis.

For instance, the somatic and psychical symptoms may present a classical picture of chronic alcoholism. Thus, in addition to the polyneuritis, there may be tremor in the lips, tongue, and hands, toxic amblyopia, chronic morning vomiting, cirrhotic liver, albuminuria, delirium tremens, or alcoholic dementia. *Arsenical neuritis* is often accompanied by vomiting, a general brown pigmentation of the skin, and the presence of arsenic in the urine. In some cases the ataxia is more pronounced than are the motor symptoms. The arsenic has usually entered the system as a result of acute poisoning after an ineffectual attempt at suicide. Occasionally the neuritis is produced by the prolonged administration of medicinal doses of Fowler's solution as used in the treatment of chorea in children, or from the inhalation of arsenical dust given off from wall paper and other articles containing arsenic. Recently a large number of cases of arsenical polyneuritis occurred in England from the use of beer in which arsenical glucose had been used in its manufacture.*

Multiple neuritis from lead poisoning is most frequently found among those whose occupation requires frequent or continuous contact with lead. The accidental causes are numerous, such as the contamination of drinking-water by leaden pipes, the cooking of food in vessels containing lead in their manufacture, the use of various cosmetics, hair dyes, etc. It has also been traced to snuff, which was found to contain lead. As a rule, the lead enters the system through the alimentary canal as a result of uncleanliness, and the pollution of food by hands that have been in contact with lead. It may also enter the system through inhalation, and by absorption through the skin. As in other forms of toxæmia individual susceptibility to the effects of lead has much to do with the development of neuritis. People in general ill health, and those addicted to alcoholics, are more predisposed to the toxic action of lead. The upper extremities are more commonly affected, a blue line is often seen on the gums, and lead may be found in the urine (see article on *Lead Palsy*).

Polyneuritis from *diphtheria* may be attended with wasting and anæsthesia; but the weakness in the limbs usually succeeds paralysis of the palate and ciliary muscle, which are never seen in other forms of polyneuritis.

Course and Prognosis.—Multiple neuritis usually takes an acute or subacute course and reaches its height in a few weeks or a few months. It then remains stationary for about the same period, and gradually recovery takes place. Some cases are very severe and are accompanied by high fever, and may terminate fatally in a week or two from paralysis of the heart or diaphragm, or from

* Glucose is made by the action of sulphuric acid on various kinds of starch. The origin of the arsenic was found in the sulphuric acid which is commonly made from arsenical pyrites.

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pulmonary œdema. It sometimes assumes a course similar to that of Landry's paralysis. The condition is always serious when the patient's general health is poor in consequence of a recent infectious disease, or in severe types of chronic alcoholism, etc. When the vagus or phrenic nerves become involved, the life of the patient may be in constant danger, but recovery has occurred even under such circumstances. When the paralysis is confined to the distal portions of the extremities, the prognosis is more favorable. In exceptional instances the course may become chronic and progressive. In the majority of cases, however, in the absence of complications the disease terminates in complete recovery. Even in favorable cases the affection may last from several months to two years or more, depending upon the underlying cause, the extent and intensity of the nerve degeneration, and the recuperative powers of the patient. The prognosis is always materially influenced by the course and virulence of the toxæmia. When the sphincter of the bladder is involved, it is usually indicative of extension of the inflammatory process to the spinal cord, thus rendering the prognosis as to recovery more doubtful.

Treatment.—The treatment of polyneuritis is essentially symptomatic. Aside from the cause of the toxæmia the various forms receive practically the same treatment. It is essential to discover, if possible, the cause of the neuritis, and to remove it or discontinue its further action. This should be the first consideration, particularly in cases due to alcohol. The sudden withdrawal of the customary stimulant is not always advisable, particularly when cardiac weakness is present. This can usually be successfully accomplished, however, by the administration of suitable heart tonics. Rest in bed, with general supporting treatment, is desirable or absolutely necessary in the majority of cases. A local or general warm wet pack for the purpose of producing diaphoresis, if the patient's strength admits, is often followed by excellent results in the early stage, or, if the patient is strong enough to bear the necessary procedures, a warm bath for fifteen or twenty minutes daily often proves beneficial. General constitutional treatment applicable to the special condition constituting the toxæmic process should never be forgotten. In order to prevent deformities, faulty positions of the extremities should be corrected by giving the necessary support to paralyzed muscles. Thus when there is "foot-drop" the feet should be kept at right angles with the leg by means of sand-bags, pillows, etc. For the purpose of relieving the pain anodynes should be administered when necessary in the same manner as mentioned in the description of the treatment of mononeuritis. When the diaphragm becomes paretic or paralyzed, artificial respiration and the hypodermatic injection of strychnine must be resorted to. Indications of heart failure are to be met by absolute rest and the administration of cardiac stimulants. When deglutition is interfered with, the patient should be fed through the œsophageal tube in order to prevent the entrance of food into the larynx or bronchi.

Fortunately such emergencies arise only in exceptionally severe cases. After all of the acute symptoms have subsided, massage and electricity will prove useful.

William M. Leszynsky.

NEURODIN, acetyl-p-oxy-phenyl-urethane, C_6H_4.$OCOCH_3.NH.COOC_2H_5$, is prepared by acetylation of the compound formed by the interaction of chlorocarbonic ether and amidophenol. It is a colorless, odorless, crystalline substance, soluble in 1,400 parts of cold water and readily in boiling water. It is antipyretic and antineuralgic in dose of 0.5–1.5 gm. (gr. viij.–xxiv.).

W. A. Bastedo.

NEUROEPITHELIOMA.—The name of neuroepithelioma was first given by Simon Flexner in 1891 to a peculiar tumor of the retina in which were found collections of cells resembling the rods and cones of the external nuclear layer. Flexner believes this tumor to have had its origin not in the supporting cells, but in the neuro-epithelial cells of the external nuclear layer, and to be therefore not a glioma but a neuroepithelioma. In this tissue he found the tubular or alveolar arrangement of the cells, so common in glioma of the retina; and among the cells of the tubules he found tiny rosettes composed of long cylindrical cells, the pointed extremities of which were turned toward the lumen of the rosette and formed there a membranous ring. These cells he considered rudimentary rods and cones. He answers the objection of Iwanoff to the formation of tumors from any cells except supporting cells by quoting Klebs' opinion that all the elements of the nervous system are capable of proliferation.

Three years later, Wintersteiner reported a case of so-called neuroepithelioma of the retina in which rosettes similar to those described by Flexner were found. Wintersteiner mentions Flexner's work, but claims to have made his discovery quite independently of the latter, and does not give him credit for the name "neuroepithelioma." He found transitions between the rods and cones and the tumor cells, and considers the membrane formed by the processes of the cells to be analogous to the membrana limitans externa. In a later monograph Wintersteiner discusses eleven tumors with epithelial rosettes which he found among thirty-two gliomata, and in two cases of microphthalmos. He regards these tumors as originating in misplaced cells of the rod-and-cone layer. Several other authors have reported similar tumors, but without giving them the same interpretation. Thus Becker describes rosettes of cylindrical cells in a tumor with a marked alveolar structure which he called "tubular angiosarcoma." Bochert, Eisenlohr, Jung, Thieme, and Van Duyse probably were also dealing with the same kind of tumor under the name of glioma or gliosarcoma, or angiosarcoma. Two observers, Greef and Hertel, working with the Golgi method, were able to demonstrate the presence of true ganglion cells among the ordinary spider cells which formed the mass of the tumor in both cases. They did not, however, apply the term neuroepithelioma to these tumors, but preferred to use the name neuroglioma ganglionare, after similar tumors in the central nervous system.

The best criticism of the views of Flexner and Wintersteiner is given by Ginsberg, who examined two tumors from a case of microphthalmos, and found in them the same rosettes of epithelial cells described by the two former. Ginsberg, however, regards these as cylindrical cells from the pars ciliaris retinæ, not rods and cones. These cylindrical cells are undifferentiated cells of the original Anlage of the retina, formed before the neuroblasts and spongioblasts. As these primitive cells are of epithelial origin he suggests the name "carcinoma retinæ," instead of neuroepithelioma. He bases his theory not only on the appearance of the cells composing the rosettes, but also on the fact that these primitive, undifferentiated cells are capable of proliferation, while in the case of highly specialized cells, such as the rods and cones, there is great doubt as to the possibility of their proliferation. The tumors which Wintersteiner has called neuroepithelioma Ginsberg regards as probably formed from primitive epithelial elements, and not from the highly specialized neural epithelium.

Alice Hamilton.

NEUROFIBROMA. See *Fibroma.*

NEUROMA. See *Fibroma.*

NEUROMA OF THE SKIN, PAINFUL.—This is an exceedingly rare affection, but two cases in which the skin was primarily affected being on record. Duhring's "Case of Painful Neuroma of the Skin," *American Journal of the Medical Sciences*, October, 1873, was the first noted and was followed by Kosinski's case in the *Centralblatt fur Chirurgie*, No. 16, 1874. Both cases occurred in men, aged seventy and thirty years respectively. In Duhring's case the tumors had been developing for ten years and in Kosinski's for fourteen.

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The tumors, varying in size from a pinhead to a filbert, confluent and disseminated, were thickly studded over the areas affected. In the first case they extended from the left scapula over the shoulder down the arm to the elbow, occupying principally the area of distribution of the circumflex nerve, and in the second case over the buttocks and upper part of the thigh, corresponding to the area supplied by the small sciatic and external cutaneous nerves. The lesions were arranged irregularly, not corresponding exactly to the course of the nerves mentioned, and formed firm, flat, or oval, elastic nodules, fixed in and extending below the skin, and movable only with it. The integument between the nodules was normal, they being purplish or pink in color. In Duhring's case the skin over the nodule was slightly scaly. At the outset pain was variable, but later it became excruciating and occurred in violent paroxysms, lasting an hour or more.

Since they are never malignant these neuromata are best not interfered with unless great distress is caused by the pain. In both the above cases resort was had to a removal of portions of the nerve supply with resulting quick relief from pain and gradual and almost complete subsidence of the nodules.

The new growth is composed of firm connective tissue and non-medullated nerve fibres.

Charles Townshend Dade.

NEUROMIMESIS. See *Joints, Chronic Diseases of.*

NEURONE, GENERAL PATHOLOGY OF THE.—Introduction.—Notwithstanding the liberal number of papers which have been published in recent years upon the pathology of nerve cells, we have still, in an essay to construct a general pathology of the neurone, only fragmentary data at our disposal. The neuropathologist, like all other special pathologists, meets with insuperable difficulties, due to the fact that a well-developed pathology of the cell in general is still lacking. Investigators are coming more and more to the opinion that in order to build up a satisfactory pathology of the cell, research ought not to be limited to the cells met with in the special tissues of highly differentiated animals, but should be extended to unicellular forms, in which the conditions of life are simpler and with which the possibilities of experiment are more manifold, and the experiments themselves are more easily subject to control. Indeed, at the present time, part of the pathology of each of the special types of cells of the vertebrate animal is based directly upon inferences drawn from work done upon one-celled species. Thanks to the very extraordinary distribution of the protoplasm of the nerve cell in space, however, it has been possible, in nerve cells or neurones, better than in any other specialized type, to study the results of injury to a part of the cell; indeed, this kind of injury can perhaps be better studied in them than in any of the simplest organisms. It is owing to this circumstance, doubtless, that such a goodly portion of that pathology of the neurone which has thus far been evolved has to deal with degenerative and regenerative processes following upon damage to some one of its parts, particularly its axone.

In view of the variety of hypotheses still advanced concerning the ultimate structure of the protoplasm of the normal nerve cell (see this Handbook, Vol. II., article, *Brain, Histology of*), it is by no means surprising that there is lack of unanimity of opinion regarding the fundamental nature of the changes which are met with in the neurone when it is diseased.

The studies of the botanist Fischer, of Leipsic, have shaken microscopical histology at its foundations. Now that we know the varying results which can be obtained, not only by the use of fixing reagents of different chemical constitution, but by the employment of the same reagent in different degrees of concentration, we must needs be chary of the conclusions we arrive at from the examination of fixation pictures in nerve cells, not only in health, but also and perhaps more particularly in disease.

The scepticism excited by these recent observations has, in some quarters, probably become excessive. Realizing that the stainable substance of Nissl can be precipitated in granules of different size by alcoholic solutions of varying strengths, that by treating nerve cells by one series of vigorous reagents, the so-called neurofibrils of Apáthy or of Bethe may be demonstrated, while by treating the same nerve cells by a different series of powerfully modifying solutions the honeycomb structure of Bütschli or the neurosome rows of Held may be put in evidence; and bearing in mind, further, that microscopic appearances similar to karyokinetic figures, centrosomes, and cytoplasmic radiations may be produced by the action of fixing reagents upon albuminous solutions injected into the empty cellular spaces of cork, there are those who would go so far as to say that the microscope and microscopical histological methods have been and can be of very little help to us in unravelling the structure and deciding upon the functions of cells. Such pessimists, however, forget the wonderful advances in neurological knowledge, anatomical and pathological, which are directly attributable to the use of the microscope. It would be as illogical for the student of the nervous system to give up the study of fixation pictures as it would be for the chemist to abandon the method of precipitation as a means of acquiring knowledge concerning the composition of solutions. It may be that the protoplasm of the nerve cell, as well as protoplasm in general, consists chiefly of colloidal particles held in suspension by virtue of the electric charges which they possess; if so, we may expect that some day new and desirable information will be derived from a study of artificially prepared colloidal solutions. Such a line of investigation, attractive and promising as it is, will unquestionably be that along which many can profitably work; but it is to be hoped that there will be others who will continue and extend those studies by histological methods which have done so much for us in the past, and which, many of us are convinced, are capable of supplying us with still more valuable information in the future.

In the brief sketch of the general pathological morphology of the nerve cell to be made here, the changes due to functional activity will first be referred to; next a description of the processes of necrosis and necrobiosis as they affect the neurone will be given, followed by a brief discussion, (1) of the various degenerations which involve the whole neurone or parts of it; (2) of regenerative phenomena; and (3) of the changes consequent upon various forms of intoxication.

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Changes due to Functional Activity in the Neurone.

In this connection the studies of Hodge upon the histology of fatigue are by far the most important hitherto undertaken. His researches were made upon the nerve cells of various animals, including sparrows, swallows, pigeons, and honeybees. A comparison of the cells of such animals captured in the morning with cells of animals of the same species killed after a long day's exercise

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showed alterations both in the protoplasm and in the nuclei of the fatigued cells. The nuclei were smaller than normal in the tired cells, had irregular margins, and stained with unusual intensity. An examination of the protoplasm revealed a shrunken appearance, and it stained more feebly than normal. The changes in the cells of the occipital cortex in the dog, as depicted by Hodge, are very convincing. Hodge's earlier reports did not contain satisfactory data with regard to the behavior of the stainable substance of Nissl, as he used osmic acid fixation for some of the cells and sublimate fixation with Gaule's stains for others.

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Later on Mann, working with other methods, compared the pyramidal cells of the cerebral cortex and the motor cells of the ventral horn of the spinal cord of a dog at rest with those of another dog after a long period of muscular activity. In a further series of experiments he bandaged one eye of dogs leaving the other exposed, killed the animals after twelve hours, and compared the retinal neurones, those of the corpora quadrigemina, of the lateral geniculate body, and of the occipital cortex of the one side with those of the other. He concludes that the stainable substance of Nissl increases in amount in nerve cells which are resting; it diminishes during functional activity, owing to direct utilization by the cell protoplasm. In addition, Mann describes an increase in the size of the cell bodies and of the nucleus and of the nucleolus in the early stages of functional activity; if the activities be prolonged to fatigue, there are shrinking of the protoplasm and contraction of the nucleus, the borders of the latter becoming irregular. Similar investigations have been made by De Moor and Pergens.

The studies just described refer to the changes which occur in nerve cells as the result of that normal excitation of cells which accompanies muscular activity or normal retinal illumination. Opportunities for studying other forms of normal functional activity might well be taken advantage of. It is desirable, too, that methods should be devised for testing the effect of alterations of temperature, light, moisture, and non-poisonous chemical stimuli upon different groups of neurones.

The effects of electrical stimulation have been investigated to a certain extent. For example, Hodge stimulated the peripheral sensory nerves of cats and afterward made sections of the spinal ganglia. In the ganglion cells on the side of excitation he found a decrease in the size of the nucleus and a change in its shape. The cell body, also, gradually diminished in size. Vas, on the other hand, stimulating the sympathetic for fifteen minutes, found a distinct increase in the size of the cell body, and a disappearance of the stainable substance of Nissl in the region of the perikaryon immediately adjacent to the nucleus. The nucleus itself, Vas states, becomes swollen and tends to be displaced toward the periphery, sometimes even causing a bulging at the periphery of the cell. The somewhat conflicting statements of Hodge and Vas have been reconciled by the experiments of Lugaro, who demonstrated during the early period of excitation a state of turgescence in the protoplasm of the cell body, while later on, when the stimulation had been continued long enough to cause fatigue in the cell, progressive diminution in the size of the cell body was met with. According to Lugaro the tigroid substance slowly increases in amount during the earlier period of stimulation; after the cell has become fatigued, it is decreased in amount and tends to be more diffusely distributed throughout the cell body.

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Necrosis and Necrobiosis of the Neurone.

By the term necrosis of the neurone is meant that condition or set of conditions in which the cell is relatively suddenly killed; by necrobiosis of the neurone is indicated the process which leads, through a series of pathological changes, gradually to the death of the cell.

Necrosis of nerve cells is met with in trauma, in infectious processes directly involving the nerve tissues, in sudden cutting off of the oxygen supply (*anæmic necrosis*) and possibly under other conditions.

The classification of direct necrosis introduced by Klebs is perhaps the most satisfactory one we possess. If the noxious agent which kills the cell affects it equally in all its parts, one gets a microscopic picture not unlike that met with in the artificial killing brought about when we fix the nerve tissues in the fixing reagents of the laboratory; the structure of the protoplasm and nucleus is relatively well preserved. The nucleus is, however, in some cases, first attacked by the noxa, in which event it may either be dissolved (*karyolysis*) or become fragmented (*karyorrhexis*); in such instances the alterations in the cell body may at first be slight, consisting perhaps merely of cloudy swelling. In forms of cell death, on the other hand, in which the protoplasm appears to be first attacked, a primary vacuolar degeneration of the cell body (*plasmarrhexis*) may be encountered.

A cell is doomed to death if its nucleus be destroyed or injured beyond a certain degree. The studies of Condorelli upon the effect of mechanical injury to cells have shown us that rupture of the nucleus not infrequently occurs as a result of trauma. Schmaus has suggested that we may here have an explanation of the direct necroses of ganglion cells which may be assumed to take place in commotio cerebralis and commotio spinalis. Tissues under these conditions should be studied in the early stages and with the aid of modern methods. A beginning has been made in this direction (*cf.* Barbacci, *loc. cit.*, p. 819).

We know but little of the effect of powerful electric currents acting directly upon the neurones. A few cases of electrocution have been examined post mortem without, it must be confessed, adding much to our knowledge. There is here room for fruitful experimentation in the light of the results which were obtained by Eschle upon artificial necrosis due to electrical influences (see also work of Corrado, cited by Barbacci).

In diseases associated with peripheral neuritis (diphtheria, lead poisoning, etc.) we have exquisite examples of partial nerve-cell necroses, the poison killing the axones of the neurones through a distance of from a fraction of 1 mm. to several millimetres. The effect on the whole neurone is the same as that which follows upon artificial section of the axone (*vide infra*).

Careful studies of karyolysis and karyorrhexis in nerve cells have still to be made. There are only fragmentary remarks upon the subject in the bibliography. The difficulty of the study is aggravated by the unusual distribution of the chromatin in the normal nuclei of nerve cells.

The so-called condition of pyknosis in which there is a condensation of the nucleus and cell body is worthy of mention. Schmaus assumes that the so-called "sclerosis" described by Friedmann in acute myelitis is closely allied with pyknosis. This author found in cells otherwise nearly intact glistening masses which stained intensely with nuclear dyes; such masses appeared at first in the periphery or in the interior of the cells, as though they had resulted from fusion of the spindles and granules of

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the stainable substance of Nissl. Later, the cells diminished in size, though the glistening staining increased. The nucleus was often well preserved for a long time. It may be that some of the "chromophile" cells of Nissl belong in this category, though in most instances it would seem that they are to be regarded as artefacts due to the fixing reagent. www.libtool.com.cn

A series of necrobiotic changes have been described by Pándi in nicotine, bromide, and cocaine poisoning. In chronic poisoning with nicotine, the nucleus of the cell becomes shrunken, the cell body is diminished in size, and the paraplasm and the nucleus stain of a dark color. In cocaine and bromide poisoning the nuclei show enlarged nucleoli; the chromatic threads in the protoplasm lie closely pressed together, sometimes becoming merged with the deeply stained ground substance of the nerve-cell body.

The experimental work of Klemm upon plant cells has shown the way for a series of experiments upon nerve cells, which, it is hoped, some one in the near future may be induced to undertake. According to Klemm, when a cell is suddenly killed there is never any contraction of it, nor any considerable alteration in configuration. These are the signs of a much slower dying process. The visible alterations in the protoplasm of plant cells on sudden killing are, according to Klemm, of three kinds: (1) Precipitates: usually granular structures giving an increased granular appearance to the cell. Such granules may be united in the form of chains, networks, and dendritic structures. Instead of granular precipitates a fibrillary appearance may be produced. (2) Phenomena of solution: vacuole formation, foam formation, and the like. (3) A mixture of granulation (coagulation) in the plasma with formations of fewer and smaller vacuoles.

Where death is not so sudden and yet very intense effects are suddenly produced, the most marked alterations in configuration are met with. In the still slower "physiological" death the terminal phenomenon is usually coagulation of the protoplasm, and there is a tendency to various forms of degeneration—granular degeneration, vacuolar degeneration, etc. Dying protoplasm has the tendency to break up into small clump-like masses which assume a more or less spherical shape.

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Atrophy of Neurones.

Hodge, of Clark University, has made us familiar with some of the changes which take place in neurones in senile atrophy. In a man ninety-two years old, dead of marasmus, the ganglion cells as a rule looked fairly normal, though he describes a diminution in the number of the Purkinje cells in the cerebellum and slight shrinking of those which were present. His study of the spinal ganglion cells demonstrated that the nucleus nearly always had an irregular contour, was more or less shrunken, and often devoid of nucleolus. The cell protoplasm was rich in fat and pigment, which were absent in the fœtus. Hodge's description of fat and pigment in a forty-seven-year-old man is accompanied by the suggestion that the man suffered from premature senescence due to alcoholism. I am of the opinion that the pigment which he describes is visible in the nerve cells of nearly all human beings and probably at all ages, except in the fœtus and in early childhood. I have been struck with the comparatively large number of times the so-called lipochrome of normal nerve cells has been described as a pathological product. Some of those who have studied the Gasserian ganglion in *tic douloureux* have fallen into this error.

Hodge studied the changes due to age in bees, as well as in human beings, and described shrinking of the nuclei, vacuole formation in the protoplasm, as well as diminution of the total number of cells.

Studies of a similar nature have been undertaken by Vas. This investigator made use of the method of Nissl in examining the nerve cells of old people. He describes various alterations in the stainable substance of Nissl, and states that in the last stage the cell body is transformed into a strongly staining, formless mass, which may be broken up into clumps. It does not seem impossible that Vas may have had to deal with artefacts, perhaps the "chromophile" cells of Nissl. They can be obtained occasionally in nerve tissues from individuals of any age. I have pictured one in a former publication (see Fig. 73, "The Nervous System," p. 124).

According to Babes, the processes in the anterior horn cells of the spinal cord are reduced in number in old age. In a group of intact nerve cells one sometimes finds in old people shrunken, colloid, or very pale elements without nucleus or nucleolus, or with a strikingly pale nucleus. The tigroid masses are pale and few in number, or they may be entirely absent in the periphery of some of the cells. In other old people the nerve cells appear to be nearly normal, which proves, Babes thinks, that the capacity for resistance varies greatly in different individuals.

The pigment (lipochrome) is certainly more abundant in older people, a fact repeatedly confirmed by Marinesco, Rosin, myself, and others.

The more one studies the descriptions of atrophy of the nerve cells in old age, the less he feels satisfied with the studies which have thus far been made. The subject should be taken up again now that we have better methods and are more familiar than formerly with changes in the neurones due to causes other than senility.

One of the later studies is that of Marinesco, according to whom the senescence of the nerve cells is due to a defect of metabolism. The anatomical changes include a decrease in the size and number of the tigroid masses; sometimes the Nissl bodies are transformed into granules of variable size (senile chromatolysis), especially around the nucleus, but often throughout the whole cell. Marinesco believes that the "pigment" really represents a product of the involution of the cell, and that when it is increased in amount it reduces the nutritive and respiratory capacity of the cell. The number of dendrites diminishes and their branches disappear. Finally the volume of the perikaryon itself decreases. He denies neuronophagocytosis due to senility. Instead of an increase in the glia cells, these cells disappear *pari passu* with the vanishing of the nerve cells.

Of the atrophy which may take place in a neurone when its axone is injured, or when impulses which normally come to it are cut off, mention will be made in connection with secondary and tertiary degenerations of the neurone.

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Degenerations of the Neurone.

Under this heading will be considered (*a*) Primary Degenerations of the Neurone, including (1) cloudy swelling, (2) fatty degeneration, (3) vacuolar degeneration, (4) pigmentary degeneration, (5) albuminous degeneration; and (*b*) Secondary Degenerations of the Neurone.

(*a*) Primary Degenerations of the Neurone.—(1) *Cloudy Swelling.*—In view of the fact that parenchymatous degeneration or cloudy swelling has been described in connection with the acute infections and intoxications in most of the organs of the body, it is rather surprising that we find so few references in the bibliography to this form of degeneration in the nerve cells. The changes which accompany infection and intoxication are so characteristic and constant in the various secreting cells that it seems probable that a similar degeneration has been frequently met with in the nervous system, but has been described under a different name. Doubtless the presence of the peculiar tigroid masses in the protoplasm of nerve cells has been responsible for the difficulty in studying this change. If one reads Benario's careful review of the whole subject of cloudy swelling and then examines the articles by Ewing, Marinesco, and others on the pathological changes in the nerve cells in acute infections, he cannot but feel that the preliminary swelling of the nucleus and protoplasm and swelling of the tigroid masses followed by their breaking up into fine granules, described by these writers, correspond more or less closely to the cloudy swelling which affects gland cells. The alterations described by Franca in the nerve cells in plague, and by Camia in the nerve cells in influenza, are very suggestive in this connection.

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(2) *Fatty Degeneration.*—Fat droplets of smaller or larger size are frequently met with in nerve cells in the most different pathological processes, but especially in infections and intoxications. These are usually met with in the protoplasm of the perikaryon and are visible as yellow, glistening droplets in frozen sections, or as black spherules in Marchi preparations. I have often seen black droplets in the nuclei of nerve cells in Marchi specimens; in some instances they appear to be coincident with the nucleolus.

(3) *Vacuolar Degeneration.*—The study of vacuolar degeneration of the nerve cell has had an interesting history. In the older publications, where the studies were nearly all made upon Müller's fluid preparations, nothing was more common than to read of extensive vacuolar degenerations in the cells of the brain and spinal cord. We know now that the majority at least of these were nothing more nor less than artefacts due to the action of the hardening reagent (work of Kreyssig and of Trzebinski). In some of the more recent studies, however, true vacuolization of both protoplasm and nucleus of the nerve cells has been described. Nerlich has investigated the origin of vacuoles in a case of cerebral tetanus in which the nucleus nervi hypoglossi, the nucleus nervi facialis, and the nucleus motorius nervi trigemini contained vacuolated ganglion cells. He found occasionally as many as twenty vacuoles in a single cell. The cell body was swollen, though often surrounded by a large pericellular space. The nuclei were not altered, though they were sometimes displaced from the normal position by the vacuoles.

Besides in tetanus, vacuolization of the nerve cells has been described in various infectious diseases, in acute poisoning with mineral acids (ganglion cells of the heart), and in fasting. Sometimes the nucleus, as well as the cell protoplasm, is vacuolar (Kazowsky).

The study of vacuole formation in cells generally has been approached recently from the experimental side. Two kinds of vacuoles may be distinguished according to their origin: (1) solution vacuoles, which increase in size with the diffusion and endosmosis of the agent producing them; (2) expulsion vacuoles which are formed suddenly as a result of coagulation and do not usually increase in size.

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For a list of diseases in which vacuolar degeneration has been described, see Barbacci: *loc. cit.*, p. 805.

(4) *Pigmentary Degeneration.*—In frozen sections and in Nissl preparations of adult nerve cells in various parts, a yellowish pigment can be made out. This is said to be entirely absent in the newly born. According to Pilcz, Obersteiner, and others it appears at different periods of life in different nerve cells, at the sixth year in the spinal ganglia; at the eighth year in the anterior horn cells. The amount of pigment increases as age advances (*vide supra*, Atrophy).

This pigment is not identical with that of the locus cœruleus, substantia nigra, or substantia ferruginea. It may be improper to speak of it as pigment at all. It stains black with osmic acid, and thus is easily visible in Marchi preparations. It seems to be related to the fats (Rosin). Ramón y Cajal regards it as a metabolic product of the cell, which the latter cannot rid itself of. Whether it arises from the stainable or from the unstainable substance of Nissl is not known. Obreja and Tatuses believe that this pigment is of a fatty or myelinic nature, probably related to lecithin. They therefore look upon it as a store of nutrient substance in the cell; according to their findings it is diminished in amount in the anterior horn cells in strychnine poisoning and in tetanus, while after prolonged rest it is increased. Against this view van Gehuchten urges that the substance is absent from the nerve cells in early life, and further that in a case of tetanus which he examined there was no diminution in the amount of pigment. The whole matter requires further investigation.

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(5) *Albuminous Degenerations.*—Accepting the definition of Klebs, by albuminous degenerations are to be un-

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derstood those disturbances of nutrition in which insoluble albuminous bodies are deposited in the tissues. In the nervous system we have to deal with two such albuminous deposits: (*a*) the so-called Russell's fuchsin bodies, and (*b*) the corpora amylacea.

Ad (*a*). Russell's fuchsin bodies described in cancer, in 1890, have since been proven non-specific as far as these tumors are concerned. They occur under normal conditions in various tissues of the body, including the nervous system, but are greatly increased in numbers under pathological conditions. They are usually extracellular in situation but may occur also inside of cells. As a rule, several of them exist together. They are small, round, homogeneous bodies, varying from 0.5 to 20 μ in diameter. Under the microscope they appear as glistening masses looking not unlike fat droplets, when examined in water. They stain intensely by Gram's method and in acid fuchsin. In Ehrlich's triacid stain they are tinged sometimes with the acid fuchsin, sometimes with the orange. In Heidenhain's iron hæmatoxylin they stain black. Lubarsch found them in large numbers in atrophic conditions of the brain. The probability is that they are products of the cell protoplasm, rather than of the nucleus. Some of them may be swollen and altered cell granules. It is not impossible that fine granules in the cell protoplasm undergo chemical change and fuse to form the fuchsin bodies. Again it has been suggested that they may have their origin from lecithin. Lubarsch found that pure lecithin yields the same staining reactions as do the fuchsin bodies; on the other hand, pure lecithin is easily soluble in alcohol, while the fuchsin bodies are not.

Ad (*b*). Corpora amylacea have long been known in the central nervous system. Their origin and significance have been much disputed, but there can be no doubt that they are very numerous in atrophic and degenerated portions of the brain and spinal cord. Under normal conditions they appear in the third decade of life and are never absent in people over forty. In the cerebrum they are found in the lining of the ventricles and in the tractus olfactorius; they are less frequently found in the cerebellum. Redlich supposed that they had their origin in the nuclei of neuroglia cells. According to a widespread opinion they arise from the coagulation of myelin. It is not unlikely that some of them at least have their origin through the union with normal tissue juices of altered cell protoplasm exuded from the cell. Spiller believes that at least a portion of the corpora amylacea have been derived from altered blood-vessels. The colloid bodies described by Bevan Lewis and also by Spiller would seem to be closely related either to Russell's fuchsin bodies or to the corpora amylacea.

Recent studies make it seem certain that greater differentiation among these structures than that ordinarily made is necessary. Thus Siegert has divided them into corpora versicolorata (including the "corpora amylacea" of th central nervous system) and corpora flava (including the "corpora arenacea" of the central nervous system). The corpora versicolorata, so-called because they take a variegated tint in iodine or bromine, yield the "amyloid reaction" with aniline dyes, and are further characterized by their brittleness and their morphology. They may be, (*a*) spherical, ovate, or polygonal with rounded angles; (*b*) concentrically lamellated, and (*c*) sometimes radially striated. They never arise through direct transformation of cells, nor do they become calcified. The corpora flava, on the other hand, behave differently in solutions of the halogens (chlorine, bromine, iodine), staining of a yellow color only in Lugol's solution; they do not yield the amyloid reaction with the aniline dyes. They are waxy rather than brittle; they vary greatly in their morphology, being sometimes smoothly spherical, sometimes very irregularly shaped. Concentric lamellation may not be visible in them and they are never radially striated. Unlike the corpora versicolorata the corpora flava are said to arise directly from the transformation of cells and to show a decided tendency to become calcified.

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(*b*) SECONDARY DEGENERATION, AND MODIFICATIONS IN THE NEURONE FOLLOWING UPON INJURY TO THE AXONE.—The nutritive centre of a neurone is in the perikaryon. The trophic influence emanates from the nucleus. If any part of a neurone be severed from its connections with the nucleus, the separated part dies. In case it is a medullated axone, which suffers solution of continuity, not only does the whole axone, distal from the lesion, undergo disintegration, but the myelin sheath degenerates in the same area and the nucleated sheath of Schwann or neurilemma undergoes important modifications. These phenomena taken in their totality are usually designated as secondary or Wallerian degeneration.

In the early part of the last century it was known that interruptions of the connection of peripheral nerves with the central system could lead to their degeneration (Nasse, Valantin, Stannius). The first careful study of the subject, with establishment of a law, was that undertaken by Waller, and from him the process has derived its name. He described it in detail—the coagulative breaking up of the myelin sheath and the dissolution of the axis cylinder. If a motor nerve is cut, all the fibres in the peripheral end degenerate completely as far as the muscles which they supply, the central end either remaining entirely intact or perhaps, as a result of the trauma, degenerating as far as the first node of Ranvier. If a sensory nerve be cut distalward from the spinal ganglion, all the sensory fibres of that nerve degenerate to the very periphery, though the portion of the nerve still in connection with the ganglion, as well as the central intramedullary continuation of the nerve, remain undegenerated. On the other hand, if a dorsal root of a spinal nerve is severed between the ganglion and the spinal cord, the portion of the nerve attached to the ganglion does not undergo degeneration, but that connected with the cord degenerates typically, not only in the portion outside the cord, but also throughout its whole intramedullary extent. This is the proof which has been brought for the view that the cell bodies in the spinal ganglia are the trophic centres for the peripheral sensory neurones. Following upon Waller's investigations came the observations of Türck, which demonstrated that the same law holds within the confines of the central nervous system—for example, for the pyramidal tract. Since Türck's studies a host of observations have established the general validity of the law for all groups of neurones. When an axone degenerates, the retrogressive process involves not only the main axone but also its terminals, together with the collaterals belonging to it with their terminals.

The study of secondary degenerations has been much facilitated by the introduction of Weigert's myelin sheath stain and the osmic-bichromate method of Marchi and Alghieri.

The finer histology of secondary degeneration has been studied by Homén, Howell and Huber, Tooth, von Notthaft, Ceni, and others. Von Notthaft subdivides the changes which occur in the nerve after section into two stages, the first including the alterations which take place during the first three days (fragmentation of myelin and of axone for a distance of one or two internodes on each side of lesion), probably due to trauma. The second stage, beginning on the second or third day and confining itself to that part of the fibre cellulifugal from the lesion, represents the true Wallerian secondary degeneration; it is not the direct result of the trauma, but is due to the severance of that part of the neurone from the trophic influence of the nucleus. In this second stage the axone swells up and undergoes fragmentation, and

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the myelin disintegrates into droplets cellulifugally from the lesion, as far as the peripheral termination. By the fourth day a multiplication of the nuclei of the neurilemma can be made out. Liquefaction of the myelin begins by the sixth or seventh day and continues until the sixtieth or eightieth day, when all of it is dissolved and most of it has been absorbed. The absorption is complete by the end of three or four months. If the degeneration affect medullated nerve fibres inside the central nervous system, neuroglia cells can be seen undergoing proliferation after some forty five or fifty days (Ceni). This proliferation ceases at the end of three months and sclerosis follows.

Marchi's method demonstrates the existence of degenerating fibres as early as eight or ten days after the lesion, and will continue to demonstrate their presence until all the myelin of the degenerating fibres has been absorbed, that is, until some three months have elapsed after the injury. At a later period we have to resort to Weigert's method; the areas which have degenerated show, of course, an absence of black fibres. Marchi's method is far more delicate than Weigert's; the former will reveal single degenerated fibres; the latter can be relied upon only when there is a considerable area of lightening in the region otherwise uniformly filled with black fibres. Anatomists have applied these methods most extensively in experimental work for the determination of the course followed by the medullated axones of the various groups of neurones of which the nervous system is made up. Pathologists utilize them to study the secondary degenerations which accompany various diseases of the nervous system in human beings.

For many years it was believed that the cellulifugal alteration, described by Waller, was the only one which occurred after axone lesion, but the introduction of more delicate methods still has revealed the fact that surprising changes occur in the neurones cellulipetal from the lesion, and particularly in the cell body or perikaryon itself. Nissl by the application of his methylene-blue-and-soap method has demonstrated definite alterations in the cell body as early as a few hours after axone lesion. The changes are most marked, however, when animals are killed from eight to fifteen days after the operation in which the axones have been cut. Nissl refers to this method of study as "the method of primary irritation." His results have been confirmed by Flatau, Marinesco, Lugaro, Van Gehuchten, Erlanger and myself, and many others.

The change which takes place in the cell bodies of the nucleus nervi facialis, for example, after section of the nerve trunk near the pes anserina, consist chiefly in alterations in the tigroid masses, in a moderate swelling of the perikaryon, and in a displacement of the nucleus toward the axone hillock. The change seems to affect the tigroid masses first. The spindles lose their typical stichochrome arrangement, break up into minute particles, become scattered diffusely throughout the cell, and finally undergo solution, the solvent process affecting the tigroid masses in the interior of the cell first, and extending gradually toward the periphery. This disintegration and solution of the tigroid has been variously designated. Marinesco calls it *chromatolysis*; van Gehuchten, *chromolysis*; Retterer, *chromophilysis*; Kohnstamm gives it the name *tigrolysis*, and the latter term is the one which I prefer.

Marinesco has described two distinct stages of the process, (1) A stage of *reaction*, in which the tigroid undergoes the changes above described; and (2) a phase of *repair*, during which the tigroid elements are restored to a more or less normal appearance. The first stage begins soon after section, and reaches its maximum in from fifteen to twenty days. The second stage lasts longer. It is essentially a phase of regeneration, and as in many cases of regeneration the elements regenerated are produced in excess; the individual tigroid masses are larger and more numerous than in the normal cell. During the first stage (that of reaction) the cell is swollen; during the second (that of repair) it gradually returns to its normal size. The nucleus, markedly displaced toward the axone hillock during the first stage, slowly reassumes its former position in the centre of the cell during the stage of repair. A few cells in motor nuclei, after section, fail to undergo this repair, and van Gehuchten assumes that in them the turgescence of the cell has taken place so suddenly during the first stage and the propulsion of the nucleus has been so violent that the latter has been completely expelled from the cell body. Such cells, deprived of their nuclei, necessarily undergo total degeneration. It was thought by Marinesco that the stage of repair was conditional upon regeneration of the distal end of the axone, but Nissl, van Gehuchten, and Foà have shown that this is an error, and that the altered cells return to their normal state entirely independently of the phenomena of regeneration at the point of section. At least this seems true of experiments upon animals, though there are some observations upon the spinal cord of human beings following upon amputation, which indicate that cells still tigrolytic may be observed in the cord for from three to seven months after the operation.

There would appear to be an intimate relation between the degree of injury to the axone and the changes which take place in the perikaryon, for when nerves are torn out, the effects are very different from those which follow simple section of a nerve. Thus Ballet and Marinesco showed that if a nerve be torn out, a large number of the cells undergo complete destruction and are absorbed. This may explain the cellulipetal secondary degenerations obtained by von Gudden's method (*vide infra*).

One of the more recent developments of the study by Nissl's method indicates that tigrolysis occurs constantly after section of a cerebral nerve, but may or may not occur after section of a spinal nerve, though it inevitably follows the tearing out of the same spinal nerve (Van Gehuchten and de Neeff). The inference has been drawn that the lower motor neurones in the spinal cord of the rabbit and dog possess a greater resistance to experimental injury than do the lower motor neurones of the medulla, pons, and midbrain.

The method introduced by Nissl is of very great importance to anatomy, since by means of it the exact cell bodies which give off the motor axones to individual muscles can be easily localized in the central system.

It is now much easier to understand the early investigations bearing upon atrophy of the motor roots and gray matter of the spinal cord after amputation. The younger the individual at the time of amputation, and the longer the time elapsing between the operation and death, the more marked are the alterations. It would appear that if an amputation be done early in life, many of the neurones concerned in innervating the amputated limb undergo complete degeneration and disappear totally, that is to say, in addition to the Wallerian cellulifugal degeneration, which of course occurs in the amputated stump, there takes place in young individuals a slow atrophy or slow cellulipetal secondary degeneration of the whole neurone, notwithstanding the fact that the perikaryon with its nucleus is left in the mutilated neurone. This vulnerability of neurones in young animals is especially well illustrated by the long series of experiments which were made by von Gudden. The distinguished Bavarian investigator showed that after removal of an eye in a young rabbit, in the course of some months not only did a total degeneration of the optic nerve of the same side and partial degeneration of the optic tract of the other side take place, but also extensive degeneration occurred in the superior colliculus of the corpora quadrigemina and lateral geniculate body of the opposite side. This general observation showed immediately what regions of the gray matter are intimately related with the optic nerve. The study of the microscopic changes in these primary optic centres proved that this method permits one to draw also important conclusions concerning the finer histological connections of the axones of the optic nerve with their centres of origin and of termination. Thus while in the superior colliculus after the operation above mentioned entire rows of nerve cells had

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disappeared from the superficial layer of gray matter, in the lateral geniculate body the ganglion cells were but very little altered; but between them, and especially in the gelatinous substance lying in the lateral part of this nucleus, there had been a very great loss by absorption of fine nerve fibres, the terminals of the optic nerve. It was easy to interpret these observations. Where as a result of the lesion there had occurred cellulifugal degeneration of the ground substance in direct continuation with cellulifugal degeneration of nerve fibres in the optic tract and optic nerve, we have to deal with the nucleus of termination of the axones of neurones, the cell bodies of which are situated in the retina. On the other hand, in the part of the colliculus superior where there had been a cellulipetal disappearance of ganglion cells, as a result of the removal of the eye, it was evident that we have to deal with a nucleus of origin of centrifugal axones which run out through the optic tract and optic nerve to the eye. That this conclusion is correct, the application of the methods of Golgi and of Flechsig to the problem have left no doubt.

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Von Gudden and his pupils utilized this cellulipetal secondary degeneration in young animals in extending widely our knowledge of the anatomy of the brain. By it the nuclear origin of the various cerebral nerves were very exactly defined, and later, the connections of the lemniscus, the brachium conjunctivum, the cerebrocortical pontal paths, and various other tracts were determined and their centres of origin and of termination accurately established.

A study of a large series of pathological cases in human beings following upon hemorrhage, softening, or pressure from various causes in the brain has proven that in human beings also the cellulipetal degeneration (corresponding to the experiments of von Gudden) occurs as well as the typical cellulifugal secondary degeneration of Waller. What is more, a study of human cases reveals the fact that if a neurone of a high order fails to receive its normal impulses from a set of neurones of the next lower order, owing to degeneration of the latter, the former undergoes a slow diminution in size throughout its whole extent (diminution in size of lemniscus accompanying sclerosis of posterior funiculi of cord). Again, if a set of neurones in a neurone chain is unable, through degeneration of the next higher group of neurones in the chain, to pass on its impulses to the latter, it undergoes a slow atrophy, all the neurones of the set gradually diminishing in size. This is well shown when, for example, the somæsthetic area of the cortex is destroyed and secondary degeneration of the thalamocortical neurone system results; the lesion is followed in the course of years by marked diminution in the volume of the lemniscus medialis, of the stratum interolivare lemnisci, and of the nucleus funiculi gracilis and nucleus funiculi cuneati of the opposite side, the cell bodies of which give rise to the axones of the lemniscus.

Bethe also studied the degenerative changes in the axis cylinder after section of the nerve. He states that the first change is the disappearance from the fibrillæ of a substance which is primarily colored by basic dyes, and that with the disappearance of the primary colorability of the nerve there disappears its excitability. There follows a breaking up of the primitive fibrillæ into large and later into fine granules; at the same time a breaking up of the medullary sheath with ellipsoid formation. Degeneration is always apparent in the primitive fibrillæ before such is seen in the medullary sheath. This degeneration does not occur in the whole nerve at the same time, but is first apparent near the seat of the lesion from which it can be traced at later periods toward the periphery. Corresponding changes are found in the central stump, though here the degeneration is limited in extent, though certain fibres may be seen degenerating far toward the cord. He denies that in the central stump degeneration ends at the first nerve of Ranvier nearest to the point of lesion (traumatic degeneration). From his investigations he confirms the opinion that sensory fibres degenerate more quickly than motor, and he further states that thicker fibres, both motor and sensory, earlier show signs of degeneration than finer fibres.

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Regeneration of the Neurones.

The topic includes regeneration of the nervous system in whole or in part during embryonic periods, the regeneration of whole neurones in the adult condition, and the regeneration of portions of a neurone after injury.

In connection with regeneration of the nervous system in the embryo much work has been done. Recent studies have revealed a wholly unexpected capacity for regeneration in young phases of the embryo. The doubling of the whole nervous system, or of one end of it, is by no means uncommon. In later embryonic phases the capacity for regeneration becomes less; but until quite a late period, especially in low forms, very considerable regeneration is possible. Interesting as regards the regeneration of the nervous system are the researches of Harrison, who experimented upon the tails of tadpoles. After cutting off the tail, its peripheral nervous system was regenerated from the spinal cord. There first arose a single pair of nerves from cells lying within the cord. A part of these cells wandered into the nerve root and gave rise to a large spinal ganglion. Subsequently groups of cells wandered farther into the periphery along the newly formed nerves and gave rise to from one to three small ganglia to take the place of those ganglia which had been lost through the operation. The total number of ganglia, however, was never completely replaced.

As to the regeneration of whole neurones in adult vertebrates much doubt has been expressed. The prevailing opinion is that if an adult neurone be once entirely destroyed, it can never be regenerated from neighboring neurones. That karyokinetic figures can occur in nerve cells adjacent to an injury has been shown by Tedeschi and Vitzou. The exact histological details of karyokinesis in neurones have been studied in the cerebral cortex of guinea-pigs after introduction of a hot needle by Levi (*cf. Barbacci's Review, loc. cit.*, p. 785).

Most interesting are the various studies which have been made to explain the well-known fact that regeneration of peripheral nerves after lesion occurs. There has been much dispute as to whether the regeneration of nerve fibres is due to an outgrowth of the axone from

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the central stump entirely or to a fusion of the axone of the central stump with a new axone developed in the periphery as a result of the activity of the neurilemma cells. In favor of the former view, the investigations of Waller, Ranvier, Vanlair, Barfurth, von Notthaft, Ströbe, and Kolster may be mentioned, while in favor of the latter view the studies of Beneke, Neumann, von Büngner, Wieting, and Ballance and Stewart may be mentioned.

According to the Waller-Ranvier-Vanlair view there is a continuous regeneration of the nerve fibres in connection with the part of the old axone preserved in the central stump. These authors observed in the distal part of the nerve the proliferation of the cells of Schwann's sheath and the formation of bands of spindle cells therefrom, but they maintain that the new axone is regenerated independently thereof. After the lesion the end of the central part of the axone becomes swollen and subdivides into several fine fibrils. These fibrils grow out from the central axones and ultimately reach the periphery; as they grow out they gradually become surrounded with myelin sheaths. The delicate young fibrils penetrate the intermediate tissue at the site of the lesion and reach the peripheral segment of the nerve, the fibres of which have undergone complete degeneration followed by proliferation of the neurilemma cells. These investigators assert, however, that the altered fibres of this peripheral segment take no active part in the formation of new fibres, but simply act as easy paths along which the new axones from the central stump can grow. If the central and distal stumps of the divided nerve are too far apart, the regenerating axones of the central stump may be unable to bridge the gap, in which event there will be no return of function; hence the importance of the immediate coaptation of the two cut surfaces of a divided nerve. Even when the coaptation has been carefully made by a surgeon, many of the newly forming fibres fail to grow out to the periphery.

According to the opposite view there is a *discontinuous* regeneration of the nerve fibres taking place independently of any connection with the central stump, the new fibres becoming connected with the latter only secondarily. The majority of those who support the view attribute the discontinuous regeneration of the fibres of the distal stump to the development of single segments from elongating cells; these single segments then fuse to form a continuous fibre, which later becomes attached to the end of an old nerve fibre in the central stump. There is thus a series of fusions of single cells to make the new nerve fibre and subsequently a fusion of the new fibre with the end of the old one. The same investigators believe that the cells which are concerned in building the new nerve fibres are derived by karyokinesis from the cells of Schwann's sheath (neurilemma); a few observers in the group, however, deny this, maintaining that the new fibre is derived from the connective-tissue cells of the endoneurium or even from leucocytes.

Neumann's ideas concerning regeneration resemble closely those just described, though they differ somewhat in details. He states that the myelin sheath and axone of the old fibre do not undergo complete degeneration and absorption, but, contemporaneously with the proliferation of the neurilemma nuclei, mix with one another, becoming transformed to a common protoplasmic mass, which possesses the chemical properties of both axone and myelin sheath. This mass, filling up the old nerve tube, gradually gives rise to the new fibre by again becoming differentiated into myelin sheath and axone. This differentiation is not, however, a *continuous* process but takes place in segments, and its origin and progress are, he thought, dependent upon and under the control of the axis cylinder of the nerve of the central stump, for the segmental differentiation begins at the lesion in contact with the old nerve fibre and gradually extends toward the periphery. The segment first differentiated fuses with the extremity of an old fibre of the central stump, and gradually the more peripherally situated segments fuse to form finally a continuous fibre.

Von Büngner undertook the study in 1891 with new methods. He decided that the peripheral portion of the nerve undergoes complete degeneration after section, and that therefore "healing by the first intention," postulated by some surgeons, does not occur. From the third day on, the neurilemma cells proliferate, the nuclei dividing by karyokinesis, and the protoplasm of these cells rapidly increases in amount. These cells fill up the interspaces between the balls of degenerating myelin and probably participate actively in the destruction and absorption of the old myelin sheath and disintegrated axone, since leucocytes are not present. No better illustrations of degenerating nerve fibres are to be found anywhere than those which accompany von Büngner's article. The neurilemma cells next line up in one, two, or more longitudinal rows and soon a slight fibrillation appears near the elongated nuclei until finally the nuclei of the row appear to be connected by bands of fibrils. Herein von Büngner saw the earliest indications of the newly forming axone. Through fusion of the rows of proliferated neurilemma cells and fusion of the segmental bands of fibrils, continuous fibril bands are formed, at the sides of which the nuclei, leaving their former central position, now arrange themselves, so that the fibres go past them in a slight curve. The process is always most advanced near the side of the lesion, the regeneration being slowest at the peripheral extremity of the nerve. Von Büngner believes that the neurilemma cells, and they alone, give rise to the new fibres; he does not hesitate to designate them "neuroblasts," and believes that they are truly "nervous" in nature and origin.

From the beginning of the third week on, new myelin sheaths begin to appear about the newly formed fibres, and a little later the new neurilemma and the new sheath of Henle appear, being derived, von Büngner believes, from the connective-tissue cells of the endoneurium. The nodes of Ranvier can be seen as early as the fourth week.

As to the mode of union of the axone of the central stump with the newly formed fibres in the peripheral nerve, von Büngner asserts that traumatic degeneration occurs in the central end up to the first or second node of Ranvier. Here the end of the old axone undergoes bulbous enlargement and fuses with new segmentally regenerated fibres derived from neurilemma cells of the central stump; the latter fuse with new segments in the space between the two ends of the divided nerve, and they with the newly formed fibre of the peripheral portion of the nerve. He denies anything like an outgrowth of the old axone to the periphery, and even an outgrowth across the space between the two cut ends of the nerve.

Neumann, more recently, states his position as follows: "At present no one doubts that a very important factor in the re-establishment of conduction in an interrupted nerve lies in the outgrowth of young fibres from its central stump; the only dispute possible concerns the extent to which this process takes place. While those who hold the Waller-Ranvier doctrine assume that the young fibres grow out into the peripheral degenerated part as far as its termination, according to the view which I have founded and which has later been supported by von Büngner and Wieting, the outgrowth from the central stump is limited, occurring only in sufficient degree to bridge over the gap in the nerve, whereupon new fibres are formed autochthonously out of the protoplasmic material supplied by the degeneration process."

Wieting agrees with von Büngner in ascribing the regenerative process in the first stages entirely to the nuclei of the neurilemma cells. He believes that the neurilemma cells give rise to a large amount of protoplasm throughout the whole extent of the degenerating nerve, and that it is through further differentiation of this protoplasm that the new structures are formed. As early as the fourth day extremely fine fibrils appear in the protoplasmic contents of the old neurilemma sheath. These fibrils are always continuous with the central axone. About the fifth day, advancing from the central stump toward the periphery, there is a sharper arrangement of

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the protoplasmic masses and fibrils with formation of fine fibrillary strips, stained of a pale rose color and otherwise homogeneous. Later, the cell boundaries disappear, the protoplasm is drawn out lengthwise, and is deposited as a finely granular covering upon the strips. The strips represent young axones. The gray covering is the beginning of the new myelin sheath, and is also to be looked upon as an excretory product of the cell, the excretion taking place first from the central stump and advancing toward the periphery. While Wieting emphasizes that the fibril formation takes place in direct connection with the old axones, and that the process advances evenly toward the periphery, he maintains that we do not have to deal with the simple outgrowth of the old fibre for which the neurilemma cells merely point the way, but have in reality to do with a fibrillary transformation of the protoplasm yielded by the nuclei of Schwann's sheath or with a fibril formation in the protoplasm in connection with the fibrils of the old axone.

A somewhat intermediate position is taken by Howell and Huber, though they incline to the view that the young axone grows out of the old one in the central stump; it grows into the young "embryonic fibre" born from the proliferating cells of Schwann's sheath. They think that when the new axone grows into the young "embryonic fibre" the formation of the myelin sheath has already begun in the latter. Their paper is readily accessible to readers of English, and need not, therefore, be further reviewed here. Their work was done independently of von Büngner's, and it is interesting to note the nearness of von Büngner's description of his fibril bands to that of Howell and Huber of their "embryonic fibre."

The whole subject was taken up again by von Notthaft in 1892, his research winning the prize offered by the medical faculty of Würzburg. His studies of degeneration of the nerve, the proliferation of the neurilemma cells, and the formation of fibrils in the protoplasm inside the old sheath confirm very closely the observations of von Büngner; but he differs entirely when he comes to describe farther stages of the process of regeneration. He asserts that the neurilemma cells do not build the young nerve fibres at all. Instead, the young nerve fibres all grow out from the axones of the central stump, and all pass, without exception, into the interior of old sheaths of Schwann. The young fibres pass by nucleus after nucleus of the proliferated neurilemma cells, but any such thing as discontinuous regeneration of nerve fibres from the spindle cells is, he maintains, impossible. The microscopic pictures do not even yield a remote suggestion of such a probability. Von Notthaft cannot conceive how von Büngner came to the idea that the fibrillary construction of the protoplasm of the proliferated neurilemma cells could be the *Anlage* of the new axones. He seems, however, to have neglected a careful study and description of the finer histological relations occurring in the spaces intermediate between the two cut ends of the nerve.

Even more convincing than von Notthaft's confirmation of the Waller-Ranvier theory is that which we owe to the still later researches of Ströbe. Instead of being satisfied with the indirect proof of the view which is embodied in this theory, he determined to make a wholly clear series of observations (so controlled that they should be free from objection) of the phenomena which occur during the earliest period of formation of the new fibres and their connection with the old. He admits that he was influenced by the promulgation of the neurone doctrine, which has emphasized the importance of the nerve fibre as a process of the ganglion cell, but did not permit this to prevent him from studying the actual process in detail. He was helped very much in his investigations by the invention of a special staining method for the axis cylinders. Preparations hardened in Müller's fluid were stained in concentrated aqueous solution of aniline blue (Gruebler), after which they were differentiated in a slightly alkaline alcohol. This gives a deep blue stain to even the finest young axones, while the cell protoplasm in general stains of a very pale blue tint, or by counterstaining in safranin it stains light red in contrast to the deep red stain taken by the nuclei. After studying all stages of the degeneration itself, and confirming again the fact that it is complete for both myelin sheath and axone to the very periphery, he took up the study of the changes of a progressive nature, finding, as had previous investigators, that the degenerative and the regenerative processes in the injured nerve accompany one another in time and place. He separates sharply the progressive phenomena which concern the cellular elements of the old nerve fibre, that is, the cells of Schwann's sheath, and the progressive phenomena of true nervous origin, namely, the new formation of the axone and the myelin sheath. The latter alone have the significance of the true regeneration of the nerves. The phagocytic activities of proliferated neurilemma cells were carefully studied. Ströbe also describes how these cells become transformed into long spindle-shaped elements with longitudinal oval nuclei filling up the old sheath of Schwann. These unite to form spindle-cell rows as the degeneration products disappear; portions of nerve fibres filled up by such rows of spindle cells may alternate with other portions of the same fibre consisting of entirely empty and collapsed Schwann's sheaths. An especial study at the site of lesion showed that the proliferating cells of Schwann's sheath enter into this region from both ends of the divided nerve; but here, instead of forming rows, the cells are prone to be irregularly mixed up and interwoven with proliferating connective-tissue cells of the endo-, peri-, and epineurium. This proved that the neurilemma cells possess no inherent tendency to the formation of longitudinal rows, but do so in the peripheral portion of the divided nerve simply on account of the adaptation of the cells to the special relations of the old nerve tube in which they arise.

True regeneration, according to Ströbe, has nothing to do with this proliferation of the neurilemma cells and the bands of spindle cells resulting therefrom, but depends entirely upon the outgrowth and splitting up of the old fibrillary axis cylinders directed peripheralward from the central nerve stump. These young fibres, by the method of staining employed, appear as sharp microscopic pictures; so sharp, indeed, that there can be no excuse longer for confusing them with the fibril-like structures in the protoplasmic bands described by von Büngner. The impression is never obtained of a new axis cylinder becoming differentiated out of the protoplasm of the rows of neurilemma cells. From the very beginning the young axones are continuous with the old axone, and show on their first appearance a very delicate but distinctly developed continuous myelin sheath. The illustrations which accompany Ströbe's article are very convincing. The new fibres gradually lengthen and grow out farther and farther distalward. The formation is continuous, not discontinuous. Passing from the central nerve stump into the tissue intermediate between the two ends of the divided nerve, the new axones pass between the rows of spindle cells, when such exist, and between the fibroblasts which have not been arranged into rows of spindle cells. Having passed through the site of lesion, the new fibres enter the old peripheral nerve, sometimes entering into the interior of old nerve tubes still open; at other times passing between the bands of spindle cells formed from the degenerated nerve fibres. The course is tortuous and the fibres frequently cross one another. The young fibres frequently possess a knobbed terminal swelling.

The young nerve fibres, delicate at first, gradually increase in thickness, the degeneration products of the old fibres gradually diminish in amount through absorption, and the normal condition is slowly restored. The cells of Schwann's sheath are not nervous elements at all, and the designation of "neuroblast" is wrongly applied to them. They are secondary connective-tissue ensheathing cells, corresponding to their mesoblastic origin in the embryo. Ströbe's work is in complete accord with the neurone doctrine, and furthermore is compatible with what

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we know must be the origin of the myelin sheath. Those histologists who assume that the myelin sheath is a product of the metabolic activity of the neurilemma cells seem always to forget that in the central nervous system we have innumerable myelin sheaths with entire absence of the neurilemma covering. That the axone builds the myelin sheath there can scarcely longer be doubt.

Ballance and Stewart have recently made an extensive publication attempting to revive the old doctrine of the discontinuous formation through fusion of rows of single cells. I cannot help but feel that they are falling into the error of a now large group of predecessors.

The bibliography of the subject must be read with great caution. Many of the statements are obvious misinterpretations. Such a finding as that of Korolow, who sees genuine ganglion cells in the central cut end, and that of Garrès, who describes regeneration of branches of the trigeminus after extirpation of the Gasserian ganglion, are based upon mistakes. What Korolow's mistake was, it is difficult to say. Garrès doubtless had to deal with partial instead of complete extirpation of the ganglion.

Regeneration of nerve fibres which have undergone solution of continuity inside the central nervous system is so imperfect that many have questioned whether it takes place at all. The physiological studies of Baer, Dawson, and Marshall, and the pathological researches of Worcester, make it seem probable that at least some regeneration takes place. The evidence in general has been sifted by Ströbe (*loc. cit.*).

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Intoxications of the Neurone.

The best review of the literature of nerve-cell intoxication up to 1899 is that given by Barbacci. He has collected with great assiduity almost the entire literature of the subject and arranged the results systematically. He distinguishes sharply between the toxic influences which are the result of the introduction of substances into the normal organism from the outside world—intoxication in the narrower sense—and those intoxications which are the effect of poisons developed in the organism itself through a disturbance of metabolism—auto-intoxications. The former, in turn, can be further subdivided according to the chemical nature of the poisons, whether they be mineral or organic; and in the latter case, whether we are concerned with a so-called organic poison proper or a vegetable alkaloid or a poison of animal origin. Finally the effects of intoxication are considered by themselves, according to the special nature of the intoxication to which the alterations met with in the nerve elements are to be referred.

In his review of the general pathology of the nerve cell Barbacci refers to a series of special modifications which the nerve-cell protoplasm undergoes in various intoxications and infections. Most of these have been dealt with above under the caption, "Degenerations of the Neurone." A few additional ones, however, deserve especial mention.

Golgi's method has been utilized by a number of investigators for the study of pathological alterations in nerve cells, though it has been, of course, of far greater service in revealing the normal anatomical relations inside the central nervous system. One is always more or less in doubt in studying pathological tissues with Golgi's method as to how many of the appearances met with are artefacts. One of the commonest findings in pathological tissues is the so-called *varicose atrophy of the dendrites*. Instead of the normal dendrite, one sees a process studded by rows of round or oval swellings connected by thinner or thicker threads, reminding one of a chain of beads. This change is preceded, as a rule, by a falling of the "gemmules" or lateral thorns from the dendrites. The alteration affects the finest branches of the dendrites first and extends to the thicker trunks, until, finally, all of the protoplasmic process of the cell may be involved. Occasionally, however, the change is limited to a single dendrite or even to a single branch. The changes in the larger protoplasmic trunks of the dendrites, however, are not, as a rule, so typically beadlike. Instead, one sees an irregularity of contour, nodules, indentations, erosions, roughenings, wrinkles, etc., in the Golgi pictures. Any of the appearances described may be met with in normal tissues, but the change may be regarded as pathological when it is extensively distributed. For a list of conditions in which these changes have been noted, Barbacci's article may be consulted (*loc. cit.*, S. 798).

A somewhat similar atrophy affects the axones as seen in Golgi preparations, under certain conditions. What appears to be the same or a similar condition has been described by Golgi as *varicose hypertrophy*.

Of the changes met with in intoxications in tissues studied by Nissl's method, that of *chromatolysis* or *tigrolysis* has already been referred to (*vide supra*). The process has been carefully described by Ewing, Marinesco, and others. It begins, as a rule, with a swelling of the tigroid masses, though this is not always demonstrable. Once begun, the process involves a gradual vanishing of the tigroid from the cell protoplasm. The tigroid masses may disappear in various ways. In the first place, it is not uncommon to see an irregularity of arrangement appear. In the cells of the anterior horn, for example, instead of the typical stichochrome arrangement, one may meet with great irregularity and disorder. Again, instead of sharply isolated tigroid units, these elements may lose their individuality and be connected with others in the cell protoplasm in the form of a network. Instead of sharp, clean-cut pictures of the individual tigroid mass, one frequently sees ragged edges and indefiniteness of outline.

Ewing has described a fine subdivision of the tigroid masses occurring when the tigrolytic process goes on slowly. In other cases, in which the process is more rapid, the tigroid elements are broken up quickly into very fine granules and become evenly distributed throughout the cytoplasm, giving it a very characteristic "dust-like" appearance. This is the change designated by Ewing as "*granular subdivision*" and by the Germans as "staubiger Zerfall." In the final stages all the stainable substance of Nissl has disappeared from the cell (stage of *achromatosis*, described by Marinesco).

The tigrolysis may be total, or it may be limited to smaller or larger portions of the cell, in which case we speak of *partial tigrolysis*. If it involves the region immediately adjacent to the nucleus, the condition is spoken of as *central* or *perinuclear tigrolysis*; when, on the other hand, it is the periphery of the cell which is affected, the central portion remaining almost intact, it is spoken of as *peripheral* or *marginal tigrolysis* (Fig. 3587). By *intermediate* or *concentric tigrolysis* is understood the involvement of the middle zone between the nucleus and the periphery—a very rare condition. Finally the tigrolytic process may involve some particular segment of the

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cytoplasm, in which event it is spoken of as *segmental* or *circumscribed tigrolysis*.

The tigrolysis which follows section of the axone has been referred to as *degeneratio axonalis* (Fig. 3588); it is of the central variety as a rule. It was supposed by many that, on the other hand, when a toxic agent acted upon the cell from without, the change nearly always consisted in peripheral or marginal tigrolysis. A review of the extensive bibliography, however, teaches that no hard-and-fast rule can be laid down.

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The changes demonstrable by

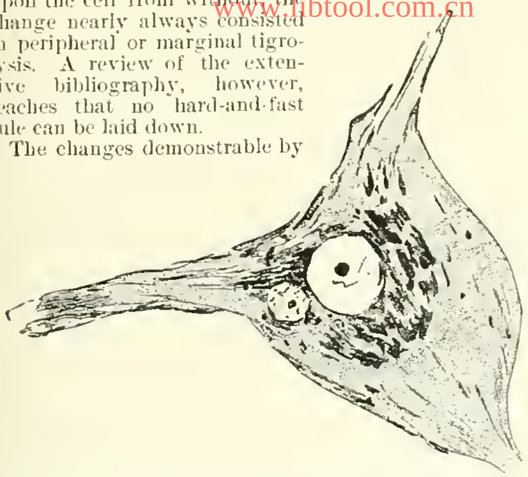

FIG. 3587.—A Nerve Cell from a Part of the Spinal Cord Deprived of Blood for Six Hours Through Ligature of the Abdominal Aorta. (After G. Marinesco, *Presse méd.*, Par., 1897, pl. v., p. 45). The peripheral portion of the cytoplasm contains only a few tigroid masses, although the latter are still numerous near the nucleus. Typical *peripheral tigrolysis*.

Nissl's method in the nucleus in various intoxications include (1) swelling of the nucleus, (2) diminution in the size of the nucleus, (3) alterations in the form of the nucleus, and (4) alterations in the contents of the nucleus.

Swelling of the nucleus may vary in degree. In extreme cases actual dropsy of the nucleus has been met with. Such swelling has been described in a whole series of conditions, including faradic excitation of the cell, commotio, uræmia, cholæmia, tetanus, rabies, and acute delirium.

A diminution in the size of the nucleus may or may not be accompanied by alterations in its nucleolus. As a rule the form of the nucleus is also somewhat altered. The contour is irregular, the nucleus looking as though shrunken. When the contents are altered, they may be homogeneous and stain diffusely and evenly. Sometimes this homogeneity is associated with shrinking—so-called "acute homogenization with atrophy" (Sarbo). Sometimes the contents of the nucleus stain evenly, but take a different tint from other constituents of the cell, especially a shade different from that taken by the nucleolus and the tigroid mass. This "metachromatic" staining has been met with by Barbacci in various pathological conditions, but especially in experimental cholæmia. He points out, however, that metachromatic staining frequently occurs in tissues which have undergone post mortem change, and that therefore great care should be exercised in reporting instances of the alteration.

Vacuolization of the nucleus has been referred to above in connection with vacuolar degenerations in general.

Eccentricity of the nucleus or peripheral disposition of that structure is one of the typical changes in the nerve-cell body following upon lesion to its axone. That it may occur under still other conditions has been manifoldly stated. Thus it has been described after ligature of the aorta, in embolism, and in various intoxications. In some of these instances, however, the eccentricity may depend not upon the direct action of the harmful agent upon the cell body and nucleus, but rather upon a simultaneous injury to the nerve fibre, in which event the change in the nerve cell would correspond to the ordinary axonal degeneration.

Various alterations in the nucleolus, under pathological conditions, have been described. All degrees of pallor of the nucleus have been observed in stained preparations, the pallor occurring most frequently when the volume of the nucleolus is increased. Swelling of the nucleolus is met with under many conditions, but particularly after tetanus or strychnine poisoning. Occasionally the nucleolus is diminished in size (Ewing). Uneven staining of the nucleolus with actual vacuole formation has been emphasized by Lugaro as a common appearance after arsenic poisoning. Similar phenomena have been described by Ewing in hydrophobia.

The shape of the nucleolus is often altered, instead of being round with regular margin, it may become polygonal. In extreme cases it may be fragmented, a condition not to be confounded with the existence of the so-called secondary nucleoli.

When one approaches the subject of special intoxications he is almost overwhelmed with the immense number of researches which have been undertaken in connection with them. The great vulnerability of the Nissl bodies and the observations of marked alterations in them in various intoxications led Nissl and others to hope that we might find in the study of the stainable substance safe criteria for the histological diagnosis of the action of specific poisons. Much disappointment has, however, been met with as the investigations have proceeded. The lesions in the majority of instances are not pathognomonic for the special poisons. If specific alterations are some day to be found, they will probably be in the ground substance of the nerve cell or unstainable substance of Nissl rather than in the tigroid masses. That specific poisons have specific effects is indubitable from the physiological and pathological results of their action. That specific physical and chemical alterations take place in certain groups of nerve cells under such circumstances we cannot doubt, but we are far from having found anything like histological changes corresponding to these specific effects. In all probability we must wait until our technique has become much more refined before we can hope for histological demonstration. It may be that the alterations concern portions of the nerve-cell protoplasm measuring less than the wave length of light, in which event microscopic demonstration would be impossible.

Of the mineral poisons, the effects of which have been studied, may be mentioned arsenic, lead, antimony, mercury, phosphorus, silver, and aluminum. Of the organic poisons proper the effects of alcohol, chloroform, antipyrin, trional, acetone, and malonnitril have been studied. The effects of powerful alkaloids have formed the basis for a large series of histological investigations. Strychnine, morphine, quinine, ergotine atropine, muscarine, nicotine, cocaine, and veratrine are among those which

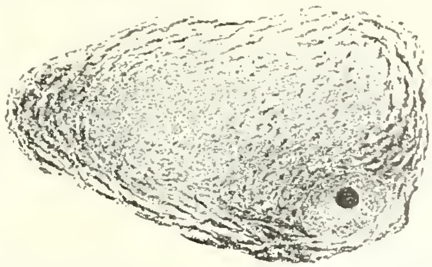

FIG. 3588.—Spinal Ganglion Cell Showing Marked Alterations Following Section of the Sciatic Nerve. Sublimate fixation, thionine staining. (After Lugaro.) Typical *central tigrolysis* with eccentric position of nucleus: *degeneratio axonalis*.

have been used. Of the poisons of animal origin blood serum of animals of the same and of other species, urine, thyreoidine, neurine, and snake poison may be mentioned as those whose effects have been particularly investigated. Special interest has attached to the examination of the changes in the nerve cells which occur in the so called auto-intoxications. Thus in the bibliography

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there are multiple references to studies of the nervous system in uræmia, cholæmia, coprostasis, adrenal cachexia, thyreoid cachexia, experimental glycosuria, insomnia, and the auto-intoxications following burns. Finally, the alterations in the neurones, occurring in a whole series of infectious diseases, have been examined and studied; tetanus, diphtheria, hydrophobia, bubonic plague, yellow fever, botulismus, septicæmia due to various micro-organisms, anthrax, infectious peritonitis are among the number. It would be beyond the scope of this article to discuss these in detail, and besides Barbacci has given an excellent epitome of the whole subject in his collective review, to which in this section reference has so frequently been made. Perhaps nothing better can be done, under the circumstances, than to quote Barbacci's summing up of the whole matter. It is his opinion that the alterations perceptible in the nerve cell under various conditions are best understood as follows: "When a harmful influence affects the nerve cell, two series of processes are possible: either the harmful influence is so intense that it quickly kills the cell, in which event the microscopic picture shows only the typical signs of cell necrosis; tigrolysis has neither time nor reason for appearance. The alterations of the protoplasmic masses, and especially those of the nucleus, are those which betray the effect of the morbid causative agent. If, on the other hand, the intensity is less, the cell reacts powerfully at first against the abnormal stimulus and uses up, in the exertion of the reaction, its reserve supply of nutriment more or less quickly. Herein we see the significance of tigrolysis; it is the expression, simply of a phenomenon of reaction. If during this first phase the total activity of the pathological stimulus becomes exhausted, the alterations in the cell progress no farther and the normal condition is quickly regained, the reserve supply of tigroid substance being quickly restored. In this phase of the reaction, the neurones retain their functional capacity unaltered—a fact which explains very well the striking contradictions between the anatomical findings and the clinical symptoms in many affections. During the development of a disease the nervous system may betray no symptoms which would indicate alterations taking place in it, and yet its elements, on microscopic examination, show that extensive tigrolytic processes have already occurred. This is seen especially frequently in infections and intoxications, and particularly in those which follow an acute course. But when the influence of the noxa continues to act upon the neurone after the latter has exhausted all its reactive powers, it becomes affected in its most vital parts and degeneration follows upon the reaction. The cell is irretrievably condemned to death, and the microscopic specimens show most often only the signs of a cell cadaver."

It would seem not unlikely that our knowledge of the general pathology of the neurone will be materially increased through the extension of experimental pharmacology, and of those modern researches which are attempting to explain the phenomena of immunity. A start has already been made in the investigations which bear upon the relations of the chemical constitution of bodies to their distribution in the organism and their pharmacological effects. Since Stahlschmidt, in 1859, proved that strychnine could be robbed of its tetanizing effect through the introduction into it of one methyl group, and so be transformed into a paralyzant, not unlike curare, interest in such problems has rapidly grown. It was soon shown by other investigators that other ammonium bases, derivable from various alkaloids, possess properties not unlike those of curare—a fact of the highest interest, since Böhm has since demonstrated that curarine itself is an ammonium base.

The work which has been done upon artificial antipyretics has furthered the ideas under consideration. The synthetic preparation of antipyrin and phenacetin may be mentioned as an illustration. It has been shown that the antipyretic effect of aniline derivatives and amidophenol derivatives like phenacetin, is proportional, within certain limits, to the amount of para-amido-phenol which is split off in the organism, and it has been demonstrated that the introduction of acid salt-forming residues (like SO_3H and CO_2H) prevents the antipyretic power of such substances. Again the studies upon cocaine and allied bodies support the same principle. It has been shown that it is the benzoyl residue which in cocaine gives it its anæsthetic power. It was a knowledge of this fact which led to the synthetic manufacture of new anæsthetics which contain the anæsthesiophore benzoyl group as their active agents; thus eucaine, orthoform, and nirvanin have been made available. The somniferous effect of the introduction of ethyl groups into molecules has been adduced as further evidence along these lines. Sulfonal, amylene hydrate, alcohol, and dulcin all owe their specific properties largely to the ethyl groups contained in their molecules.

Ehrlich's studies upon the staining of the living nerve tissues by a certain small number of basic aniline dyes (methylene blue, Bismarck brown, chrysoidin, neutral red, etc.) is calculated to throw some light upon the subject. He has shown that these neurotropic dyes entirely lose this power if a sulpho-acid group be introduced into their molecules. The introduction of the acid group alters the distribution in the organism and completely destroys the neurotropic properties. Ehrlich has pointed out as specially significant the fact that the majority of basic dyes which stain the living brain substance have also an affinity for adipose tissue. In other words, neurotropy and lipotropy are intimately connected with one another. It is obvious, therefore, that when substances are ditropic or polytropic their distribution in the organism, and with it their pharmacological effect, will vary more or less with the quantitative relations of the tissues for which they have affinity. Thus the poisons which have at the same time neurotropic and lipotropic effects, if administered in equal amounts per kilogram of body weight, will have a much more marked influence upon the nervous system in an emaciated animal than in one which is very fat; for, according to the *loi de partage*, much more poison will be taken up by the brain.

One of the most important questions which we meet with is that which deals with the reason why certain tissues are selected by certain chemical substances. That the reasons are chemical in nature seems very probable. It is well known, however, that certain indifferent substances possess neither basic nor acid characters; and when introduced into the organism, though they have no marked chemical affinities, they nevertheless often exercise extremely toxic effects. This is true, for example, of ether, alcohol, and various narcotics. In such cases it is thought that direct chemical affinities on the part of the organism are not concerned, but that we have to deal with a sort of contact effect, due to the influence of unaltered and chemically unbound molecules present among the constituents of the tissue. But if this is true, what is it that determines the typical localization of these compounds in certain tissues, such as those of the central nervous system? Ehrlich has compared this kind of localization with the principle of the Stas-Otto extraction procedure. Writing in 1887 he said: "The principle of the mode of extracting poisons introduced by Stas-Otto is based on the fact that in general basic bodies, like the alkaloids, enter into firm chemical combination in acid solutions, and hence can only with difficulty be extracted, while they can easily be shaken out of alkaline solutions. Acid compounds show, of course, the opposite behavior, since they are held firmly in alkaline media, but are easily given up by acid media. If we transfer these principles to the questions in which we are here interested we can easily understand why basic dyes, particularly those which are not retained in the blood by chemical affinities, are preferably taken up by the brain, while the acid dyes and sulpho-acids which are firmly held by the alkalies of the blood in the form of salt, and, as it were, are anchored there, show exactly the opposite behavior." Ehrlich's observations that adipose tissue takes up many substances which are also taken up by the brain is significant when added to the finding of Pohl in 1891, that the

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receptivity of the red blood corpuscles for chloroform depends upon the presence in the corpuscles of cholesterin and lecithin, and to his conclusion that the relation of the chloroform to the nerve tissues of the brain is dependent upon the existence of substances of a fatty nature in the brain. These studies afforded the basis for more accurate examinations of the cerebral effects of those substances which are easily soluble in fats and fat-like compounds. That these examinations have been fruitful will be clearly seen from the work of Hans Meyer on alcohol narcosis, and that of H. Overton on the causal relations existing between solubility in fat and narcotic effects.

But this loose contact effect of poison upon the brain and spinal cord will not explain another series of intoxications due to bodies like the antipyretics, various substances of a basic nature (alkaloids and phenols) which are not chemically indifferent, but, on the contrary, may be capable of entering into actual synthetic relations with the tissue cells. Loew suggested some years ago the existence in protoplasm of definite atomic groups endowed with powerful affinities; to these atomic complexes he ascribes an important rôle in the phenomena of intoxication. It was his opinion that atomic groups, on the one hand, perhaps, of the nature of aldehyde groups, on the other hand, the labile amido groups, were active in the protoplasm proper in catching hold of chemical substances circulating near them, and for which they had an affinity. Any compound, he thought, which could combine with either of these atomic groups could act as a protoplasmic poison; and the greater its affinity for these groups the stronger its toxic effect. But Ehrlich's experiments with aniline dyes speak against such a substitutive action of poisons, at least of poisons like the alkaloids; for most of them can be extracted from the tissues by indifferent solvents, and this would scarcely be the case if chemical combination with the protoplasm took place. Ehrlich assumes, on the other hand, that only two modes of explanation are possible, and that in one case one may be true, in another case the other. The one explanation is based upon Knecht's theory of the action of dyes depending upon the formation of insoluble salt-like compounds. Pfeffer, in studying the vital staining of plant cells, has convinced himself that the staining is due to the precipitation of granules of the difficultly soluble tannate of methylene blue. In animal cells the affinity of the tissue for an alkaloid might be due to the formation of a salt with nucleinic acid, or with various products of secretion present in the cell; that is to say, with substances in the protoplasm rather than with the protoplasm proper. The second possibility which Ehrlich sees lies in the probability of the formation under certain circumstances of so-called "solid solutions" (*feste Lösungen* of van't Hoff), a view which Witt has advanced in dye chemistry. Possibly, as he suggests, the distribution of an alkaloid in the organism sometimes depends upon both causes, the selection being due to a combination of "salt formation" and of "solid solution."

There is a class of poisons, however, quite different from all these thus far mentioned, poisons which like food-stuffs may actually enter into the molecules of the protoplasm proper and be *fixed* in the protoplasm and become non-extractable by indifferent solvents; for such poisons a view like that advanced by Loew would be more applicable. Sugar residues, for example, cannot be withdrawn from the cells by simple solvents; they must first be split off by acids in order that they may be obtained in a free condition. For such chemical anchorage, as in all syntheses, two combining groups of maximal chemical affinity must be assumed to exist, one in the cells designated by Ehrlich as a "side chain" or "receptor," the other in the food-stuff molecule and called by him a "haptophore" group. Ehrlich assumes that living protoplasm is supplied with a large series of such "side chains" (*Seitenketten*), which by virtue of their chemical constitution have the power to anchor the various kinds of food-stuffs; in other words, the activities of such side chains underlie the phenomena of cellular metabolism. It is this "side-chain theory" also which forms the basis of Ehrlich's doctrine regarding the action of bacterial toxins and the production of antibodies. He believes that the toxins, like the food-stuffs, possess definite haptophore groups which, uniting with corresponding receptors in the protoplasm-molecules of the cells, permit the toxic effect. As a result of the throwing out of function of these receptors the cells "regenerate" new receptors of the same kind in excess, many of them being thrown off into the blood to form "antitoxins." Only such poisons as possess haptophore groups can give rise to the formation of antibodies; against alkaloids, glucosides, or the antipyretic substances, no true immunity can be produced.

In tetanus, to take a concrete example, the symptoms all point to an intoxication of the central nervous system. According to Ehrlich's side-chain theory, the poison acts on the nerve cells because its haptophore group combines with corresponding receptors in the nerve cells. Tetanus antitoxin consists of such receptors regenerated in excess and thrown off into the circulating blood. When tetanus poison enters the blood of an immunized animal it is bound by these receptors and the side chains in the nerve cells themselves are protected. Wassermann has shown that the normal tissue of the central nervous system of most animals that are susceptible to tetanus is capable of entering *in vitro* into firm combination with tetanus poison, and that a mixture of normal nerve tissue and tetanus poison is harmless when introduced into animals, because the haptophore groups of the poison are saturated with receptors, and so cannot combine with the living nerve tissues of the animal under experiment. Other organs of the body do not combine with the tetanus poison *in vitro*.

Interesting, too, in connection with the pathology of the neurone is another series of facts—those bearing upon specific cytotoxins. It is now known that the injection of the red blood corpuscles of a species *a* into a species *b* leads to the development in the blood serum of species *b* of specific products of reaction which are highly toxic to the corpuscles of species *a*. These toxic substances are the so-called specific hæmolysins. Delzenne and Madame Metchnikoff, by treating animals with the central nerve tissues of other species, have been able to prepare a specific highly neurotoxic serum. Small amounts of this serum injected into the cerebrum of species *a* caused paralysis and epileptiform convulsions. Experiments made with other cells give similar results; thus specific leucotoxins (for the white blood corpuscles) and specific spermotoxins (for spermatozoa) have been produced. The fact that anti-hæmolysins and anti-leucotoxins can be made experimentally is very hopeful for the future of therapy.

Along the pathways just indicated the hope of the experimental pathologist and therapeutist would seem to lie. But an immense amount of work must yet be done before extensive practical application of these ideas in clinical neurology may be expected.

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REFERENCES BEARING UPON INTOXICATIONS OF THE NEURONE.

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NEUROSES, PROFESSIONAL. See *Hands and Fingers, etc.*

NEUROSES, TRAUMATIC. See *Nervous System, Traumatic Affections of.*

NEUROSES, TROPHIC. — DEFINITION. — Derangements of nutrition determined by variations in the supply of nervous energy, without observable change in the nerve tissues.

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The study of the diseases usually included under this head is in large part a matter of the last few years. Several members have been added to the group, and those known for a longer time have been more closely scrutinized and their phenomena described. In spite of this fact considerable doubt exists as to what particular diseases belong in this category. Authorities differ a good deal in regard to the nature of some of the diseases and their ultimate causes. In order to obtain an adequate conception of the general features of trophic disorders it is necessary to consider with them some of the vaso-motor diseases. Nourishment and decay are closely and necessarily linked with the blood supply; this latter is varied, at least in quantity, by a special nervous mechanism constituting the cardio-vaso-motor system, so that the action of the nervous system on nutrition must be divided into its direct action, and the one exerted through the vaso-motors.

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It is obviously impracticable to include in the group all neuroses associated with trophic change. Nutrition is profoundly affected in many, somewhat affected in most of the neuroses, including such widely varying diseases as chorea, epilepsy, and various neuralgias. Overgrowth or decay should be the predominant and essential feature of the process, and should affect specific structures. The results of ordinary vaso-motor action and mere connective-tissue hyperplasias should not be classed as trophic disorders.

It is first to be noted that a neurosis is properly a nervous disease without observable organic basis in the nerve tissues. It will not be here used in its broader sense of nervous disease, whether organic or functional, as the tropheneuroses would then of necessity include diseases (syringomyelia, poliomyelitis, neuritis, and many others) which, although accompanied by trophic changes in various tissues, are evidently not contemplated in the present classification.

Granted that the changes in these diseases may occur under the immediate influence of the nervous system, whether by so-called trophic nerves or otherwise, there still remains the question whether the nerve changes are determined by the action of poisons or take place as a result of inherited or acquired tendency or from other causes. Nutritional and degenerative abnormalities are usually the result of poisons taken into the body from without, or formed in the body by bacterial or glandular action. The idea that there are purely functional disorders without organic change is being much modified, and is giving place to the conception of function as varied by changes of structure or of environment, and especially by variations of the blood supply and blood content. Especially in the group of diseases known as the trophoneuroses the symptoms from which the patient suffers are almost exclusively those of obvious organic change in the most various tissues. To suppose a functional basis for such changes is a theory to be adopted, if at all, after a careful scrutiny of the facts.

The idea of trophoneuroses is suggested by analogy from the muscular atrophy that supervenes on destruction of the fibres of motor nerves or of motor ganglion cells in the cord. While trophic changes in such diseases as tabes and syringomyelia suggest the possibility of tissue death from deficient innervation alone, facts are rapidly accumulating which tend to show that some trophic diseases formerly classed as neuroses are in reality vaso-motor and trophic disorders determined by lack or superabundance of secretion of some of the ductless glands. The discovery of the importance of the secretion of the thyroid gland in myxœdema, cretinism, and possibly scleroderma, and the close relationship of the latter in its varied forms with the atrophies and hypertrophies, facial hemiatrophy, acromegaly, and other diseases has thrown much light on nutritional variations.

With these facts in view it will be well critically to examine the diseases sometimes classed as trophoneuroses, so as to find out which, if any, of them are entitled to a place in this category.

Acroparæsthesia affects mainly women who are much exposed to cold, and especially those who have their hands much in cold water. The symptoms are numbness and tingling of the extremities, especially of the hands, sometimes increasing to burning or tearing pains. There may be either hyperæsthesia or anæsthesia, and analgesia, usually of moderate degree. The symptoms do not follow the distribution of any nerve or nerves. The sensory symptoms constitute the essential elements of the disease. Vaso-motor phenomena are sometimes added, and consist of either redness or blanching of the hands. Nutritional changes are slight and unessential.

The fact that vaso-motor symptoms are variable and sometimes absent indicates that the disease is an affection of the sensory nerves, possibly a hyperæmia or low grade of inflammation. The efficiency of ergot in controlling the symptoms makes this view probable. The disease usually runs a long but mild course.

Angioneurotic œdema is the name given to œdematous swellings which occur suddenly in various parts of the body, sometimes without apparent cause, sometimes on exposure to cold. The swellings do not pit on pressure; they may be white or pink in color; they disappear completely. The neurotic nature of the disease is sufficiently indicated by the skipping of the œdematous spots from one place to another, sometimes with a rapidity quite remarkable. It is not in any sense trophic, but is purely vaso-motor; sometimes, possibly always, on a toxic basis.

In many people of low vitality one or more fingers become white, cold, and corpse-like on plunging them into cold water in the morning, especially in winter. These are the so-called "dead fingers." The blanching in severe cases may involve the hands and extend to the elbows, or even to the shoulders. Numbness and tingling are present but moderate. The phenomena soon pass off when the hands are warmed by the fire. The disease is not dangerous, nor even threatening except in some cases in which vascular spasm may be so great as to induce faintness. The condition is related on the one side to acroparæsthesia; on the other to Raynaud's disease, the first stage of which it may simulate. Trophic features are absent. A more profound affection of the vaso-motors is seen in Raynaud's disease, one essentially of vascular spasm of extreme degree. The stages of blanching, of local asphyxia with blackish discoloration and of gangrene, are those of tissue death rather than of retrogressive metamorphosis. These phenomena are vaso-motor. There are, to be sure, trophic symptoms in many cases, amounting to marked scleroderma. The fact that scleroderma may exist without perceptible vaso-motor change, that in Raynaud's disease blanching and local asphyxia may go on indefinitely without atrophy, and the lack of proof that there is any necessary connection between the two sets of phenomena, show the non-identity of the two diseases in spite of the existence of mixed forms. Vascular spasm of known origin is usually toxic. An extreme instance of this kind is seen in the gangrene of ergot poisoning. Organic lesion of the vaso-motor centres is also capable of setting up vascular spasm and gangrene. No poisons have been found to account for Raynaud's disease, and organic nerve lesions have not been discovered.

It is hardly necessary to discuss the question whether the foregoing diseases are essentially trophic. The symptoms are those of derangement of the vaso-motor system; variations of nutrition are not prominent and are absent in many cases. The ultimate cause of these diseases is an interesting problem, but is not germane to the present inquiry.

The general diseases connected with abnormalities of the thyroid gland are interesting instances along the boundary between the vaso-motor and the trophic. They have so lately been assigned to their proper place that they still often figure as trophic neuroses, and they are so closely related with the other diseases under discussion that they deserve a brief mention.

Exophthalmic goitre is characterized by vaso-motor phenomena with some secondary nervous manifestations. The rapid heart action, vascular enlargement of the thy-

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roid gland, and bulging of the eyeballs point to an involvement of the sympathetic system, and tremor, nervousness, and vomiting make up the usual picture of the disease. There seems little doubt that the symptoms are caused by increased functional activity of the thyroid gland. The cause of this increase is not known, but there is no ground for thinking it to be a neurosis, and exophthalmic goitre now finds its place among the glandular affections. Changes of nutrition of the body tissues are great but not specific.

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It is otherwise with myxœdema, a disease now known to be due to lowered function of the thyroid gland. The deposit of mucinous material in the skin, giving the characteristic œdematous appearance, is not a condition of overgrowth, and the changes in the kidneys, blood-vessels, and nerve tissues are degenerative, not trophic. The disease makes good its title to a place among trophic disorders chiefly by arrest of development in patients in whom the disease begins in childhood. To this condition the name of cretinoid idiocy is given. Its dependence on lack of secretion of a ductless gland (the thyroid), its improvement by administration of thyroid extract, and its close relationship with myxœdema are pregnant with suggestions in regard to trophic variations and many so-called trophic diseases. Meanwhile, in spite of the fact that trophic conditions are so largely present in cretinism, and are so closely simulated in myxœdema, neither of them is a neurosis, and neither of them is properly a trophic disease.

So far we have considered diseases that vary by more or less perceptible degrees from sensory into vaso-motor, and from vaso-motor into trophic phenomena. In few of them is trophic change entirely absent; and while sensory symptoms do not increase in proportion with the severity of the remaining symptoms, they are still present throughout the entire series. We now come to a disease in which sensory and vaso-motor symptoms play an entirely minor part, and in which changes mysterious in origin are apparently essentially trophic.

Scleroderma is a disease not, as its name implies, of the skin alone, but in its well-developed form is a wasting of the tissues in general, including skin, bones, muscles, mucous membranes. Clinically the present tendency of authorities is to include in the same category all cases, whether of atrophy limited to a small portion of the skin or of wasting of almost all of the tissues of the body, as in the terrible but happily rare instances of diffuse scleroderma. These cases have the one symptom of skin wasting in common, but it is improbable that they depend upon the same cause. In fact the partial cases, the so-called morphœa, have in some instances been shown to be due to organic changes in the nerve tissues, which is not the case with general scleroderma. The striking features of this disease are the atrophy without sensory disturbance, whether anæsthesia, hyperæsthesia, or pains other than the discomfort due to the shrinking tissues; and the absence of vaso-motor changes as an essential part of the phenomena. The latter is limited to a hyperæmia of moderate degree, shown in the lilac border about the patches of morphœa. Pathologically the tissues show a change into connective tissue and a disappearance of the normal elements.

That so profound and widespread changes as occur in well-marked scleroderma should be brought about by changes in the structure or functions of the nerve tissues without direct involvement of their more familiar functions, those connected with motion and sensation, is sufficiently improbable. We may leave out of account organic change in the nerve tissues. If such were present and could be shown with a fair degree of probability to be in causal relation to the symptoms, the disease would be assigned to the organic nerve diseases. Let us examine in brief the reasons usually urged for considering any disease neurotic in origin.

Symmetry of the lesions or of the symptoms is often supposed to indicate their nervous origin. It is sufficient to observe on this head that although the nervous system is symmetric, so are the other organs of the body. In especial the blood-vessels are in the main symmetrically disposed. Accordingly vascular disturbances, whether conditioned by blood supply or by blood content, are usually symmetric, except when determined by local causes, as heat, cold, violence, pressure. It is to be noted that of the two ways in which these agencies have their effect, one is by mechanical change, and the other is change of tissue through the action of the vaso-motors, so that asymmetry itself is in many cases the result of nerve action. While vascular action is usually symmetric, nerve action is not usually so. Walking is alternate, not symmetric action; the hands are sometimes moved together, usually separately; the finer motor acts, as of speech and writing are functions of one side of the brain; the possession of special sense organs in pairs is an instance of redundance for safety in case of accident rather than a necessary symmetric arrangement.

General sensibility is only symmetric in the sense that the whole of the skin and the other tissues is supplied; the very point and essential feature of the whole mechanism is the distinguishing of one side from the other and of one spot from another. In some special instances, as with contraction of both pupils from the impact of light on one retina, a bilateral result follows from a unilateral cause. Dilatation of the pupils, however, from an injection of atropine is not an instance of the same kind, but is determined by distribution of the poison to the sympathetic on both sides; excitation of the sympathetic in the neck on one side, by galvanism, and the action of atropine on the nerve filaments of one side, by instillation into the eye itself, are followed by dilatation of the pupil of the corresponding eye alone. These and other considerations of a like kind tend to show that symmetry of nerve action is usually the result of causes acting bilaterally.

The proposition that most nervous symptoms are not symmetric, and most symmetric symptoms are not nervous, is susceptible of easy proof, and lends little support to the inference often made that symmetric lesions are of nervous origin if not proved otherwise.

Another usual reason for considering a manifestation of any kind as of nervous origin is its association with so-called neurotic or hysteric symptoms, such as causeless laughing and crying, wandering anæsthesia, clavus, and the like. Leaving aside the inherent improbability that grave organic changes depend on vague and so-called nervous conditions, or that they have no better excuse for being than is implied by the insufficient and unnecessary word hysteria, we may at any rate leave this factor out of account in considering scleroderma, sufferers from which disease are singularly unemotional considering the hideous and destructive changes which they are undergoing.

Acromegaly is characterized by increase of size of the extremities, the hands, feet, and head; and this fact gives the name to the disease. The name, however, is a misnomer, for the enlargements are true hypertrophies affecting almost every organ in the body. The muscles are large, and in the early stages of the disease they are powerful. The bones are thickened and the subcutaneous tissues form great pads in the palms and soles. The lips protrude, there is an undershot lower jaw, the nose is big and bulbous. This is, however, only a superficial view, for the heart, the liver, the kidneys, and the spleen are also enlarged. The brain is increased in size, the skin is thick and coarse, and the voice is heavy from roughening of the vocal cords. When the disease begins in early life the general increase in size produces true gigantism. Marie's saying that "acromegaly is gigantism in the adult, gigantism is acromegaly in the adolescent," while only partly true, is accurate as regards many cases. One feature of the disease, the enlargement of the pituitary gland, early attracted Marie's attention. He considered this the cause of the disease. Further study brings to light the following difficulties in the way of this theory. First, not all cases show enlargement of the pituitary gland. In one case the gland was entirely absent. Second, the changes in the gland are not uniform but of the greatest possible variety. Third, many cases

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of disease of the gland are reported in which no symptoms of acromegaly were present. Fourth, pituitary extract administered to patients does not control the disease as does thyroid extract in myxœdema. Last, and possibly most important of all, experimental removal of the hypophysis does not produce the symptoms of the disease in animals.

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Disregarding for a moment the evidences in regard to the pituitary gland as the cause of the disease, let us consider the theory that acromegaly is primarily the result of disordered nerve action. The only alternative theory worth considering is that it is due to alterations in the blood supply, either quantitative or qualitative. In estimating comparatively the trophic influence on the tissues of nerve and blood supply, the balance is largely in favor of the blood in regard to the importance of its action. That nervous influences do affect nutrition is undoubted, especially in the case of the muscles and of the skin. It is to be observed, however, that even in these instances the muscles increase in size under stimulation, apparently as a result of the increased action of the muscle fibres and their increased vascularity, rather than as a result of any inherent trophic activity of the nerves supplying them. The muscle fibres disappear after the nerves are cut, not directly as a part of the degeneration of the nerve fibres, but as an indirect and remote result of their loss of function. Atrophies of the skin sometimes occur as the apparent result of nerve lesion, but usually there is only a limited amount of change, such as is seen in the glossy skin of neuritis and hemiplegia; ulcerative processes are in such cases probably the result of germ action from lowered resisting power rather than destructive processes the direct result of nerve lesion. But many of the tissues have a much less rich nerve supply than have the muscles and the skin. The widespread hypertrophies of acromegaly would, if of nervous origin, require for their explanation a trophic influence out of all proportion with the comparatively scanty facts at our disposal in regard to the trophic influence of the nervous system on the organs in general.

The blood supply we know, on the other hand, to be everywhere and always of vital importance in nutritional processes. To say that nutrition is always carried on by the blood supply is a platitude, but in this connection it needs statement. The nervous system, when it affects nutrition through the blood-vessels, does so by changing their calibre. In acromegaly congestions play no part in the clinical phenomena. We are driven to the conclusion that, so far as we know, the hypertrophies in acromegaly are due to qualitative changes in the blood; whether these changes consist in an increased or deficient secretion from the ductless glands, the pituitary or the thyroid or both, it remains for the future to determine.

Facial hemiatrophy is characterized by a wasting of all the tissues of one side of the face. The disease occurs at all ages. Various causes have been assigned, especially injury at the time of birth, blows, abscesses, infectious diseases, and cases have been reported in which it has followed division of the fifth nerve. The mechanism of its production is not apparent, as division of the nerve is usually not followed by it. On the other hand, although undoubted changes have been found in the fifth nerve in cases of apparently spontaneous development, the nerve has in these cases seemed to share in the general progress of the disease rather than to be primarily affected.

Severe neuralgic pains may usher in the disease, or it may begin quite painlessly as a small atrophic spot on the skin of the cheek, much like a sclerodermatous patch. The atrophy gradually involves more of the skin and the other tissues, especially the subcutaneous tissue and the bones. One-half of the tongue and the mucous membranes and other structures of the mouth of the affected side share in the process. The cranial bones are thinned and wasted, the forehead is furrowed, and the whole side of the face hollowed and much smaller than the other side. The hair and beard are thinner than normal

The changes in the skin may be accompanied by anæsthesia, especially in cases in which the nerve trunks are much affected. Sensibility to tactile and painful impressions and the temperature sense may be retained, however, even when the skin and the other tissues are markedly atrophic. The muscles often show less change than do any of the other tissues. They may retain voluntary power and electric excitability, or may share in the general atrophy. Tears, saliva, and perspiration may be secreted normally on the affected side. The pupil remains normal and there is no change in the fundus of the eye.

The changes are progressive, but may come to a standstill at any time. The disease is not dangerous to life and the changes do not extend beyond the face, which it disfigures in a way very distressing to the patient. All known methods of treatment are quite ineffective. Electricity, massage, and cod-liver oil have been tried without much apparent effect. The relation of the nervous system to the disease is not definitely known.

Hyperostosis cranii, otherwise known as *leontiasis ossea*, is an enlargement of the bones of the head. The rest of the body tissues are not affected. The fact that the bones alone are enlarged brings the disease into interesting relation with the so-called progressive pulmonary osteo-arthropathy. The latter disease consists in an enlargement of the bones of the extremities, so that patients present a superficial resemblance with those afflicted with acromegaly. These patients, however, show no involvement of the head and no thickening of the soft parts; they lack the pads in the palms and soles, the roughening of the voice, the bulbous nose and thick lips of acromegaly, and simply show enlargement of the bones of the arms and legs, and chronic joint affection with creaking, pains, and resulting disability. While there is not always lung disease, as was at first thought, there is always toxæmia from some cause, tuberculosis, syphilis, gastrectasis among others. The changes in both these diseases are inflammatory, the osteitis in the one disease affecting not only the long bones but the joints as well, in the other the change being curiously limited to the bones of the head. Such peculiarities of distribution do not, in the writer's opinion, show that the poisons work primarily on the nervous system. A similar selective action is exercised by rheumatic poisons on certain joints, on the pericardium, the endocardium, at times the skin and meninges in different patients, and in the same patient at different times. The selective action of poisons is sometimes on the nervous system, at other times through the nervous system; but in these diseases there is nothing to show that the action is not on the affected tissues direct. The organs most richly supplied with nerves are not the ones affected, the nervous system shows no special sign of involvement, and osteitis, even though chronic and proliferating, is not a usual accompaniment of any known nerve change.

Two diseases which may be grouped together are *adiposis dolorosa* and *symmetrical lipomatosis*. Both are characterized by enormous deposits of fat; the essential difference is that in one the fat deposits are the seat of severe pains, in the other the nutritional changes are painless. The symmetry of the lesions, and in adiposis dolorosa the occurrence of pains, have been supposed to indicate a neurotic basis for the overgrowth of tissue. These diseases are certainly essentially trophic. They are both, however, to be traced to either syphilis or overindulgence in alcohol; that is, in either case to poisons which are necessarily symmetrically distributed by the blood stream, apart from any intervention of the nervous system. In the case of adiposis dolorosa it is still somewhat doubtful whether the symptoms are the expression of a separate disease process or are simply an extreme accumulation of fat and a low grade of neuritis, both common results of chronic alcohol poisoning. Symmetrical lipomatosis is a curious symptom of toxic origin.

Localized hypertrophies of varied distribution have been described. Facial hemihypertrophy is the analogue and opposite of facial hemiatrophy. It is much more rare. It is sometimes acquired, but may be congenital.

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Hypertrophy of one-half the body has been described, and so also have hypertrophies of single limbs. One finger may be involved alone. These hypertrophies usually involve all the tissues. Nothing is known of their causation. The affected part may be unduly large at birth and may continue to grow or increase in size, or the enlargement may begin in later life. No cause has been traced for these strange variations from the normal, and in the absence of evidence to the contrary they must be regarded as the result of an innate tendency, possibly but not surely of an atavistic character.

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Returning now to the criteria to be applied in distinguishing toxic from functional nervous diseases, we may observe that functional diseases are properly vicious habits set up in the nervous system by irritants or poisons, and are to be distinguished from symptoms due to their direct and continuing action. The poisons of most of the infectious diseases, as well as alcohol and other volatile poisons taken into the body from without, are apparently capable of leaving their impress on the nervous system, causing symptoms which long outlive their exciting cause. The action of toxins on the affected tissues themselves, and their action by indirection through the nervous system, are not always easy to distinguish. The symmetry of the lesions, as already pointed out, usually means simply bilateral diffusion through the blood stream; in the one case to symmetrically disposed nerve structures, in the other to the affected tissues direct. In especial when inflammatory lesions are the result, the chances are much in favor of direct toxic action and against intervening nerve action.

The above considerations warrant the following conclusions in regard to the diseases under discussion, which permit, however, the elements of a provisional classification only.

Acroparæsthesia is a sensory neurosis. Angioneurotic œdema is a sensori-vaso-motor and Raynaud's disease a vaso-motor neurosis. Exophthalmic goitre and myxœdema, including cretinism, are diseases of the thyroid gland; the first is characterized mainly by vaso-motor symptoms, the second with special trophic features when occurring in adolescence. *Hyperostosis cranii* and progressive osteoarthropathy are inflammatory diseases, the first probably, the second undoubtedly on a toxic basis. Acromegaly and scleroderma are trophic diseases, probably of toxic origin; the same may be said of *adiposis dolorosa* and symmetrical lipomatosis, but the poison in these diseases is usually if not always alcohol or the toxins of syphilis. Facial hemiatrophy and the localized hypertrophies are trophic diseases of unknown origin, possibly neurotic. *Henry S. Upson.*

NEW-BORN, PATHOLOGY OF.—The pathological conditions which may be present in the new-born at the time of birth, or which may develop during the first days of extra-uterine life are very numerous and of the greatest variety. These conditions are of great importance, not only from a scientific standpoint, but also from the fact that they may hinder or render impossible the normal delivery of the child, or cause its death either before, during, or following birth; or finally they may affect its after-development, either by giving rise to pathological states persisting throughout life, or by the establishment of such changes that death, though deferred to a later period, ultimately results.

The conditions known as congenital, further those pathological states acquired from the parents, the causes of still-birth, the disease processes incidental to delivery, the pathological conditions and diseases peculiar to the first days of life, are all to be considered in this connection. For convenience these conditions may be divided into the following groups: *Intrinsic*, inheritable conditions, arising either in the individual sexual cells or through germ variation; *anomalies of development*, due to extrinsic causes affecting the mother, abnormal conditions of the fœtal membranes, etc.; *infections* transmitted from the parents, particularly from the mother, acquired either during intra-uterine life, or during delivery, or after birth; *intoxications*, either acquired through the maternal blood, or auto-intoxications developing in intra- or extra-uterine life; *diseases of individual tissues, organs, or systems*, peculiar to the new born, idiopathic, or produced by infection, intoxication, etc.; *new-growths*, developing in intra-uterine life or immediately after birth.

The Autopsy of the New-born.—The methods employed in the autopsy of the new-born differ in a number of details from the ordinary autopsy technique. These differences are dependent partly upon different anatomical conditions, and partly upon certain procedures which are of great importance in the determination of certain pathological or medico-legal questions. In other respects the autopsy methods are the same as those given under the head of "Autopsy" (Vol. I., page 649). The chief points of difference are as follows:

1. *Section of Spinal Cord.*—The spinal canal is opened by cutting through the laminæ with the curved bone shears.

2. *Section of Cranium.*—After the removal of the scalp the skull cap is opened in the median line, in the posterior angle of the great fontanel. By means of the curved bone scissors the longitudinal sinus is then opened both anteriorly and posteriorly by cutting through the bone in the line of the sagittal suture. The sutures between the frontal and parietal bones and between the parietal and occipital are then cut through from above, downward to the sides of the cranium, far enough to expose the brain sufficiently for its safe removal. The dura being adherent to the inner surface of the skull cap is cut through and turned back with the bones. The two halves of the frontal bone, the parietal and occipital, are pressed back from the brain at the level of greatest circumference. If the head is to be restored the bones are held back by an assistant while the brain is removed, otherwise the bones and dura are cut through at the level of greatest circumference and removed. The anterior falx is then cut and the brain removed, as in the adult.

3. *Section of Thorax, Neck, and Abdomen.*—A small block of wood is placed beneath the lumbar vertebræ. The main incision is then made in the median line, downward from the thyroid cartilage, dividing just above the umbilicus into two diverging cuts, extending on each side of the umbilicus to the pubis. The abdominal cavity is then opened just below the ensiform cartilage, and the opening extended in the line of the skin incision, passing to the left of the umbilicus. The right flap of the abdominal wall is then lifted and turned over to the right, while the umbilical vessels are dissected from their peritoneal covering and slit open toward the liver and toward the umbilicus. The skin incision passing to the right of the umbilicus is now extended downward through the abdominal wall, severing the umbilical vessels. The flap of abdominal wall between the two diverging incisions is now turned back over the symphysis and the two diverging umbilical arteries are exposed, the urachus and bladder lying between them. The arteries are now exposed by careful dissection, cut through at the umbilicus, and slit open.

The thorax is opened by cutting through the ribs instead of the cartilages in order to obtain more room. This may be done with the bone shears or a dull knife. The thymus gland is first examined and then removed. After the opening of the four heart chambers the ductus Botalli is carefully examined. This is done by extending the incision through the conus of the pulmonary artery and through the wall of the artery. The ductus Botalli is then found and probed. When the thoracic organs are removed with the neck organs, the aorta may be opened and the ductus Botalli opened by means of a probe passed from the aorta into the pulmonary artery. The heart is now removed and examined, the foramen ovale receiving careful inspection.

In many cases it is better to take out the neck and thoracic organs together. When the question is raised as to the child's having breathed after birth, the section should be conducted as follows: After the abdominal cavity is opened the height of the diaphragm is taken.

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The opening of the abdomen must precede that of the neck or thorax. Before the thorax is opened the upper air passages are tightly ligatured. The thoracic cavity is then opened, and pericardium and heart are examined. The larynx and trachea are opened longitudinally above the ligature. The thoracic organs are then removed. The thymus and heart are removed. The buoyancy of the lungs is then tested by placing the organs in a large vessel filled with cold water. The air passages below the ligature are then opened. Incisions are then made into the tissue of both lungs, noting the occurrence of crackling sounds, bubbles, and the amount and character of the blood. Cuts are also made into the lungs beneath the water, in order to see if any bubbles arise from the cut surface. Finally the lungs are cut into small pieces, and the buoyancy of the separate pieces is tested. The presence of air in the gastro-intestinal tract points in general to extra-uterine movements of "swallowing." From this it may be inferred that the child was born alive. The swallowed air collects in the stomach and gradually passes down the intestines. In cases in which the stomach appears to contain air or gas the organ should be ligatured at both ends and removed and opened under water.

The lower epiphysis of the femur is examined with regard to the size of the centre of ossification. The knee-joint is opened by a transverse incision beneath the patella, the leg flexed, and the patella removed. Cuts are then made at right angles into the thin layer of cartilage until the greatest diameter of the centre of ossification is cut through. In the case of premature birth the eye may be examined with regard to the presence or absence of the pupillary membrane. The anterior half of the eyeball is removed and fixed in Müller's fluid for microscopical examination.

Special Points to be Noted in the Examination of the Cadaver of the New-born.—The external examination of the cadaver of the new-born has for its chief aim the determination of those characteristics which give information as to its age and development. The most important of these points are as follows: The average length of a mature new-born child is 50–51 cm., maximum length 58 cm., minimum 48 cm. Boys are somewhat longer than girls. The average weight of a mature fœtus is for boys, 3,310 gm.; girls, 3,230 gm.; maximum weight, 5,500 gm., minimum, 2,500 gm. During the last five months of intra-uterine life the length of the fœtus in centimetres divided by five will give the age of the fœtus in months. The skin of a mature new-born is not wrinkled but smooth, of rather light color, the fine body hair being visible only on the shoulders. The umbilical cord has an average length of about 50 cm., and is inserted about the middle of the body, being thrown off about the fifth or sixth day. The hairs of the scalp measure 2–3 cm. in length. The great fontanel is about 2–2.5 cm. wide. The circumference of the cranium is 34.5 cm. The pupillary membrane vanishes in the eighth month. The cartilages of the nose and ears are firm in healthy mature infants. The finger nails are hard, horny, and extend beyond the finger tips. The shoulder breadth measures 11–12 cm., the distance between the trochanters is 9–10 cm. The testicles should be present in the firm and wrinkled scrotum (the descent of the testicles should begin during the seventh month). In girls the outer labia meet, but occasionally the inner labia are visible. The centre of ossification in the lower epiphysis of the femur usually measures 2–5 mm. in the full-term child, but in very rare cases it may be absent in fully developed children. It is not present before the thirty-seventh week of fœtal life. It appears in the blue-white epiphyseal cartilage as a lenticular mass of reddish or brown color in which minute blood-vessels are distinctly visible. The cranium should be carefully examined for evidence of injury received at birth, "caput succedaneum," hæmatoma, depressions, overlapping, etc. In the judgment of the color, consistence and moisture of the brain substance it should be remembered that the brain of the new-born is normally rosy red, somewhat translucent, and soft. In the examination of the umbilical vessels the thickness of the walls, the contents (blood, pus, thrombi, etc.), infiltrations of the surrounding connective tissue, as well as of the tissue of the umbilicus, should be noted. The lung should be carefully examined for areas of atelectasis or pneumonia. In the case of the heart the foramen ovale and the ductus Botalli (closes on the fourth or fifth day) should receive particular attention. The adrenals should be examined for evidences of hemorrhage; the degree of uric-acid infarction of the kidneys should be noted, and in male infants the spermatic, renal, and adrenal vessels should be examined for thrombi.

1. Intrinsic Pathological Conditions of the New-born.—The intrinsic pathological conditions of the new-born are those which arise in the germ independent of any external influence. They may be inherited, existing in either one or both of the sexual nuclei, or they may occur for the first time, in a given family, as a primary germ variation. The inheritance may be either *direct*, or *collateral*, or *atavistic*. The conditions which are inherited are the same as those arising as primary germ variations. From this the principle may be formulated that only those pathological conditions are inherited which originally occur as primary germ variations. In explanation of such variation we are at present limited to the hypothesis that either one or both of the sexual nuclei which combine to form the new individual are abnormal, or that from the union of two normal nuclei a pathological variety may arise, or finally that the pathological variety may be the result of disturbances in the process of copulation.

The most important of the intrinsic pathological conditions of the new-born are certain malformations, such as *polydactylism, cleft-hand, cleft-foot, webbed fingers, as well as other malformations of hands and feet, harelip, abnormal hairiness, elephantiasis, ichthyosis, albinism*, etc. The majority of the *typical monsters and malformations* may also appear as intrinsic conditions, and are not infrequently inherited. Of these may be mentioned the *malformations of the face and cranium, spina bifida, atresias of the body orifices, transposition of the viscera, malformations of the heart and blood-vessels, and of the sexual organs*, etc. (see also article on *Teratology*). Further, certain tumors, as *fibromata, multiple neurofibromata, angiomata, lymphangiomata, osteomata*, etc., often appear in certain families as inheritable conditions. All of these conditions may be present at birth, though they not infrequently appear in later life.

Abnormal size of the new-born may be explained as due to intrinsic causes. In some cases the weight of the full-term fœtus may reach as high as 12,000 gm., the length of the body exceeding that of the normal. An *abnormal size* of individual parts of the skeleton or of the soft structures may also be referred to intrinsic causes. Similarly, *abnormal smallness* of the new-born, of the body as a whole or of certain parts, may be of intrinsic origin.

Struma congenita is regarded by some writers as of intrinsic origin. *Congenital hæmophilia* may be manifested in the new-born by hemorrhage from the umbilicus, under the scalp, between the meninges, or from the body passages (melæna neonatorum). *Deaf-mutism* and *abnormal conditions of the retina* are also congenital conditions, manifesting themselves in the new-born. It must be borne in mind, however, that many of the above conditions may also be acquired as the result of extrinsic injurious influences exerted upon the fœtus during intra-uterine life.

2. Acquired Anomalies of Development.—In the production of monsters and malformations extrinsic injurious influences probably play the chief rôle. Among the most important of such influences may be mentioned trauma to the mother, jarrings of the uterus, pressure, uterine contractions, tumors of uterus or pelvic organs, dislodgment of the ovum, partial separation of the placenta, hemorrhage into the placenta, placental disease, diseased conditions of the uterus or of the mother, disturbance in the supply of oxygen and nutrition, intoxi-

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cations, infections, etc. Abnormal conditions of the amnion are also particularly likely to cause malformations of the fœtus. Abnormal tightness of the amnion, particularly of the cephalic or caudal end, adhesions between amnion and fœtus, etc., cause a great variety of malformations, such as *intra-uterine amputations, aplasias and hypoplasias, anencephalia, acrania, thoracic and abdominal clefts, spina bifida, phocomelia, curvatures of the spine*, etc. Deficiency of the amniotic fluid (oligohydramnios) may also produce various malformations, such as *spinal curvatures, club foot, club-hand*, and a great variety of *malformations of the extremities*. Of especial importance are adhesions between the amnion and the surface of the fœtus; they are found very frequently in association with oligohydramnion. They may occasion a great variety of malformations, particularly those characterized by a *failure of the body clefts to close*. Through the stretching of such adhesions about the fœtal extremities *amputations* of the latter may be produced. Forcible separation of the adhesions from the fœtal surface may cause *wounds of the fœtal skin*. Intra-uterine *fractures* and *dislocations* are also caused by amniotic adhesions. An excess of amniotic fluid (hydramnion) may also cause malformations and disturbances of development in the fœtus. In the case of twins one fœtus may develop at the expense of the other, the latter showing various malformations due chiefly to abnormal pressure. Such abnormalities are especially likely to occur, if in one amniotic sac there is an excess of fluid and in the other a deficiency.

Congenital Fractures.—Not all of the fractures found in the new-born are the results of difficult labor, but a part at least may be referred to trauma affecting the mother. The bones of the fœtal head are more frequently fractured than are the long bones. Abortion or premature delivery usually results from such trauma, but occasionally a fœtus so injured may be carried to full term and be born alive. At birth the fracture may be in the process of healing or entirely healed. Apparent intra-uterine fractures may be caused by deficient ossification or by disease of the fœtal bones (intra-uterine rachitis).

Congenital dislocations are not rare. The hip-joint is most frequently affected; more often in girls than in boys. The causes are partly intrinsic, due to an abnormal smallness and faulty position of the joint, as well as a primary relaxation of the ligaments. Extrinsic causes, pressure, poor nutrition, deficient amniotic fluid, etc., play an important part, however, in the production of the condition.

Pathological Conditions Produced during Labor: Caput Succedaneum.—During the birth of the child an œdematous swelling of the loose connective tissue beneath the scalp often forms, as the result of the passive congestion of the parts presenting. The condition is more marked in cases of protracted labor with unusually severe labor pains. The œdema is often accompanied by minute hemorrhages. It must not, however, be mistaken for the true hæmatoma of the scalp. Caput succedaneum has no pathological significance except in extreme cases; ordinarily it disappears within from twenty-four to forty-eight hours.

Cephalhæmatoma Neonatorum.—Occasionally there occurs during birth an extravasation of blood between the periosteum and the bone, leading to a detachment of the former. The extravasation is usually accompanied by caput succedaneum, and becomes more prominent as the œdematous swelling disappears. The condition occurs most frequently upon the parietal bones, less frequently upon the occipital, near the posterior fontanel. The tumor usually reaches its maximum on the third to fourth day. It may extend over the entire surface of the bone involved, but is limited by the sutures. Bilateral extravasations are rare. The tumor is fluctuating, the scalp covering it bluish, resembling a bruise. If the amount of extravasation is large, or if absorption is delayed, the detached periosteum forms bone around the edge of the hæmatoma. In this way there may arise around the extravasation a wall of newly formed bone, or the latter may become encapsulated by bony plates. In some cases the extravasate becomes purulent. The blood may be absorbed in from four to six weeks, the cavity obliterated, and the bony plates united, so that ultimately there may remain only a localized thickening of the cranium at the site of the extravasation. Rarely there may persist a crater-like depression with a thickened rim.

Hæmatoma of the sterno-cleido-mastoid muscle occurs rarely after prolonged labors, particularly after breech presentations involving traction upon the neck. The swelling of the muscle is probably more the result of a local myositis than of a hemorrhage. Suppuration results very rarely. The condition usually disappears in a few weeks without giving rise to permanent changes.

Fractures, dislocations, and *injuries* of internal organs may result from difficult or instrumental labor. Rupture of the liver or spleen may occur, or in rare cases of the intestines. External soft parts, as the ears, may be damaged by the forceps. Of the greatest importance are the damages caused to the central nervous system in delivery by the forceps or through turning. Schultze and Pfeiffer found multiple hemorrhages in the bulb, medulla, and cord in such cases. Degeneration of the ganglion cells also occurs. From the occurrence of such anatomical lesions it is easy to understand the frequent development of nervous lesions in children born in difficult or instrumental labor.

3. Infections.—According to the views of the majority of writers micro-organisms are not able to pass from the maternal blood through a normal intact syncytium into the fœtal circulation. It must be borne in mind, however, that owing to the natural processes of atrophy and new formation of chorionic villi, which occur constantly in the placenta from the earliest stages of its development onward, and which are especially marked during the later months of pregnancy, there are to be found in every normal placenta atrophic or necrosing villi the syncytial covering of which is either partly or wholly desquamated or is undergoing degenerative changes. Such senile villi form, therefore, points of least resistance to the passage of micro-organisms. The constant presence of such villi in the normal placenta favors the passage into the fœtal blood of micro-organisms which may be present in the maternal circulation; in other words, such a thing as a perfectly intact syncytium throughout the entire chorionic surface does not exist normally, and in every normal placenta there are conditions favoring the passage of micro-organisms. There is, however, good reason for believing that the fœtal tissues are more immune to many infections than are the maternal, and bacteria having passed the chorion may either fail entirely of producing pathological changes, or remain latent until a later period. The probabilities of the transmission of infection from the mother to the fœtus are in direct proportion to the severity of the maternal infection, death of the fœtus usually resulting when the disease of the mother is very severe.

Syphilis.—The most common and most important infection of the new-born is syphilis. This may be acquired from the mother through the ovum, from the father through the sperm, or through a later infection from either parent. The chief pathological changes shown at birth are: skin lesions (in about twenty-four per cent. of cases), either papular, macular, or hemorrhagic, bullous eruptions (pemphigus syphiliticus) affecting chiefly the palms and soles; less frequently macular, papular, or ulcerative lesions of the mucous membranes; fibroid hyperplasia of liver (cirrhosis) and spleen; "white pneumonia"; gummatous processes in the lungs, thyroid, thymus, liver, bones, adrenals, etc.; swelling of the mesenteric lymph glands; osteochondritis; obliterative changes in blood-vessels, particularly in the umbilical vessels. The changes found in the bones are very characteristic, particularly those so frequently present in the zone of ossification of the epiphyseal cartilages. The long bones should be split longitudinally, the change

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being found most often in the femur, humerus, and ribs. In normal cases there is seen in the bluish, opaque, resting cartilage a layer of proliferating cartilage recognized by its bluish-gray translucent appearance. This is bounded in turn by a narrow white zone of ossification, which separates the cartilage from the bone by a straight or convex line. In the so-called osteochondritis of congenital syphilis the area of ossification is increased, and the boundary line between it and the cartilage is irregular. The area of proliferating cartilage is also increased and may contain medullary spaces which appear as red stripes. Between the zone of ossification and the bone there is a layer of soft yellowish granulation tissue rich in cells. Three stages may be distinguished; in extreme cases the epiphyses may be completely separated by the softening of the yellow layer. Many authors assert that the so-called syphilitic osteochondritis is pathognomonic of congenital syphilis. According to Mewis it is found only in sixty-two per cent. of cases. By other writers the changes in liver and spleen are regarded as the most characteristic and constant signs of this condition.

Tuberculosis.—Though nearly seventy cases are reported in the literature as instances of congenital tuberculosis, in only six cases (Sabouraud, Lehmann, Henl, Ustenow, Auché and Chambrelente, and Lyle) is the diagnosis placed beyond any doubt by both the histological and bacteriological findings. The other cases must be regarded as doubtful or probable, the diagnosis either not confirmed by the demonstration of the presence of tubercle bacilli, or doubtful because of the age of the child, non-exclusion of syphilis, etc. There is, however, no doubt that in acute miliary tuberculosis, advanced pulmonary or genito-urinary tuberculosis of the mother, tubercle bacilli may pass through the placenta into the fetal circulation, either with or without the production of tuberculous changes in the chorion or decidua, and give rise to characteristic tuberculous lesions in the fœtus. There is also reason to believe that the fœtal tissues possess a greater resistance to the tubercle bacillus, so that tubercle bacilli may be present in the fœtal blood without giving rise to tuberculous lesions. At a later period the disease may become manifest, so that the possibility of a latent infection must be considered.

Variola.—It has long been known that in cases of variola occurring during pregnancy the fœtus may have the eruption during intra-uterine life, or present it at birth or develop it soon after birth. The transmission to the child does not, however, occur in all cases of variola; further, in the case of twins with separate placentas, one fœtus may exhibit the disease, the other escape it. These phenomena have been explained by the hypothesis that the disease does not pass an intact placenta; in the case of twins one placenta may admit the infection, the other not. The stages of the disease in mother and child do not usually coincide, the fœtus as a rule acquiring the infection in the stage of suppuration of the maternal eruption. The occurrence of variola during the earlier months of pregnancy usually causes death of the fœtus and abortion; in the later months the child often survives.

Scarlatina.—Since adults rarely suffer from this disease, there are but few recorded observations (eighteen in all) of its transmission to the fœtus. The child at birth may present the eruption. In other cases of scarlatina of the mother, the child may be born without showing the disease.

Measles.—The recorded observations of the transmission of measles to the fœtus in utero are very few. In maternal measles during pregnancy the fœtus may or may not be affected.

Typhoid Fever.—The child usually dies in cases of maternal typhoid during the early months of pregnancy, but may survive in cases which occur in the later months. The typhoid bacilli can traverse the normal as well as the abnormal placenta. Since the typhoid bacilli pass directly into the fœtal circulation, intra-uterine typhoid is of the nature of a general septicæmia, the classical intestinal lesions are not present. Infection of the fœtus does not, however, always occur in maternal typhoid. Blumer has reported an apparent undoubted case of congenital typhoid, which is of very great importance as indicating a latent infection. The child was born four and a half months after the recovery of the mother from typhoid. On the ninth day it died, after having presented symptoms of hemorrhages from gums and vagina, petechial eruption of skin, slight fever, and convulsions. The autopsy findings were cloudy swelling of organs, presence of phagocytic endothelial cells in the heart, lungs, liver, kidneys, adrenals, pancreas, and uterus. Typhoid bacilli were recovered from the lung, spleen, umbilical cord, bile, and large intestine. Alimentary infection was excluded, the child being breast fed, and the short period between birth and beginning of symptoms made extra-uterine infection very improbable. The case is unique as showing a long period of latency.

Typhus Fever.—Only one case occurs in the literature of a probable case of intra-uterine infection with typhus. The five- to six-months-old fœtus showed black, irregular petechiæ and small vesicles over the body. The spleen was enlarged, the mesenteric glands and Peyer's patches were swollen.

Recurrent Fever.—In a small number of cases the transmission of the disease from mother to fœtus has been observed. Albrecht found the spirillum present in the blood of two cases. He regarded it as most probable that the spores and not the spirillum passed the placenta.

Malaria.—This disease is also sometimes transmitted to the fœtus, which may be prematurely born living or dead, or come to full term. Moncorvo saw four undoubted cases of the transmission of the plasmodium. The new-born child may have fever and enlarged spleen. The autopsy findings are those characteristic of the disease, pigmentation, acute congestion of the spleen, etc.

Cholera.—A small number of observations occurs in the literature, of cases showing the transmission of the cholera bacillus to the fœtus. The occurrence of a hemorrhagic endometritis in this disease favors the passage of micro-organisms through the placenta. Death of the fœtus usually results from the changes in the placenta and decidua. The fœtus may show hyperæmia and hemorrhages of the internal organs, intestinal inflammation, etc.

Influenza.—According to Townsend an intra-uterine infection of this disease occurs.

Pneumonia.—In a few cases the transmission of the pneumococcus from the mother to the fœtus has been observed.

Meningitis.—In two cases the meningococcus has been shown to have passed from the mother to the fœtus.

Erysipelas.—In children born of mothers suffering from erysipelas there may be present a desquamation of the epidermis. The streptococcus is not infrequently transmitted to the fœtus, the infection being manifested in a condition of general sepsis rather than of erysipelas. The so-called erysipelas neonatorum is an affection usually acquired during the early days of extra-uterine life.

Sepsis.—The staphylococcus and the streptococcus are probably frequently transmitted from the mother to the fœtus, though the published observations of such intra-uterine transmission are not numerous. The cases reported as congenital empyema, pleuritis, peritonitis, endocarditis, pericarditis, meningitis, abscesses of internal organs, and certain skin conditions show the frequency of such transmission. The occurrence of puerperal sepsis in the mother, or of intercurrent pyogenic infections gives rise to such transmission; but in certain cases the infection of the fœtus appears to be cryptogenic, a perfectly healthy mother giving birth to a sick child which dies soon after birth, the autopsy findings being a streptococcus pleuritis, peritonitis, etc.

Bacillus Coli Communis.—This organism is also transmitted from the mother to the fœtus, producing in the latter a general sepsis, or a localized infection, such as peritonitis, pleuritis, internal abscess, etc.

Parotitis Epidemica.—According to Müller this disease

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may be transmitted to the fœtus. It is possible, however, that the case described by Müller was one of pyogenic infection.

Anthrax.—The fœtus may be infected in utero, or may escape the disease. In the former case the fœtus may be still-born, or be born alive and apparently well, dying from the disease a few days later.

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Leprosy.—A congenital infection is claimed for this disease, but it has not yet been proved.

4. INTOXICATIONS.—According to Ahlfeld those poisons are capable of being transmitted from the mother to the fœtus which occur in the maternal blood in the form of gases or in solution, providing that such changes have not been produced in the maternal blood as to render diffusion impossible. It is to be noted, however, that even in those cases in which transmission of poisons from mother to fœtus occurs, the effect upon the fœtus is often very different from that upon the mother. In the case of many poisons, particularly the vegetable alkaloids, the effect upon the fœtus is of a much less intense degree. In the case of animal experiments, strychnine and morphine have been found to affect only slightly the fœtus, the undeveloped fœtal nervous system appearing to possess a certain insusceptibility to poisons which have an intense action upon the highly developed nervous system of adults. In the case of certain mineral poisons the fœtus also appears to possess a relative immunity. Inasmuch as the germ cells cannot be regarded as existing in the reproductive organs of the parents wholly independent of the bodily conditions of these individuals, since they must assimilate food from the lymph and discharge their metabolic products, it must follow that diffusible poisons in the body of either parent must be absorbed by the germ cells and so cause pathological changes in their protoplasm. This is well shown in the case of children born of fathers showing lead poisoning or alcoholism. It may be taken as a general principle that intoxications affecting the general metabolism of either parent are very likely to cause deterioration of the germ cells.

Carbon monoxide and *illuminating gas* may cause death of both mother and fœtus. A number of observations have been reported in which the mother recovered, but death of the fœtus resulted.

Chloroform passes directly into the fœtal blood, a few whiffs given to the mother being evident in the blood from the umbilical vessels. The fœtus is, however, very insusceptible to chloroform, even in cases of deep and prolonged anæsthesia of the mother. If in such cases asphyxia of the fœtus occurs, it is probably to be referred to other conditions of the delivery than to the chloroform.

Alcohol.—The sexual cells may be affected by the intoxication of either parent. The new-born of chronic alcoholists very frequently show malformations, and later psychical disturbances. This is particularly the case in maternal alcoholism during pregnancy.

Chloral hydrate in medicinal doses has practically no effect upon the fœtus; in chronic poisoning of the mother the effects are similar to those of alcohol. *Morphine* in ordinary medicinal doses does not affect the fœtus, even when given to the mother for some time. Chronic morphinists may bear healthy children, but these are very likely to show psychical disturbances in later life. Occasionally the offspring may show signs of chronic morphinism. That the drug passes through the placenta is shown by the action upon the fœtal heart. *Digitaline* and *atropine* are said to produce marked and lasting effects upon the fœtus. As mentioned above, the effects produced by *strychnine* are slight. Fatal poisoning of the mother may cause the death of the fœtus or it may be born alive prematurely.

Ptomains and Toxins.—That many poisons produced in the maternal body by micro-organisms pass through the placenta into the fœtal blood and produce pathological effects cannot be denied. Numerous clinical observations support this view, though the actual demonstration of such passage has not yet been made. Likewise, the poisons of certain auto-intoxications of the mother, nephritis, etc., affect the development of the fœtus.

Mineral Poisons.—The passage of mercury into the fœtus has long been known, and advantage has been taken of this knowledge in the hope of curing fœtal syphilis. Chronic mercurial poisoning is well borne by the fœtus.

Lead.—In chronic lead poisoning of the mother death of the fœtus and abortion usually result, although in some cases the child may be born alive. In this case the child is under-developed and very often dies soon after birth. In chronic lead poisoning of the father the spermatozoa are undoubtedly affected, inasmuch as children from such fathers show characteristic changes which without doubt are to be ascribed to the lead poisoning. The bones of the cranium undergo changes in form which may interfere with delivery. A large proportion of the children of fathers affected with plumbism die before term; of the children born alive few pass the age of puberty.

Phosphorus may cause the death of the fœtus with the occurrence of fatty degeneration of the liver and multiple ecchymoses as in the phosphorus poisoning of adults. *Arsenic, copper,* and *silver* also pass the placenta. Copper and mercury are said to accumulate in the placenta; lead on the other hand does not.

5. DISEASES OF COMMON OCCURRENCE IN THE NEW-BORN, IDIOPATHIC OR ACQUIRED, AFFECTING CERTAIN TISSUES, ORGANS, OR SYSTEMS.—*Asphyxia Neonatorum.*—The fœtus at birth may exhibit a condition of apnœa and cyanosis. This may be due to a congenital malformation of the heart or blood-vessels, atelectasis, "white pneumonia," catarrhal or croupous pneumonia, hydrothorax, thoracic tumor, congenital struma, or disturbances of the circulatory and respiratory centres. In normal births the respiratory centres are stimulated by the increase of carbonic acid and decrease of oxygen in the blood, in addition to certain external stimuli. As a result of such stimulation respiration is inaugurated. If placental interchange is rendered difficult or impossible through the compression of the umbilical vessels or prolonged uterine contractions, there may occur intra-uterine respiratory movements of dyspnœic character. As a result the lungs become filled with amniotic fluid and asphyxia follows. Asphyxia may also be produced by the occurrence of rapidly succeeding uterine contractions. Dyspnœic movements are not produced, but from the rapidly increasing venosity of the blood there results a paralysis of the respiratory centre. The cessation of placental circulation through birth of the child is therefore not followed by respiratory activity.

Albuminuria Neonatorum.—According to Virchow, Dohrn, Hofmeier, and many other writers the urine of new-born children almost always contains a varying amount of albumin, hyaline casts, and epithelium. Such findings have been associated with the uric acid infarct. They cannot be regarded as pathological as they are found in wholly healthy children. The albumin usually disappears after from eight to ten days. The cause is not known but is referred to the increased metabolism after birth, imperfect formation of glomeruli, changes in blood pressure and in the character of the blood. The pressure in the renal arteries is increased after birth. This fact may explain the albuminuria and the desquamation of epithelium. *Pathological albuminuria* occurs in rare cases of congenital nephritis. The amount of albumin is always greater than that found physiologically.

Anasarca Neonatorum.—This condition may be found in cases of still-birth in association with hydatid mole. The œdema of the fœtus may depend upon a maternal dropsy, obstruction of the umbilical veins, malformations or disease of the fœtal heart, absence of the thoracic duct, fœtal nephritis, syphilis, œdema of the placenta due to syphilis, leukæmia, etc. Fœtal anasarca is often associated with hydramnion. In some cases the skin of the fœtus shows an elephantiasis-like thickening. In the majority of cases of fœtal anasarca the child is still-born; in those cases in which it survives birth the increased

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size of the fœtal body may render delivery more difficult. (See also Œdema neonatorum, in article on *Œdema*.)

Fatty Degeneration of the New-born.—Acute fatty degeneration of the liver, heart, etc., of the new-born is not infrequent. It is explained by decreased oxygenation and increased metabolism of albumin depending upon any of the causes given above, also infections and intoxications. Fatty infiltration of the liver is often associated with fatty degeneration of this organ. The condition occurs most frequently in cachectic and poorly nourished new-born suffering from circulatory or respiratory weakness.

Gangræna Neonatorum.—Symmetrical gangrene may occur in congenital syphilis. Further, symmetrical, diffusely spreading, or localized gangrene (noma) occurs in the new-born as the result of certain infections, diphtheria, measles, etc. A variety of organisms have been found in these cases.

Gonorrhœa Neonatorum.—The new-born is very frequently infected with the gonococcus during birth. An intra-uterine infection may also occur. Usually the conjunctiva, vulva, vagina, and urethra are involved, but there may occur also gonorrhœal peritonitis, pleuritis, pericarditis, endocarditis, meningitis, arthritis, etc. It is very probable that the majority of the cases of peritonitis occurring in the new-born female are of gonorrhœal origin. The presence of a coincident vulvitis or ophthalmia favors strongly the gonorrhœal origin of the peritonitis. (See also *Gonorrhœa*.)

Hemorrhage of the New-born. Umbilical Hemorrhage.—Hemorrhage from the cord may occur at birth, either from laceration, from disease of the vessels, or from imperfect ligation. Fatal hemorrhage may occur from injuries to the cord before or during birth. In other cases of more rare occurrence there may take place a constant oozing from the umbilicus itself or from the properly ligated stump. Such hemorrhage is most likely to occur between the fifth and fifteenth days. The children affected are usually cachectic or under-developed. Congenital hæmophilia, syphilis, abnormal composition of the blood, imperfect coagulability, failure of the normal retrogressive changes in the umbilical vessels so that these remain distended and patulous, vascular ectasis, etc., are causes adduced. In some cases no adequate cause can be discovered. Cachectic conditions of the mother are regarded as predisposing causes.

Hæmatemesis and Melæna Neonatorum.—Hemorrhage from the gastro-intestinal tract occurs occasionally in the new-born without other appreciable symptoms, and has therefore been regarded as an essential pathological condition. Hæmophilia, syphilis, congestion of the gastro-intestinal tract, ulcerations of stomach or intestines, infection, etc., are the chief causes adduced. According to von Preuschen melæna neonatorum is secondary to the occurrence of cerebral hemorrhage resulting from delivery. It is known that under other conditions certain diseases of the brain give rise to secondary hemorrhages in the stomach and intestine.

Hemorrhage of adrenals is of relatively frequent occurrence in the new-born. The cause is not clear, but traumatism during birth, thrombosis of the adrenal vessels, infection, and marasmus are supposed causes.

Hemorrhage into the kidney may result from thrombosis of renal vessels.

Hydrocephalus Neonatorum.—Congenital hydrocephalus is an accumulation of fluid within the ventricles of the brain. The cranial bones, not being united, yield to the internal pressure and are separated, the frontal, parietal, and occipital bones become expanded and thinned. The cerebral convolutions become flattened, the hemispheres finally being spread in thin laminæ on either side, the thickness of the brain substance decreasing from the base to the vertex. The membranes usually become thickened. The head becomes greatly enlarged, soft, and fluctuating. The cause is not clear; the condition by some being regarded as an inflammatory process of the arachnoid, by others as due to stasis, caused by obstruction of the veins of Galen or of the sinuses. (See *Hydrocephalus*.)

Icterus Neonatorum.—A slight degree of yellowish color is of such frequent occurrence in the skin of the new-born that it must be regarded as physiological. In strict usage the term icterus neonatorum should be applied to this condition alone. According to Frerichs the icterus is due to a fall of pressure in the liver capillaries, thus favoring the entrance of bile into the blood. By others the condition is explained as due to the excessive destruction of red blood cells and an increased production of bilirubin which is absorbed. The dilatation of the blood-vessels may cause obstruction of the bile capillaries. According to Birch-Hirschfeld the jaundice is due to compression of the biliary capillaries by the dilated vessels in Glisson's capsule. As a result of the venous congestion the connective tissue of the capsule becomes œdematous, this also aiding in the compression of the vessels. According to Ziegler the icterus is caused by resorption of the bile pigment not only in the liver, but also from the meconium which is absorbed and carried back to the liver. The physiological icterus neonatorum is characterized by a diffuse yellowish pigmentation of the tissues and a deposit of bilirubin in various organs and tissues, especially in the kidneys.

Pathological icterus of the new-born may be caused by sepsis (in the majority of cases), syphilis, malformations of the biliary passages, new formation of connective tissue about the bile ducts, patency of the ductus venosus, acute hepatitis, etc.

Myotonia Neonatorum.—In the early weeks of life the child may be affected by persistent, painless, muscular spasms without increased excitability of the muscles or nerves. In this respect it is distinguished from tetanus, for which it is often mistaken. It is to be regarded as an exaggeration of the physiological hypertonia of the new-born (pseudotetanus). The anatomical basis consists of degenerative changes in the anterior roots and cells of the anterior horns; the exciting causes are gastro-intestinal disturbances, congenital syphilis, etc.

Ophthalmia Neonatorum.—Catarrhal or purulent conjunctivitis is of frequent occurrence in the new-born. The great majority of cases are of gonorrhœal origin, but it must be borne in mind that other organisms (streptococcus, staphylococcus, etc.) may also cause the disease, as well as the use of too strong antiseptic solutions. (See *Conjunctiva, Affections of.*)

Pemphigus Neonatorum.—The condition of the skin characterized by the formation of blebs or bullæ in the epidermis occurs in a great variety of forms, and its pathology has been variously described. The etiology of the affection is not clear. Some of the cases described under this head are of syphilitic origin, others are due to an infection with the streptococcus. The form described as *pemphigus acutus contagiosus neonatorum* is probably a distinct disease of bacterial origin. In certain congenital cases there appeared on the second day a general pemphigus eruption over the palms, soles, and mucous membranes, the fluid of the bullæ being at first clear, later becoming slightly bloody. Bacteriological examinations have been negative; syphilis and all ordinary causes of pemphigus being excluded, the condition is regarded as due to an intra-uterine intoxication. (See *Pemphigus*.)

Pneumonia.—Catarrhal pneumonia occurs very frequently in the first few days of life. In the case of premature births over forty per cent. of the deaths are due to this condition. In eighty per cent. of cases born at term the infant is poorly developed, with congenital weakness of the respiratory tract. The so-called "white pneumonia" is due to congenital syphilis. Pneumococcus pneumonia may be acquired during intra-uterine life as well as in the first weeks of extra-uterine life.

Rachitis.—Congenital rickets is rare. Its etiology is not clear. The condition is associated with hydramnion and hydrocephalus. Premature birth usually takes place. Congenital rickets presents a pathological picture similar to that of extra-uterine rachitis. Two forms of fœtal rickets are described, *rachitis micromelica* and *rachitis annulans*. The true rachitic process is to be distinguished from the disease of the primordial cartilages, the so-called

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chondrodystrophia fœtalis, which is associated with cretinism. (See *Rachitis*.)

Sepsis Neonatorum.—Sepsis of the new-born is one of the most frequent and important conditions of this period of life. The streptococcus, staphylococcus, pneumococcus, bacillus coli communis, typhoid bacillus, gonococcus, etc., are the exciting causes. The organism may be transmitted from the mother during intra-uterine life, or acquired through injury received during delivery, through infection of such wounds after birth, or through the stump of the umbilical cord. The latter mode of infection is very common. Cryptogenic infection may occur. The skin of the new-born possesses much less resistance to the entrance of micro-organisms than the skin of adults; the primary seat of infection in infants often being a small localized purulent process in the skin, of relatively slight importance.

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Struma Congenita.—The condition of congenital enlargement of the thyroid is regarded partly as inherited from mother or father, partly as an idiopathic or endemic disease. The thyroid may present a simple hyperplasia or cyst formation. Delivery may be rendered difficult. The infant may die after birth from the result of compression of the trachea. The condition is of relatively frequent occurrence in the Tyrol.

Uric-acid Infarction.—In the kidneys of the new-born infant there is almost always present an accumulation of urates which appears as glistening, golden, or yellowish-red lines converging toward the papillæ of the pyramids. The urine in the pelvis of the kidneys also contains an abundance of urates. Microscopically the collecting tubules are found to be filled with dark granular masses which on the addition of acetic acid dissolve, uric acid crystallizing out. An albuminous framework is usually left behind. This condition is termed uric-acid infarction. It is most marked after the second or third day, but may be present up to the seventy-sixth day. It usually disappears promptly, but if persistent may lead to irritation of the kidney and nephritis. It was formerly believed that such infarctions occurred only in children breathing after birth, but it has been shown that they are found also in still-born children. The cause is not known. Changes in metabolism following birth, defective oxidation, inability of the urine of the new-born to dissolve the acid, are among the causes adduced in explanation of the phenomenon.

Tetanus Neonatorum.—Tetanus is one of the earliest and most fatal diseases of the new-born, occurring with greater frequency in the first and second weeks of life than at any other age. The infection occurs through wounds received during delivery or through the stump of the cord. The favoring conditions are: uncleanliness, atmospheric and climatic conditions, primary pyogenic infection, etc. In nearly every case evidences of inflammation and suppuration are found in the umbilical vessels.

Thrombosis.—Thrombosis of the adrenal, renal, or spermatic veins may occur in the new-born. Hemorrhage (so-called hemorrhagic infarction) of the adrenal or kidney may result, and in the male infant gangrene of the testicle and scrotum. Such thrombosis may be the result of traumatism during delivery or septic infection. In anæmic and cachectic infants there may occur marantic thrombosis, affecting most frequently the left renal artery. Hemorrhage and necrosis of the kidney result.

Sclerema Neonatorum.—See Œdema neonatorum, under *Œdema*.

6. New Growths.—The most common forms of new growths affecting the new-born are the congenital *fibromata*, *neurofibromata*, *angiomata*, and *lymphangiomata*. Birth-marks, vascular, pigmented and hairy nævi, moles, warts, etc., belong to this class. Special forms of lymphangiomatous tumors occur in the tongue, lips, and neck (*macroglossia*, *macrocheilia*, *hygroma colli congenitum*). *Elephantiasis-like* growths may occur locally or form diffuse thickenings in certain regions. *Lipomata* of the neck, back, and axillary spaces are not rare.

Congenital teratoma, representing either a monogerminal or bigerminal inclusion, are relatively frequent. They may be found in any part of the body, but are especially common on the head, in the mediastinum, kidneys, ovaries, and testicles. Congenital *rhabdomyomata* of the heart, kidney, etc., are to be placed in this class. The most frequent malignant tumor of the new-born is the so-called *embryonal adenosarcoma* of the kidneys (*mixed sarcoma*). Such growths are most probably derived from inclusions of the myotome and are to be classed with the teratomata (*malignant teratomata*). The most common epithelial tumors occurring in the new-born are *papillomatous* growths of the larynx, and cystic tumors of the kidneys, liver, and ovary. Adenomata of the adrenals and kidneys have been described. Carcinoma has also been found in the new-born in a number of cases (carcinoma of the liver, kidneys, stomach, and intestine). Cases have been reported by Jacobi, Wedl, Brown, Friedrich, Ritter, and others. Cystic tumors of the pineal gland, cholesteatomata, dermoid cysts, and teratomata of the brain and meninges have been described.

Aldred Scott Warthin.

NEW MEXICO.—New Mexico has climatically the same features as Colorado, and in a less degree those of Arizona. The State runs from the Raton range, which divides it from Colorado, for 390 miles south, to the boundary line of old Mexico. On the west is the main range of the Rocky Mountains or backbone of the continent, separating it from the State of Arizona. Its eastern boundary ranges with the great State of Texas. New Mexico is for the most part a high plateau rising to 7,000 feet at Santa Fé and dropping to 3,500 feet in the lower Pecos valley. The general tendency of this high plateau is to drop from the northwest corner toward the southeast. As it is on the leeward side of the main range, the winds from the Pacific Ocean are dried for the most part before reaching it, so that there is very little winter rain and only a light snowfall. What rain there is falls, as it does in Colorado, principally during the months of July and August, and New Mexico does not have the well-marked double rainy season of Arizona. The winter precipitation falls usually between January 1st and April 1st, though in the Pecos valley region this period is somewhat extended and the rainfall is heavier than the average for the State. The winter rains or snow-storms are marked by almost parallel curves of from one to seven inches of precipitation. These curves are outside the mountain lines, where, of course, the precipitation is greater. They are caused by the diffuse or diverting influence of topography on the aqueous currents borne to New Mexico from the south Pacific Ocean across Arizona. "The summer rains," writes Captain Glassford, "are otherwise influenced, and the higher precipitations appear upon the levels west of the Canadian River and upon the Cañon course of the Pecos, which includes Las Vegas and Fort Union. At this point the fall reaches seventeen inches. The lowest summer precipitation is found in sections most favorably influenced by the winter rains. The minimum is found in the southwest."

It is very much to be regretted that, in spite of the climate being the chief attraction of New Mexico to the travelling invalid, it is almost impossible to get full and accurate meteorological data concerning the various resorts, and the observations that are reported are usually for only a very short period, and the humidity and wind have very seldom been recorded. Many have written in general terms of the fine climate, but have failed to give the facts about the local topography, aspect, and soil of the towns. Unfortunately for health purposes, on the lower elevations the towns are usually situated upon an adobe soil in the river bottoms. However, the literature being such as it is, we will proceed to discuss the more important places available for health seekers.

In travelling by railway from Colorado into New Mexico, as the descent is made on the southern slope of the Raton range, one notices that the air is warmer and the sunshine more brilliant. However, the elevated towns in the northern portion of New Mexico are very

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similar in climate to those of Colorado, although they are somewhat higher in elevation. Las Vegas (6,500 feet) and Santa Fé (7,000 feet) closely resemble Denver in temperature, while Silver City in the southwest, standing at an elevation of 5,800 feet, has a markedly milder climate, which is partly accounted for by its admirable shelter from severe winds.

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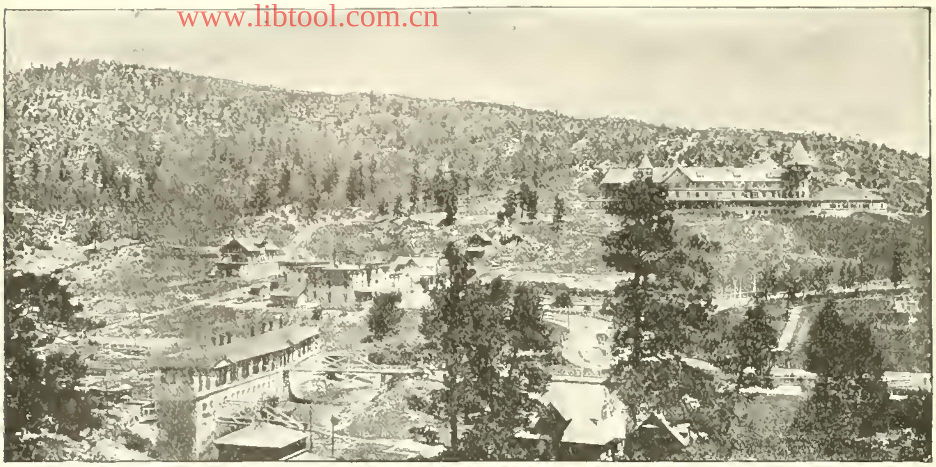

FIG. 3589.—View of the Montezuma and Bath-houses, Las Vegas Hot Springs, New Mexico.

The annual average precipitation for the State is 13 inches, ranging from 5 inches at Deming to 33 inches at Chama, while the average of 13 inches does not include what falls upon the mountain summits, which is probably double this amount.

The annual mean relative humidity approaches 40 per cent. with an annual temperature of 60 per cent.; the absolute humidity is 2.3 grains, a little more than that of Colorado, which the higher temperature accounts for.

In the elevated northern portions of the State the annual wind movement is about the same as that of Colorado, but it is markedly less in the southern and lower portions.

Vegetation is sparse throughout the State, as irrigation has been very little carried out. The soil generally is of the peculiar clay which is known as adobe. This does not readily absorb the moisture, but when baked in the hot sun gives rise to a very fine dust. The treeless character of the most part of the plateaux and valleys combined with the adobe dust, which is light and volatile in character, makes the dust storms in this country peculiarly disagreeable.

Charles F. Lummis, in his delightful book upon New Mexico, which he calls "The Land of Poco Tiempo," summarizes the country in this sentence, "Sun, silence, and adobe." He laments, as all visitors to New Mexico must, the absence of large and well-equipped cities, and the general scarcity of the resources of civilization. All this, however, is rapidly improving each year. Good soft water, gravel soil, and good and well-cooked food are scarce, but the climate is superb. Above the thirty-fifth parallel of latitude the climate resembles that of Colorado, but is somewhat milder in the winter and warmer in the summer. Below this latitude the winters are markedly milder. Those for whom the more bracing climates of the northern latitudes are not desirable, and who also need a somewhat lower elevation, can find in New Mexico almost unrivalled climates for their purpose. The summer heat, however, begins to be felt early in April, and seems to gather force well into October, but for those who can stand a rough camping life the summer climate of the mountains is delightful.

On the southern slopes of the Raton range is a fine farming country with a good all-the-year-round climate. The air is dry, but the soil is adobe, and there is considerable irrigation carried on. There are no towns of any importance, but for those convalescent invalids who can carry on farming and cattle raising it is a good country. Throughout this district the rainfall and humidity are higher, and the temperature lower than they are in the country lying farther south.

Raton is a small town on the main line of the Santa Fé just over the Colorado border. It stands at an altitude of 6,600 feet and has 4,000 inhabitants. It faces south and east with the Raton range behind it. It has an attractive country around it, and there are several small hotels and boarding-houses where the rates are from $25 to $30 per month for board and room.

A few miles farther south and lower down lie Maxwell City and Springer, both of them small villages where cheap accommodations can be found in the town or among the farmers of the neighborhood.

Las Vegas, elevation 6,384 feet, population 8,000, of which perhaps half are Mexicans and Indians. It is somewhat exposed to north winds, and lying in the valley with an adobe soil, is hot and dusty in summer. It is generally warm and pleasant during the winter. The average mean temperature in winter is 40°; spring 55°, summer 80°, autumn 60° F. The rainfall averages twenty inches, of which a large half falls during April and August. The Atchison, Topeka and Santa Fé Railroad has recently built a very handsome and comfortable hotel and eating-house, where the famous Harvey catering can be enjoyed, but accommodations at a more moderate price can be obtained in the town, and there is a good sanitarium in charge of the Sisters of Charity.

Las Vegas Hot Springs, elevation 7,000 feet, is reached by a stub railway running seven miles from the town of Las Vegas up into the western hills. Here is an excellent hotel, The Montezuma, with a few other smaller buildings and some good bath-houses. The Montezuma is situated on the edge of the cañon facing south, and is well sheltered from the winds. Las Vegas Hot Springs has a delightful winter climate, for the most part warm and dry. It is reasonably cool in summer. The springs are both hot and cold. The hot water has a temperature of 144° F. The mineralization of the springs is alkaline and small in amount. They are not very potent waters, but the bathing is good, and there are some excellent mud baths which have been found valuable for rheumatism and allied disorders.

Santa Fé is reached in a similar manner from the main line of the Atchison, Topeka and Santa Fé Railroad. It is one of the oldest and most interesting of the towns of New Mexico. It retains the character of a Mexican town, which is an outgrowth of the old Indian pueblo. It has many quaint features and buildings to interest visitors. The chief hotel is a fairly good wooden structure, but is usually indifferently kept; but there is a sanatorium well managed by the Sisters of Charity. "The town lies on a treeless plateau at the base of one of the spurs of the Rocky Mountains. The general trend

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New Mexico.

of the site is west-southwest, the mountains affording protection to the north and east. Within thirty miles are peaks of 12,000 and 13,000 feet elevation. The low hills are covered with a growth of piñon trees. The town has of late improved its water supply, but much is yet to be desired in the matter of drainage, and there are few shade trees. The soil is light and sandy. The climate is not very different from that of Denver. It is somewhat cooler in summer, not quite so cold in winter, and a little less windy throughout the year." *

The climate is very similar to that of Las Vegas Hot Springs, but being less sheltered, is somewhat more bracing, though also more windy.

Continuing the journey southward on the Atchison, Topeka and Santa Fé Railroad, the traveller crosses the lower end of the upper Pecos valley between San Maguel and Glorieta. This is a beautiful upland valley twenty-five miles north of the Glorieta Mountains through which are scattered stock ranches and small farms. It is a well-timbered, park-like district surrounded by mountains. It has a fine climate and good soft water. There are capital hunting and fishing, and much of the country still remains wild, there being a timber reservation covering 702 square miles.

Albuquerque, elevation 5,000 feet, population 10,000, is situated in the valley of the Rio Grande, and it is here that the main line of the Santa Fé Railroad joins its western division along which flows the travel to California. The Atchison, Topeka and Santa Fé Railroad Company have built a handsome and commodious hotel and eating-house similar to that at Las Vegas, where the best food is served. The old town, which lies near the river bed, is not very desirable for residence, but the newer part of the town on the bench above it is well situated. It is a live, modern city with fairly good accommodations. It has a good climate, though it is somewhat too windy in winter and too hot in summer.

Deming, elevation 4,300 feet, population 2,500, stands on a plain, just about fifty miles square, surrounded by mountains. It has a mild climate, it never freezes during the day in winter, the mean seasonal temperature being: winter 44°, spring 63°, summer 87°, autumn 64° F. The wind record has not been kept, but during the spring the winds are said to be quite high. The precipitation is 8.8 inches, the greater part of the rain falling in the summer. Accommodations are good.

Silver City is situated on an elevated plateau in the Chichuachua valley south of the Pinos Altos Hills. The soil is sandy, the rock formation consisting chiefly of slate and limestone. It is at the end of a branch line of the Santa Fé Railroad, forty-eight miles from Deming and about ten and one-half hours by railway from El Paso. Foot-hills several hundred feet in height surround it except toward the south, while a few miles farther back are mountains several thousand feet in height. In this way it enjoys excellent shelter from winds. No wind record is obtainable, but evidence tends to show that the wind movement is moderate. The mean temperature for January is 37°, for July 72°, and for the year 54° F. In ten years there have been only six days in which the temperature fell below 10°, and only twenty-two days when it rose above 90° F. The average annual precipitation is 11.58 inches, of which as much as 8.11 inches must usually be credited to the months of July, August, and Sepember. The average number of cloudy days is 37. The average relative humidity is 46 per cent. The absolute humidity is 1.71 grains; dew point 29. The water is pure, but rather hard.

Silver City lies in the same latitude as Savannah, Ga., but owing to its elevation is, of course, much cooler and dryer. There are four hotels of moderate excellence, and there is a good sanatorium kept by the Sisters of Mercy. The country around, particularly among the pines, lends itself to a delightful camping life.

Nine miles to the north, at an altitude of 6,040 feet, is Fort Bayard. The old army fort has been converted into a general government hospital for the treatment of pulmonary tuberculosis. It is now in the third year of its existence. Major D. M. Appel, M.D., surgeon in command, writes under date of June, 1901, as follows:

"The selection of Fort Bayard as a site for a sanatorium for the treatment of pulmonary tuberculosis has been amply justified by our results. Its location in the arid mountainous region of southern New Mexico, at an altitude of 6,040 feet, affords a climate permitting comfortable outdoor life during the entire year. The mean maximum and minimum temperatures and the precipitation for the past decade are as follows":

Month.	Mean maximum. Degrees Fahr.	Mean minimum. Degrees Fahr.	Precipitation. Inches.
January	52.77° +	23.15°	1891, 19.30
February	54.13	25.83 +	1892, 8.89
March	60.52 +	30.92 +	1893, 15.47
April	68.43	37.10	1894, 9.12
May	77.33	45.45 +	1895, 15.09
June	86.45	52.68	1896, 18.85
July	82.91 +	55.34	1897, 18.00
August	85.32 +	56.98	1898, 15.91
September	81.97	52.09	1899, 10.43
October	71.34 +	41.20	1900, 12.66
November	61.29 +	31.90	
December	53.20 +	24.66	
General average	69.56°	39.79°	

FIG. 3590.—Meadows near Las Cruces, New Mexico.

The statistics of the results obtained up to the present time confirm the general favorable opinion of the exceptional value of sanatorium treatment at high altitudes.

* Solly's "Handbook of Climatology."

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Las Cruces, elevation 3,872 feet, population 3,500. This little town is situated on the Old Mexican division of the Santa Fé Railroad, forty-three miles north of El Paso. It lies in the Mesilla valley, which is a portion of the Rio Grande valley. At this point the valley is wide and fruitful under irrigation, there being large fields of alfalfa. The water is pure but somewhat alkaline. There are moderately good accommodations in the town, but more suitable ones for the invalids are found in the ranches around, particularly at the Alameda, which is a mile distant.

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The Organ Mountains are twelve miles east, rising to a height of 8,949 feet. The winter climate is delightful and continues pleasant until April, when the heat becomes too great for the comfort of Eastern visitors. The mean maximum temperature is, as computed for the three years, 1896 to 1899, autumn, 78°; winter, 58°; spring 76°; summer, 92° F. The mean minimum temperature is: autumn, 41°; winter, 23°; spring, 41°; summer, 60° F. The average annual rainfall for the last twenty years was only eight inches. The number of cloudy days for the year is twenty-five. In the winter the average is four cloudy days a month. The average wind movement is believed to be about five and one-half miles an hour.

The Alameda can accommodate forty guests. The rooms are of good size, and there are plenty of porches. The rates are from $10 to $15 per week. Fifteen miles east of Las Cruces Van Patten's resort stands in a valley of the Organ Mountains at an altitude of 6,000 feet. Here there is a substantial stone house which can accommodate twenty-five persons, and it is surrounded by tents, and is a cool and pleasant place in which to pass the summer.

Pecos Valley.—Separated from the Rio Grande valley by high mountains is the Pecos valley region lying to the east; it comprises a wide belt of land running southward for a distance of one hundred and seventy miles from Roswell to Pecos City. Here irrigation is extensively carried on, and it is a good place for those who have sufficiently recovered their health to carry on farming or stock raising. The accommodations in the hotels and boarding-houses are, however, not very good, and the valley is rather too hot in summer and too windy, particularly in the spring, to make it desirable for most invalids. Roswell, at the northern end of the valley, is rather better sheltered than the town of Carlsbad. The elevation of the valley varies from 4,000 to 3,000 feet. At Carlsbad the mean temperature for autumn is 63°, winter 44°, spring 63°, summer 79° F.

S. Edwin Solly.

NEW ORLEANS, LOUISIANA.—This great Southern city and port is situated upon a double curve of the Mississippi River, one hundred and seven miles from its mouth, although a much less distance from the coast in a straight line. The city lies chiefly upon the left bank of the river, and actually covers about forty square miles, although the city limits embrace an area of something like one hundred and eighty square miles. One of the peculiarities of this city, and one that is doubtless conducive to its healthfulness, is the great area which it covers, thus permitting liberal air spaces and grounds about the buildings in the residential districts. The city is built upon low land, lower than the surface of the river at high-water mark, and huge embankments of earth called "levees" are required to prevent an overflow, and even these are occasionally broken through. The soil is of an alluvial nature, and by digging from three to four feet one usually reaches water; hence the houses have no cellars, and the dead have to be buried in tombs elevated above the ground.

There are a large number of bodies of water—lakes, bayous, swamps, and the like—about the city, and to the north of the city is Lake Pontchartrain, forty miles long and twenty-four miles wide. This lake is connected with the Gulf of Mexico, and forms with the Mississippi River an isthmus upon which the city is built. The population at the census of 1900 was 287,104, composed of Creoles, Americans, and negroes. It is obvious, from the low, level situation of the city, that the problem of drainage is a difficult one; this is partially accomplished by gutters which run into open canals, and these in turn empty with a sluggish current into Lake Pontchartrain. A comprehensive system of sewerage, which will effectually dispose of the house waste and other sewerage and cause it to be discharged into the river below the city, is said to be now under construction. The drinking-water is generally obtained from the rain, stored in tanks or cisterns, each house being provided with such a receptacle, which is a peculiar feature of the architecture. For other purposes the water of the Mississippi River is used, this being taken directly from the river without filtration.

The city itself and its surroundings are very attractive, especially to a Northerner. The vegetation is of a semitropical nature and very luxuriant. The variety of races and the common use of the French language, the streets, markets, cemeteries, parks, and various points of historic interest, and the extensive wharves with the vast amount of inland and foreign shipping, all afford interest and diversion. The French market is the great "sight" of New Orleans, and is best visited in the early morning.

The accommodations are good, the principal hotel being the comparatively new St. Charles, occupying an entire square in the heart of the city. A favorite winter excursion is to New Orleans at the time of the famous "Mardi Gras," which is said to be more brilliant than the carnival at Nice or Rome.

The mortality of the city is about 27.58 per 1,000. The following meteorological table gives the principal characteristics of the climate of New Orleans:

CLIMATE OF NEW ORLEANS, LA. LATITUDE, 29° 58'; LONGITUDE, 90° 4'. PERIOD OF OBSERVATION, THIRTEEN YEARS.

	Jan.	Mar.	June.	Aug.	Nov.	Year.
Temperature—						
Average mean temperature or normal (degrees Fahr.)	54.7°	63.1°	81.0°	81.7°	61.0°	69.8°
Average range	13.9	15.0	12.4	12.1	13.1	
Mean of warmest	61.2	71.7	87.2	88.1	67.8	
Mean of coldest	47.3	56.7	74.8	76	54.7	
Highest or maximum	78	84	97	96.5	82	
Lowest or minimum	20	36.5	65	69	31.5	
Humidity—						
Average mean relative	72.2%	70%	72.3%	73%	71.6%	71.4%
Precipitation						
Average in inches	5.52	5.75	6.04	5.99	5.58	64.63
Wind						
Prevailing direction	N.	S. E.	S. E.	S. E.	N.	S. E.
Average hourly velocity in miles	7.8	8.6	6	5.5	8	7.4
Weather—						
Average number of clear days	7.6	10.1	8	7.8	9.5	110.5
Average number of fair days	12.2	10.6	16	18.4	10.2	156.4
Average number of fair and clear days	19.8	20.7	24	26.2	19.7	266.9

It will be seen that the climate is tropical or semitropical in nature, warm and moderately moist. The mean temperature of the year is 69.8° F. The highest average summer temperature is 91° F., and the lowest average winter temperature is 27° F. On February 13th, 1899, an extraordinary and unheard-of event occurred, in the formation of ice at the mouth of the Mississippi River, the thermometer indicating a temperature of 10° F. On the 17th of the same month ice flowed past New Orleans into the Gulf of Mexico.*

Snow is a rare phenomenon, but cold waves occasionally occur, accompanied by frost, which nips the sugar cane and cotton plant.

The annual rainfall varies from 31 to 64 inches, the spring and summer being the rainiest seasons. The average mean relative humidity is 71.4 per cent., about the same as that of New York City.

* "The Cold Wave of February, 1899," Guy Hinsdale, Transactions of the American Climatological Association, 1899.

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According to Hinsdale ("Climatology, Health Resorts," vol. iv., part ii., of "Physiological Therapeutics") there is about sixty-two per cent. of possible sunshine. Such a climate is more or less enervating, but in itself not unhealthy. A strict quarantine is exercised against the importation of yellow fever, of which several epidemics have in former years occurred. The amount of water about the city would appear to be favorable for the propagation of the mosquito, and hence malaria must be frequent.

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There are several resorts on the gulf coast at not a great distance from New Orleans, which are frequented both in summer and in winter. Indeed, the entire route from New Orleans to Mobile along the Gulf is very attractive. Pass Christian on this line has a mild winter climate, favorable for persons suffering from bronchial disease, from malaria, or from Bright's disease, for convalescents from some acute disease, and for those of feeble vitality. It possesses a good hotel, cottages, and boarding-houses. The sanitary conditions are good; there is pure artesian well water; the soil is dry and porous; and extensive pine forests lie immediately in the rear of the town. The average mean winter temperature is given by Solly as 70° F. There are opportunities for driving, boating, fishing, and hunting.

Covington, thirty miles to the north of New Orleans, reached by a picturesque journey across Lake Pontchartrain and up the Tchefuncta River, situated in the midst of pine woods, is said to have a very salubrious winter climate, with a "soft air," and is sheltered from all "Northers." It is considered by some local physicians to be favorable for pulmonary diseases.

Bay St. Louis is another resort frequented by the New Orleans Creoles, and said to be rapidly growing in favor with winter visitors. Biloxi, Beauvoir, Ocean Springs, and Long Beach are other resorts on the Gulf coast.

For those seeking rest and diversion the trip down the Mississippi River can be recommended, and from personal experience the writer can testify to its charm and variety. The portion from Baton Rouge to New Orleans along the sugar plantations is of especial delight and interest to the Northern traveller. Below New Orleans, through the "delta country" to the jetties and the Gulf, the voyage is also one of great interest.

New Orleans can be reached from the north by various lines of railroads, and steamers with good accommodations run directly there from New York, occupying about five days on the voyage.

New Orleans is a convenient port of departure for Central America and the West Indies.

Edward O. Otis.

NEWPORT NEWS. See *Old Point Comfort.*

NEWPORT, R. I.—Newport, until very recently one of the capitals of Rhode Island, and in some respects probably the most celebrated of American health resorts, occupies the isthmus and much of the remainder of a peninsula which forms the southwestern termination of the island of Aquidneck or Rhode Island. This island, lying in the middle of the lower portion of Narragansett Bay, is entirely exposed at its southern end to the full sweep of the Atlantic billows, so that Newport, although partly sheltered by the land, partakes in a measure of the climate of the neighboring oceanic islands of Block Island, Martha's Vineyard, and Nantucket. Newport is the seat of the Naval War College, of the United States Torpedo Station, and of the large military post of Fort Adams, at the entrance to the harbor. It has a resident population of 23,000, increased in summer by nine or ten thousand, contains public buildings, many churches, banks, schools, shops of all kinds, an opera house, excellent libraries, the Newport Casino, and an admirably equipped institution, the Newport Hospital; it is also the home of numerous societies, clubs, and associations. It is lighted by gas and electricity and has an electric street railway, running north and south with a branch line to the beach.

The old town, settled in 1639, and built chiefly on the western slopes of a broad and elevated ridge rising directly from the harbor, still retains much of the aspect of colonial days, and in its narrow streets and ancient buildings, of which, in spite of the increasing encroachments of modern civilization, many replete with historic associations are still standing, presents the features of an old New England seaport town and contrasts vividly with the newer suburbs by which it is surrounded. The summer homes are constantly extending until they have already taken up a considerable part of the peninsula. Bellevue Avenue, a modern extension of one of the main city thoroughfares, Touro Street, has been continued due south as far as the ocean, and forms a wide and splendid highway two and a half miles in length, on each side of which are placed the stately houses and beautifully kept grounds of the wealthier summer residents.

The natural features of Newport and vicinity are very attractive. Bishop Berkeley justly described the island to his friends as "pleasantly laid out in hills and vales and rising grounds, and hath plenty of excellent springs, and fine rivulets and many delightful landscapes of rocks, and promontories and adjacent lands." On the one side, the waters of the land-locked harbor and Narragansett Bay studded with islands offer numerous inducements to the lovers of sailing, boating, and fishing. On the other, the ocean is quickly reached at the First or Easton's Beach, at a point where the coast line of the island turns sharply to the east. This beach, seven-eighths of a mile in length, lies in a sheltered bay and in the season is crowded with bathers. Hot salt baths are provided there in summer. Further to the east, beyond Easton's Point, lies the longer, Second or Sachuset Beach, and still farther, facing the east passage of Narragansett Bay, is the Third Beach. Besides these, the principal beaches, the shore near Newport presents a very varied and irregular outline. One of the most striking parts is "The Cliffs" which may be said to extend from the west end of the bathing beach to the end of Bellevue Avenue, for nearly three miles. The public walk along these cliffs through the grounds of some of the finest places constitutes one of Newport's greatest attractions. Of the various drives, the "Ocean drive" from the southern end of Bellevue Avenue, westward along the shore, is justly celebrated. The interior of the island, traversed by two main thoroughfares, the East and West roads, and numerous cross roads, presents a pleasing diversity of hill and dale with charming views of the bay and ocean, and there are many peaceful woodland lanes bordered with dense shrubbery, which remain quite secluded even in summer.

The geological formation underlying Newport and its vicinity is somewhat complex, and consists mainly of various rocks of the carboniferous period. Newport Neck, as the extreme southwestern corner of the island is called, consists of pre-carboniferous rocks, supposed to be partly of igneous origin. In the middle portion of the Neck a conspicuous reddish granite (protogine) is to be observed. On this part of the island the rocks are largely exposed, and are grouped in picturesque masses. The Paradise Rocks back of the second beach offer interesting features to geologists by whom they have been frequently studied. Many of the rocks about Newport have undergone metamorphic processes, and have also been greatly disturbed, and in many cases bent and folded, besides having been eroded by glacial action. There are several large ponds in the vicinity of the city.

The soil under the city proper is a tenacious clay, beneath which frequently occurs a stratum of water-bearing gravel. Most of the wells in the compact quarter of the city receive their supply from this gravel and are for the most part dangerous from liability to contamination from deep cesspools dug through the clay.

The climate of Newport is less trying and more equable than that of most other places on the New England coast. Although snow and ice are far from infrequent, yet the winters are milder and the daily thermometric range is less than in New York, Providence, and Boston. Owing to the influence of the ocean, the spring is rather more

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Climate of Newport, R. I. Latitude, 41° 29'; Longitude, 71° 19'. Condensed from a Climatic Chart of Seven Years and Eight Months from Observations of the United States Signal Service, in the Previous Edition of this Handbook

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Data.	Jan.	Feb.	Mar.	April.	May.	June.	July.	August	Sept.	Oct.	Nov.	Dec.	Average for year.
Temperature—													
Average or normal	30.3°	31.7°	36.2°	44.5°	54.4°	64.4°	70.4°	72.0°	66.7°	58.0°	46.1°	40.6°	49.6
Average daily range	15.4	15.0	14.1	9.4	14.0	14.5	8.7	12.6	12.2	13.6	12.8	14.1	13.0
Mean of warmest	37.7	39.0	43.7	50.2	62.3	71.3	74.7	76.3	70.9	62.6	49.3	42.2	
Mean of coldest	22.3	24.0	29.6	40.8	48.3	56.8	66.0	63.7	58.7	49.0	36.5	28.1	
Highest or maximum	61.5	56.0	63.0	69.5	85.2	89.0	92.0	87.0	88.3	81.5	71.2	60.0	
Lowest or minimum	– 7.8	– 2.0	8.9	22.0	33.0	44.8	53.5	53.0	41.0	30.0	4.0	– 3.0	
Humidity—													
Average relative	74.8%	74.0%	72.7%	70.6%	74.3%	76.2%	77.8%	79.6%	79.1%	75.7%	76.0%	75.2%	75.5%
Precipitation—													
Average in inches	4.38	4.58	6.50	4.81	2.75	3.28	3.67	3.65	3.10	3.83	3.50	3.86	47.91
Wind—													
Prevailing direction	W.	W.	N. W.	S. W.	S. W.	S. W.	S. W.	S. W.	S. W.	S. W.	W.	W.	S. W.
Average hourly velocity in miles	11.1	11.1	11.1	9.9	8.1	7.1	6.8	6.4	7.7	9.5	11.1	11.5	9.3
Weather—													
Average number clear days	9.2	7.5	8.3	7.8	8.2	9.5	8.6	9.0	8.4	11.0	8.2	8.0	103.7
Average number fair days	12.2	12.5	11.9	11.1	12.9	13.6	13.8	12.4	12.4	10.7	10.0	13.0	146.5
Average number clear and fair days	21.4	20.0	20.2	18.9	21.1	23.1	22.4	21.4	20.8	21.7	18.2	21.0	250.2

backward, the summer cooler, and the autumn warmer than in the interior. Cultivated flowers have been observed in bloom at Newport late in November. The humidity in summer is often excessive, and in consequence of this there are many days extremely close and relaxing although the temperature is not remarkably high, seldom rising above 85° F. The prevailing winds at Newport are from the southwest. The rainfall is about the average for the New England coast. Fogs are frequent during the warmer part of the year, especially in early summer. Thunder storms are infrequent in Newport itself. The Newport season may be said to last from June 1st to October or even November. The city is, however, much frequented by visitors before and after these dates, and in fact to some extent throughout the year. June, except for those who dislike the occasional heavy fogs, is a very pleasant month, when the foliage is at the height of its beauty. The temperature of the water at Newport in summer is remarkably warm, making bathing very agreeable, and a large proportion of the fishes and marine flora are southern forms. Whether this warmth, as supposed by Lorin Blodget, Storer,* and others, is due to currents from the Gulf Stream, which is more than one hundred miles distant, may be doubted, but there is no question of the fact, and to the temperature of the waters which surround its shores the mild climate of Newport is in large measure undoubtedly due. There are decided climatic as well as other differences between the various parts of Newport. The situations in and about the city, which is two miles from the south end of the island, and some distance from the Atlantic Ocean, are the warmest and most relaxing in summer, though on the other hand generally preferable and more convenient in winter. The cottage sites on the cliffs are cooler and always in great demand both on account of the sea breezes, convenience, and beauty of scenery. The southwest point of the island, Brenton's point, as the prevailing winds are from the southwest, is the most exposed and coolest. Lying along the harbor at the north end of the city is a district known as "The Point," which offers conveniences for boating and is sheltered from easterly winds in winter. Another attractive but limited section is the high ground just south of the harbor.

The accompanying meteorological table is taken from the former edition of this Handbook. The government station at Newport was discontinued in March, 1883, so that no recent records from this source are obtainable. Additional partial observations until 1895 will be found in the Bulletins and Investigations of the New England Meteorological Society and in the Bulletins and Reports of the United States Weather Bureau.

The death rate of Newport is low and the temperate and equable climate seems to be especially favorable to longevity, which is further aided by the abundance of air space and the absence of injurious trades and occupations. Newport is admirably adapted for children, who thrive there greatly, with the exception that in early autumn a tendency is noticed to the prevalence of diarrhœal diseases. For those suffering from tuberculosis and from bronchial, renal, and rheumatic affections, Newport shares too much in the general characters of the New England climate to be recommended, but for convalescents and delicate persons who reside in more inclement places and who for any reason are not able to seek an ideal climate at a distance, it will often be found in winter to be very advantageous. Though well known to the residents, the mildness of the winter climate is as yet hardly appreciated.

The very sedative and soothing effect of the Newport climate renders it useful in many cases of overtaxed brain and nervous system, and neurasthenia—particularly those which require a sedative rather than a tonic treatment. On the other hand, in a limited number of cases, especially in women, the summer climate exercises such a weakening and relaxing influence (felt by every one in a slight degree) that its effect is actually harmful. For gastro-intestinal disorders it is, generally speaking, contraindicated, chiefly during summer. Asthmatics are sometimes benefited, but sometimes the reverse is the case.

The sanitary conditions at Newport, though susceptible of much improvement in the older part of the city, are on the whole good. Newport has a satisfactory sewerage system, the main outlet pipe of which is carried for some distance beneath the waters of the harbor and discharges at the outer side of Goat Island. The city water taken from Easton's Pond and supplementary sources, though not as yet devoid of organic matter which supports a growth of vegetable organisms and infusoria, is of fair quality and has never been recognized as the cause of any epidemic. Everything for comfort and health is attainable to a degree not met with elsewhere outside of the larger cities, though Newport is deficient in hotel accommodations. There are, however, many excellent boarding-houses open at all seasons.

Newport is reached from New York by the large and comfortable night boats on Long Island Sound in ten hours, or by railway to Wickford in five hours, thence by steamboat across Narragansett Bay in another hour. From Boston and Providence there is direct communication by rail. The latter city may also be reached by boat. The neighboring pleasant resorts of Jamestown and Narragansett Pier are readily accessible, and there is also direct communication in summer with Block Island.

William C. Rives.

* "The Mild Winter Climate of Newport, R. I., as the Effect of the Gulf Stream," by H. R. Storer, M.D., Medical Record, December 22d, 1883.

NEWSOM'S ARROYO-GRANDE SPRINGS.—San Luis, Obispo County, Cal.

Post-Office.—Arroyo Grande. Hotel and cottages.

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Access.—By rail to Arroyo Grande, thence by stage two miles to springs.

The ocean beach road affords one of the finest drives in that section of the country. The springs are pleasantly situated at an altitude of about four hundred feet. They lie about fourteen miles south of San Luis Obispo. The climate here is one of almost perpetual sunshine, with occasional spring and winter rains. On the place are three principal springs whose waters range in temperature from 40° to 100° F., and flow 49,000 gallons hourly. The following analysis was made by Winslow Anderson:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	4.10
Sodium carbonate	1.75
Sodium sulphate	3.92
Potassium carbonate	.15
Potassium sulphate	2.90
Magnesium carbonate	6.41
Magnesium sulphate	2.47
Calcium carbonate	8.25
Calcium sulphate	.76
Ferrous carbonate	3.98
Alumina	.33
Silica	2.03
Organic matter	.27
Total solids	37.32
Gases.	**Cu. in.**
Free carbonic-acid gas	14.90
Free sulphureted hydrogen	3.56
Temperature of water analyzed, 100.5° F.	

These waters have gained considerable reputation in the treatment of old cases of chronic rheumatism and gout, catarrhal affections of the bladder and bowels, skin diseases, etc. For uterine disorders the hot sulphurous douche has been highly recommended.

James K. Crook.

NEW YORK is situated in 41° north latitude, 74° longitude west from Greenwich. Its temperature range is wide (from −6° F. to 99° F. with a mean of 52.6° F. in 1899), subject to extremes, especially to extreme heat in summer, and often to sudden changes. Owing to its insular and seaboard position, the extreme summer heat is usually a few degrees less in New York than the average of sister cities. Its climate is moist, the relative humidity in 1899 averaging 76 per cent. at 8 A.M. and 73 per cent. at 8 P.M. In the same year the rainfall was 42 inches, but in other years it has often exceeded 52 inches. The average hourly movement of wind varied from 8.6 miles in July to 18.9 miles in March. The prevailing direction of wind is northwest. In 1899 there were 29 thunder-storms, 128 clear days, 127 partly cloudy days, 110 cloudy days. Both in summer and in winter the temperature in New York is milder than that of Chicago, and, compared with that city, its relative humidity is less (in spite of its seaboard situation) and there is less wind, but there are fewer clear days and more foggy days. There is more sunshine in New York than in Boston, Chicago, St. Paul, or Portland, Ore.; but less than in Philadelphia, Baltimore, or Denver. The climate of New York, though stimulating, being moist, changeable, and in winter rather cool, is unfavorable for those subject to bronchial and laryngeal disorders, and for patients ill with, or convalescing from, pulmonary tuberculosis. In spite of this, New York is a healthful city. Its water supply, from Croton and Kensico lakes, is of excellent quality and free from contamination. As to typhoid fever, a large proportion of cases are infected outside of the city or from sources imported into it. The same may be said of malaria in recent years, although this class of affections formerly prevailed in Harlem and the East River districts; and the extensive digging up of the city now in progress (1903) for the construction of the rapid transit tunnel has not altered the morbidity statistics. Contagious diseases, developing at home or in school-houses, are watched by an active health board; and tropical diseases, such as cholera, typhus fever, etc., are almost unknown in New York. The city's annual mortality records for the last three years show an average of 67,503, a death rate of 19.42 per 1,000 per annum. Of these, the average annual mortality from pulmonary and other forms of tuberculosis was 9,491; from pneumonia, 9,032. The average mortality from typhoid fever and from diarrhœal diseases for 1899 and 1900 (1898 being omitted from this calculation because of the unusual increase in those diseases among soldiers returning from the war in that year) was, respectively, 632 and 6,897. Of the deaths from diarrhœal diseases a little more than one-half were among children under five years of age, who supplied one-third of the deaths from all causes. In 1899 there were reported to the city Board of Health 33,486 cases of contagious diseases, of which 1,950 were of typhoid, 99 of smallpox, and 11,001 of diphtheria. Of 41,709 contagious cases reported in 1900, 2,658 were of typhoid, 156 of smallpox, and 12,913 of diphtheria.

In 1901 there were about 4,000 cases of smallpox in New York, but by adopting the most vigorous measures the disease ceased to exist in Manhattan in August, 1902. The total number of deaths from all causes in 1902 in Greater New York was 68,082. The general death rate of New York was reduced in 1902 to 18.74 per 1,000. Up to August 16th it was 17.60 per 1,000 against 21.19 in 1901.

Manhattan's death rate was 17.76; Brooklyn's 16.87; that of the Bronx, 16.45; Queens', 19.97; Richmond's, 24.34. These figures show that irrespective of its population New York is one of the healthiest cities in the country, and ranks in comparative mortality records with thousands of small towns and villages.

Climate of New York, N. Y. Latitude, 40° 43′; Longitude, 74° 0′. Period of Observation, Thirteen Years.

	January.	March.	May.	July.	September.	November.	Spring.	Summer.	Autumn.	Winter.	Year.
Temperature (Degrees Fahrenheit)—											
Average or normal	30.1°	36.8°	59.0°	73.7°	65.3°	42.1°	47.5°	71.5°	51.3°	31.4°	51.2°
Average range	13.6	14.6	16.7	17.4	14.9	13.6					
Mean of warmest	36.7	45.9	68.5	83.7	74.4	50.9					
Mean of coldest	23.1	31.3	51.8	66.3	59.5	37.3					
Highest or maximum	64	72	94	99	100.2	74					
Lowest or minimum	−6	3	34	57	36	7					
Humidity—											
Average relative	72.4%	67.6%	65.0%	70.4%	72.8%	69.6%	65.8%	70.1%	70.7%	72.3%	69.7%
Precipitation.											
Average in inches	3.50	4.07	2.74	4.46	3.90	3.34	10.06	12.40	10.36	9.70	42.52
Wind—											
Prevailing direction	W.	N. W.	S. W.	S. W.	S. W.	N. W.	N. W.	S. W.	N. W.	W.	N. W.
Average hourly velocity in miles	9.7	11.3	8.5	7.5	8.8	10	9.8	7.6	9.3	10.2	9.2
Weather—											
Average number of clear days	7.6	7.5	9.7	7.5	8.8	8.4	24.8	24.6	27.4	21.8	98.6
Average number of fair days	11.6	13.5	13	15.5	12.1	11.5	38.9	43.2	36.4	34.9	153.4
Average number of clear and fair days	19.2	21	22.7	23	20.9	19.9	63.7	67.8	63.8	56.7	252

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The lessened mortality of 1902 is attributable in part, no doubt, to the remarkable and widespread absence of excessive heat during the summer months. In New York City there was only one day in this year in which the maximum temperature rose to 91° F. During the so-called "dog days" the temperature did not go above 88° F., and the nights were unusually cool. www.libtook.com.cn The State of New York lies in the main track of the cool waves which emerge from the northern Rocky Mountain region and drift thence eastward over the Great Lakes where the conditions have been unusually moderate during the past season, dominated by a series of cool anti-cyclones from the northwest.

The summer rainfall has been excessive, amounting throughout half of the State of New York to more than twelve inches during June and July. This is attributed to an "exceptional strength and persistency in the southerly winds bearing the vapor of the tropical ocean to feed the rain clouds producing the excessive precipitation in our northern States."

The great concentration of population in New York, now embracing over three and a half millions of people, complicates all problems of health and municipal hygiene. There are over forty thousand hotels, apartment and tenement houses in the city. The extremes of society are more widely separated than in any other American city. Philanthropic measures on a very large and generous scale have been carried out for years in New York and have done much to improve the condition of the poor and sick and outcast. It is impossible to enumerate them, but they are rapidly extending their work and are more and more generously supported.

New York is now well provided with small parks in which the poor have an opportunity for recreation and temporarily escape from their crowded quarters. Music is provided on summer evenings, and public-school properties which formerly were tightly closed all summer, are now thrown open as playgrounds for the children. Recreation piers along the river front serve a similar purpose and are specially grateful to tired mothers with sick infants. The floating hospitals of St. John's Guild, the country week associations, kindergartens, and free ice funds contribute largely to diminish misery and promote health. Van Cortlandt, Bronx, and Riverside parks are largely uncultivated, but very popular. Van Cortlandt has fine golf links and skating facilities; in the Bronx there are opportunities for picnicking, rowing, and flower gathering. Prospect Park, Brooklyn, and Central Park, Manhattan, are the largest cultivated parks in the city. Facilities for tennis, baseball, football, croquet, and amusements for small children are provided. Taken in connection with its superb water front, the bay, the rivers, and the sound, New York, aside from its commercial supremacy, is one of the most desirable places of residence in the world. *Guy Hinsdale.*

NICE.—This city is the most popular resort on the Riviera, as it is the largest, containing 93,760 inhabitants. It is one hundred and forty miles northeast from Marseilles, nineteen and one-quarter miles northeast from Cannes, and nine and one-half miles west from Monaco. It is situated on the Baie des Anges, opening toward the south, at the mouth of the little river Paillon. To the east is the hill of Villefranche, affording protection from the east winds, and to the west the promontory Cap d'Antibes, which affords partial protection from the mistral or northwest wind. To the north are the foothills of the Maritime Alps, the highest of which is Mount Chauve, with an elevation of 2,824 feet, and standing seven miles back from the coast. These foothills, as Dr. Sparks has observed, are too far distant and too much intersected by valleys to afford very good protection against winds coming from that direction.

The city of Nice consists of three distinct portions: the old town, on the left bank of the Paillon; the Port, with a seafaring population; and the Strangers' Quarter on the right bank of the river, which is the portion occupied by the winter visitors. This last section is the fashionable part of the city, and contains attractive avenues and gardens, broad streets with fine buildings, and innumerable hotels and pensions.

Along the coast runs the Promenade des Anglais, a beautiful, broad-terraced walk, two miles in length. It is shaded by palms and other trees, with a pier and casino near the beginning, and is bordered with hotels and villas.

In the season from November to May, Nice is visited by one hundred thousand people, and it then resembles a northern capital with all its gayety. During the year about one million people are said to visit it. Between the foothills proper and the shore, a distance of four or five miles, is a sloping area of country consisting of low ridges and shallow valleys. Immediately adjacent to the coast is a level tract of ground.

In seeking a health resort along the Riviera it must not be forgotten that Nice is a large, extensive city, and consequently possesses the disadvantages and perturbing influences of a city, viewed from a health-resort point of view.

The sanitary condition of Nice is said to be the best on the Riviera, and the water supply "excellent in quality and quantity" (Linn).

Nice, by reason of its situation and size, possesses innumerable resources for diversion and pleasure. Here congregate visitors from almost every civilized country, and life in this gay winter city is made most attractive for them. At the height of the season the carnival is celebrated with great display. Nice is considered a healthy city, its death rate comparing favorably with that of most French towns. In 1890 there were 21.63 deaths per 1,000.

The following table from Teysseire's figures give some of the meteorological data for the season, October to April inclusive, extending over a series of years:

	October.	November.	December.	January.	February.	March.	April.
Temperature (degrees Fahr.)							
Mean	61.61°	52.80°	48.2°	46.72°	48.43°	51.22°	57.54°
Absolute maximum	88.16	74.7	65.3	66.6	66	70.5	82
Absolute minimum	36.7	31.1	36.9	36.5	38.3	33.1	37.2
Humidity—							
Mean relative	62.6%	62.4%	63%	65.8%	59.9%	55.7%	60.4%

"The mean annual temperature," according to Burney Yeo, "is 60.3° F. The mean winter temperature 49.1° F., and the mean spring temperature 58.1° F. The minimum temperature at night is 26.6° F. The coldest months are January and February. The relative humidity is small, as is seen by the table. The mean annual rainfall is 32.43 inches, and 19.45 inches for the six winter months November to April. The mean proportion of sunny, cloudy, and rainy days for twenty years is: sunny 219.2, cloudy 77.3, rainy 67.4, and for the winter season, from October 1st to May 31st, sunny 135.8, cloudy 55.3, rainy 52.8." March, April, and May are the windiest months. Of the stormy winds the east wind is the most common, says Burney Yeo, and blows forty-five days in the year.

"Like Cannes," says Huntington Richards, "Nice is one of the windiest of the Riviera resorts. The mistral blows about nine times in the year, chiefly in February and March, and is accompanied by clouds of dust. The average number of days of complete calm during the nine autumn, winter, and spring months, as quoted by Sparks from Teysseire, is 18.6, while the average number of days of gentle wind is 203.8, and that of strong wind days is 69.4, out of which 29.4 occur during the three spring months."

"It must be admitted," says Sir Hermann Weber, "that the changes of temperature are very great, even in sunny places, when passing from a sheltered position to a spot exposed to winds, and likewise on passing from the sun into the shade. A great part of the town is also exposed to the northeast wind, owing to a gap left in the sur-

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rounding heights by the Paillon torrent, and the mistral is often very annoying, the protection by some rather low hills to the northwest being inefficient. But the character of the climate is remarkably sunny and invigorating, and the bright days considerably exceed in number the dull and rainy ones". Frost rarely occurs, and then at night. Fogs are unknown. The temperature of the sea water in winter is between 53° and 61° F., and in summer between 64° and 75° F.

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"Nice enjoys," says Dr. Wendt, in the previous edition of this HANDBOOK, "nothing more nor less than a fair average of Riviera climate. This means that it is not devoid of drawbacks, and that ideal winters are not found there. Nice is more sheltered than some places, but is nevertheless exposed to the mistral, which blows at Nice just as it blows at most other Riviera spots. It should be borne in mind by invalids and tourists that Nice and the Riviera in general really possess two distinct and different climates, viz., seashore or marine climate and an inland or mountain climate. It is quite well known that immediate proximity to the sea may induce sleeplessness and other symptoms, denoting too exciting an action on the nervous system. The dry, sunny inland air is tonic and sedative; the air in immediate proximity to the shores of the sea is bracing and exciting. The air of the city and its suburbs is often a mixture of the two. It is thus apparent that a number of local climates are found at Nice, concerning which the resident physicians will inform invalids."

As a genuine health resort it will be seen from the preceding climatic considerations that Nice possesses grave defects, and is perhaps the least desirable of the Riviera stations, particularly toward the close of winter and the beginning of spring. As has been well said, it is "rather a pleasure resort than a refuge for invalids." It does, however, offer much to a certain class of patients or semi-invalids. Those seeking sunshine, a certain degree of warmth, dry air, and comfortable living, even luxury, will find it here, under most attractive surroundings.

Anæmia, chlorosis, scrofula, gout, rheumatism, dyspepsia, diabetes, Bright's disease, chronic bronchitis, asthma, and catarrhal conditions of the upper air passages are said to be more or less favorably influenced by the climate of Nice. It is not to be recommended for pulmonary tuberculosis, although it was formerly much resorted to by this class of cases. For the feeble, from old age or other cause, it is of value.

The suburb of Cimiez, two miles from the sea, appears to possess especial climatic advantages. It is said to be better sheltered and has a more equable climate, and its influence is more sedative. The late Queen of England visited this quarter of Nice several times.

Three and a half miles to the east of Nice is Beaulieu, said to be one of the best protected spots on the coast. The high mountains rise directly in the rear, cutting off the north winds. The situation of this little place is most attractive, and the groves of olive trees, orchards of orange and lemon, and the luxuriant vegetation enhance the beauty of the scenery.

The excursions in the vicinity of Nice are many and most attractive, affording marvellously beautiful views of this picturesque region. La Turbie, 1,600 feet above the level of the sea, on the Corniche road between Nice and Monaco, is perhaps one of the most strikingly beautiful spots in all this region of magnificent scenery.

For the true invalid the Riviera may possess many disadvantages, but for one weary with the routine of life, to roam along this coast from Genoa to Cannes in the late spring or early summer when the vegetation is at its best, is a source of unending delight, as the writer can testify from personal experience. *Edward O. Otis.*

NIGHTMARE. See *Consciousness, Disorders of.*

NIRVANIN—diethyl-glycocoll-p-amido-ortho-oxybenzoic acid methyl hydrochloride, $HC(C_2H_5)_2NCH_2.CO\,HN.C_6H_4.OH.COOCH_3$—occurs in white neutral prismatic crystals, very soluble in water. Elsberg at Mount Sinai Hospital in New York City, found the toxic dose in rabbits to be 0.22 gm. per kilogram of body weight, while that of cocaine is 0.02 gm. per kilogram. Boiling causes very slow deterioration of anæsthetic power and is practically harmless to the drug for short periods. Solutions purposely infected soon became sterile, and one- to two-per-cent. solutions were still sterile at the end of six months. Joanin found 0.5–0.7 gm. per kilogram toxic for guinea-pigs, while betaeucaine is twice, and cocaine nine times, as toxic. But M. Didrickson affirms that the toxicity is greater than these authors report, very small doses having resulted in excitement, hallucinations, and convulsions.

Clinical evidence seems to favor this new compound as a stable, sterile, very soluble local anæsthetic. In 0.2–0.5-per-cent. solution it is suitable for infiltration anæsthesia, and in five-per-cent. strength for local application. It is somewhat irritating, and if used for the eye should be combined with cocaine. It has but little power of penetration, a five-per-cent. solution applied to a mucous membrane scarcely affecting the submucous tissues. It is said to be of value in pruritus and in dentistry. *W. A. Bastedo.*

NITRIC ACID.—*Aqua fortis.* Under the title *Acidum Nitricum*, Nitric Acid, the United States Pharmacopœia makes official a liquid composed of sixty-eight per cent., by weight, of absolute nitric acid [HNO_3]. Such grade of nitric acid is a heavy liquid of about 1.414 specific gravity, colorless when freshly made and perfectly pure, but, as met with in the shops, apt to be of a distinctly yellowish shade. The acid fumes upon exposure, is powerfully corrosive and stains animal tissues and woollen fabrics a bright yellow. It dissolves silver, mercury, copper, and other metals with evolution of red fumes. It mixes in all proportions with water and alcohol. It is a pretty potent oxidizer, yielding up a portion of its oxygen to oxidizable material, and it has a strong affinity for water, by reason of which affinity, in part, it is powerfully caustic to animal tissues. It should be kept in well-stoppered, dark amber-colored bottles.

The valuable properties of strong nitric acid are the power of the acid to oxidize on the one hand, and to cauterize on the other. By its oxidizing virtues nitric acid is a serviceable disinfectant in situations where its corrosive action will do no injury; and its cauterant powers are convenient for surgical application. The acid burns searchingly and thoroughly, yet not unmanageably. When using nitric acid as a caustic, it is well to bound the area intended for cauterization by a ring of oil or of adhesive plaster, to prevent the action from spreading unduly. The acid is then applied by a glass rod or bit of stick, care being taken to avoid excess. Swallowed in any considerable quantity nitric acid is a powerful corrosive poison, producing effects substantially similar to those caused by sulphuric acid (see *Sulphuric Acid*). The most striking difference between the poisoning by the two agents is, that in sulphuric-acid corrosion the sloughs tend to be brown or blackish, while in that from nitric acid they are yellow. Inhalation of the fumes of nitric acid also may kill.

In proper dilution nitric acid operates physiologically as do all the sour mineral acids (see *Sulphuric Acid*), and shares with hydrochloric acid a sort of selective efficacy in disorders of the digestive apparatus. Vomiting, from many causes, is often relieved effectually by nitric acid, and so is diarrhœa, and so is the functional disorder of digestion commonly ascribed to sluggish action or even congestion of the liver. Even a special curative action over constitutional syphilis has been proclaimed of nitric acid, but is at the present day quite properly discredited. For internal giving, the following preparation of the United States Pharmacopœia is to be used:

Acidum Nitricum Dilutum, Diluted Nitric Acid. This preparation is a simple dilution of the official strong acid with distilled water, in the proportion a little less than six parts of added water to each one of acid. It

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represents ten per cent., by weight, of absolute nitric acid; is a colorless and strongly sour liquid, non-corrosive but highly irritant. Its specific gravity is 1.057. The internal dose is from twenty to forty drops, largely diluted with water, and the mouth to be rinsed well after the taking of each dose. *Edward Curtis.*

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NITRITES.—Physiological experimentation and clinical testing with a number of different nitrites, both of metallic and ethereal bases, have now developed the fact that such compounds possess certain strongly marked properties in common. These properties evidently belong to the acid radical of these salts, so that the nitrites are to be regarded as forming a natural group of medicines whose peculiar virtues are due to nitrous acid. The effects wrought by nitrites upon the animal system are, broadly, twofold, as follows: On the one hand, a chemical change in the composition of hæmoglobin, and, on the other, an influence upon nervous and muscular structures, showing itself by profound and, in sufficient dosage, even fatal derangement of function. As regards the effects upon the blood, it is observed that in an animal under the influence of a nitrite the arterial and the venous blood both have acquired in common a peculiar chocolate hue, which does not change when the drawn blood is agitated with air. Examined by the spectroscope such blood shows a replacement of the bands of hæmoglobin by those of a new compound (Gamgee) very probably identical with the *methæmoglobin* of Hoppe-Seyler; and, tested chemically, this changed hæmoglobin is found to have its ozonizing power very seriously compromised. Treatment with ammonia restores normal color and normal functional power to this nitrite-poisoned blood. The nervous and muscular derangements produced by nitrites are as follows: In moderate dosage there are felt a fulness and throbbing of the head and neck, with almost simultaneous very rapid and disorderly action of the heart, and excited and panting breathing. The face is deeply flushed and feels uncomfortably hot, but the internal general temperature is found by the thermometer to fall. So, too, though the heart and carotids are felt to throb disagreeably hard, yet arterial tension is proved to suffer a very great decline, obviously due to the general capillary dilatation, of which the flushed face is an evidence. In large doses, as observed in animal experimentation, initial great acceleration of the heart's action, and violent and hurried breathing are followed by slow, irregular, and failing pulse and respiration, fall of temperature, weakened voluntary and reflex motor activity, and finally, death by respiratory arrest. As regards the mechanism of these derangements, the initial circulatory phenomena—acceleration of pulse, capillary dilatation, and sinking of blood tension—are mainly the expressions of paralysis, severally, of cardiac inhibition, of resisting power of the muscular elements of the arterioles, and, to a less degree, of vaso-motor control over the same. The heart failure following large dosage is probably due to direct poisoning of the cardiac musculature; the agitated and panting breathing of the earlier stages of the nitrite effect seems to be secondary to the other derangements, but the final arrest of respiration in fatal poisoning appears to result from direct paralysis of the nerve centres concerned in the function. Similarly, the failure of voluntary and reflex motor power seems to be mainly from paralysis of the motor tract of the cord, although to a certain extent the muscular contractility is itself impaired.

Nitrous acid in combination is thus seen to be an agent that immediately attacks the ozonizing function of the blood and the vital endowments of nerve and muscle tissues. Many have thought that the paralytic phenomena are probably but consequences of the blood lesion, but various physiological considerations make it more likely that they result from immediate and independent poisoning of the substance of the nerve centres.

The principal therapeutic applications of the nitrites are to relieve spasms, or pains referable to spasm, and to arouse the heart in syncope. The most notable instances of the first application are the use of nitrites in the treatment of angina pectoris, spasmodic asthma, and epilepsy. In the first two of these diseases nitrites often prove of astonishing temporary power, but in the last they are, as compared with bromides, second rate in efficacy. Still, in some cases of epilepsy, where bromides have ceased to impress or where the supervention of bromism has forced their discontinuance, nitrites have shown themselves serviceable alternates (Law). For the relief of syncope nitrites are theoretically indicated where the cardiac arrest is presumably referable to excess of inhibition; and, clinically, the nitrite of amyl has been reported to have restored heart action in cases of syncope from emotion, from hemorrhage, and from chloroform poisoning.

The nitrites recognized by the United States Pharmacopœia are the ethereal nitrites of amyl and of ethyl, respectively—the latter in the single preparation, *spirit of nitrous ether* and the salt sodium nitrite. Also, though unofficial, potassium nitrite has been tried in medicine. Properly also, *nitroglycerin* should be included in a summary of the group of nitrite medicines, since, though not itself a nitrite, there is little doubt that its medicinal effects are wrought by a nitrite resulting from decomposition of the nitroglycerin within the body. In this place the nitrites, respectively, of *ethyl, amyl, potassium,* and *sodium* will be discussed, nitroglycerin being treated of under its own title.

Ethyl Nitrite: $C_2H_5NO_2$. Ethyl nitrite, formerly called *nitric ether*, and now *nitrous ether*, is a compound that forms by reaction of nitric acid with alcohol. It is an ethereal fluid of agreeable apple-like flavor and pungent taste—exceedingly volatile, somewhat soluble in water, and more freely in alcohol. Experimented with in the pure condition, this body produces promptly and fully the classical effects of the nitrites as above set forth (Richardson). It is used in medicine, however, only in the form of a weak alcoholic solution—the time-honored and well-known preparation formerly called *sweet spirit of nitre*, but now official in the United States Pharmacopœia under the title *Spiritus Ætheris Nitrosi*, Spirit of Nitrous Ether. This preparation is made by distilling a mixture of solution, in alcohol and water, of sodium nitrite, and of sulphuric acid. After purification of the ethereal product, enough alcohol is added to make a spirit containing in solution four per cent. of ethyl nitrite. Spirit of nitrous ether is a clear, mobile liquid, volatile and inflammable, of a pale straw color, inclining slightly to green, and a fragrant, ethereal odor. Its taste is sharp and burning. Specific gravity, about 0.836 to 0.842 at ordinary temperatures. It slightly reddens litmus paper, but should not effervesce when a crystal of potassium bicarbonate is dropped into it. It should be kept in small glass-stoppered vials, in a dark place, remote from lights or fire. Spirit of nitrous ether as found in the shops is apt to be of deficient strength from the fraudulent addition of water or alcohol.

The effects of this spirit are the conjoint effects of its two constituents, alcohol and ethyl nitrite. In the small doses commonly prescribed for medicinal purposes the peculiar nitrite effects are but faintly seen, and the medicine operates as a grateful stomachic, which is at the same time mildly diaphoretic and antispasmodic. The spirit is accordingly much prescribed as an ingredient of so-called fever draughts or mixtures, its tendency being to ameliorate the discomforts of the febrile state. In large dosage with this preparation the typical nitrite effects are clearly seen—giddiness, headache, and throbbing arteries having been reported as following an overdose, while in another case death occurred from inhaling the fumes from a broken three-gallon jar of the spirit accidentally spilled in a room. Spirit of nitrous ether is prescribed in doses of from 2 to 4 gm. (practically from ♏ xxx. to fl. ʒ i.) several times a day. The dose may be mixed with water for the taking, or prescribed as an ingredient of mixtures containing saline solutions. Such mixtures should not be ordered in quantity beyond present need, since dilution with water tends to set on

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foot chemical changes in the ethereal spirit. Spirit of nitrous ether is an ingredient of the official *Compound Mixture of Glycyrrhiza* ("Brown Mixture") of the United States Pharmacopœia.

Amyl Nitrite: $C_5H_{11}NO_2$. Amyl nitrite is used in medicine under its own form. Under the title *Amyl Nitris*, Amyl Nitrite, the United States Pharmacopœia recognizes the ordinary article of pharmacy, which is an ethereal liquid containing about eighty per cent. of amyl nitrite. The remainder of the percentage is made up of various associated but undetermined ethers. The substance is a clear, very mobile ether, of a pale yellow color, having a fruity odor almost exactly resembling that of ripe bananas, and an aromatic taste. When freely exposed to the air it decomposes, leaving a large residue of amyl alcohol. It is insoluble in water, but soluble, in all proportions, in alcohol, ether, chloroform, benzol, and benzin. Its specific gravity is 0.870 to 0.880, and it boils at about 96° C. (205° F.), giving an orange-colored vapor. It burns with a fawn-colored flame. It should be kept in small, dark glass-stoppered vials, in a cool and dark place. Amyl nitrite is excessively volatile, and the utmost care is necessary to preserve a specimen both from loss of bulk and from spontaneous decomposition by exposure.

Amyl nitrite is the nitrite commonly used in medicine for the specific sake of the nitrite effects proper, and it is, perhaps, the most striking of medicines in the matter of rapidity and intensity of action. From its extreme volatility and pleasant odor the ether is efficiently and conveniently given by inhalation. When the quantity of from three to five drops, poured upon a handkerchief, is inhaled, the subject is conscious, within so short a time as from three to ten seconds, of a sensation of heat, fulness, and throbbing of the face and head, immediately followed by an indescribable and most distressing commotion within the chest, the heart beating fast and furiously, and the breathing being panting and hurried. Giddiness and some muscular languor accompany these phenomena, and perspiration may break out; but in a very few minutes the derangements of function begin to recede, and rapidly, and upon their complete disappearance the subject is left without after-effects, save, possibly, a little dull headache and lassitude, lasting from half an hour to an hour. Assuming such dosing with the ether to have been in a case open to the therapeutic powers of the nitrites, the therapeutic effect will have been as swift and pronounced as the physiological derangement. No medical relief, indeed, so nearly merits the designation of "as if by magic," as the sudden and complete abrogation of an anginal or asthmatic seizure that is so often wrought by the swift and profound action of amyl nitrite. The drug, however, must not be expected to be infallible, for many cases of angina pectoris, of asthma, and syncope—notably profound chloroform syncopes—often set the nitrite at defiance.

Amyl nitrite is an important medicine for the conditions enumerated above as being peculiarly amenable to the nitrite influence, and also has proved serviceable in dysmenorrhœa and other affections, painful or spasmodic. The remedy is most conveniently given by inhalation, from three to five drops being poured upon a handkerchief, and the cloth then held to the nose and mouth. Those who are subject to angina or asthma, and who find relief from amyl nitrite, may carry a small vial of the ether about with them, and, upon the occasion of a seizure themselves dash a few drops upon a handkerchief. Or it may be sufficient to sniff strongly at the opened vial itself until the characteristic sense of flushing and arterial throbbing proclaim the absorption of a sufficiency of the vapor. If a vial be so carried and used, it should be but a small one, not over 2 c.c. (♏ xxx.) capacity, since by frequent uncorking of the bottle the contained sample of amyl nitrite gets "flat" and loses its efficacy through chemical change brought about by the exposures to air. More convenient than a vial, both because of better preservation of the medicine and because of combined rapidity ease, and certainty of dispensing of the dose, are what are commonly called *pearls* of amyl nitrite. These pearls are small, flattened, sealed chambers, blown of very thin glass, and charged with fixed quantities of the nitrite, generally from to two to five minims. For use a single "pearl" containing the prescribed dose, is crushed in a handkerchief and the fumes of the liberated ether are inhaled in the usual way. The glass of which the pearl is made is so thin that the broken fragments do no harm. These pearls are not official, but are quite universally to be procured. Amyl nitrite can, if preferred, be given by the mouth, dropped upon sugar, or dissolved in alcohol, in doses of from two to five drops.

Potassium Nitrite: KNO_2. Potassium nitrite is not official in the United States Pharmacopœia. It is a colorless salt, slightly deliquescent, soluble in water, and occurring in crystals or in fused sticks. Tested upon man and the lower animals, potassium nitrite is found to produce all the typical nitrite effects; but, as might be expected, more slowly, while yet more enduringly, than amyl nitrite. In the experiments of Weir Mitchell and Reichert[1] full doses made themselves felt by symptoms during a period of from one and a half to five hours, beginning within one or two minutes after swallowing. The doses ranged from three to ten grains, single or repeated, and one individual experimented upon took, in divided doses, within a period of six hours and thirteen minutes, thirty-five grains of the salt. But from the behavior of sodium nitrite of ascertained purity (see below), the question cannot but protrude itself, Was the sample of the potassic salt used in these experiments tested for purity? In the present condition of knowledge of the subject, the comparatively large quantities cited above should certainly not be prescribed medicinally for an untried subject.

Potassium nitrite gives rise, during the period of its action, to eructations of gas of a very offensive phosphureted odor, so disagreeable as even to lead in some cases to nausea and vomiting (Reichert).

Sodium Nitrite: $NaNO_2$. The salt is official in the United States Pharmacopœia under the title *Sodii Nitris*, Sodium Nitrite. It occurs in crystals or fused sticks, freely soluble in water. Commercial samples are rarely pure, being composed of nitrate and nitrite in varying proportions. The better grades may contain 98.5 per cent. of nitrite, but specimens of a salt sold as sodic nitrite have been found to contain but the merest trace of that body—0.011 per cent. only (McEwen). The condition of small crystals, as against that of large transparent crystalline forms or the fused nitrite, is said to be the best for purity. Sodium nitrite deteriorates on keeping—a fact doubtless accounting for the poor quality of the drug so often found.

Sodium nitrite produces the peculiar nitrite effects in a manner generally similar to potassium nitrite, and, when a good sample is employed, can be fatally poisonous, as has been proved by experimentation upon animals. In full dosage with the human subject, extreme distress, and even an alarming condition, have been reported; the prominent complaint being of excessively violent and turbulent heart action, with great giddiness and general weakness. In such cases lividity of the lips and nails has quite commonly been observed.

Therapeutically sodium nitrite has proved efficient in the usual way of nitrites to control the pain in many cases of angina pectoris, and in cases of frequently recurring paroxysms has, in single dose, established freedom therefrom for half a day in subjects to whom amyl nitrite gave immunity for but an hour or two (Matthew Hay). Such immunity, furthermore, was secured by a dosage small enough not to produce any pronounced throbbing or giddiness or headache. In epilepsy this nitrite has also been used with some abatement of the fits; but it is, in a general way, inferior to bromides for this particular therapeusis. From the experience with the salt so far acquired, sodium nitrite can be said to be available for all the therapeutics of the nitrites, and to have the advantages over the ethereal salts of a more deep-rooted and lasting influence, and of much greater

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cheapness. On the other hand, as compared with amyl nitrite, the sodic salt is slower in establishing its effects, so that when urgency of relief is demanded the amylic salt is preferable. Sodium nitrite gives rise to some disagreeable eructations of gas, but in therapeutic dosage the occurrence is slight. The sodium nitrite should, for a pure sample, not exceed 0.13 gm. (gr. ij.), for the larger doses of five, ten, and twenty grains that were at first used by investigators have, with good specimens of the salt, produced very distressing and even alarming effects. The effects of a two-grain dose will persist a number of hours. Care should be taken in prescribing this medicine that the sample is of good quality and not too old. *Edward Curtis.*

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[1] American Journal of the Med. Sciences, July, 1880.

NITROBENZENE, POISONING BY.—This substance, also called nitrobenzol, is made by the action of nitric acid on benzene (benzol), which is one of the ingredients of coal tar. The formula of nitrobenzene is $C_6H_5NO_2$; it is a substitution product of benzene. It is a clear, straw-yellow liquid, insoluble in water, and possessing a strong odor, sufficiently like that of bitter almonds to permit of its use in perfumery and confectionery. It has become a rather familiar article of commerce under the name of oil of myrbane. It appears from several recorded cases that small doses of the liquid are poisonous, and even its vapor is active. The symptoms resemble somewhat those of prussic acid, but there are no immediate insensibility and no convulsions. The skin becomes clammy, the lips and fingers purple, the eyes glassy, and the breathing very slow and infrequent. In a case that occurred in the practice of Dr. H. M. Dean, of Muscatine, Iowa (*Medical Bulletin*, vol. i., p. 50), violent effects followed the mere tasting the article. The pulse was not much affected, but the respirations occurred at long intervals. The mind usually remains clear for some time, but unconsciousness ultimately ensues. The diagnosis will generally be determined by the powerful and characteristic odor of the substance, which can easily be distinguished from that of both prussic acid and oil of bitter almonds, which it most nearly resembles.

Nitrobenzene is partly converted in the body into aniline, but its poisonous action does not depend on this conversion.

There is no specific treatment, the symptoms must be combated as they arise. Free washing out of the stomach with lukewarm water has been found to be of great advantage in many cases of poisoning, and would be applicable here. Dr. Dean, in the case above referred to, used fluid extract of digitalis, one drop every hour, and also, every few minutes, a teaspoonful of a mixture of one part of alcohol and two of hot water. He could make the patient swallow by putting the spoon well back on the tongue. *Henry Leffmann.*

NITROGEN MONOXIDE.—Nitrogen monoxide (N_2O) is the body commonly called *nitrous oxide gas*, and formerly popularly known as *laughing gas*. It is a colorless gas, practically without smell, and with a very faintly sweetish taste. It dissolves in a little more than its own measure of cold water, to a less extent in warm water, and to a less extent still in a saturated aqueous solution of sodium chloride. By combined exercise of cold and pressure the gas can be condensed to the liquid condition, yielding a colorless and very mobile fluid. Upon release of pressure this fluid immediately springs again into the state of gas. Nitrogen monoxide actively supports the combustion of inflammable bodies, undergoing decomposition and yielding up its oxygen to the burning substance.

Nitrogen monoxide is, physiologically, absolutely bland, and being also odorless is perfectly respirable even when substituted, pure, for atmospheric air. When so respired, the gas, from its free solubility in watery fluids, is rapidly absorbed into the blood. If inhaled with admixture of enough atmospheric air for the ordinary needs of the system, nitrogen monoxide proves peculiarly exhilarant. A sort of tingling thrill runs through the nerves down to the very finger ends, and, if enough of the gas be taken, the experimenter is irresistibly driven to the commission of some extravagant and silly act, almost always such as betokens an uncontrollably joyous state of mind. Singing, shouting, laughing, dancing, and capering are thus the common expressions of the exhilaration—manifestations whence comes aptly the old name *laughing gas*, applied to a mixture of nitrogen monoxide and air. When inhaled pure, in entire substitution for atmospheric air, there is, first, a very transient exhilaration, and then rapidly follow the same phenomena as when pure nitrogen is respired, namely, such as result from the respiration of an atmosphere devoid of available oxygen. The blood returning from the lungs ceases to acquire the arterial hue, its free oxygen rapidly diminishes in quantity, the animal speedily loses consciousness, and, if the inhalation be continued, dies by asphyxia, in the same time that it dies in an atmosphere of plain nitrogen, and with a similar reduction of the percentage of free oxygen contained in the blood. These various facts sufficiently prove that at the temperature of the animal body nitrogen monoxide resists decomposition, so that the oxygen of its molecule is unavailable for the purposes to which ordinarily respired oxygen is put.

Nitrogen monoxide inhaled pure is, then, practically an agent that will, without other derangement, produce the unconsciousness of coma from asphyxia, while not interfering with the free play of the lungs in the respiratory act. The clinical phenomena of the inhalation are, *subjectively*, a beginning feeling of the peculiar tingling and sense of exhilaration noted above, which, however, is soon overwhelmed in swift-rushing unconsciousness. According to the fulness of the respirations the unconsciousness may supervene in from a few seconds to two or three minutes. In a carefully observed experiment the writer of this, practising the fullest possible forced inspiration and expiration, and beginning the inhaling after a forced expiration, was noted to have passed into complete unconsciousness in the middle of the third inspiration. During the continuance of the unconsciousness anæsthesia is absolute; and upon withdrawal of the gas and substitution of atmospheric air the senses are regained as rapidly as they were lost, and in two or three minutes the experimenter is in perfectly normal physiological status again. *Objectively* the phenomena are a swiftly developed lividity of the skin and mucous membranes, staring, and sometimes convulsively rolling eyeballs, a convulsive twitching of the hands, and, when unconsciousness has supervened, a slow, snoring respiration. The pulse is little affected. During the unconsciousness the muscles, with the exceptions noted above, are quite thoroughly relaxed.

Nitrogen monoxide is used as a medicine proper and as an "anæsthetic." Taken in small quantities, so as not to interfere with normal absorption of oxygen, the substance often seems to abate symptoms of nervous debility or exhaustion, and hence to be of value in the treatment of many so-called functional nervous diseases. For such purposes the gas may be given by inhalation, a few whiffs being drawn from a bag through the usual mouthpiece, while at the same time atmospheric air is breathed through the nostrils, purposely left unclosed. Another method of administration is to give an aqueous solution of the gas by swallowing. A patented solution of such character, made under a pressure of five atmospheres, has been used under the title of *oxygenous aerated water*. Nitrous oxide water has but little odor, and is slightly sweetish to the taste. But by far the commonest use of nitrogen monoxide is the administration of the pure gas by inhalation, in order to produce the anæsthesia of unconsciousness. For this administration a bag of a capacity of from four to thirty-two litres (one to eight gallons), according to the proposed duration of the inhalation, is charged with a pure article of the gas, undiluted. From

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the bag the gas is drawn through a connecting tube out of a mouthpiece so constructed that by an arrangement of valves the products of expiration pass into the air and not back into the bag, and also that the operator may, by the turn of a switch, admit air and cut off gas at pleasure. The patient's clothing being so adjusted as to offer no impediment to respiration, the mouthpiece is put in place, the nostrils are gently compressed by the fingers of the administrator, the stopcock that controls the delivery of the gas from the bag is turned, and the patient is enjoined to breathe as fully as possible. As soon as full lividity of the face and stertorous breathing proclaim the development of unconsciousness, the patient is ready for operation, and if such operation be one of brief duration, like the opening of an abscess or the drawing of a tooth, the administrator at once removes the mouthpiece as soon as unconsciousness is attained, anæsthesia persisting for a number of seconds after withdrawal of the gas. If the operation be a prolonged one, then, as soon as coma is complete, the administrator, by turning the switch in the mouthpiece, gives a little air, and then again, by a reverse turn, a little gas, and so, guided by the color of the blood as seen through the skin, by the snore of the respiration, and by the presence or absence of voluntary muscular movements, he skilfully gives, alternately, air to keep his patient alive and gas to keep him in practically continuous unconsciousness. In this way a practised administrator can maintain prolonged anæsthesia with nitrogen monoxide; but by the very necessities of the case the patient is always just on the verge of awakening to consciousness of pain on the one hand, and to the undesirable sudden movement of a limb on the other. Obviously, therefore, despite its advantages of swiftness and pleasantness of action, nitrogen monoxide is more appropriate, given in the above manner, as an anæsthetic for momentary than for prolonged operations. In order to secure an easy continuance of anæsthesia, Dr. Paul Bert, of Paris, has proposed the method of administering a mixture of nitrogen monoxide and oxygen under increased atmospheric pressure. Under such circumstances the oxygen of the mixture prevents asphyxia, yet the characteristic anæsthetic unconsciousness of nitrogen monoxide supervenes with the usual quickness and kindliness, and can be maintained continually without dangerous or even disagreeable effect. Bert mixes the gases in the proportion of 85 parts of nitrogen monoxide to 15 parts of oxygen, and conducts the administration in a special chamber of compressed air representing a total atmospheric pressure of 93 cm. of mercury. Anæsthesia has thus been maintained safely and pleasantly without break for over an hour, but the large volumes of gas required for such prolonged application and the trouble of providing the compressed-air chamber will probably always interfere seriously with the extension of the method into practice. Many surgeons use nitrogen monoxide as a preliminary to ether, in the administration of the latter as an anæsthetic.

Nitrogen monoxide is obtained from the salt *ammonium nitrate* by heating the same in a retort. At an elevated temperature the salt decomposes, and from its constituents water and nitrogen monoxide form ($NH_4NO_3 = 2H_2O + N_2O$). The gas is supplied by manufacturers, condensed to a liquid in strong iron cylinders—a convenient method of storage, since in this way a large volume of gas occupies but a small space. From these cylinders the administration bag is filled as occasion demands. It is not wise to attempt to make the gas, unless provided with apparatus constructed for the purpose, since, unless the distillation be done in a certain precise manner, the resulting gas may contain dangerous impurities. A pure article of fused ammonium nitrate is to be used; the heat is to be gradually applied and never allowed to exceed 400° F. and the gas, after passing through a series of wash-bottles, one of which contains a solution of potassa, is to be collected in a gasometer, over warm water, or over an aqueous solution of common salt.

Edward Curtis.

NITROGLYCERIN.—Nitroglycerin, called also *glonoin*, is, chemically, a trinitrate of the radical glyceryl, represented by the formula, $C_3H_5(NO_3)_3$, equivalent to the replacing of the three hydrogen atoms of the hydroxyl groups in the molecule of glycerin by the nitro-group NO_2. Nitroglycerin is made by the action of nitric acid upon glycerin, and is a transparent, colorless, dense oily fluid, of about the specific gravity 1.6; slightly soluble in water, but freely soluble in ether or alcohol. It is slightly volatile, inodorous, and of a sweet, pungent, aromatic taste. Upon concussion, as is well known, it explodes with extreme violence. Nitroglycerin itself is not official as a medicine, but the United States Pharmacopœia recognizes a one-per-cent. alcoholic solution of the substance under the title *Spiritus Glonoini*, Spirit of Glonoin. This spirit presents only the physical characteristics of alcohol, in appearance, taste, and smell, and is entirely non-explosive. But if some of it be spilled, so that the alcohol has a chance to evaporate, the nitroglycerin will become concentrated, and a dangerous explosion becomes possible. The spirit should, therefore, be handled with great care. It should be kept in tin cans instead of in glass bottles, and these should be well stoppered and stored in a safe and cool place, away from exposure to light or fire.

The effects of a one-per-cent. solution of nitroglycerin upon the animal system are, in kind, exactly those of the nitrites (see *Nitrites*), with the additional symptom of a severe and obstinate headache. In rapidity of action, nitroglycerin occupies a position between amyl nitrite on the one hand, and the nitrites of the alkali metals on the other. The agent is powerful; a single drop of the one-per-cent. solution taken upon the tongue produces within three or four minutes a transient feeling of cerebral fulness and frontal pain, and a dose of four or five drops quickly determines a full nitrite derangement—flushed face, throbbing arteries, violent and disorderly heart action, hurried respiration, and splitting headache. Over-dosage is extremely dangerous, as shown by a reported case in which, after a dose of two and a half drops of a *five*-per-cent. solution, the typical nitrite effects were quickly succeeded by sickness, faintness, and coma with stertorous breathing. The heart's action became alarmingly weak, but the patient finally recovered.

Nitroglycerin produces thus exactly the effects of a nitrite, and accordingly the inference is that in the career of the compound in the animal economy it suffers change into a nitrite, and as such nitrite exerts its activity. This subject of a possible chemical conversion of nitroglycerin within the system was studied by Matthew Hay (*Practitioner*, June, 1883), who found that nitroglycerin is decomposed by alkalies and alkaline carbonates, with the conversion of two-thirds of its nitric acid into nitrous, which nitrous acid then combines with the alkali to form a nitrite of the same. This reaction, furthermore, Hay was able to produce by treating a one-tenth-per-cent. solution of nitroglycerin in water with freshly drawn defibrinated blood, and digesting the mixture for forty minutes in an oven at a temperature ranging between 104° and 113° F. Such mixture assumed the peculiar chocolate color of nitrite-poisoned blood, and by analysis, after an hour's digestion, nearly the whole of the nitroglycerin present was found to have undergone decomposition.

Nitroglycerin thus seems to be, for the pharmacologist and physician, but a nitrite-furnishing compound, whose distinguishing feature is solely the extraordinary intensity of its action, a feature which Hay accounts for by the fact that nitroglycerin is, by the peculiarity of its composition, exempt from the decomposition by the acid of the gastric juice to which nitrites are liable—a decomposition which always renders inert a certain proportion of each dose of a nitrite swallowed as such.

The therapeutic applications of nitroglycerin are those of the nitrites. The remedy has been used with benefit in angina pectoris, asthma, and epilepsy, especially in *petit mal*, and also in the anæmic form of migraine (Hammond), and in nephritis attended with a hard, corded

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pulse (Robson). The dose, in an untried subject, should be at first but a single drop of the customary one-per-cent. alcoholic solution, to be repeated every fifteen minutes until four or five drops shall have been taken or relief experienced. In habitual use, as for epileptics, the dose will very [illegible] increase. At the rate of an additional drop per dose each month so large a dosage as twelve drops three times a day of the one-per-cent. solution has been taken without the production of undue derangement. *Edward Curtis.*

NITROHYDROCHLORIC ACID. — (Aqua Regia.) Under the title *Acidum Nitrohydrochloricum*, Nitrohydrochloric Acid, the United States Pharmacopœia recognizes the product of mixing together 180 measures of nitric acid and 820 of hydrochloric. On making such mixture effervescence occurs and a golden-yellow, fuming fluid results, strongly acid and intensely corrosive—more so than the original acids of its composition—and also possessed of the peculiar properties of smelling of chlorine and of dissolving readily gold-leaf. This fluid is wholly volatilizable by heat. As its smell suggests, nitrohydrochloric acid contains free chlorine, and the fresher the sample of the acid the higher the percentage of chlorine, since by keeping, especially if exposed to light, the chlorine constantly tends to undergo conversion into hydrochloric acid, deriving hydrogen by the decomposition of water. Nitrohydrochloric acid should therefore be made and kept only in small quantities, and these, after all effervescence has subsided, should be put up in glass-stoppered bottles, half filled only, and stored in a cool place, protected from the light. The reaction whereby free chlorine is evolved in a mixture of nitric and hydrochloric acids is now commonly regarded by chemists as the following:

$$HNO_3 + 3HCl = 2H_2O + NOCl + Cl_2.$$

As already said, nitrohydrochloric acid is intensely corrosive to animal tissues. The acid is possible, therefore, as a surgical caustic, but the more manageable nitric acid is commonly and properly preferred. The special medicinal value of nitrohydrochloric acid lies in the influence of the preparation over the functions of the liver, and also over certain obscure derangements of metabolic processes, notably over that leading to considerable appearance of calcium oxalate in the urine—the condition, in short, clinically dubbed *oxaluria*. As regards influence over the liver, nitrohydrochloric acid has long enjoyed the reputation of tending to abate congestions of the organ, to oppose the march of cirrhosis, and even to favor the limitation of abscess, and, in so called functional disorders of the liver, to cause recedence of the symptoms. Experimentally, also, Rutherford has shown that the acid possesses considerable cholagogue power. Nitrohydrochloric acid is therefore a standard remedy for the treatment of oxaluria and the various above-named diseases of the liver. The medicine can be introduced into the system either by baths or by swallowing. For a bath the acid should be diluted in the proportion of 8 gm. of the acid to a litre of water (one fluidounce to the gallon), and the bath taken in a *wooden* tub. Such baths should be about blood-warm, and should be administered daily, or twice a week, according to indications. The duration of the bath will range from ten to thirty minutes, or until a tingling or pricking sensation is experienced. After removal from the bath the skin of the bather should be wiped very dry. Instead of a general bath, a foot bath or a sponging with a dilution of the acid of the strength already given may be substituted. These external applications are undoubtedly efficient, and an occasionally developed salivation proves beyond question the absorption of the acid when administered in this way. For internal giving the dose is a very few drops—from three to five—diluted, at the time of taking only, with a wineglassful or so of water, and the draught sucked through a glass tube, with subsequent thorough rinsing of the mouth. For prescription internally there is also in the United States Pharmacopœia an official preparation entitled *Acidum Nitrohydrochloricum Dilutum*, Diluted Nitrohydrochloric Acid, consisting of freshly made nitrohydrochloric acid diluted, after making, with nearly four times its measure of distilled water. The preparation is a colorless or faintly yellow liquid, odorless, or having a slight odor of chlorine, and a very acid taste and reaction. By heat it is wholly volatilized. This dilute acid is, medicinally, objectionable, because the mere fact of dilution tends to favor the conversion of the free chlorine of nitrohydrochloric acid into hydrochloric acid. As actually dispensed and used, this preparation is, therefore, much more likely to be a mere mixture of nitric and hydrochloric acids than the specific chlorine-containing compound represented by a freshly made sample of the strong acid. The dose of the dilute acid may range as high as twenty drops, to be taken in the same manner as a dose of the strong acid. *Edward Curtis.*

NOBSCOT MOUNTAIN SPRING.—Middlesex County, Massachusetts.

POST-OFFICE.—Framingham.

ACCESS viâ Northern Division of Old Colony Railroad or Southern Division of Boston and Maine Railroad to station, one and one-half miles distant from the spring.

The spring is located five miles from Framingham, at the base of Nobscot Mountain, the highest point in Middlesex County, and comes through crevices in what appears otherwise to be a solid ledge of rock. The water has a uniform temperature of 41° F., and an average flow, summer and winter, of fourteen thousand gallons per day. The surrounding watershed is a heavily wooded glacial moraine, free from human habitations of any description. Several sanitary analyses have shown the water to be thoroughly pure and wholesome. The following mineral analysis was made in 1891 by Davenport and Williams, of Boston:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Organic and volatile matter	0.64
Silica	.53
Iron oxide and alumina	.02
Lime carbonate	.75
Magnesium carbonate	.23
Sodium chloride	.36
Sodium carbonate	.38
Potassium sulphate	.30
Total	3.21

There is no hotel on the spring property. The water is shipped in glass packages and supplied to the markets of numerous New England towns and cities. The sales in 1896 amounted to slightly more than six hundred thousand gallons. *James K. Crook.*

NODOSITAS CRINIUM. See *Atrophia Pilorum Propria.*

NODOSITIES, NON-ERYTHEMATOUS, OF ARTHRITIC PATIENTS.—Though known for a long time without any particular attention being paid them, these curious formations have been more specially observed since Barlow and Warner made a careful study of them a few years back. They were followed by several French observers, more particularly Brocq of Paris, who elaborated them into two varieties—a merely clinical distinction, both forms being made up of round and spindle-shaped cells. They are more common in children than in adults. They may be considered as affording positive evidence of rheumatism, though they do not necessarily appear during the fever but may develop on its decline, or even altogether independently of any acute attack. (Osler.) Often their appearance is coincident with the development of symptoms of pericarditis, sometimes of pleurisy, but especially of severe chronic rheumatic endocarditis.

The first variety, which Brocq calls *ephemeral cutaneous nodosities*, is confined entirely to the forehead, occurring there as ill-defined prominences in and movable with the skin, although they are sometimes adherent to the peri-

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osteum. They are entirely painless always, and there is no change of color in the overlying integument. They are never very numerous, rarely more than two or three, sometimes only one, being discovered. They vary in size from a small shot to a pea, and their ephemeral nature constitutes their chief characteristic. Appearing toward the end of the day or during the night (Féréol) without any subjective symptoms whatever, they last but a day at most, and disappear, leaving no traces, to spring forth again, without known cause, in a new place on the forehead.

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The second variety (*rheumatic subcutaneous nodules*), by far the more common and better known, differs from the first form in that the tumors are subcutaneous and are more stationary. The overlying integument, unchanged in color, moves freely over them and they strongly resemble syphilitic exostoses or gummata. To the touch they are firm and elastic, freely movable upon the underlying structures. At times, however, this fact may be demonstrable only with attention, when, for instance, the tumors occur over bone, as in the scalp, where they give the impression at first of being exostoses. They are sometimes tender on pressure, seldom spontaneously painful. In size they vary from a pea to a filbert and are sharply defined. Coming in successive crops without premonition they increase slowly, sometimes quite rapidly, in volume to their maximum, remain stationary for a variable length of time—amounting frequently to weeks or months,—then disappear, leaving no trace of their existence. Their favorite locations are the periarticular regions—elbows, knees, wrists, and joints of the fingers. They occur also superficially along the long bones, over the spines of the vertebræ and scapulæ, over the iliac crests, and frequently over the frontal and occipital bones, these last two being particularly favorite sites. The nodules, which as a rule are separate and distinct from one another, although in rare cases they may be confluent, occur at times in large numbers; more particularly in adults.

They are to be distinguished from the swellings of erythema nodosum by the absence of color and from other cutaneous and subcutaneous tumors by their own peculiar evolution.

Treatment should be directed toward the underlying rheumatic diathesis. *Charles Townshend Dade.*

NOMA. See *Mouth, Diseases of*, in The Appendix.

NORTH HAVEN POOL.—New Haven County, Connecticut. The waters of this pool have had a local reputation for more than one hundred years, and it is said that Dr. Trumbull, the historian of Connecticut, was in the habit of accommodating boarders who came to avail themselves of their medicinal effects. According to an analysis by Prof. S. W. Johnson, the following ingredients are found:

Sodium sulphate.	Ferrous carbonate.
Sodium chloride.	Silicic oxide
Potassium sulphate.	Alumina } Traces.
Calcium sulphate.	Ammonia } Traces.
Calcium carbonate.	Phosphoric acid } Traces.
Magnesium carbonate.	

The iron is present in sufficient quantities to give the waters useful tonic properties. They are said to be of decided value in chronic skin affections. The waters are bottled and sold in one-, two-, and four-gallon jugs.

James K. Crook.

NOSE, INJURIES OF THE.—Injuries of the nose may be caused by firearms or by sharp or blunt instruments. Falls upon the nose and blows with the fist are by far the commonest causes of traumatism. The various lesions which may be produced are: damage to the soft parts, ecchymosis, hemorrhage, emphysema, obstruction to the tear duct, dislocation and fracture, and a variety of deformities resulting therefrom.

The soft parts of the nose, like those of the rest of the face, are abundantly supplied with blood-vessels, and therefore heal readily; hence ragged wounds should be carefully sutured and no tissue cut away even though it is badly lacerated, since its vitality will usually be preserved. Swelling may be limited, if the patient is seen early, by very hot or very cold applications. Later, mild antiseptic lotions, such as a solution of boracic acid, if applied upon a thin layer of gauze so as to facilitate rapid evaporation, will be found most grateful to the patient. At a later stage the wounds may be covered with a dry dressing, such as one of cotton and collodion. Suppuration, on account of the free blood supply, is usually superficial and easily controlled. The skin of the nose is, however, a favorite starting-point for facial erysipelas, for the treatment of which see article on *Erysipelas*. Deeper suppuration should be promptly treated by free incision and drainage on account of the risk of its extending to the cranial cavity.

If the tip of the nose is lost, or the damage to some other portion of it is so great that disfigurement results, a plastic operation will have to be undertaken at a later date to repair the deformity. (See article on *Reparative Surgery*.)

Injuries to the nose, like those to the eye, often give rise to an ecchymosis which is very annoying to the patient. Hot applications and a firm bandage, if applied sufficiently early, may prevent the spread of blood subcutaneously. Later, the discolored skin can be painted so as to be less noticeable. The ecchymosis will begin to fade out in the course of five days or a week.

Hemorrhage from the external parts of the nose is easily controlled. That from the anterior or posterior nares, either with or without accompanying fracture, may be more alarming. It is sometimes kept up by the position of the patient, who, for the sake of convenience, may lean forward over a wash bowl so as to permit the blood to flow out through the anterior nares. Such a position, by producing congestion of the face, tends to keep up the flow of blood. Ice applied to the nose or placed on the back of the neck is sometimes of service in stopping hemorrhage. If the flow of blood is really serious one should not trust to such means, but should attempt to check the blood by pressure directly upon the wounded vessel, or by styptics. Hemorrhage, both that which occurs spontaneously and which has received the name of epistaxis, and that which follows an injury to the nose, usually comes from the septum. If, therefore, the anterior nares be examined by reflected light the bleeding point will usually be discovered. It may be touched with the point of the galvanocautery or with some caustic or astringent preparation, by far the best one being a dilute solution of suprarenal extract which may be applied, after the nostril has been cleansed, either upon a swab of cotton or in the form of a nasal douche or a nasal spray. This remedy is so efficacious that it will rarely be necessary to plug the nostrils with gauze for the purpose of stopping the hemorrhage. When gauze is used, it should be inserted in narrow strips under the guidance of the eye until sufficient pressure is obtained. At the end of from twenty-four to forty-eight hours it should be removed, after thorough moistening, in order to detach it, and the nares should be cleansed by antiseptic irrigation. The old habit of stuffing the nostrils full of sponges or cotton and leaving them undisturbed for several days is absolutely indefensible in view of the modern methods of controlling hemorrhage. (See also article on *Hemorrhage*.)

Emphysema is a complication due to the patient's attempt to cleanse his nostrils by violent blowing. Air is forced through the ruptured mucous membrane and fractured bony framework into the subcutaneous tissue. This complication distorts the visage, but is in no wise a serious one, and the emphysema will speedily disappear of itself as soon as the cause ceases to act. The patient whose nose has been broken should be cautioned against blowing his nose, an act which may also set up hemorrhage and spread infection, as well as cause emphysema.

Obstruction to the tear duct may follow nasal injuries, being usually the result of swelling. It requires no

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treatment and will disappear of itself when the swelling subsides.

Fracture and Dislocation.—The solid framework of the nose may be broken or dislocated. It is made up of the vomer and the perpendicular plate of the ethmoid, to which are attached the nasal bones and the quadrilateral cartilage. These structures may be broken in a variety of ways which it is unnecessary to specify, since there are general principles of treatment which should be followed in the case of every fracture or dislocation associated with deformity. Many fractures are compound internally; hence the necessity for perfect cleanliness, to be secured by antiseptic irrigation. Gentle external manipulation will often elicit crepitus and abnormal motion, while examination of the anterior nares will reveal the presence of existing deformity. Such examination is very important, for the future well-being of the patient depends far more upon a free nasal passage than it does upon the correction of external deformity. Internal deformity usually consists of a deviation of the septum so decided as partially to obstruct one or both nostrils. The quadrilateral cartilage may be loosened and rotated upon its articulation with the vomer. A moderate twist of this sort will greatly obstruct both nasal passages. Whatever the deformity, it should be forthwith overcome and the bones kept in a correct position for a few days until they have begun to unite. Instruments for this purpose should be smooth, strong, and not too large. A small periosteal elevator is a suitable instrument with which to raise the depressed bridge of the nose. The septum may be straightened by sequestrum forceps whose blades are protected by short sections of rubber tubing. There are, of course, special instruments for these purposes. It is necessary that the displaced fragments be thoroughly reduced; indeed, over-reduction is generally desirable. When this is accomplished, there is little tendency for a reproduction of the deformity, so that a retaining apparatus is not usually needed. A number of internal and external splints have been devised. Gauze packing carefully applied answers satisfactorily if only one nostril needs to be filled; if the deformity is such that pressure is required in both nostrils, rubber tubes moulded to fit the nostrils are far more comfortable. Various splints have been devised to keep up external pressure upon the nose. The most successful consists of a firm band or plate strapped across the forehead from which by means of a second band or rod pressure can be exerted upon the nose. The direction of the pressure can be regulated by screws or by bending a stiff wire. In some fractures a pin thrust through the nose from side to side will keep the bones in position better than any splints. Such a pin may be withdrawn at the end of four or five days.

Deviation of the septum may also be overcome by two pins passed in the sagittal plane of the body and crossing one another. This is a method of treatment more often used to correct old deformities than fresh ones. (Fig. 3591.)

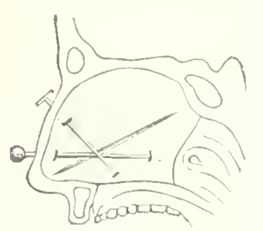

FIG. 3591.—Method of Pinning the Nasal Septum. (Roberts.)

Fracture of the nose is not of itself a serious injury. When the broken bones are replaced they will unite with great rapidity, so that the cure will be complete in from two to four weeks. If the fracture extends upward so as to involve the cribriform plate the patient is exposed to the risk of septic meningitis. Such an injury is really a fracture of the base of the skull, and should be treated as such from the first if the diagnosis can be made. (See article on *Head, Wounds of.*)

Deformity following Injury.—If a fracture or dislocation of the nose is left untreated, or if the surgeon merely pays attention to external appearances and does not correct deviations of the septum, partial obstruction of one or both nares may result. In many cases it is possible to correct such a deformity under a general anæsthetic by forcibly loosening or refracturing the deformed bones with a strong pair of forceps and moulding the nose into the proper shape. Deviations of the septum may require incision or a punching out of certain portions to facilitate complete reduction. (Consult also the article on "*Nasal Cavities, Diseases of: Congenital and Acquired Deformities.*") If the bridge of the nose cannot be lifted, a platinum, or, better, a celluloid support may be inserted underneath the skin and allowed to cicatrize there, thus forming an artificial nasal bridge; which, if it is properly shaped, is not to be told from a natural one. The details of these operations are given in the article on *Reparative Surgery.* *Edward Milton Foote.*

NOSOPHEN — tetra-iodo-phenolphthalein $(C_6H_2I_2OH)_2CO\cdot C_6H_4CO$—is obtained by the action of iodine on phenolphthalein, and is a fine yellowish, odorless, and tasteless powder, insoluble in water and acids, and soluble with difficulty in alcohol, ether, and chloroform. It contains 61.7 per cent. of iodine and may be heated to 220° C. (428° F.) without decomposition. It forms soluble salts with alkalies and insoluble salts with the heavy metals.

Antinosin, the sodium salt of nosophen, is a dark blue amorphous powder, which is freely soluble in water and alcohol.

Eudoxin, the bismuth salt of nosophen, contains 52.9 per cent. of iodine and 14.5 per cent. of bismuth, and is used internally as a gastric and intestinal antiseptic. Dose, 0.2–0.5 gm. (gr. iij.–viij.), or for an infant 0.06 gm. (gr. i.) or less.

Nosophen is a non-irritant iodoform substitute which does not liberate iodine. It is an impalpable powder, of use not only as an antiseptic but also for drying up wound secretions. It forms crusts, however, which must be lifted to allow the escape of the underlying secretions.

Caldwell treats ulcers with nosophen in powder or ten-per-cent. ointment, or with a fifty-per-cent. solution of antinosin. Steele uses three-per-cent. nosophen gauze for the treatment of wounds, abscesses, ulcers, etc., and as intra-uterine packing after curetting. Owing to its freedom from odor, it meets with much favor in nasal cases. E. Klebs uses 0.1-per-cent. solutions of antinosin for mouth and nares, and administers the same solution internally as an antiseptic in dose of 12–24 c.c. (ʒ iij.–vi.). Nosophen has been used in capsule as an intestinal antiseptic, and Millener employed it with success in combination with antinosin in thirty-six cases of chronic suppurative otitis media. The antinosin was instilled into the ear in two- or three-per-cent. solution, and the nosophen dusted into the canal. Antinosin in two-per-cent. solution is also used for bladder irrigations. *W. A. Bastedo.*

NOTIFICATION OF INFECTIOUS DISEASES.—Among the different measures employed by sanitary authorities for the prevention of the spread of infectious diseases, the notification of the occurrence of such diseases now occupies a prominent place. Municipal authorities especially should have the requisite power everywhere to require immediate notice to be given them of every fresh outbreak of diseases dangerous to the public health in order that such authority may take proper measures for the protection of the community.

The chief advantages of a system of notification lie in the possibility which is thus given to a local board of health to determine the extent of prevalence of an epidemic or a localized outbreak, and to inquire into the local causes which have operated to produce it. The board can then act intelligently in applying the proper remedies for preventing its further spread.

Laws enacted with this object in view have been in force in the older States for many years, but not until within the past ten or twenty years have pains been taken to execute such statutes with such degree of efficiency as to make them really protective. The law requiring the householder to report each case of dangerous

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disease to the local authority was enacted in Massachusetts in 1792, and that which requires the same duty on the part of the attending physician was enacted in 1827. Little attention, however, had been paid to the enforcement of these laws until toward the end of the 19th century.

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Various attempts have been made in England to enact a similar statute, but these efforts were unsuccessful until 1889. By the terms of the law then enacted the notification of infectious diseases to the sanitary authority was made compulsory throughout London, while the principle of local option was applied to all other districts.

During the year in which this bill was under consideration by Parliament, intense opposition had been manifested by many of the members of the medical profession throughout England. Objections were offered not only by the people but also by the medical profession, but the bill passed and finally became a law.

The fallacy of the objections has been abundantly proven by the experience of the towns of England where the Notification Act has been adopted. The notification of each case is made by a certificate furnished by the attending physician, for which a fee of two shillings and sixpence is paid, except in a case in which the person giving the certificate is the medical officer of a public institution, when the fee is one shilling.

The diseases to which this act applies are smallpox, cholera, diphtheria, membranous croup, erysipelas, scarlet fever, typhus, typhoid, and puerperal fever, and any other infectious disease which may be added to this list by the sanitary authority of a district.

In 1899 the provisions of the act had been adopted in cities and towns containing more than twenty-eight millions of inhabitants out of a total of about thirty millions, and in that year, by the enactment of a new statute (62 and 63 Victoria, chap. viii.) the law became compulsory throughout the whole kingdom.

There can be no doubt that the law relative to notification has been productive of excellent results in the prevention of disease, especially in the cities and large towns. It has furnished local boards of health with the necessary information relative to the origin of outbreaks of infectious disease, and in many instances has enabled them to take timely steps for preventing its further spread.

In compiling certain data for the Paris Exposition of 1900 the writer collected the statistics of six registration States and nineteen cities outside of those States, including the ten largest cities of the Union, with the following result. The figures are mainly for the years 1891-98:

Diseases.	Reported cases.	Registered deaths.	Fatality, per cent.
Smallpox	9,222	2,385	25.8
Typhoid fever	69,758	13,284	19.0
Diphtheria and croup	195,783	44,411	22.7
Scarlet fever	127,847	9,211	7.2
Measles	217,755	6,424	2.8
Total	619,765	75,715	....

These results agree fairly well with those of the English local government board for the eight years 1890-97, which showed a fatality for typhoid fever of 18.05 per cent., for diphtheria of 23 per cent., and for scarlet fever of 4.9 per cent.

Another advantage of the practice of notification in recent years consists in the exact data which it furnishes relating to improved methods of treating disease, and the consequent saving of human life. In the thirty-third annual report of the State Board of Health of Massachusetts for 1901 it appears that the notified cases of diphtheria in the pre-antitoxin period, 1891-94, in reporting cities and towns were 13,332, and the deaths in the same places and time were 3,768, making a fatality of 28.3 per cent., while in the following seven years, 1895-1901, after the introduction of antitoxin the cases were 56,459 and the deaths 7,416, a fatality of only 13.1 per cent. The fatality of diphtheria in 1901 was only 10.5 per cent. (see also *Disease, Fatality of*). *Samuel W. Abbott.*

NOTOCHORD.—The notochord (*chorda dorsalis, Wirbelsaite*) is a rod of peculiar tissue, constituting the primitive axial skeleton of vertebrates. It begins immediately behind the pituitary body (hypophysis) and extends to

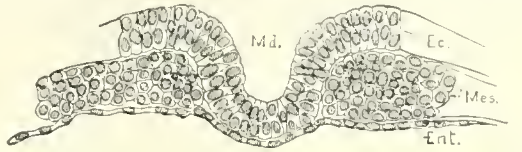

FIG. 3592.—Transverse Section of a Young Mole's Embryo. (After Heape.) *Ec.*, Ectoderm; *Md.*, medullary groove; *Mes.*, mesoderm; *Ent.*, entoderm. Site of the notochord is the central line of the entoderm.

the caudal extremity. It occurs as a permanent structure in the lower types, and as a temporary one in the embryos of amphibia and amniota, including man. Comparative embryology has shown that it is a greatly modified epithelial tube, which arises as a furrow in the median dorsal line of the entoderm, being, in position and mode of development, analogous to the ectodermal medullary canal or primitive tubular nervous system.[5]

DEVELOPMENT IN MAMMALS.—The notochord appears very early in the course of development; its differentiation from the entoderm begins at the time when the medullary groove is not fully marked out posteriorly, and is nowhere closed. The notochordal *Anlage* can be first detected in the entoderm just at the front of the primitive streak, as an axial band of cells, which at first in mammals is not well marked off from the mesoderm; as the medullary groove deepens it pushes down toward the midgut until it comes into actual contact with the notochordal epithelial band (see Fig. 3592), thus dividing the mesoderm into two lateral masses; this also leads to the temporary transverse stretching of the notochordal band, which thereby loses for a while its sharp demarcation. It soon re-acquires it, and becomes considerably thicker (Fig. 3593, *nch*) than the adjoining entoderm, and forms a distinct though shallow groove. Subsequently the band separates off, and the entoderm proper closes across under it so that the notochordal band lies between the entoderm and the floor of the medullary groove (or later canal), as shown in Figs. 3598 and 3604, *nch.* This separation does not take place at the anterior extremity of the chorda until somewhat later, so that for a considerable period its front end remains fused with the walls of the midgut (Fig. 3598). The separation from the entoderm is effected, at least in mammals, by the entoderm proper, showing itself under the notochord toward the

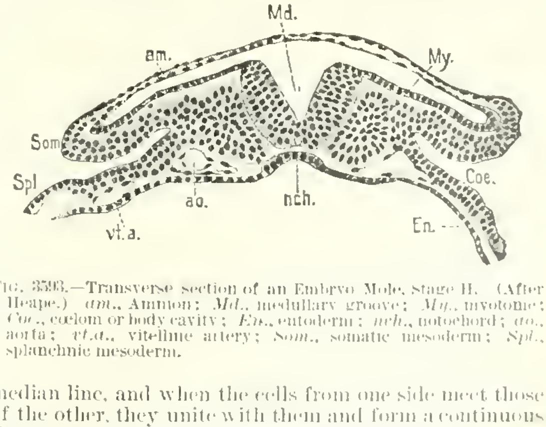

FIG. 3593.—Transverse section of an Embryo Mole, Stage H. (After Heape.) *am.*, Amnion; *Md.*, medullary groove; *My.*, myotome; *Coe.*, cœlom or body cavity; *En.*, entoderm; *nch.*, notochord; *ao.*, aorta; *vt.a.*, vitelline artery; *Som.*, somatic mesoderm; *Spl.*, splanchnic mesoderm.

median line, and when the cells from one side meet those of the other, they unite with them and form a continuous sheet of entoderm below the notochordal cells.

The chorda is now a narrow band of cells, starting anteriorly from the wall of the alimentary tract and run-

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ning backward to the blastoporic canal or its equivalent, the primitive streak; but, at the period when the canal is open, the chorda terminates in the entodermic epithelium lining the canal (Heape,[9] Pl. xxi., Fig. 50; compare

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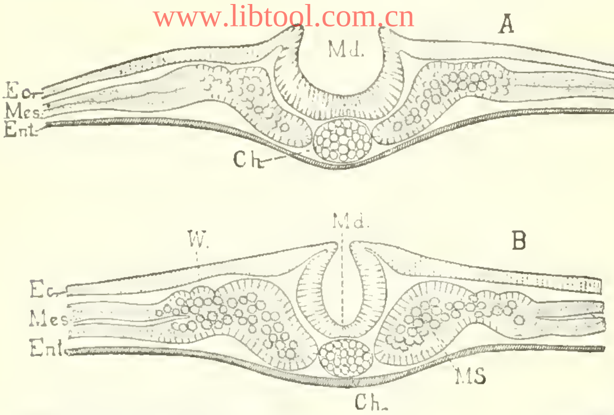

FIG. 3594.—Transverse Sections of an Embryo Chick, with Eleven Pairs of Myotomes. (After Waldeyer.) *A*, Some distance behind the last myotome; *B*, close behind the last myotome; *Ec.*, ectoderm; *Mes.*, mesoderm; *Ent.*, entoderm; *Md.*, medullary groove; *Ch.*, notochord; *W.*, commencement of the Wolffian duct; *MS.*, muscular segment or myotomes.

also Vol. II., Fig. 505, *C*). The canal remains open for a time, and is called by some writers on mammalian embryology the chorda canal (*cf. infra*). For a certain period the chorda continues growing tailward by accretions of cells from the walls of the blastoporic passage,

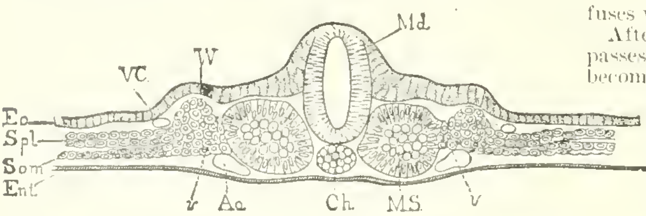

FIG. 3595.—Transverse Section of a Chick Embryo of the Second Day. (After Waldeyer.) *Som.*, The somatic mesoderm, and *Spl.*, the splanchnic mesoderm; *Ec.*, ectoderm; *Ent.*, entoderm; *V.C.*, vein; *W.*, Wolffian duct; *Md.*, medullary canal; *Ao.*, aorta; *Ch.*, notochord; *MS.*, myotome.

and after the canal is permanently obliterated the chorda may still continue its lengthening by acquisitions, at its caudal end, of additional cells from the primitive streak; such cells may, however, properly be regarded as coming from the entodermic lining of the blastopore. We can, then, distinguish three portions of the notochord: the first arising from the entoderm of the midgut; the second from the entoderm of the blastoporic canal; the third presumably from the entoderm of the obliterated blastopore in the primitive streak. Braun and others have sought to attribute essential importance to these differences, but, it seems to me, improperly. It is more reasonable to say that the chorda arises in the amniota, as in the lower forms, directly from the entoderm, but presents certain secondary modifications in its development.

Lieberkühn has directed attention to a special peculiarity in the early development of the notochord in mammals. There appears at first a passage—half canal, half furrow—which extends nearly the whole length of the primitive streak; it may be described as a tube running along the median line, and having an irregular series of openings into the entodermic cavity. The canal is lined by epithelium, which is thickened on the dorsal side to form the *Anlage* of the notochord. In transverse section the chorda appears according to the level of the section to constitute part of a furrow or a canal (compare also Heape,[9] *loc. cit.*, p. 441, Figs. 40 and 41). Lieberkühn calls this canal mesoblastic, and Kölliker follows him; but this opinion seems to me based upon misconceptions. It is more reasonable to suppose that the canal is really the blastoporic canal, which is preserved for an unusually long period. We know that the blastopore first appears well forward, and as the primitive streak grows by concrescence of the ectental line the blastopore moves backward, its anterior portion fusing with the general entodermic cavity. There is no difficulty apparent in assuming that such fusion occurs quite late in mammals; this interpretation is confirmed by the fact that the canal becomes later a furrow throughout its entire length in

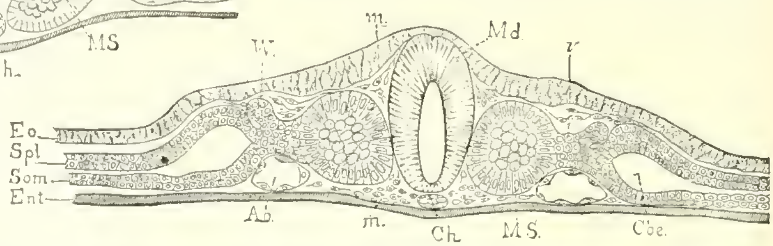

FIG. 3596.—Section of a Chicken Embryo of about Thirty-six Hours. (After Waldeyer.) *Ec.*, Ectoderm; *Som.*, mesoderm of the somatopleure; *Spl.*, mesoderm of splanchnopleure; *Ent.*, entoderm; *W.*, Wolffian duct; *m*, mesoderm cells; *Md.*, medullary canal; *v*, vein; *Coe.*, cœlom; *MS.*, myotome; *Ch*, notochord; *Ao.*, aorta.

front of the blastoporic canal proper, so that its cavity fuses with that of the entoderm proper.

After it is once formed as a band of cells the notochord passes through various changes of form, but ultimately becomes a cylindrical rod with tapering extremities. It attains considerable size in the embryos of most vertebrates, but in those of placental mammals is always small, particularly so in the mole (Heape[10]). It is probable that in mammals the notochord, when first separated from the entoderm, is a broad, flat band, as if compressed be-

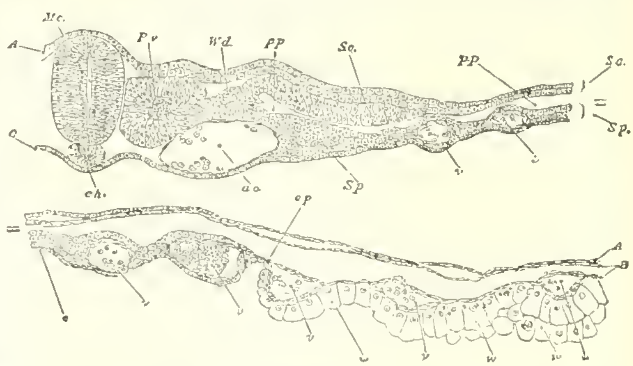

FIG. 3597.—Section through the Dorsal Region of a Chicken Embryo of Forty-five Hours. *A*, Ectoderm; *c*, entoderm; *Mc.*, medullary canal; *P.v*, myotomes; *W.d*, Wolffian duct; *p.p.*, pleuro-peritoneal space or cœlom; *So.*, somatopleure; *v*, *v*, blood-vessels; *Sp.*, splanchnopleure; *op*, inner edge of the area opaca; *w*, *w*, *w*, entoderm of the area opaca; *ao*, aorta; *ch*, notochord. (After Balfour and Sedgwick.)

tween the medullary canal and entoderm (*cf.* Kölliker, *loc. cit.*, Figs. 194 to 197, and *loc. cit.*, Fig. 94; also Heape,[10] Pl. XIII., Figs. 36 to 42). The band then draws together, diminishing the transverse and increas-

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ing the vertical diameter, until it has acquired a rounded form; finally its outline becomes circular in cross section.

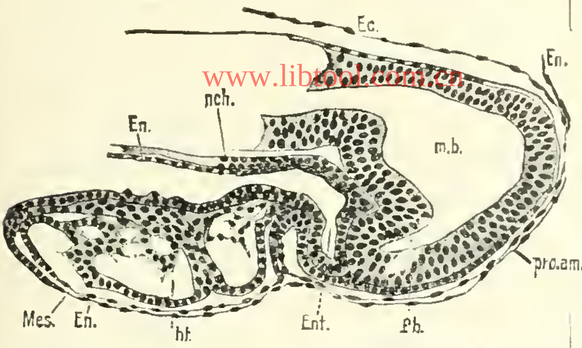

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FIG. 3598.—Longitudinal Section of the Head End of a Mole Embryo, Stage H. (After Heape.) *Ec.*, Ectoderm; *En.*, entoderm; *pro.am.*, pro-amnion; *mb.*, mid-brain; *fb.*, fore-brain; *Ent.*, entodermic cavity; *ht.*, heart; *Mes.*, mesoderm; *nch.*, notochord.

This series of changes begins near the anterior end of the chorda, and progresses both forward and backward.

The mesoderm early grows in between the entoderm and the notochord, which, however, for a considerable time remains close to the medullary tube (Fig. 3600). Later the mesoderm penetrates between the notochord and medulla. The layer of mesodermic cells immediately around the notochord, which are of the well-known anastomosing type (Fig. 3601), forms a special sheath, which at first comprises only a single layer of cells, at least in batrachia (Götte,[6] p. 357, Fig. 187). This is the commencement of the so-called outer chorda sheath; it subsequently becomes much thicker. In the lower types it is an important axial structure (Fig. 3602, *s*); in most cases it is replaced by cartilage, and in all the amniota the cartilage is replaced by the osseous vertebræ, the invertebral ligaments, etc. The formation of the vertebral column involves the disappearance of the notochord as described below.

HISTOGENESIS.—After the notochord has been formed as a rod of cells, its cells undergo a process of histological differentiation unique in vertebrates. The cells at first become greatly compressed in the line of length of the chorda; and hence appear quite thin in longitudinal sections (Fig. 3603, A, *nch.*)—hardly greater in diameter than their own nuclei. Thus, in the chick, by the third day some of the central cells become vacuolated, while the peripheral cells are still normal; at first, as in the frog, there seems to be only one large vacuole in each cell (Fig. 3603, B). Around the vacuole is a peripheral layer of granular protoplasm, in which the nucleus lies embedded, while the vacuoles themselves are filled with a perfectly clear and transparent material, which is supposed to be fluid in its natural condition. During the fourth day (chick) all the cells become vacuolated, with the exception of a single layer of flattened cells at the periphery. In the anura, it is said, there is no distinct peripheral layer of protoplasmic cells. The vacuoles go on enlarging until by the sixth day they have so much increased at the expense of the protoplasm that only a very thin layer of the latter is left at the circumference of the cell; at one part of which, where there is generally more protoplasm than elsewhere, the remains of a nucleus may generally be detected. Thus the notochord becomes transformed into a spongy reticulum, the meshes of which correspond to the vacuoles of the cells and the septa to the remains of their cell walls (Foster and Balfour). As Götte has pointed out, the process is accompanied by an expansion of the cells, which is the main factor in the widening and lengthening of the notochord, which goes on *pari passu* with the growth of the surrounding tissue.

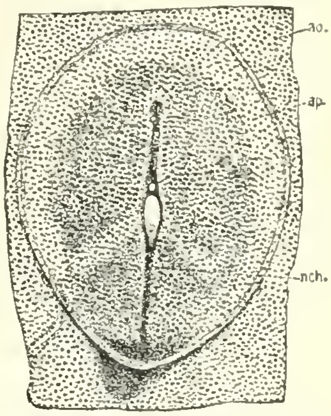

FIG. 3599.—Germinal Area of a Guinea-pig at Thirteen Days and Twenty Hours. (After Lieberkühn.) *ao.*, Area opaca; *ap.*, area pellucida; *nch.*, *Anlage* of the notochord as a canal with several irregular openings on the entodermic side. × 24 diameters.

The histogenetic process is stated to be essentially similar in mammals (W. Müller, 337–338). There is the central layer of vacuolated cells and the peripheral layer of protoplasmic cells. The latter are, however, ultimately converted into vacuolated

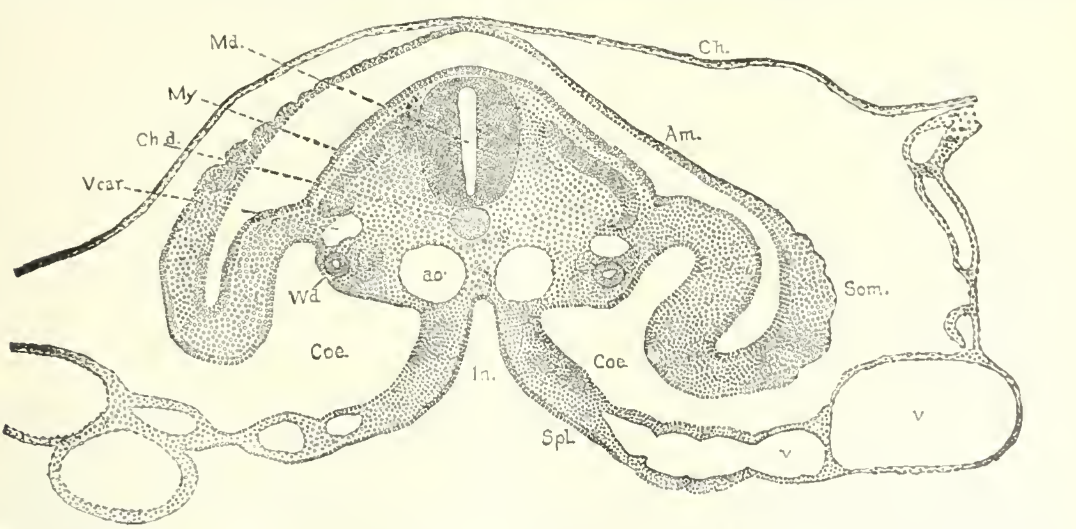

FIG. 3600.—Section through the Rump of an Embryo Chick of the Third Day. *Ch.*, Chorion; *Am.*, amnion; *Som.*, somatopleure; *v, v, v*, blood-vessels; *Coe.*, cœlom; *Spl.*, splanchnopleure; *In.*, intestine; *ao.*, caudal branch of the aorta; *Wd.*, Wolffian duct; *Vcar.*, vena cardinalis; *Ch.d.*, chorda dorsalis; *My.*, myotome; *Md.*, medullary canal.

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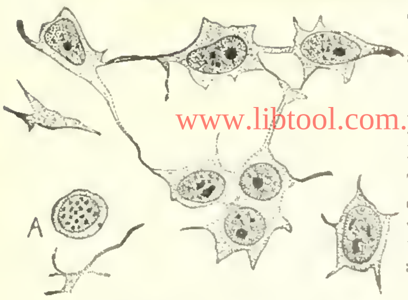

FIG. 3601.—Mesoderm of Chick of the Third Day, from close to the Otocyst. *A*, Nucleus with the chromatin loops seen in optic section, being in karyokinesis.

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cells. The cell walls are perforate, having fine pores, that correspond probably to intercellular bridges of protoplasm. The inner chorda sheath appears early and is to be regarded as an anhistic basement membrane secreted by the notochordal cells.

SHAPE AND RELATIONS TO OTHER PARTS.—As soon as the head bend (first cerebral flexure) appears (Fig. 3604) the notochord becomes correspondingly bent, and its anterior extremity lies close to Rathke's pocket (Fig. 3604, *hy.*)—the evagination of the oral epithelium, which is destined to form the pituitary body or *hypophysis cerebri*. The notochord never extends farther forward than this, hence the skull and head may be divided into two parts, the præ-pituitary and the post-pituitary regions. The latter region alone contains the notochord. Romiti finds that in the chick the end of the notochord is united, at the end of the fourth and during the fifth day of incubation, with an irregular solid cord of cells, which grows out from the epithelium of the hypophysis. The cord soon disappears. Its significance is quite unknown. Romiti suggests that it may produce a strain resulting in the pulling out of the hypophyseal evagination. This notion seems to me untenable. The cranial portion of the notochord has not only the bend shown in Fig. 3604, but also follows the other curves of the head; it takes a sinuous course besides within the base of the cranium; finally, in the region corresponding to the middle third of the spheno-occipital cartilage, it makes a great dip ventralward. The sheath of the notochord in the cranial region is converted into the spheno-occipital cartilage; at the dip just mentioned, however, the notochord lies entirely below the cartilage, close against the wall of the pharynx (Froriep, Romiti). Writers before Froriep had represented the chorda as having disappeared at the bottom of the dip.

DISAPPEARANCE.—The disappearance of the notochord in man commences with the second month of fetal life. The first step is an alteration of the characteristic histological structure, accompanied by shrinking of the tissues, so that a clear space appears around it (see Fig. 3605). The inner chorda sheath is lost. The cell walls disappear, the tissue becomes granular, and breaks up into multinucleate, irregularly reticulate masses (Fig. 3606), which are gradually resorbed (Leboucq). In mammals the resorption progresses more rapidly in the cores of the vertebræ than in the intervertebral spaces, and again more rapidly at the ends than in the centre of each vertebra; hence the chorda persists a little longer in the centre of the vertebra, and considerably longer in the intervertebral spaces; in these last the final remnants of the chorda may be detected in man even after birth. The cavity between the vertebral cartilages is a new structure, and is not the space left by the notochord, as has been sometimes asserted. It appears, however, that the resorption of the chorda may leave a small space, which becomes included in the intervertebral cavity. A peculiar feature is the frequent persistence of calcified cartilage immediately around the notochord in ossifying vertebræ.

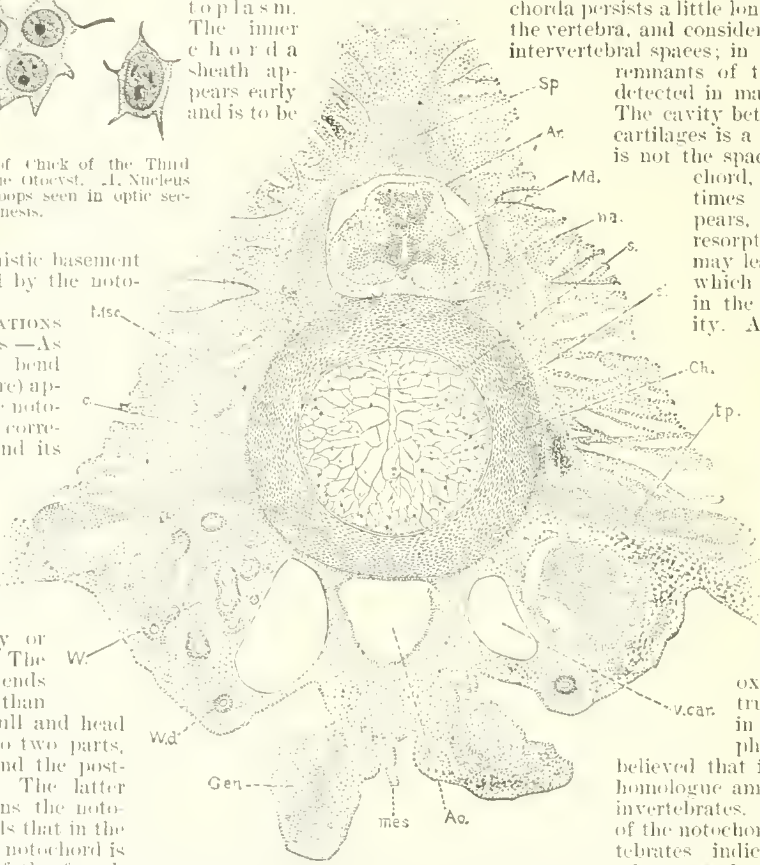

FIG. 3602. Transverse Section of an Advanced Embryo of a Shark, *Scymnus lichia*, through the Abdominal Region. (The dots represent nuclei.) *Sp*, spinal process of the vertebra; *Ar.*, arachnoid space; *Md.*, spinal cord; *n.a.*, neural arches of the vertebra; *s.*, inner sheath of the notochord; *s'.*, outer sheath of the notochord; *Ch.*, notochord; *t.p.*, transverse process of the vertebra; *v.car.*, cardinal vein; *Ao.*, dorsal aorta; *mes.* mesentery; *Gen.*, genital fold; *W.d.* Wolffian duct; *W.*, Wolffian body with tubules; *c*, young cartilage; *Msc*, muscles developing.

MORPHOLOGY.—The notochord was for a long time supposed to be exclusively characteristic of vertebrates. It is now known to exist in amphioxus, which is not a true vertebrate, and in the tunicata. Morphologists have long believed that it must have some homologue among the organs of invertebrates. The development of the notochord in the lower vertebrates indicates very plainly what must have been the general character of such an homologous invertebrate organ. In certain fishes and amphibia the notochord has been ascertained to arise as a furrow along the median dorsal line of the entoderm; the furrow deepens and then closes over to form a canal separate from the entodermic canal proper; but the notochordal canal retains for a time its anterior and posterior connections with the entoderm.

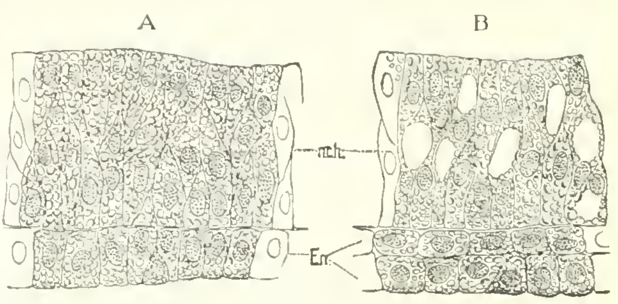

FIG. 3603.—Longitudinal Sections of the Notochord of Bombinator. (After Götte.) *A*, Before the appearance of the vacuoles; *B*, after the appearance of the vacuoles; *nch.*, notochord; *En.*, entoderm. (The cells, as is usual in amphibian embryos, are charged with yolk granules.)

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Ultimately the lumen is obliterated, the ends become detached, and so arises the solid isolated chorda. In the higher vertebrates the course of development is similar, although several of the primitive features in the formation of the chorda are obscured. Ehlers[3] has pointed out that in various invertebrates there is a similar canal, the "Nebendarm" of German writers, which is derived from the entoderm and connected anteriorly and posteriorly with the entodermal cavity. It is a very plausible suggestion, which homologizes the vertebrate notochord with the invertebrate "Nebendarm." Hubrecht has sought to homologize the notochord with the proboscis of

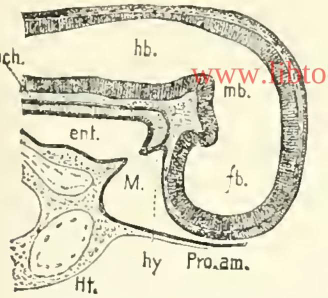

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FIG. 3604.—Rabbit Embryo of 6 mm.; Median Longitudinal Section of the Head. (After Mihalkovics.) The connection between the mouth, *M.*, and pharynx, *ent.*, is just established; *nch.*, notochord; *hb.*, hind-brain; *mb.*, mid-brain; *fb.*, fore-brain; *Pro.am.*, proamnios; *hy.*, hypophysis cerebri; *Ht.*, heart.

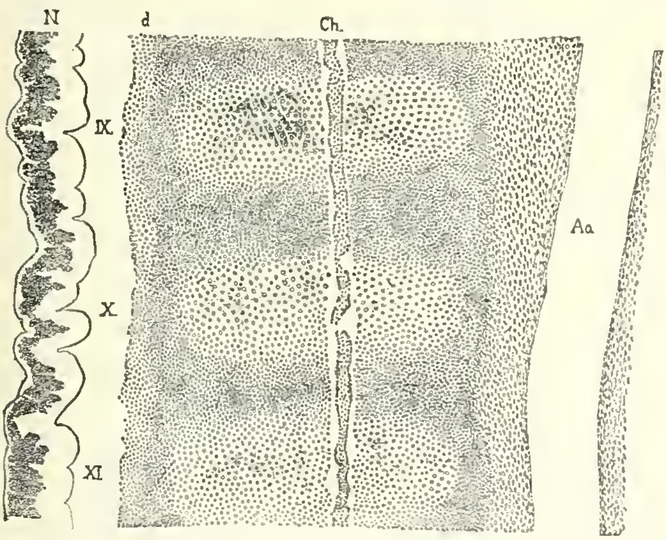

FIG. 3605.—Human Embryo of about Thirty-five Days; Longitudinal Section of the Ninth to the Eleventh Vertebræ, as numbered IX. to XI. *N*, Nervous system, wall of the spinal marrow; *d*, meningeal layer; *Ch*, notochord; *Ao*, aorta.

Nematodan worms. There is not a single fact which seems to me to justify, even remotely, this attempt at guesswork phylogeny.

LITERATURE.—Very numerous embryological articles

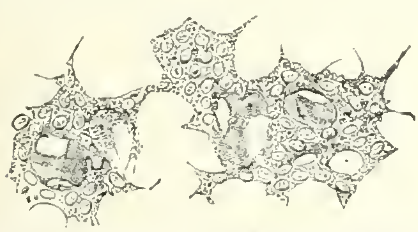

FIG. 3606.—Degenerating Notochord Tissue, from the Central Portion of the Intervertebral Disc of a Cow's Embryo. (After Lebouc.)

contain references to the chorda; below is given a list of the principal authorities. The best discussion is given by Balfour, in his "Comparative Embryology";[2] the best observations on its origin in mammals by Heape.[9, 10] For its histology see W. Müller; for its histogenesis see Götte;[6] for its anterior anatomical relations see Mihalkowics, Froriep,[4] Rabl-Rückhard, and Romiti; for its atrophy in mammals see Leboucq; for its evolution see Ehlers.[3]

Charles Sedgwick Minot.

[1] Balfour: A Monograph on the Development of Elasmobranch Fishes, London, 1878. (Reprinted Works, i., pp. 203-520.)
[2] Balfour: Comparative Embryology, vol. ii
[3] Ehlers, E.: Nebendarm und Chorda dorsalis. Nachr. Ges. Wiss., Göttingen, 1885, pp. 390-404.
[4] Froriep: Kopftheil der Chorda dorsalis bei menschlichen Embryonen, Festschrift für Henle, 1882, pp. 26-40, Taf. iii.
[5] Gegenbauer, Carl: Ueber das Skeletgewebe der Cyclostomen (Histologie der Chorda, S. 47-49). Jena Zeitschr. Nat. Wiss., v., 1869, pp. 43-53. Taf. i.
[6] Götte, Alex.: Entwickelungsgeschichte der Unke (especially pp. 349-361), Leipzig, 1875.
[7] Hasse, C., und Schwarck, W.: Studien zur vergleichenden Anatomie der Wirbelsäule, etc. Hasse's Anat. Studien, i., p. 21.
[8] Hatschek, B.: Studien zur Entwickelungsgeschichte des Amphioxus. Arbeiten Zool. Inst. Wien, iv., Heft i., Taf. xiii.
[9] Heape, Walter: The Development of the Mole (Talpa Europea); the Formation of the Germinal Layers and Early Development of the Medullary Groove and Notochord. Q. Jour. Micr. Sci., 1883, pp. 412-452. Pls. xxviii.-xxxi.
[10] Heape, W.: The Development of the Mole. Q. Jour. Micr. Sci., xxvii., pp. 123-163.
[11] Hensen: Zeitschrift f. Anat. u. Entwickelungsges., i., p. 366.
[12] His, Wilhelm: Erste Anlage des Wirbelthierleibs, 4to, Leipzig, 1868.

NOVA SCOTIA.—Nova Scotia is one of the maritime provinces of Canada to the northeast of the State of Maine, lying in latitude 43° to 46° N. and longitude 60° to 66° W. It is a long, rather narrow peninsula, with a great extent of coast line, parallel to the mainland, extending in a direction from northeast to southwest. It is 350 miles in length, including Cape Breton, and varies in breadth from 50 to 100 miles. Its area is 20,550 square miles and it has a population of 450,396. The surface is undulating and is traversed by several ranges of hills. It has a cool, marine climate, and is a favorite summer resort for visitors.

The following table, condensed from the more elaborate ones in the article on Nova Scotia in the previous edition of the HANDBOOK, conveys an idea of the summer and autumn climate of this region, the seasons when one would visit Nova Scotia as a resort. As will be seen, the mean summer temperature is about 61° F., similar to that of the British Isles at this season, the highest temperature being about 80° F. and the lowest between 43° and 46° F.

The relative humidity is high and there is considerable rain. Fogs are also not infrequent. The number of fair days is, moreover, not large for the summer.

CLIMATE OF HALIFAX.—LATITUDE, 44° 39′; LONGITUDE 63° 36′. MOSTLY FOR THE YEAR 1883 ONLY.

	June.	July.	Aug.	Sept.	Oct.	Year.
Temperature (degrees Fahr.)—						
Mean average	57.26°	63.40°	63.77°	57.56°	47.99°	42.74°
Average range	18.67	17.19	19.78	18.63	15.95	
Mean of warmest	68.82	70.85	73.26	65.66	54.23	
Mean of coldest	50.15	53.66	54.48	47.03	38.28	
Highest or maximum	80.4	81.7	81.2	76.8	73.4	
Lowest or minimum	43.2	46.7	45.6	40.5	29.0	
Humidity—						
Mean relative	85%	86	86%	83%	84%	84%
Precipitation—						
Average in inches	3.32	3.54	5.34	3.86	5.81	48.52
Wind—						
Prevailing direction	S. E. & W.	S. E.	S. W.	W., S. W.	W.	
Average hourly velocity in miles	4.51	4.88	4.88	5.78	6.97	6.75
Weather—						
Number of fair days	16	19	16	21	15	172
Number of days on which rain fell	17	16	12	14	15	145

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Such a climate is manifestly unsuited for an invalid or delicate person, but affords a grateful change to those who have become debilitated by the summer heat of a large city, or for such as need a change of scene and air. One is always sure of finding it cool in Nova Scotia, and it is wise for those intending to visit this region to be provided with warm clothing.

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"Certain sufferers from hay fever," says Huntington Richards, "enjoy perfect immunity from that disease at Halifax, and probably the same experience may be had at many other points in Nova Scotia." The natural attractions of Nova Scotia are many and varied, and its chief city and port, Halifax, "The Garrison City by the Sea," presents many objects of interest to the American traveller. It possesses a superb harbor in which, in the summer, is the headquarters of the British North Atlantic fleet, and on land a garrison is always quartered here. The public gardens are very attractive, and the drives in Point Pleasant Park afford delightful views of the water. The country round about Halifax offers many attractive excursions; and the roads are fairly good either for driving or for cycling.

In the interior is "Evangeline's Land," a lovely, pastoral region immortalized by Longfellow. The Annapolis basin and valley, the Bay of Fundy, and the numerous shore places likewise offer many attractions, both to the casual traveller and to those interested in the early history of America. Cape Breton, Prince Edward's Island, and Newfoundland are conveniently visited from Halifax.

Good facilities for hunting and fishing are to be had in various portions of this province. One has a choice of various routes to Nova Scotia: by boat from Boston direct to Yarmouth or Halifax; or by boat along the coast to St. John and then across the Bay of Fundy to Digby; by rail to St. John; or all the way by land by the Intercolonial Railway from Montreal or Quebec. The steamers to Yarmouth and Halifax afford excellent accommodations. *Edward O. Otis.*

NUCLEINS are a class of organic bodies of acid reaction, intermediate in composition between proteid and nucleinic acid, and containing from three to ten per cent. of phosphorus. They occur in association with proteids in all animal and vegetable tissues, especially in the nuclei, and in milk. They are separated from the proteids by artificial digestion, the latter being changed to soluble peptones which are removed, while the nucleins undergo little if any alteration (Bunge). The nucleins are then brought into solution by potassium hydroxide. The commercial article is prepared from yeast or yolk of egg, and may be either nuclein or nucleinic acid. According to Chittenden, many of the marketed preparations are worthless.

Nucleins are insoluble in water, alcohol, ether, or dilute mineral acids, but are soluble in alkalies. On boiling with weak acid or alkali, and more slowly with plain water, they yield phosphoric acid in combination with organic bases. Some, at least, of them split in the body into xanthin, hypoxanthin, guanin, and adenin (Piccard). It is not known to what extent nucleins are absorbed, but probably very little is absorbed, as abundant nuclein was found in the fæces of dogs experimented upon (Bókay).

The asserted value of nuclein in medicine depends on its ability to stimulate the antibacterial power of the animal body, and to cause an increase in the number of leucocytes. The solutions have been used in tuberculosis and septicæmia. (Hare.) Vaughan cured guinea-pigs inoculated with tuberculosis, and rendered others quite immune to pneumococcus infection. J. Mount Bleyer used it with good results in diphtheria. Sir R. D. Powell reports recovery in one out of five cases of malignant endocarditis. The dose is 2 to 3 gm. (gr. xxx.–xlv.) daily. (Shoemaker.) *W. A. Bastedo.*

NURSES, TRAINING SCHOOLS FOR.—That "the old order changeth and giveth place to the new" would seem to describe well the condition of nursing affairs during the past decade and to foreshadow the future. It must be confessed that during the first fifteen years of their existence, dating from 1873, training schools for nurses made little if any progress from an educational standpoint; nevertheless, from the very first their influence upon the establishment of hospitals throughout the country has been enormous. Once the value of systematized methods of caring for the sick was realized, hospitals began to multiply rapidly, and in almost every instance a training school for nurses formed part of the organization, until at the present time there are few towns in the United States of any size that cannot boast of one or more hospitals in which the nursing is at least far superior to that of bygone days.

The history of the organization and development of training schools for nurses is of so great interest that I venture to introduce here a part of the excellent sketch which was written in 1889 by Prof. W. Gilman Thompson, of New York, for the first edition of this HANDBOOK.

"Organized nursing schools are of very recent date, and their establishment arose from the experience of army hospitals in European wars, especially the Crimean War. The nurses of religious sisterhoods, midwives, and monthly nurses were originally the women who followed nursing as an occupation. In France the nursing is mainly in the hands of Roman Catholic sisterhoods, and in the hospitals of Paris alone are over six hundred sisters who superintend the hired attendants. In Russia the Sisters of Mercy have done the nursing since the Crimea, and in Italy a similar arrangement obtains. But in January, 1883, the 'St. Paul's Home for Trained English-speaking Nurses' was started in Rome by a few graduates of American and English training schools. This institution has been very successful. Its object is, however, merely to afford a home to nurses who have been trained elsewhere. In Germany, among a great variety of Protestant and Roman Catholic nursing systems, many have become famous. Pastor Theodor Fliedner founded the 'Institute of Deaconesses' at Kaiserswerth in 1836, where, in after years, Miss Nightingale completed the early training which made her such a successful advocate of thorough instruction in nursing. There are upward of three thousand deaconesses at present connected with this institute and with others in Germany modelled after it. There are many Sisters of Charity who serve as nurses, and one of the best secular schools similar to the training schools is at the 'Kaiserin Augusta Hospital' in Berlin.

"The 'International Hospital and Field Service Society of Surgeons and Nurses' became famous on foreign battlefields, and after the experiences of the two last German wars the 'Albert Verein' was organized in Dresden and Leipsic. The nurses of this society are thoroughly trained by practical courses and lectures. Rewards and favors are granted for merit, and, if, after three years of active service, their health should become impaired, they are pensioned. They are sent out from the school to nurse private cases.

"In Vienna the nursing is done by sisters, and also by women who work without special organization. In England female nurses in hospitals are mentioned as early as 1760, and in 1791 they were indorsed by the governors of the London Hospital. In 1801 there were women nurses in the Woolwich Artillery Hospital. For the past thirty years special attention has been directed in England to nursing systems. At Guy's Hospital nurses were trained by Mrs. Elizabeth Fry for many years before a school was formally opened in November, 1879. The Protestant orders of St. John and of All Saints for many years performed satisfactorily the nursing for King's College Hospital, Charing Cross Hospital, and the University College Hospital. The Order of St. John sent nurses with Miss Nightingale to the Crimea. In June, 1860, a training school was founded at St. Thomas' Hospital, London, through the generosity of Miss Nightingale. This school, after being in successful operation for several years, was made the subject of special study by the New York State Charities Aid Association, and taken as a

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model for the Bellevue Hospital School, as well as for most of the other American schools. In 1874 a school was opened at Westminster Hospital, London, and ten years later a special building was erected with accommodation for fifty nurses. It is desired to establish district nursing among the poor in connection with this school. In 1861 a training school was founded in Liverpool for district nursing, and a great reform in the quality of nursing was instituted at the Liverpool Workhouse. In 1866 there were two schools in Dublin, and there is now an excellent school at the Glasgow Royal Infirmary. In 1867 a school was founded at the Sydney Infirmary, New South Wales. There are also new schools in Russia, Sweden, and Holland.

"Toward the end of the eighteenth century Dr. Valentine Seaman gave a course of twenty-six lectures to the nurses of the New York Hospital upon important topics in relation to nursing and hygiene. These lectures were published in 1800, and they are the first recorded effort for the improved training of nurses in the United States. In Philadelphia in 1838 the Society of Friends formed a nurse society by which they raised the standard of nursing and relieved the Roman Catholic sisterhoods from doing the work alone. The Philadelphia Lying-in Charity has instructed nurses in special branches for forty-two years. St. Luke's Hospital in New York has been supplied since 1853 (until recently) with nurses of the Protestant Episcopal Order of the Holy Communion. Several Lutheran charitable societies have trained nurses in various parts of the country, and some two thousand of these women served during the War of the Rebellion. During this war women nurses were also sent to the field and hospitals under the auspices of the Sanitary Commission and of the American Society of the Red Cross. The latter society, aided by the enthusiasm of Miss Clara Barton, has done a great deal in recent years to nurse the sufferers from yellow fever and from floods in the South and elsewhere. At Syracuse, N. Y., a Protestant Episcopal sisterhood has nursed for the Hospital of the Good Shepherd for ten years, and the deaconesses are sent out to nurse in private families, in other institutions, and among the poor. Many excellent orders of like nature have long existed throughout the country for the purpose of training and supporting nurses.

"In 1873 three training schools for nurses were almost simultaneously established in New York, New Haven, and Boston, and from this year dates the impetus to the improved nursing system which has led, in fourteen years, to the establishment of over thirty-five schools in various cities of the United States, with an outlay of many thousand dollars. There have been thus far nearly two thousand nurses graduated."

During the period which has elapsed since Professor Thompson wrote this account, many new training schools for nurses have been established, and on the whole these organizations—both those of recent date and the older ones—have accomplished in a fairly satisfactory manner the purpose for which they were created. Nevertheless, while the progress which these schools have made affords much cause for gratitude, there still remain not a few things to deplore. In the first years of the organization of these schools but little thought and care were given to the theoretical part of the nurse's work; her education was almost entirely of a practical nature, and even in this she was allowed to pursue a somewhat haphazard method, so that what she did with her hands was largely mechanical and but little dominated by the mind. The system of nursing as first instituted in the leading hospitals required, as a rule, a two years' course of training, and provided during the first year only theoretical instruction in the form of classes and lectures with examinations, at the end of the time, in medical and surgical nursing; these examinations being conducted by two or three physicians. The didactic course was usually covered in a dozen or fifteen lectures, and as these were given gratuitously by busy practitioners it too frequently happened that the nurses were assembled only to be dispersed again without the lecture, as the doctor was not able to come. Furthermore, since these lectures were almost invariably given at eight o'clock in the evening, a nurse on night duty was necessarily obliged to miss this part of her theoretical training for a whole month. Again, since in those days the pupils were often sent out to care for private cases during the first year, a nurse who averaged attendance at half the lectures given during her period of training was considered as doing well. Added to all this was the fact, which scarcely needs to be emphasized, that a woman who does not reach this portion of her theoretical studies until the end of a long day, after twelve or more busy hours in the wards, is in no mental condition to remember what she hears. An overpowering sense of fatigue usually renders her attitude one of painful but not always successful effort to keep awake. As regards the classes conducted by the superintendent or her assistants the student fared little better, as these were held in the afternoon and her attendance depended entirely upon whether the head nurse could spare her from the ward, or not. Here, again, night duty interfered, as the pupil nurse could not attend the class work without losing a part of her sleeping hours. Thus, when all these drawbacks are considered, it will readily be understood that to attend a consecutive course of class instruction was a rare occurrence with a first-year pupil.

The aids to study, in the way of books especially prepared for teaching the principles of nursing, were meagre in the extreme; the first manuals on nursing being exceedingly elementary in their subject matter. So far as the acquisition of knowledge in anatomy, physiology, and materia medica was concerned the pupil was left practically to her own resources, to obtain it as best she could, from Gray's "Anatomy" and Wood's "Materia Medica"; and as such books were in most cases unknown territory to the women before their entrance into hospitals, the knowledge acquired was seldom very deep or very much to the point. The subject of invalid dietary, if attempted at all, was covered in a few informal lectures delivered by any one who was willing to give them, and the nurse was only required to sit and observe the teacher's methods, being seldom called upon to prepare food with her own hands. Here again, as was true of her other classes, the pupil nurse was so frequently absent that little if any benefit was derived from this course. The only ethical training was that which was unconsciously experienced from the admirable discipline which existed, and from the unquestioning obedience which was always required from the junior nurse toward the medical staff, her superintendent, and the senior nurses. In making this statement I do not wish to be understood as minimizing the importance of these factors, since it was just this discipline which has stood so many nurses in good stead in after years and which has helped them to do their part in winning a favorable recognition of nursing work. In addition to the above, classes and lectures were held at any and all times during the year, and vacations were in order continuously, so that in a school for nurses there was little if any resemblance to the usual order that obtains in almost any kind of institution of learning.

This brief sketch of the educational condition in the early days of training schools for nurses has been given in order that the changes that have come about in recent years and the efforts that nurses have made, and are still making, to improve nursing education may be more readily understood and appreciated, and the obstacles that still hinder the highest order of work may be realized. As training schools increased in number the graduates from the older schools were selected to become the superintendents of the new ones, but unfortunately they were obliged to enter upon their new fields of work without any special preparation for their arduous and responsible duties, and with no experience beyond what they had acquired as pupil nurses. Hence it necessarily followed that much the same methods, or lack of methods, were introduced wherever a school opened, and any improvement over the old régime was due entirely to the superintendent's own originality, powers of imagination, and

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aptitude to impart instruction. But among these same superintendents there was gradually developing a feeling of dissatisfaction with the courses of instruction, as outlined in the circulars of information, and they were beginning to appreciate that not enough care was given to these courses, and that justice was not being done the women who entered training schools but who received nothing beyond a thorough course of training in nursing the sick. At the same time came the many changes in methods of medical work, the hospital physicians and surgeons requiring at the hands of their nurses greater thoroughness in the details of the work and a fineness of finish which had not heretofore been expected, and which demanded a higher order of intelligence to execute. I think that hardly any one at the present day would venture to deny that the science of bacteriology and preventive medicine requires both physicians and nurses to be people of intelligence. Of the nurse it is now expected that she shall have some knowledge of the principles of bacteriology in order to appreciate the value of surgical cleanliness in the prevention of disease, and to be able to do effective work. In order to surround her patient with intelligent care she must understand the principles of ventilation and hygiene; for the proper care of the body she requires a knowledge of physiology; to aid it to overcome or resist disease she must be taught more than a mere smattering about foods and the preparation of invalid dietary. Upon the nurse must devolve the execution of all such minutiæ, and to do such work well it is necessary that she should be endowed with good common sense, practical ability, and intelligence, and then receive a proper education in her profession.

As soon as the trained nurse became a factor in everyday life abuses began to creep in, the salaries commanded began to attract the purely commercial woman with no aptitude for nursing, and the fact that a better class of students could be obtained by the offer of a degree, and that cheaper and at the same time better nursing could be secured in this way led the owners of sanatoriums and the trustees of small special hospitals to establish training schools in which the facilities for obtaining a proper professional education did not exist. As a consequence nurses who had devoted some of the best years of their lives to learning their profession were in danger of being classed with those who had obtained a certificate as a price for so many weeks' or months' nursing, but who possessed little real skill or knowledge. Hence arose two evils—the real graduate nurse lost standing and the public was in danger of being imposed upon.

In the face of these many and serious problems it is not to be wondered at that the leaders in the nursing world set to work to find remedies. At first, individual efforts took the form of trying to improve the educational side of nursing by grading the two years' course of instruction, making a junior and a senior year, with a separate course of classes, lectures, and examinations for each year. The junior year now included instruction in the first principles of nursing together with such medical and surgical subjects as were needed to be put into immediate practice. The senior year was devoted to more advanced teaching and the study of more difficult subjects. This theoretical course was confined to the eight scholastic months of each year, beginning in October and ending with examinations in June, while vacations were given only during the summer months. An effort was also made to divide the two years in such a way that each nurse might spend a nearly equal amount of time in the various branches of the medical and surgical services. In many schools the practice of sending the pupil out to private duty during her period of training was done away with, in order that she might follow an uninterrupted course of instruction. Thus by degrees the curriculum in many schools was greatly improved.

But to protect the public and the educated nurse against the badly trained woman, to overcome the commercial spirit, and to establish a uniform standard of education, individual superintendents, however earnest and influential, could at first do little; and until unity among nurses as a body had been effected and the need for reform and improvement had been generally recognized by each individual nurse, nothing in the way of permanent progress could be attained. As this conviction gradually spread among women who regarded their work seriously, it became evident that for nurses, as for other workers, organization was necessary. For many years anything like unity of thought or work, or friendship among superintendents and graduates of training schools in America was practically unknown, and there was even no *esprit de corps* among graduates of the same school. But among the many congresses held in Chicago during the World's Fair there was one made up of trained nurses, working as a subsection of the hospital section of the Congress of the Associated Charities. This was the first time in the history of nursing in America that nurses had come together as members of the same profession. The most important result of this meeting was the organization of the American Society of Superintendents of Training Schools for Nurses, and to the efforts of this society is chiefly due the progress since made in the teaching of nursing. The avowed objects of this organization were to lay a solid foundation upon which a good practical educational standard might be established, and to further the best interests of the nursing profession by promoting fellowship among its members. Recognizing that any advance must come by the creation of an interest and enthusiasm in the work and in the awakening of an *esprit de corps* among graduates of the same school, the first step was the organization of school alumnæ associations. If these were once well established, the leaders foresaw, a national association would naturally follow. With such rapidity were these alumnæ associations formed that at the end of two years thirty-one were reported, and the proper time having now arrived, steps were at once taken to form the national association, which held its first meeting as the Associated Alumnæ of the United States and Canada in April, 1898. Since that time its membership has steadily increased until it now includes fifty-six alumnæ associations.

With the formation of this association, representing the nurses, and that of the Society of Superintendents, representing the teachers and leaders, nurses were prepared to do effective work. Nor was motive wanting, for almost simultaneously with the organization of the Associated Alumnæ, the Spanish-American war began. Although too late in its organization to be of service as a body in the war, the association soon found an opportunity to work for a permanent reform in army nursing. The lessons taught by the lack of an efficient and properly organized nursing force were so severe that at the close of the war the nurses' societies took steps to remedy the evil; and largely to their work and influence was due the establishment of the army nursing service with a properly qualified graduate nurse in charge. The army nurses have passed their probationary stage and have so far overcome the strong prejudice against women in army hospitals that they may now be regarded as a permanency, and another new field of work is opened up to the graduate nurse.

The next important event was the establishment of a nursing journal, controlled and managed by nurses for the benefit of nurses. The need for such a publication had been long felt, and to establish it had been one of the objects of the Associated Alumnæ. In October, 1900, two years after the organization of the association, the *American Journal of Nursing* was started under its auspices, through the exertions of individual members who assumed the financial responsibility. The undertaking is now an assured success.

Both societies have also been active in promoting a system of hourly nursing, by means of which good care of the sick at home is supplied at reasonable rates to people of moderate means and to those who cannot very well go to hospitals. The nurse who lives at home and pays her own carfare visits her patients once a day, or oftener if necessary, at a charge of about fifty cents an hour. By this plan she is enabled to care for several patients dur-

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ing the day, undertake the most important duties herself in each case, regulate affairs in the sick-room, and then instruct some member of the family what to do during her absence. The method has been tried in several of the large cities, and physicians who have employed it have pronounced in its favor in many cases. There is much to be said for some such form of private nursing, which, when properly carried out, insures proper care for many whose circumstances do not entitle them to the services of the district nurse, relieves the family of the constant presence and maintenance of the nurse, and lessens the expense of the illness; at the same time it enables the nurse to lead a more systematic life, gives her more rest, and secures for her a greater degree of independence while pursuing her work.

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New avenues of work and fresh opportunities are constantly opening up to the graduate nurse by which she may be enabled to do her full share in bettering social conditions. Notable among special efforts made by the nurses themselves is that of the Nurses' Settlement in New York, situated in the most densely populated east side portions of the city. It aims, in addition to nursing the sick poor, to be to the neighborhood all that the college settlements stand for. This settlement has steadily increased in size and usefulness, and now has branches in other parts of the city. Those who know whereof they speak are ready to bear witness that it has already done an incalculable amount of splendid work.

Outside of merely caring for the sick, the special training of the graduate nurse is being utilized in many ways. She is now regarded as a useful member on boards of hospital managers, on health commissions, and on inspection boards, and in at least one city a trained nurse is a member of the school board. The project is seriously being considered of having nurses appointed to visit the public schools daily under the supervision of a physician, to report to him suspicious cases, to indicate the homes in which any infectious diseases have developed, to point out unsanitary conditions existing in the schools, and at the same time to care for the numberless minor ailments and troubles to be found among large bodies of children.

As the Society of Superintendents stands first and foremost for the educational advancement of the nurse, much thought and attention has been devoted to the subject by its members, the one chief desire on the part of all being to supply the public with good, intelligent, practical nurses. To this end many changes have been made. The course of training in the majority of schools has been increased to three years, but unfortunately in only a few instances has it as yet been found possible to lessen the daily hours of practical work. Even to-day the pupil nurse spends from nine to ten hours daily at work in the wards. In a few schools, however, in which a serious endeavor is being made to place a true value upon education, a three years' course of training, eight hours of daily practical work, and the non-payment system have been established. According to this arrangement the pupil receives no monetary recompense, her education being considered an ample equivalent for her time and work, but text-books and uniform are allowed her in addition to her board, lodging, and laundry work. Good general and reference libraries are usually provided in the school. Nursing literature has been much improved and good text-books in the subjects taught have been specially prepared in most cases by superintendents themselves who have gained by long experience a far better appreciation of the needs and requirements of the pupils than physicians could possibly attain to. A graded course of instruction is arranged for in most schools, but no uniform curriculum has so far been adopted. Such a course embraces, as a rule, the fundamentals of anatomy, physiology, bacteriology, hygiene, and materia medica, and the principles of nursing in all branches of medicine and surgery. In the third year a course of lectures and demonstrations in massage, obstetrics, and nursing in infectious diseases and in diseases of the eye, ear, and skin are given. More and more attention is being paid to instruction in invalid dietary; and in a few schools a teacher is engaged for this branch alone, and the pupils take a regular four to six weeks' course of study in food constituents and in the preparation and serving of invalid diet. During this time they are not expected to perform any ward duties. In the matter of nursing in cases of infectious disease, in which isolation is necessary, instruction can be obtained in only a limited number of hospitals. This matter belongs to post-graduate work.

Lastly, superintendents are beginning to realize the importance of giving more detailed and systematic teaching in the ethics of nursing, the constant observance of which is just as important to the graduate as that she should be an expert in practical work.

Although the instruction given in all these various branches must of necessity be very elementary in substance, it has been found that the pupil nurse finds it exceedingly difficult to prepare her class work, write up her lecture notes, do any collateral reading, and at the same time pursue her long hours of work in the wards. Lack of time and bodily fatigue make it practically impossible to assimilate the theoretical knowledge imparted in the courses of instruction. Added to this, the women of to-day have not as a rule a thorough systematic practical knowledge of the details of housekeeping, so essential for any one who expects to become a good nurse and a good manager in a ward. For these reasons an attempt has been made in one school in Scotland, one in London, and one in the United States to give the probationers, before entering the wards, a so-called preliminary course in household economics, in the theory of their work, and in the elements of nursing. By this arrangement the probationer is gradually fitted to begin her more arduous tasks in the ward, with an understanding of what is expected of her. Results are much better for the patients, and the head nurse is spared having so much crude material always on hand to teach; while the superintendent of nurses can feel sure that the preliminary ground has been thoroughly covered. The chief drawback to the general adoption of such a plan lies in the extra cost it entails, an outlay which few hospitals can afford. Under the auspices of the Society of Superintendents a course in hospital economics was established in 1899, in connection with the Teachers' College, Columbia University, New York, the object of which is to qualify specially selected graduates for the duties of superintendence in hospitals and training schools.

Among the more pressing matters calling for reform at the present time are the following: (1) The establishment of uniform entrance requirements for probationers and a uniform curriculum, as a result of which a graduate's degree obtained in any part of the country and from any hospital would practically mean the same thing. (2) Some arrangement by which the small general hospital may become a branch of the larger training school, so that every woman after she has been accepted as a pupil in a hospital of good standing—no matter whether it be large or small—shall be assured a thorough practical and theoretical education as a nurse. (3) Some plan in accordance with which only properly qualified graduates shall be employed at reasonable rates to do the nursing in special hospitals, and thus do away with one most objectionable form of training school. (4) The establishment in certain large centres, in different parts of the country, of post-graduate courses in general hospitals, which may be attended by graduate nurses, who will then be able to keep themselves up to date and become acquainted with the latest changes in medical and surgical methods. (5) The establishment of methods by which the public may be protected from inefficient and untrained nurses, while the women who have taken the time and trouble to perfect themselves in their profession may be accorded their proper status.

With the solution of the first four of these problems the Superintendents' Society is more especially occupying itself; the fifth has been left mainly in the hands of the Associated Alumnæ, and on this point it may not be out of place to say a few words. Before a physician is allowed to practise his profession he is obliged to satisfy

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the State board that he is properly qualified, after which his name is duly registered. May not some form of State examination and registration equally well find application in the case of graduate nurses? We are not suggesting a panacea—registration will not cure all defects in nurses, but it will at least afford some sort of a guaranty, and to a certain extent put it in the power of the public to learn for itself the legal status of any woman who offers herself as a nurse for their sick; at the same time it will serve as a hall mark, as it were, upon the woman who has spent time and labor to render herself a good nurse, and will distinguish her from the nondescript individual who so often poses as a trained nurse.

In this paper reference has mainly been made to changes which have occurred in the nursing world on this continent during the past decade. But even should we be inclined to flatter ourselves that America has led the van, it must not be supposed that other countries have been far behind in these matters. It should be a matter for sincere congratulation that there has been established an *entente cordiale* between the members of the nursing profession in all countries, whereby we have been brought into closer touch than ever before. One professional link has been forged between America and England in the form of the International Council of Nurses, which has as its object "the furtherance of the social and professional progress of all nurses and the maintenance of a high standard of nursing ethics and *esprit de corps*," and to which we trust nursing associations in all countries may become affiliated in the course of time.

It is a satisfaction to be able to record that in no civilized country has the development of the nursing profession been at a standstill, and everywhere our members have been working out their own problems according to their several needs. A more comprehensive account of the work being done by nurses throughout the world will be found in the Proceedings of the Third International Congress of Nurses held in Buffalo in September, 1902.*

While the greater part of the progress in nursing has been mainly due to the efforts of nurses themselves, they have been fortunate in securing in their undertakings the active sympathy of the medical profession and of hospital authorities who have appreciated the fact that the better the nurse the more are their own efforts strengthened. It still remains for the well-to-do laity to realize how necessary and important to them is every step taken for the betterment of the nurse. After all, the sole object of all the work and progress is to render the greatest good to the greatest number when sick and in sore need of the best that human skill can afford, and were some portion of the financial aid so lavishly poured out upon university and other institutions of learning given to render the profession of nursing still more worthy of its name, such an outlay would assuredly be returned in good measure pressed down and running over.

Isabel Hampton Robb.

NUTGALL.—*Galla*, U. S.; Br., *Galls*; *Galla*; *Galla halapensis*; *G. Turcica*; *G. levantica*; *G. tinctoria*; *G. quercina*. Excrescences on *Quercus lusitanica* Lam. (*Q. infectoria* Olivier, fam. *Cupuliferæ*), caused by the punctures and deposited ova of *Cynips* (*Diplolepis*, Latreille) *Gallæ tinctoriæ*, Olivier (Class *Insecta*, Order *Hymenoptera*).

The species of oak here named is very variable and widely disseminated, growing over the greater part of Southern Europe, in the Levant, and in Western Asia. The variety which produces the galls is usually a mere shrub less than six feet high. The insect named is a small, wasp-like fly. The female punctures certain of the unexpanded buds, leaving a single egg in each, thus causing it to develop into a gall, instead of a leafy branch. A spherical cavity is formed by the growth of the gall, its lining being of a different structure from that of the remainder of the gall. The larva, when fully developed, gnaws its way out, leaving a pinhole perforation. After this occurrence the gall presents quite a different appearance, being larger, lighter in color and weight, and less rich in active constituents, such galls being distinguished in commerce as White galls, and less highly esteemed than those collected at an earlier period.

DESCRIPTION.—Nearly spherical, about 2.5 cm. (1 in.) or less in diameter, with a short stipe, the surface smooth,

FIG. 3607.—The Nutgall Oak, Showing Leaves, Acorns, and One Nutgall. (Baillon.)

except for a number of short, thick tubercles toward the summit; externally deep greenish- or bluish-gray or blackish; heavy and hard, but readily broken with a hammer, exhibiting a more or less dense granular fracture, sometimes with a waxy lustre; internally, yellowish or pale brownish-gray, with a central nucleus or a cavity containing the more or less perfectly developed insect. The granular tissue of the nucleus is mostly filled with small starch granules and surrounded by a layer of thick-walled cells forming a shell, on the outside of which is the cellular tissue containing the tannin. This tissue has often a radiated appearance near the shell, and contains toward the surface small scattered bundles of vascular tissue. Nutgalls are nearly inodorous and have a very astringent taste. Light, spongy, and whitish-colored nutgalls should be rejected.

Nutgalls are distinguished in commerce according to their color, the *blue* or *black galls* of Syria (Aleppo) being preferred. *Smyrna galls* are usually of a grayish olive green, more spongy in texture and intermixed with *white galls*.

Many other varieties of galls, especially the Chinese variety, have a similar composition and uses, though sub-

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stitution or adulteration of the medicinal article is hardly to be looked for. Chinese galls are large, occasionally three inches in length, oblong-ovoid and somewhat flattened, coarsely tuberculate, the tubercles very irregular in size and often prolonged into branches. This gall is of a yellowish-gray color, densely and softly tomentose or velvety, light in weight and hollow, the wall being thin and crustaceous.

Nutgalls contain upward of sixty per cent. of gallotannic acid, two or three per cent. of gallic acid, occurring as a natural derivative of the former, and small amounts of resin, sugar, and starch.

Action and Uses.—The properties of nutgall are those of tannic and gallic acids, in a degree corresponding with their percentages as stated above, and the reader is referred to those drugs for an account of its action and uses.

The official preparations of nutgall are the tincture, containing twenty per cent. of nutgall with ten per cent. of glycerin, and the ointment, which consists of twenty per cent. of the drug rubbed up with eighty per cent. of benzoinated lard. *Henry H. Rusby.*

NUTMEG.—(*Myristica*, U. S.; Br. *Semen Myristicæ*; Ger. Muskatnuss; Fr. Muscade.) The dried ripe seed of *Myristica fragrans* Houttuyn (fam. *Myristicaceæ*), deprived of its testa.

Nutmeg is the product of a handsome, small, evergreen, diœcious tree, native of the Molucca Islands, now widely cultivated in tropical regions, such cultivated trees, mostly in the Malay Archipelago, supplying the commercial article. The fruit is fleshy, one-seeded, and when ripe much resembles the peach. The fleshy pericarp is tardily dehiscent and the seed is enclosed, though only partially covered, by a fleshy network, consisting of the aril. This is removed and dried to form *mace* (which see), leaving the seed as an oval body faintly grooved, where the aril has rested upon it. It is dried by a slow and tedious process, requiring about two months. When dry the nutmegs are beaten to break the testa, from which the kernel has now shrunken away, and the latter then constitutes the official nutmeg. It is nearly an inch in length and somewhat more than half as broad, oval to ovoid, very slightly flattened in one direction and not quite equilateral, of a rich brown color, slightly shining, more or less furrowed, with a circular scar at the broader end, from which a slight groove runs to a deeper depression near the smaller end. When cut transversely it exhibits a pale, brownish-yellow surface, of a fatty lustre, and marked by narrow curved brown lines entering from the surface and containing folds of the tegmen or inner coat. The odor is strong and agreeable, the taste similar and somewhat bitter. The ordinary nutmeg of commerce differs from this in being grayish-white from a partial covering of lime, which serves the purpose of protecting it against the attacks of insects, to which it is very liable. Such nutmegs are distinguished as "limed" or "Dutch," the others as "brown" or "Penang."

The important constituent of nutmeg is its volatile oil, stated in most books to amount to from two to eight per cent., but of which there is very much more. The other constituents are the following: about forty per cent. of fixed oil, of which about three-fourths is removable by expression, a small amount of an unstudied bitter principle, starch, protein, gum, and other ordinary constituents. The volatile oil (*Oleum Myristicæ*, U. S., Br., or *Oleum Nucistæ Æthereum*) varies considerably in character, according as a larger or smaller percentage has been distilled from the nutmeg. When freshly distilled it is colorless, but grows yellow or even reddish and thicker with age, at the same time changing its odor to a heavy and somewhat disagreeable character. It has a pleasant flavor, followed by a warming and biting or slightly acrid effect. Its specific gravity ranges from 0.87 to 0.90 at 15° C. (59° F.). It is soluble in an equal volume of alcohol, the solution being neutral, and in the same amount of glacial acetic acid; it is freely soluble in carbon disulphide. It consists chiefly of *myristicol* ($C_{10}H_{16}O$?) and *myristicin* ($C_{12}H_{14}O_3$), together with pinene, myristinic acid, and other unimportant substances. This oil possesses the properties of nutmeg in an intensified degree. The commercial article holds a small amount of the fixed oil in solution. The fixed oil (*Oleum Myristicæ Expressum, Oleum Nucistæ, Adeps* or *Butyrum Myristicæ* or *Nucistæ, Nutmeg Butter*) is expressed by the aid of heat. It usually occurs in the form of cakes, wrapped in palm leaves, is solid and firm at ordinary temperatures, melting at about 45° C. (113° F.), has a mottled, orange-brown and whitish color, a specific gravity of about 0.995, a pleasant buttery taste, but with a slight fragrance and taste of nutmeg, due to the presence of a little of the volatile oil in solution. It dissolves in four parts of boiling alcohol or in two of warm ether. It consists chiefly of *myristin*, $C_3H_5(C_{14}H_{27}O_2)_3$, with three or four per cent. of free myristic acid. This oil is very much subject to adulteration with, or substitution by, the fixed oils derived from other species of *myristica*, especially that from *M. fatua* Houttuyn. This fat has no special medicinal properties but merely those of other vegetable fats.

Whole nutmegs are at the present day scarcely ever sophisticated, though the long, wild, or male nutmegs above mentioned as being used to adulterate nutmeg butter, as well as some other species, are occasionally offered for them. Artificial nutmegs, pressed from a prepared paste and very inferior in odor and taste, have been frequently reported. Ground nutmeg is usually adulterated, often very heavily so, and the freshly grated article should be insisted upon.

Properties and Uses.—Almost the entire use of nutmeg is for flavoring purposes, although it possesses useful properties as an ordinary aromatic stimulant and carminative. Many cases of mild, and several of rather severe poisoning by overdoses (from two to five nutmegs) are reported, the symptoms being those of a narcotic or severe depressant, in some respects similar to those of overdoses of camphor. There is no preparation, properly speaking, of nutmeg, though it enters into the aromatic powder and the compound tincture of lavender. Of the volatile oil there is an official five-per-cent. spirit, the dose of which is 2–4 c.c. (fl. ʒ ss.–i); the dose of the oil as a carminative is ♏ i.—iij., and a small amount of it enters into the aromatic spirit of ammonia.

Henry H. Rusby.

NUTRITION. See *Metabolism.*

NUX VOMICA.—U. S., Br., *Semen strychni*; P. G., *Semen nucis vomicæ*; *Poison Nut*; *Dog Buttons*; *Quaker Buttons.* The dried ripe seed of *Strychnos Nux vomica* L. (fam. *Loganiaceæ*).

Nux vomica seeds are produced in the East Indies by a small tree which bears a fruit similar in appearance to a small orange. There are from one to four seeds, usually with a few undeveloped ones, found embedded in the whitish, jelly-like pulp of the fruit. The smaller the number of seeds the larger they are likely to be, and the richer in active constituents. Although the principal constituent of the pulp of the fruit is the indifferent glucoside *loganin*, yet it also contains strychnine (about 1.5 per cent. in the dried pulp) and brucine (about one per cent.) and is highly poisonous. The leaves also contain a considerable percentage of brucine, and probably some strychnine, and are poisonous to cattle.

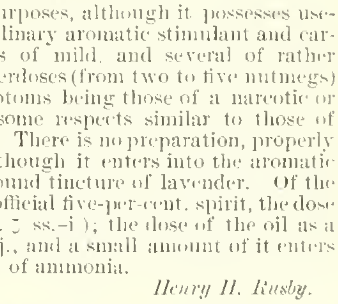

Fig. 3608.—Nux Vomica: outer surface and longitudinal section. (After Baillon.)

Description.—About 1.5–2.5 cm. (⅗–1 in.) broad, lenticular, but irregularly curved, with an elevated central spot upon one or both sides and upon one side a low ridge

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(the raphe) running thence to the edge; externally gray, greenish-gray or light yellowish-gray, silky in lustre and to the touch, densely clothed with a coat of closely appressed, shining hairs; internally hard, very tough, somewhat translucent, consisting of two discs of perisperm which www.libtool.com.cn cavity and the embryo which has small heart-shaped, palmately nerved cotyledons; inodorous and intensely and persistently bitter.

Nux vomica seeds are so abundant and cheap that there would appear to be little temptation to adulterate them; yet not only is the powdered drug subject to adulteration, but, what is of more importance, it varies widely in quality. Hence the great importance of insisting upon official standards as to the alkaloidal assay of the preparations.

CONSTITUENTS.—The one important constituent of nux vomica, from a medicinal point of view, is strychnine. The activity of the drug is wholly dependent upon that substance, and the degree of this activity conforms closely to the amount which it contains, although the latter statement is subject to certain modifications, in accordance with the following facts. Associated with the strychnine is a certain quantity of the similar alkaloid brucine,—a quantity which either may be equal to, or may be twice as great as, that of the strychnine present. The action of this alkaloid is almost identical with that of strychnine, although variously estimated at from five to ten times weaker. This variation in the strength of brucine is undoubtedly due to the presence in it of variable amounts of strychnine, which it is almost impossible completely to remove. It is to be remembered that the alkaloids, besides being highly insoluble, exist in nux vomica intimately associated with an extremely tough, horny albuminous substance, so that if the powdered drug be taken, they may be less quickly and completely absorbed than when strychnine alone is administered. Constituents which are not important from a medicinal, though more or less so from a pharmaceutical, standpoint are the tannin-like *igasuric* or *strychnic acid* with which the alkaloids are combined, a considerable amount of fixed oil, a small amount of the glucoside loganin, a little gum, sugar, etc. The combined percentage of strychnine and brucine ranges from two to five per cent. or even more, of which the strychnine represents from one-third to one-half. Strychnine will be fully discussed under that title. *Brucine* ($C_{23}H_{26}N_2O_4 + 4H_2O$) occurs in very fine colorless crystals, forming a whitish powder, soluble in alcohol. It is distinguished from strychnine by being reddened by nitric acid. It forms salts freely, several being upon the market; the sulphate, which is soluble in water, is the one chiefly employed.

ACTION AND USES.—Excepting as to the preparations and dosage, an account of the action and uses of nux vomica would be a duplication of that given under *Strychnine*, to which the reader is referred. Brucine is somewhat used in a similar way, in doses of gr. $\frac{1}{16}$ to gr. $\frac{1}{4}$, the total daily amount not to exceed gr. iij. It is also sometimes applied externally to relieve itching.

The dose of nux vomica, in very fine powder, is 0.06–0.24 gm. (gr. i.–iv.). Of nux vomica the following are the official preparations, subject to assay by processes prescribed by the Pharmacopœia: The extract, to contain 15 per cent. of total alkaloid, dose 0.008–0.06 gm. (gr. $\frac{1}{8}$ to gr. i.); the fluid extract, to contain 1.5 per cent. of total alkaloid, dose ♏ i.–iv.; the tincture, to be made by dissolving 20 gm. of the dried official extract in 1,000 c.c. of a mixture of three volumes of alcohol and one volume of water—this tincture to contain a total of 0.3 per cent. of the alkaloid, and the dose to be 0.3–1.8 c.c. (♏ v.–xxx.). It will thus be seen that the fluid extract is five times as strong as the tincture, and the extract ten times as strong as the fluid extract. *Henry H. Rusby.*

NYE LITHIA SPRINGS.—Wythe County, Virginia. POST-OFFICE.—Wytheville. Hotel and boarding-houses.

ACCESS.—Viâ Norfolk and Western Railroad to Wytheville, thence two miles over macadamized carriage roads to springs.

These springs are located in the southwestern part of Virginia, in a charming, picturesque locality, one-quarter of a mile from the corporate limits of Wytheville. The elevation of 2,360 feet above the sea level gives assurance of a cool and delightful summer temperature. The country about Wytheville has long been celebrated in the South as a summer health resort, and the yearly visitors came from far and near. The average yearly temperature of Wytheville is 53° F. The seasonal temperatures are as follows: Spring, 52° F.; summer, 70.6° F.; autumn, 53° F.; and winter, 32.3° F. The highest summer temperature observed during the past three years has been 88° F. in the shade. The region is quite free from malarial and miasmatic influences. The springs are surrounded by a tract of eighteen acres of the primeval oak forest, which furnishes a delightful shade in the summer. The accommodations for visitors are as yet somewhat limited, but a commodious hotel is in contemplation for the near future. Two good hotels and numerous excellent boarding-houses will be found in Wytheville. The springs are three in number, two lithia and one chalybeate. The summer temperature of the two lithia springs is respectively 53° and 54° F., and the chalybeate 56° F. The following analysis of two of the springs is furnished by Dr. George L. Nye, the resident physician:

NYE LITHIA SPRING, NO. 1.

(Analyzed by W. L. Dudley, Vanderbilt University.)

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	10.63
Lithium carbonate	6.41
Iron and alumina oxide	.31
Silicic acid	1.19
Total	18.54

NYE CHALYBEATE SPRING.

(Analyzed by J. L. Jarman, of Emory and Henry College.)

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Potassium carbonate	0.01
Sodium carbonate	.81
Lithium carbonate	1.89
Calcium carbonate	11.60
Magnesium carbonate	2.35
Iron and alumina oxide	1.33
Silicic acid	.66
Total	18.65

Rating the lithium in these analyses as the bicarbonate it would amount respectively to 11.77 and 3.48 grains per gallon.

The waters have long been highly prized in the treatment of a variety of disorders. Dr. Nye presents numerous reports of cases from competent physicians illustrating the beneficial influence of these waters in diabetes and other urinary disorders. Their action in cases of dyspepsia and intestinal affections is also very advantageous. The chalybeate water is in high repute among physicians for the relief of menstrual and uterine disorders consequent upon anæmia. *James K. Crook.*

NYMPHÆACEÆ.—*The Water-lily Family.* This small family of aquatic plants contributes several large, coarse, spongy, dark-colored rhizomes which have been used in medicine. The white water-lilies pertain to the genus *Castalia* Salisb., though long miscalled *Nymphæa*, the latter name still being applied to them as drugs. The species most used are *C. alba* (L.) Lyons (*Nymphæa a.* L.), the European white water-lily, *C. odorata* (Dryander) Woodv. et Wood (*Nymphæa o.* Dryander), the Fragrant or Sweet scented white water-lily, chiefly of Eastern North America, and the *C. tuberosa* (Paine) Greene, the tuberous white water-lily, chiefly of Central North

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America. The yellow water-lilies or pond-lilies, Spatter-docks, or Flatter-docks, pertain to the genus *Nymphæa* L., though long miscalled *Nuphar*. The species of this genus which has been most employed, and the nature of which is best known, is *N. lutea* L., the European yellow pond-lily. From this rhizome has been extracted the white amorphous alkaloid *nupharine*, to which its bitter properties are probably due. The constituents of the other species named are but little known, though they contain bitter principles apparently similar to nupharine. All contain resin, tannin, starch, and gum.

The uses of these drugs are not based upon any scientific knowledge other than that they are mild astringents and bitter tonics. In this way they have been used as astringent gargles, intestinal astringents, and for local applications in gonorrhœa, leucorrhœa, etc. The dose of the fluid extract is i.–iv. cc. (fl. ʒ ¼–i.). *Henry H. Rusby.*

NYSTAGMUS is an involuntary rhythmic contraction of the ocular muscles producing oscillation of the eyeballs. It is due to imperfect cortical innervation of the voluntary muscles of the eye, and may result from either central or peripheral causes, or from both. The movements, which usually affect both eyes, may be vertical, rotatory, or lateral, but the most common form is from side to side. It is most commonly observed in eyes that are defective congenitally, as in albinos, or from coloboma of the choroid, microphthalmos, etc. Various inflammatory or degenerative diseases of the eyes, chiefly when they occur in early infancy or childhood, frequently cause nystagmus. This condition must not be confounded with the slight tremor observed upon voluntary movement of the eyes in efforts at fixation in various directions which is so often found in association with weakness of the ocular muscles.

Nystagmus may be acquired, and is often seen in those employed in coal mines, and is due to the work being done in cramped positions under poor illumination, the gaze being directed obliquely upward. Fatigue is thus induced in the superior recti and inferior obliques, and also in the internal and external recti muscles, finally causing their spasmodic action. This type of nystagmus may also be regarded as a fatigue neurosis.

Nystagmus also occurs in various diseases of the nervous system, and is often a conspicuous symptom in multiple sclerosis, cerebellar disease, and Friedreich's hereditary ataxia. It occurs in many diseases of the brain, such as tumor, softening, hemorrhage, meningitis, sinus thrombosis, etc. As a localizing symptom it is of no value, but it is an important diagnostic sign in the early stage of degenerative affections of the central nervous system.

In multiple sclerosis nystagmus is a frequent symptom. Spontaneous movements like those seen in albinism or in congenital ocular defects are rare. The nystagmus is usually manifested when the eyes are moved voluntarily in various directions, especially on lateral movement.

In cerebellar disease nystagmus has been classified as an irritative symptom, being ascribed to pressure on the pons and corpora quadrigemina.

William M. Leszynsky.

OAK ORCHARD ACID SPRINGS.—Geneseo County, New York.

Post-Office.—Medina, Orleans County.

Access.—Viâ New York Central Railroad to Medina, a station forty miles west of Rochester, thence six miles south by stage.

The springs are not used as a resort, but the waters have been sold to some extent. The accompanying analyses show the waters to possess exceptional properties.

These springs are remarkable in the amount of free sulphuric acid which they contain—more, indeed, with one or two exceptions, than is to be found in any other waters known. Waters containing this acid in free state are exceedingly rare. It is said that none of the kind is known in Europe. Among the few known on this side of the Atlantic are the following: One in the town of Byron,

One United States Gallon Contains:

Solids.	Spring No. 1. (Silliman and Norton.) Grains.	Spring No. 2. (E. Emmons.) Grains.	Oak Orchard, acid water, (Prof. Porter.) Grains.
Sodium sulphate	6.34	....	3.16
Calcium sulphate	74.89	12.41	13.72
Potassium sulphate	5.52	....	2.48
Aluminum sulphate	21.69	....	6.41
Magnesium sulphate	35.60	4.98	8.49
Iron sulphate	....	39.23	....
Iron protosulphate	28.62	....	32.22
Sodium chloride	2.44	...	1.43
Silica	4.59	1.84	3.33
Organic matter	....	10.88	6.65
Sulphuric acid	134.73	129.06	133.31
Total	314.42	198.40	211.20

near the Oak Orchard Spring; the Tuscarora Sour Spring in Canada; the Matchless Mineral Well in Alabama; and several acid springs in Texas, California, and Virginia. According to Prof. J. H. Armsby, of Albany, the Oak Orchard water has been used with advantage in "ill-conditioned ulcers, diseases of the skin, passive hemorrhages, diarrhœas depending upon an atonic condition of the mucous membranes, and in depraved and impoverished conditions of the body from specific diseases and from intemperance." The water requires dilution before drinking. *James K. Crook.*

OAK, WHITE.—Quercus Alba. *Oak Bark.* "The bark of *Quercus alba* L. (fam. *Cupuliferæ*)," U. S. P. This species of oak-tree is one of the commonest and most abundant of its genus, as well as the largest, in Eastern and Central North America. It yields one of the most highly prized of American hard-wood timbers. The bark is thus officially described: "In nearly flat pieces, deprived of the corky layer, about a quarter of an inch (6 mm.) thick, pale brown; inner surface with short, sharp, longitudinal ridges; tough; of a coarse, fibrous fracture; a faint, tan-like odor, and a strongly astringent taste. As met with in the shops, it is usually an irregularly coarse, fibrous powder, which does not tinge the saliva yellow." The last character distinguishes it from the largely employed bark of *Quercus tinctoria*. In nearly all temperate countries some locally occurring oak is used as an astringent; the British oak, *Q. Robur* L., in Europe, the holly oak, *Q. Ilex*, in France and elsewhere. In our own country, also, other species besides the white oak are sometimes used and were formerly official (*Q. coccinea vel tinctoria*, Gray, etc.).

White oak bark is simply an astringent. It contains from five to ten per cent. of tannic acid—probably identical with the *quercitannic acid* of *Q. Robur*—and a little coloring matter.

It is used in decoction (5%) for cracked or tender nipples, indolent granulations, leucorrhœa, nasal catarrh, etc., and is occasionally given internally, in doses of i.–iv. gm. (gr. xv.–lx.). Finely powdered white oak is often blown into the nares to check hemorrhage.

Henry H. Rusby.

OBESITY. See *Adipositas*.

OBSTETRIC OPERATIONS.—Induction of Abortion.—This means the interruption of pregnancy before the period at which the child is viable. It is an operation performed solely in the interests of the mother and, as Hirst says, should be undertaken as reluctantly as justifiable homicide. The indications are: pernicious vomiting, pulmonary and cardiac disease, nephritis, chorea, acute mania, melancholia, and pernicious anæmia. Pregnancy may have a very deleterious effect upon each of the above disorders, and in allowing gestation to continue, the physician may sacrifice the lives of both mother and child; the induction of abortion should be regarded only as the last resort and never be undertaken without consultation. Among the local conditions which may call for the termination of the pregnancy must be men-

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tioned incarceration of the retroflexed uterus, hemorrhage from the normally or abnormally situated placenta, and excessive contraction of the pelvic canal. In this last condition the choice lies between abortion and Cæsarean section; the claims of each operation should be presented to the mother.

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Methods of Inducing Artificial Abortion.—The uncertain methods of drugs and electricity are to be condemned. The induction of artificial abortion should be made a surgical operation, and, if possible, completed at one sitting. There is but little danger if the procedure has not been delayed until the patient's strength is exhausted and if careful asepsis is observed throughout. The instruments required are: rubber pad, leg-holders, weighted speculum, volsella forceps, steel-branched dilators, a large intra-uterine curette, ovum forceps, intra-uterine irrigating tube, and fountain syringe. The patient, having been anæsthetized, is placed in the dorsal position with knees well drawn up and secured with the leg-holders; the parts about the vulva are shaved and cleansed, the vagina is scrubbed with soap and irrigated with warm sterilized water. By means of the speculum and volsella the cervix is exposed and secured; with the dilators the cervix is gradually stretched up to two or two and a half inches. Owing to the softening the tissues usually yield readily, but this part of the operation must be conducted without haste. The finger is the best instrument for removing the contents of the uterus, and in the first two or three months of pregnancy there is but little trouble in reaching the fundus, especially if counter-pressure be made upon the abdomen with the other hand so as to crowd the womb down upon the internal finger. After the attachments of the ovum have been freed the membranes are drawn out over the hooked finger. In case of difficulty the curette may be used to loosen the tissue and the pieces removed with the forceps, but the finger is the guide for all intra-uterine manipulation, and touch alone will determine when the operation is completed. Finally, an intra-uterine irrigation of hot sterile salt solution will remove clots and act as an efficient stimulant to the uterine muscle. Chemicals should not be injected into the uterus; when strong enough to affect bacteria they become poisonous to the woman. Some operators advise the introduction of a gauze drain, but this should be unnecessary. In some cases the cervix may be rigid or the pregnancy too advanced for the operation to be readily completed at one time. Under these circumstances some authors recommend making use of tents, but the difficulty in rendering them aseptic should forbid their employment. The cervix may be partially dilated with the steel dilators and then the lower uterine segment and cervix firmly packed with gauze supported by a vaginal tampon. Such treatment controls hemorrhage and stimulates the uterus so that at the end of twelve hours the packing can be removed, when the cervix is found softened and contractions are established. If there is no haste the case may be allowed to progress naturally or the operation can be completed, but in all cases the finger must be used before deciding that the uterus is empty. During the performance of artificial abortion there may be profuse hemorrhage which usually ceases as soon as the uterus is emptied and stimulated with the hot saline solution. If oozing continues the hypodermatic administration of ergot and even the introduction of the intra-uterine tampon of gauze are indicated. In bad cases of retroflexed uterus it may be impossible to reach the cervix; in such cases the fundus should not be tapped through the vagina, as some books recommend, but the proper treatment is abdominal section and manual reposition of the uterus.

Induction of Premature Labor.—*Indications.*—Many of the indications for this operation are the same as those mentioned under the heading of Induction of Abortion, the pregnancy having been allowed to proceed in the hope of obtaining a viable child. It is evident that the later the operation can be delayed the better the chances for the child, and that the after-care will make a great difference in the infant mortality. Deformed pelves: Here the operation comes into competition with symphyseotomy and Cæsarean section. Heymann says that in cases of disproportion between child and maternal pelvis the best time for the induction of labor is from the thirty-third to the thirty-fifth week. Among children so born the mortality is 64.3 per cent. In simple flat pelves an internal conjugate of two and three-fourths inches is considered the lowest limit; three to three and three-fourths inches in the generally contracted pelvis. The success of the treatment of deformed pelves by induction of premature labor depends upon careful measurement of the diameters, accurate estimation of the size of the fœtal head, and correct calculation of the duration of pregnancy. Each case must be studied by itself, and for further particulars the reader should refer to the article on *Pelves, Deformed.* Placenta prævia: In the majority of cases the first hemorrhage does not occur until after the period at which the child is viable. Labor should be induced at once, as further delay does not improve the chances for the child and threatens the life of the mother. Eclampsia: most authorities advocate the induction of labor not only when the convulsions appear, but whenever the pre-eclamptic symptoms refuse to yield to treatment. On the other hand, Stroganoff reported fifty-eight successful cases without the induction of labor (*American Gyn. Journal*, May, 1901).

Methods of Inducing Premature Labor.—Puncture of the Membranes: This method is uncertain and contrary to nature. Tamponing the Vagina: This also is uncertain and not advisable unless there is severe hemorrhage. Injection of Glycerin: This is dangerous, although many successful cases have been reported. Insertion of an Elastic Bougie: This is known as Krause's method, and is advocated by many. An aseptic bougie is passed up as far as possible between the membranes and the uterine wall; the bougie is then supported by a tampon placed in the vagina. If no contractions set in at the end of eight hours, a second bougie is introduced. When the labor is induced, the bougies are allowed to be expelled along with the fœtus. This method is frequently unsuccessful, and there is some danger of sepsis, as a bougie is difficult to disinfect without ruining it. The chief advantage lies in the fact that the procedure is an easy one for a person who has very little skill in manipulation. Dilatation of the Cervix: This is the most desirable method and may be carried out in various ways. The patient is anæsthetized, the cervix slightly dilated with the steel dilators, and then the entire cervical canal and vagina are packed with iodoform gauze. If contractions are not evoked at the end of six or eight hours more gauze should be introduced. As soon as the labor is started it may be allowed to proceed unaided. Instead of gauze the rubber bags of McLean or Barnes may be used; these are passed into the cervix and distended with sterile water. Before introduction their strength should be tested and the number of syringefuls of water required should be noted. McLean's bags are divided by a compartment through the centre so that each side can be distended separately. Charpentier de Ribes' bag is made of silk covered with rubber and, when dilated, forms an inverted cone measuring three and one-fourth inches at the base. This bag is folded, introduced into the lower segment of the uterus, and filled with water; the stimulation is increased by making traction upon the tube connected with the apex of the bag. These hydrostatic dilators both open the cervix and cause uterine contractions. De Ribes' bag is very useful in placenta prævia as it makes direct pressure upon the bleeding lower segment. A certain amount of preliminary dilatation is necessary for the passage of any of these bags. When haste is essential, as in placenta prævia, the cervix can be stretched by the fingers, later by the passage of the entire hand; manual dilatation may be independent of, or may supplement, the other methods. The delivery of the fœtus may be accomplished by version or by the application of forceps according to the requirements of the case.

Laceration of the Cervix.—Slight ruptures of the cervix occur in almost every first labor; they may add

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somewhat to the danger of septic infection, but are otherwise unimportant. Deep tears are the result of the rapid passage of the fœtal head through a rigid or imperfectly dilated cervix. Precipitate labor, the application of high forceps, and version frequently cause cervical laceration. Malignant disease and the presence of cicatricial tissue are predisposing conditions. The tears usually are longitudinal and situated on the left side, but may also be bilateral or stellate; in rare instances the anterior lip has been torn away by being caught between the inner surface of the pubis and the presenting part. Evidences of Cervical Laceration: The lesion may be suspected whenever the presenting part takes a sudden jump through a partially dilated cervix, but the chief sign of serious rupture is hemorrhage. Whenever hemorrhage continues from an empty and well-contracted uterus the parts should be inspected for lacerations. A speculum is seldom necessary as the parts are so relaxed; the cervix can be caught with a volsella forceps and pulled down into view. *Prophylaxis:* Non-interference with normal labor, care in avoiding premature rupture of the membranes, and the postponement of operative procedures until the cervix is dilated or dilatable are the important points under this head. *Treatment:* Extensive tears, especially those giving rise to hemorrhage, require the introduction of sutures. For this procedure anæsthesia is rarely needed as the parts are not sensitive, particularly just after labor. By means of a speculum and volsella the cervix is exposed and secured; with a curved needle in a holder catgut sutures are introduced from side to side. If the gut be chromicized there is no danger of its too early absorption, although some operators use silkworm gut. No special after-treatment is called for, except the removal of non-absorbable sutures upon the tenth day.

Secondary Trachelorrhaphy.—Neglected lacerations of the cervix may give rise to symptoms and, under some circumstances, they seem to predispose to the development of cervical cancer. The laceration allows the cervical canal to gape open and exposes its interior to friction against the sides of the vagina; hypertrophy and hyperplasia of the epithelial tissue may ensue, giving rise to the so-called "granulations" and being accompanied by profuse leucorrhœa. In other cases there is an extensive deposit of cicatricial tissue making the cervix club-shaped and producing reflex disturbances. A tear in the cervix may cause prolonged congestion of the uterus, thus delaying involution and weakening the supports so that displacements readily occur. *Symptoms:* In chronic cases these may be leucorrhœa, backache, dragging sensations, menorrhagia, and dysmenorrhœa, as well as a wide variety of reflex symptoms. The diagnosis can be readily made by vaginal touch; on inspection we may see a club-shaped cervix or a red, eroded-looking surface covered with exuberant "granulations" and purulent discharge. The varieties of tears are unilateral, bilateral, and stellate.

Trachelorrhaphy. — Lacerations which give rise to symptoms or show signs of irritation should be treated by operation. The instruments needed are: a rubber pad, leg-holders, weighted speculum, a knife or Emmet's scissors for denudation, volsella forceps, tenaculum, hæmostatics, needle-holder, and straight cervix needles with large eyes. The patient is anæsthetized, placed in the lithotomy position, and the vagina cleansed. After the introduction of the speculum and exposure of the cervix the anterior and posterior lips are brought together by means of tenacula so that the extent of the tear and the position of the canal may be judged. Each lip is then denuded, care being taken to remove all the cicatricial deposit from the angle of the tear. In a bilateral laceration a strip of mucous membrane is left in the centre of each lip to form the lining of the canal; stellate lacerations are denuded in such a way as to make the lesion unilateral or bilateral; all diseased tissue containing Nabothian ovules and hypertrophied glands should be removed. The field of operation is kept clean by means of small sponges on holders or by continuous irrigation. Chromicized or formalin catgut answers every purpose as suture material, although many operators use silkworm gut. The sutures are passed from the outside of one lip just below the angle of the tear, the needle coming out at the edge of the undenuded cervical canal, then reintroduced into the other lip and brought out so as to correspond with the point of entrance. The first or angle suture is the most difficult to insert. The sutures are caught in the grasp of a pair of hæmostatic forceps and not tied until all are introduced. After knotting and cutting the ends of the stitches iodoform is dusted upon the cervix and the speculum withdrawn. The patient is kept quiet for a week or ten days at which time non-absorbable sutures are removed.

LACERATIONS OF THE PERINEUM.—Schroeder states that the perineum is torn in thirty-four per cent. of primiparæ and nine per cent. of multiparæ. The general cause of laceration is disproportion between the size of the fœtal head and that of the vulvar opening. Sometimes the child is so rapidly expelled that the tissues have not time to become pliable, or, as is the case with elderly women, the parts may not be sufficiently elastic When the mechanism is faulty the axis of the presenting part may be directed too far backward and plough into the posterior wall; this is the case in occiput permanently posterior. The perineum is often lacerated when the delivery is by means of forceps. Tears are divided into complete and incomplete, according as they rupture through the sphincter ani or not; the incomplete tears may extend as far as the border of the muscle or stop short of it. In rare instances there occurs a "central rupture," the child being born through an opening between the anus and vulva. The laceration extends for a variable distance up the vagina on one or both sides, rarely in the median line. It is important to remember that the function of the levator ani may be impaired by overstretching without there being any evidence of external tear. The prophylaxis of perineal laceration is discussed in the article on *Labor, Normal*. Briefly, this consists in carrying out one or more of the following procedures: 1. Restraining the descent of the head to allow time for the gradual stretching of the tissues. 2. Diminishing the power of the expulsive efforts by the administration of chloroform. 3. Keeping the presenting part well forward under the symphysis. 4. Performing manual extension or flexion, according to the requirements of the mechanism, between the pains by means of a finger in the rectum. After the second stage is over every case should be examined to learn the condition of the pelvic floor.

Treatment.—All lacerations should be repaired immediately if possible; the stitches may often be inserted before the delivery of the placenta while the parts are numb or the woman still under the anæsthetic, the sutures not being tied until after the third stage is completed. When circumstances make postponement unavoidable just as good results in the way of union are obtained at the end of twenty-four hours. Primary Operation—Incomplete Tear: The instruments needed are: curved needles, needle-holder, scissors, thumb forceps, and suture material. The rubber pad is placed beneath the buttocks and the leg-holders are applied; the parts are cleansed and bits of ragged tissue trimmed away with the scissors; a wad of sterile cotton or gauze may be placed in the vagina to prevent blood from obscuring the field of operation. The closure of the incomplete tear is a simple matter and requires the application of none but the ordinary surgical principles. The rent in the vagina should be closed by a running suture of catgut and the remainder of the tear brought together by side-to-side sutures of silkworm gut. If no vaginal stitches are required the silkworm gut may be introduced and the ends secured with a hæmostatic until the placenta is expressed; but if there is much laceration of the vaginal wall, it is best to defer all suturing until after the third stage. Complete Tear: The essential point of this operation is to bring together the ends of the torn sphincter ani. The first suture should be introduced well back, about on a level with the posterior margin of

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the anus, then buried in the recto-vaginal septum and brought out at a corresponding point on the other side; usually two sutures suffice for the sphincter. The rest of the operation is the same as that for incomplete tear. If the laceration extends up the rectum, the rent in the bowel should be united by means of catgut stitches introduced from the rectal side of the bowel. There are no special features about the after-treatment; the parts should be irrigated after each urination and kept dusted with iodoform. Even when the tear was a complete one the bowels should be moved on the second and each succeeding day, the fæces being softened by the injection of a little olive oil.

If lacerations involving the pelvic floor are not sewed up at the time of their occurrence there may be unpleasant results. The posterior vaginal wall may begin to roll out, forming a rectocele; as the anterior wall is supported by the posterior a cystocele may be added, and these two conditions interfere with the functions of bladder and rectum. The prolapse of the vaginal walls drags upon the uterus until its supports yield and displacement occurs. The attempt to innervate the weakened or ruptured muscles is a severe strain upon the woman's system, and the general health becomes impaired, while the altered position of the uterus interferes with the functions of the pelvic organs so that menorrhagia and dysmenorrhœa may be present. In cases of complete tear there is incontinence of fæces. The diagnosis of old laceration is made by inspection and digital examination; the tear may be represented by cicatricial tissue; the vulvar opening may gape; on directing the patient to "bear down," the lack of support is manifested by a protrusion of vaginal tissue. The only treatment is by operation, which must not be performed inside of two months after labor in order to give the uterus time for involution.

Secondary Perineorrhaphy.—During the week preceding operation it is well to direct the patient to avoid milk and live upon a diet of animal broths and food which will produce but little residue; such a course of preparation will add greatly to the prospects for success if the operation is to be for a complete tear. For several days in advance the patient should be given daily laxatives and high bowel washes; a large enema should be administered on the morning of the operation. The instruments required are: rubber pad, leg-holders, long scissors curved on the flat, scalpel, rat-toothed forceps, tenacula, hæmostatics, needle-holder, curved and straight needles, suture material of catgut and silkworm gut. After the patient is anæsthetized she is placed in the lithotomy position, the perineum is shaved, and the parts are rendered aseptic. If, by means of tenacula, the two lower carunculæ myrtiformes and a point on the posterior vaginal wall are brought together, a good idea of the area requiring denudation may be obtained. There are two typical operations which meet the demands of the majority of cases, Hegar's and Emmet's.

Hegar's Operation.—The three points to be determined in this operation are the apex of the rectocele and the two lower caruncles. With the scalpel a line is made at the margin of the skin and mucous membrane connecting the lower caruncles of either side, and from these points the line is carried up to the apex of the rectocele on the posterior vaginal wall. This triangular area with a curved base is then denuded with the scissors. Beginning at the point farthest up the vagina catgut sutures are introduced, the needle being directed in a slanting course downward on one side until the centre of the vaginal wall is reached and then upward to a spot corresponding with the starting-point. In this way the upper part of the triangle is closed almost down to the caruncles. A straight needle is now threaded with silkworm gut and a suture is passed from side to side, beginning just above the posterior commissure. The next two sutures are inserted above the first and passed into the vagina and out again on the opposite side, drawing the two caruncles and the centre of the vaginal wall into their correct relations.

Emmet's Operation.—This operation is particularly well adapted to those cases in which the tear involves the lateral aspects of the posterior vaginal wall. The denudation is triangular on either side, leaving a V-shaped piece of mucous membrane in the centre. The lateral areas are closed by catgut sutures; the edges of the lower part of the denuded area are brought together with silkworm gut, the upper suture being known as the "crown suture," as it secures the apex of the V before emerging on the other side. If the tear has extended into the rectum, great care must be taken to freshen the edges of the sphincter ani; the insertion of the sutures and the after-care do not differ from the description given when treating of the primary operation. Non-absorbable sutures are removed on the eighth or tenth day.

Forceps.—Forceps consist of two blades, and are either of the long or the short variety; long forceps may be provided with appliances for axis traction. The curves of a forceps are two, cephalic and pelvic; the former adapts the blade to the side of the fœtal head, and the latter coincides with the axis of the pelvic canal. Short forceps have no pelvic curve. To insure a firm grasp good forceps should have a moderately long handle, and should be as stiff as possible without making the construction too clumsy. The cephalic curve should be of moderate sharpness, viz., about that represented by the arc of a circle whose diameter is nine inches; such a curve will grasp the head securely and yet not be difficult to introduce. The tips of the blades should be about one inch apart when the handles are closed. Long forceps should measure not less than nine and one-half inches from the lock; when the instrument is applied to the head the pelvic curve has its concavity directed upward toward the symphysis. The blades of forceps are locked either by means of a pin and slot, or there are grooves on the shoulders into which the shank of the opposite blade sinks. Shoulders upon the handles or a loop in the shank above the lock for the insertion of the forefinger are desirable features. There are many varieties of excellent forceps in the market, and choice is only a matter of individual taste provided the forceps have the characteristics just enumerated.

Axis-Traction Forceps.—When the blades are applied to the head at or above the brim of the pelvis the traction should be made in the axis of the superior strait, that is, downward and backward. With the ordinary long forceps traction in this direction is very difficult to carry out, and the force exerted acts at a disadvantage. In all axis-traction forceps rods are applied to the blades in such a way that the traction can be made in the axis of the blades, that is, in the axis of that portion of the canal in which they lie. The handles are held in apposition by means of a screw, and there are joints between the rods and bar as well as between the rods and blades, so that the head can move freely either in rotation or flexion and extension. The standard axis-traction forceps is that which was devised by Tarnier, but there are many modifications of the original instrument, one of the best being the Jewett forceps (Fig. 3611). Edward Reynolds has devised rods which hook into the blades of any pair of long forceps, and are fairly satisfactory. Forceps should be made of metal throughout so as to insure perfect cleansing and sterilization; for the same reason all the parts of axis-traction instruments should be detachable.

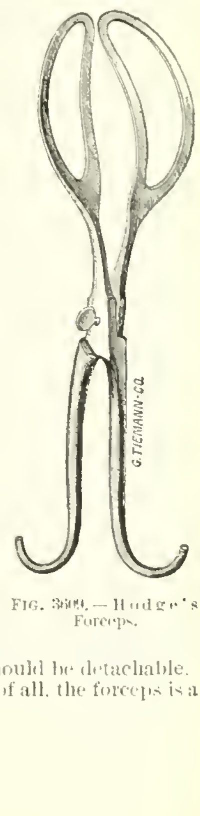

Fig. 3609.—Hodge's Forceps.

Action and Uses of Forceps.—First of all, the forceps is a

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tractor; it is also a lever as far as producing flexion and extension of the head is concerned; but leverage carried out by swaying the instrument from side to side is to be avoided as very dangerous to the soft parts of the mother. In rare instances the instrument is used as a rotator, as in turning an occiput forward; but this also is dangerous, and, as a rule, the blades should be allowed to turn with the head as it descends. Finally, the powerful axis-traction forceps are compressors, and great care must be exercised lest this action of the instrument injure the fœtus.

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FIG. 3610.—Jenks' Long Forceps.

Indications for Application of Forceps.—Most frequently the application of forceps is required because the maternal forces are unable to expel the fœtus on account of simple uterine or abdominal inertia. Provided there be no contraindications, it is a general rule that when the presenting part has remained stationary for two hours forceps should be applied; of course such a rule is a very rough one, as each case should be managed to suit particular conditions. Forceps may be demanded either in the interest of the child or in that of the mother, and in many instances these interests are combined. Under the head of maternal conditions should be mentioned: pneumonia, valvular disease of the heart, and eclampsia; accidents, such as placenta prævia, accidental hemorrhage and rupture of the uterus; abnormalities of the parturient canal, such as contracted pelvis, tumors, and rigidity of the soft parts. Fœtal indications are undue variation in the strength and rapidity of the heart beat, prolapse of the funis, and sudden death of the mother. There are certain definite contraindications to the use of forceps which are important to bear in mind. The forceps never should be applied when the contraction of the pelvic canal is excessive. As a rule, a conjugate of three and one-half inches is the limit in cases of contracted pelves. Forceps should not be applied to the hydrocephalic head nor to one that has been perforated or is decomposing. Except in a few cases of placenta prævia in which version is contraindicated the instruments should not be applied to a head which is still movable above the brim. Before performing a forceps operation the membranes must be ruptured and the cervix must either be dilated or dilatable. The bladder and rectum should be empty and the position of the head known. It is unjustifiable to make traction upon a head which is descending in such a way as to develop an impossible mechanism, as in persistent mento-posterior and brow cases.

Technique in Applying Forceps. — The operation is known as high forceps when the head is at the brim; as low forceps when on the perineum; and as intermediate forceps when it is between these points. Only the operations of high and low forceps need to be described.

High Forceps.—The operator should have at hand whatever is necessary for the treatment of post-partum hemorrhage and the repair of ruptured perineum; strict asepsis should be observed throughout. The forceps are sterilized by boiling, and the outer surfaces of the blades smeared with sterile vaseline. The patient is anæsthetized and placed across the bed, or better, upon a table, the knees being held by assistants or secured by leg-holders. After the urine is drawn and the parts are cleansed the physician should make a thorough examination in order to determine the exact position of the head. The left blade is introduced first; this is the one lying in the left hand of the operator and occupying the left side of the pelvis. The operator grasps the handle of this blade near the lock, holding it lightly between the thumb and fingers of the left hand in a position almost parallel with the right groin of the mother; two fingers of the right hand are introduced into the vagina, and the tip of the instrument guided gently along their palmar surfaces until the blade comes to lie beside the fœtal head. During introduction the handle of the forceps swings toward the median line of the mother and at the same time downward so as to cause the pelvic curve to adapt itself to the axis of the superior strait. The shank of the instrument presses back the edge of the perineum when the blade is in place. Giving the handle to be steadied by an assistant, the physician passes the other blade in the same way over the one already inserted, reversing the position of his hands to do so. If at any time during the operation contractions of the uterus are evoked the physician must suspend operation until they have passed. The next step is locking the forceps. To do this the handles are gently depressed. If the blades do not readily come together no force must be used, but with a finger within the vagina they should be carefully rotated until they come into proper relation. If it is now impossible to lock them, it is because they are improperly applied, so they should be removed and reinserted. After they have been locked, the handles are brought together or a towel can be placed between them if the operator wishes to avoid the danger of making too much compression upon the head. Before making traction it is well to make an examination to assure one's self that the blades are within the cervix, and that neither the hair nor any of the soft parts are caught in the instrument. At first the tractions are made in a direction downward and as far back as possible; they should imitate the action of the uterus by being intermittent, and the handles should be slightly separated during the interval of rest so as to relieve the head from compression. In difficult cases the traction may be made with the pains, the patient being placed in Walcher's position, viz., at the edge of the table with her heels just touching the floor. This posture increases the antero-posterior diameter of the inlet, but diminishes that of the outlet; so when the head has passed the brim the woman is returned to her original position. As the head descends in the curve of Cärus, the direction of the traction changes more and more to the front until, when the head is on the perineum, the handles of the forceps point almost directly upward. The forceps should now be grasped in the right hand with the palmar surfaces toward the operator; with the left hand he supports the perineum and shells out the head by swinging the handles until they are almost parallel with the woman's abdomen. As flexion or extension of the head is under perfect control when the forceps are applied, ample time may be taken to allow for full dilatation. Sometimes it is wise to remove the forceps just before the largest diameter of the head comes through the vulva. When axis traction is used, the handles are secured by means of the screw and the force is exerted upon the cross-bar. As the axis-traction instruments are very powerful, it is most important to relax the handles between pulls.

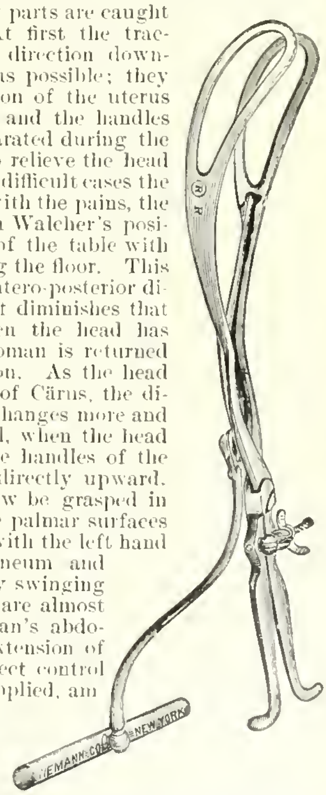

FIG. 3611.—Jewett's Axis-Traction Forceps, with Separate Traction Rod Attached. (For a detailed description of this instrument see the *Brooklyn Med. Journal*, January, 1895.)

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Low Forceps.—In applying forceps to the head when low down no regard need be paid to the pelvic curve of the instrument—in fact, there is no such curve upon the short forceps. The application of the blades is easy, and the extraction of the head is performed in the same way as during the last stage of a high forceps delivery.

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Forceps in Breech Labors.—The forceps are devised to fit the child's head, but they are sometimes applied to the breech when impacted. The blades are applied either over the trochanters or over the sacrum and posterior part of thigh according as rotation has or has not taken place. The first pulls must be gentle as the blades are apt to slip; axis traction is particularly useful in these cases.

Prognosis in Forceps Operations.—Low forceps should cause no danger either to mother or child, but the high operation is not to be undertaken lightly. The dangers to the mother are sepsis and injury to the soft parts; to the child the long and severe compression often proves fatal.

VERSION.—Version or turning is an operation which alters the position of the fœtus in utero so that the presenting part is changed and a different pole of the fœtal ellipse is made to occupy the lower segment. There are three varieties of version: (1) Cephalic, when the head is brought to the internal os; (2) pelvic, in which the breech is made to present itself; (3) podalic, when one or both feet are pulled into the vagina. According to the nature of the manipulations used in its performance, version is divided into external, internal, and combined.

Cephalic Version.—Theoretically this form of version should be performed in all cases of breech and transverse presentation, provided there is no need of immediate delivery and narrowing of the pelvis is absent. The advantage is that there results a normal presentation; but, unfortunately, the field for its employment is limited. It can be carried out only when the liquor amnii is present or immediately after the rupture of the membranes. To perform external cephalic version, the patient is put in the lithotomy position with knees and thighs well flexed. One hand is placed over the head and the other over the breech; then by a succession of gentle impulses the head is pushed toward the pelvis and the breech toward the fundus. During a uterine contraction all efforts at turning should cease, the operator only attempting to hold the fœtus stationary. When the head has once entered the pelvis pads should be placed on either side of the abdomen until engagement has taken place. The *combined method* is known as the bipolar method of Braxton Hicks, and is carried out as follows: The patient is anæsthetized and placed in the lithotomy position; the bladder and rectum must be emptied. After the parts have been rendered aseptic, the disinfected hand is passed into the vagina and one or two fingers into the cervix. The presenting part is pushed away from the internal os in a direction toward the breech, while the outside hand forces the head toward the pelvis. When the fœtus lies obliquely the operator uses externally the hand which corresponds to the position of the head. By the conjoined action of the internal and external hand the head is gradually carried into the pelvis.

Pelvic Version.—This operation is not often performed, as podalic version has largely taken its place. It is indicated in cases in which there is slight pelvic narrowing and no need of immediate delivery, also in transverse presentation when the breech is situated lower than the head. It is carried out by the external and combined methods in the same way as described under Cephalic Version.

Podalic Version.—This is the most common form of version. The indications are: malpresentations and malpositions, minor degrees of pelvic narrowing, especially of the flat type in which this operation may compete with symphyseotomy. A conjugate of three and three-fourth inches is placed as the lowest limit for the elective operation; this limit may be reduced to three inches if the woman be placed in Walcher's position. Podalic version is also indicated in emergencies such as prolapse of the cord and placenta prævia. The contraindications are tetanic contraction of the uterus with marked thinning of the lower segment, rupture of the uterus, impaction of the presenting part, and extreme contraction of the pelvis. The difficulty of the operation increases according to the length of time which has elapsed since the rupture of the membranes. The chief dangers are rupture of the uterus, sepsis, and constriction of the child's neck by an imperfectly dilated cervix. Podalic version is carried out by both the combined and the internal methods. The *Combined* or *Bipolar Method* of Hicks: The first part of the operation is performed in the same way as that described in treating of cephalic version, the breech instead of the head being forced into the pelvis. As soon as a knee or foot is felt opposite the internal os the membranes are ruptured, the extremity is seized and brought into the vagina, and the version is completed by traction upon the leg thus brought down.

Internal Podalic Version.—The bipolar method becomes impossible as soon as the membranes have ruptured and the uterus is closed down upon the fœtus. The hand is introduced into the uterus, one or both feet are seized, and the turning is made by traction, while the external hand makes counter-pressure upon the abdomen. The important points in the technique are as follows: Place the woman in the lithotomy position, empty the bladder and rectum, use an anæsthetic, and carry out strict asepsis. Make sure of the presentation and position, and see that the child is alive and in no immediate danger. Do the version as early as possible after rupture of the membranes. Introduce the hand corresponding to the position of the feet. If the membranes are unruptured, do not rupture them until the feet are reached. Grasp one or both feet, and during the traction keep them in line with the fœtal ovoid. If the hand or arm is delivered, put a tape around it and keep the extremity alongside the trunk.

Extraction after Version.—Usually the child is immediately delivered, after internal podalic version, by pulling successively upon the legs and trunk, the line of traction being directly downward toward the floor until the scapulæ appear. The body of the trunk should be covered with a cloth both for the sake of warmth and to prevent the operator's hands from slipping. The next step is the *freeing of the arms* which have dragged behind and become extended alongside the head. The posterior arm should be freed first in the following manner: The operator holds the child's legs near the malleoli and forcibly swings the trunk upward and outward over the thigh of the mother, keeping the back of the child anterior. If the right fœtal arm is posterior, the trunk is swung over the mother's right thigh and vice versa. The operator passes two fingers over the posterior shoulder into the vagina until he can reach the forearm and sweep it across the child's face by flexion, finally delivering it by extension. The trunk is then swung in the opposite direction, and the other arm delivered in the same way.

Extraction of the Head.—In the delivery of the head firm pressure from above by the hands of an assistant is most important. The child should be made to straddle the left arm of the operator, two fingers being inserted into the mouth to maintain flexion; the fingers of the right hand are laid across the shoulders. Traction is first made downward and then the face carried over the perineum by swinging the child's body up over the abdomen of the mother. If the pelvis is of the flat type, the head should be rotated into the transverse diameter of the inlet. When necessary Walcher's position may be employed. *Prague Method:* The feet are grasped in one hand, and the fingers of the other hand are placed over the child's clavicles; the feet are carried upward while the fingers on the shoulders act as a fulcrum around which the head swings. *Deventer's Method:* No attention is paid to the arms which are left alongside of the head. Tractions are made upon the feet and shoulders directly downward and then the child is swung under the mother's buttocks. This method is said to be very speedy in appropriate cases. Forceps may be applied to the child's head by passing the blades underneath the elevated

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trunk. Extraction, as a rule, should not be attempted until the cervix is dilatable, having been rendered so either by nature or by the manual efforts of the operator. Forceps is said to be particularly useful when there is constriction at the cervix. After the extraction of the arms, the head must be delivered in from three to five minutes at the longest if a living child is to be obtained.

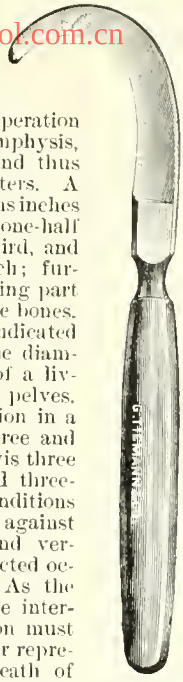

Fig. 3612.—Galbiati's Knife for Symphyseotomy.

Symphyseotomy.—This is an operation for cutting through the pubic symphysis, allowing the bones to separate, and thus increasing all the pelvic diameters. A separation of two and three-fourths inches increases the conjugate about one-half inch, the oblique one and one-third, and the transverse a little over one inch; furthermore, a portion of the presenting part may enter the opening between the bones. *Indications.*—The operation is indicated whenever a slight increase in the diameters will permit of the delivery of a living child, hence in contracted pelves. The lowest limit for the operation in a generally contracted pelvis is three and three-fourths inches; in a flat pelvis three inches (some authors say two and three-fourths). Thus under certain conditions symphyseotomy enters the field against Cæsarean section, craniotomy, and version. Other indications are impacted occiput posterior and chin cases. As the operation is designed solely in the interests of the child, the final decision must usually rest with the woman or her representative. *Contraindications.*—Death of the fœtus, the existence of ankylosis of one or both sacro-iliac joints. The operation should not be performed before the cervix is dilated or dilatable.

Methods of Operating.—The open or direct method should be avoided, as the wound is so situated that septic infection is wellnigh certain. The instruments required are the Galbiati or Morisani sickle-shaped knife, a blunt-pointed bistoury, scalpel, hæmostatic forceps, needles and needle-holder, silkworm gut, metal catheter, iodoform gauze, adhesive plaster, dressings, and a strong binder. Sometimes there is difficulty in cutting through the symphysis (usually because the operator misses the joint), so a chain-saw should be at hand. The patient should be anæsthetized, abdomen and vulva cleansed and shaved, the bladder and rectum emptied. An incision about two inches long is made just above the upper border of the symphysis and the attachments of the recti muscles cut sufficiently to permit the introduction of the left forefinger behind the symphysis. The catheter is inserted into the bladder and the urethra and bladder are depressed downward and to the right. The sickle-shaped knife is passed along the left index finger and hooked under the symphysis; by a sawing motion the joint is cut through in a direction from below upward and from within outward. If a few fibres of the ligament are missed they can be cut with the bistoury. The wound is now packed with gauze to control the hemorrhage and the catheter is removed. The child is delivered by means of the axis-traction forceps while two assistants support the sides of the pelvis to prevent excessive separation of the bones. An excellent method of operating is the *subcutaneous*, as advocated by Dr. E. A. Ayers, of New York. He makes an incision under the elevated clitoris, inserts a probe-pointed bistoury, and cuts through the joint from above downward and from behind forward, the left index finger being in the vagina and pressed against the posterior groove of the joint to serve as a guide.

After-Treatment.—The placenta is expressed and uterine contractions are secured as after normal labor. The catheter is reintroduced to hold the bladder and urethra away while the pubic bones are pressed together, the abdominal wound is sutured with silkworm gut and a broad strip of adhesive plaster passed is about the pelvis. The woman must be confined to bed for at least three weeks and the most scrupulous cleanliness observed. Unless the suspended bed of Dr. Ayers be used, the care of the bowels and bladder is a very troublesome and difficult matter. The patient usually requires catheterization for a certain length of time. The dangers of the operation are sepsis, hemorrhages, development of fistulæ, and lacerations of the soft parts, all avoidable with proper care. In a very few cases undue amount of motility at the symphysis has remained and the sacro-iliac joints have been injured by permitting the separation of the bones beyond three inches.

Prognosis.—The general mortality is given as from eight to twelve per cent., but many of these fatal cases were operated upon after the patient was already exhausted or septic. Ayers has reported thirteen cases without the death of a mother, and eleven children saved. As the chief danger is sepsis, there should be no maternal mortality when the operation is performed under favorable conditions, and, for the average practitioner, it is an easier operation than either craniotomy or Cæsarean section. The fœtal mortality is not the result of the operation, but of the antecedent conditions.

Embryotomy.—This term includes all operations designed to reduce the bulk of the fœtus, namely, craniotomy, decapitation, and evisceration.

Craniotomy.—This operation diminishes the size of the fœtal head. The indications are: Death of the fœtus. If the fœtus is already dead, there is no reason why the suffering of the mother should not be shortened and the case concluded as rapidly as possible, even if the parturient canal is of normal calibre. Contracted pelvis: two and one-half inches in the conjugate is placed as the lowest limit, and even before this limit is reached the operation may be more dangerous for the mother than Cæsarean section. Obstruction of the canal by tumors, monstrosities, large size of the fœtal head, and impacted malpositions of the fœtal head are other indications. The sacrifice of a normal child's life is seldom justifiable when the very favorable results of Cæsarean section and symphyseotomy are considered. How far the physician should go in carrying out the wishes of the patient or her friends is an individual question of ethics. Instruments required for the operation are: volsella forceps, perforator, cranioclast or cephalotribe, metal catheter, and Davidson syringe. The patient is anæsthetized and prepared as for the application of forceps; the fœtal head is steadied by grasping the scalp with the volsella forceps, and the skull is perforated. For this purpose there are several instruments, such as Blot's perforator, Smellie's scissors, and Braun's trephine; this latter instrument is very satisfactory when the head presents, as it removes a button of bone. When the scissors are used, they are thrust through a suture or fontanel and then opened in various directions to enlarge the hole. For the after-coming head the point of selection is the occipito-atloid ligament, but it may be necessary to perforate through the lambdoid suture, near the ear, or even beneath the chin. After the perforation is completed the brain substance is broken up and washed out by means of the catheter. Extraction of the head is performed in one of two ways, either with the cranioclast or with the cephalotribe. When the cranioclast is used

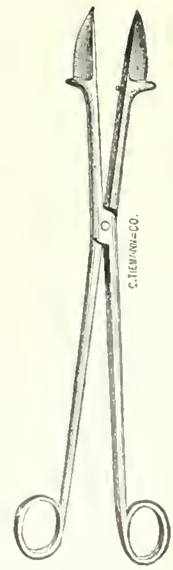

Fig. 3613.—Smellie's Scissors.

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one blade is inserted into the opening in the skull, the other blade grasping the head over the face or ear; the handles are brought together by means of a nut and screw and the head is delivered by traction; as the skull is empty the head undergoes compression and is moulded in obedience to the pressure of the parturient canal. The cephalotribe is applied like the ordinary forceps, and when the handles are screwed together the base of the skull is crushed. Tarnier's cephalotribe has a perforator combined with it, but the crushing usually is unnecessary. Before the performance of craniotomy the cervix must either be dilated or dilatable. Apart from the danger of sepsis, the soft parts of the mother may be severely injured in cases of extreme contraction of the pelvic canal.

Decapitation.—The indications for this operation are impacted shoulder presentations with thinned lower uterine segment, interlocked twins, and monstrosities. The usual instrument employed for decapitation is Braun's hook, but scissors, fine wire, or even cord can be employed in an emergency. The patient is anæsthetized and prepared as usual; while an assistant pulls down upon an arm, if prolapsed, the hook, guided by the internal finger, is passed over the neck of the fœtus and the tissues are cut through by a series of twisting motions. The trunk is delivered by traction upon an arm or leg; the head being extracted by hooking one finger into the opening at the base of the skull aided by pressure from above. In difficult cases the head is seized in the forceps or cephalotribe.

Evisceration.—This operation consists in removing the contents of the thoracic and abdominal cavities and is indicated in some neglected cases of transverse presentation and in monstrosities. The puncture is made with the scissors and the viscera are dragged out with the hand or blunt hook; delivery is by podalic version. In difficult cases the child's spinal column is cut and the body doubled up before extracting.

Montgomery A. Crockett.

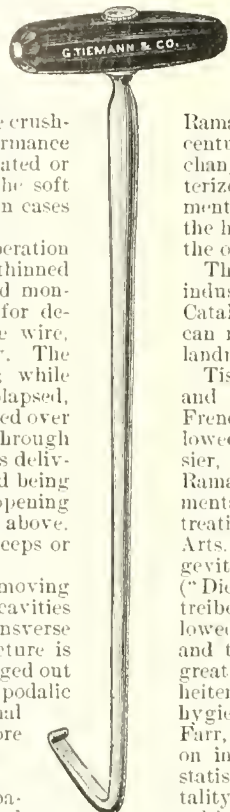

Fig. 3614.—Blunt Hook.

OCCUPATION, HYGIENE OF.—By "occupation" we mean the regular use of our physical functions and mental faculties in business and employment for remuneration, comfort, and luxuries. The functional activity of our organs in a normal way is a physiological condition of health; the disuse, more or less prolonged, of any organ being, as a rule, followed by atrophical changes. While the normal pursuit of occupation is therefore a condition of health, as well as a corollary of economic life, there have always existed, in occupations, certain factors which are productive of pathological changes.

The medicine of antiquity and of the Mediæval Ages ignored the problem of the injurious influence of certain trades on health, partly because these trades were pursued by the lower classes and the slaves, whose health was of no special consideration to the ruling classes, partly because the most injurious effects of occupation on health are but a product of the modern system of industry.

Apart from the few hints in the works of Hippocrates, Celsus, and others, and the mention by Pliny of the "diseases of the slave," we find nothing on the subject of the relations of occupation to health until we come to the seventeenth century, in the latter half of which we first come across a notice of occupational disease in the Transactions of the Royal Society of England, in which we find many pertinent observations on the effects of lead and coal mining, manufacturing of mirrors, etc., on the health of the operatives. To Italy, however, is due the great credit of the first attempt at a detailed description of the evils of certain occupations, the treatise of Bernardo Ramazzini, "De Morbis Artificum Diatriba," published in Modena in 1700, and soon after translated into many languages, being the first work accurately and vividly to describe the special effects of each occupation on health. Ramazzini laid the foundation for all further investigations on the subject, and it is no detraction from his deserved reputation that his book partly suffers from the superstitions and ignorance of his age; indeed we must feel respect and admiration for the many excellent and true observations, and the systematic exposition of the injurious effects of occupations which are found, for the first time in medical literature, in his work.

More than two centuries have passed since Ramazzini's epoch-making work was published—centuries not only full of remarkable revolutionary changes in trades and industries, but also characterized by a no less wonderful, progressive development of the sciences, among which the study of the hygiene of occupation has kept equal pace with the other branches of medical research.

The list of monographs, articles, and books on industrial hygiene fills many pages of the "Index Catalogue of the Surgeon-General's Library," and I can make mention here of only the more important landmarks on the subject in medical literature:—

Tissot's work on "Diseases Incident to Literary and Sedentary Persons," published in 1768 in French, was the next important book; it was followed nearly a half-century later by that of Patissier, who, however, gave but a republication of Ramazzini's work with additional notes and commentaries. After these follow, in succession, the treatises of C. Turner Thacrah ("The Effects of the Arts, Trades, and Professions on Health and Longevity," published in 1831), and of A. C. Halfort ("Die Krankheiten der Kuenstler und Gewerbetreibenden," published in 1845). These were followed by the works of Lévy, Tardieu, and Layet, and then finally, in the year 1871, by that of the great epoch-making work of Hirt—"Die Krankheiten der Arbeiter"—which first placed industrial hygiene on a true scientific basis. In England, Farr, Chadwick, Simon, Ogle, and others worked on in the same line, giving special attention to the statistical part of the subject of occupational mortality and morbidity. Of the later works on the subject, we can mention only the more systematic treatises of Popper, Eulenburg, Merkel, Albrecht, Arlidge, the volume on "Gewerbehygiene" in Weyl's "Handbuch der Hygiene," the work by Thomas Oliver ("Dangerous Trades," published in London, 1902), and the latest work just published in Germany, O. Dammer's "Handbuch der Arbeiter Wohlfahrt."

The immense bibliography and the vast extent of the subject matter of industrial hygiene render any attempt to review or even to summarize our knowledge of this branch of medical science within the limits of a short article, a very ungrateful task, it being utterly impossible to do justice to it under such restrictions.

I have decided to abandon the alphabetical order of treatment by "trades," handed down by Ramazzini, and adopted by the writer on this subject in the former edition of this Handbook, and I shall treat the subject matter under the following heads: Occupational Mortality Statistics; The Diseases of Occupation; The Worker; The Workplace; The Conditions of Work; The Processes of Work; Prophylaxis; and, last, "Offensive Trades."

Occupational Mortality Statistics.

Occupation is a potent factor in the determination of human longevity. If we deduct from man's life the time of infancy and childhood, and the hours devoted to sleep, the greatest part of it is spent within the periods of industrial activity, and is necessarily largely influenced by occupation. The relative number of those who die while in pursuit of their occupations bears an important relation to the healthfulness of the occupations. Moreover, if the figures revealed by the relative mortality statistics corroborate the scientific *a priori* de-

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Occupation.

ductions from the study of the processes of occupations and their pathological influences, we then have quite a valuable criterion of the influence of the different trades on the lives of the operatives. Herein lies the importance of mortality statistics, as determined by occupations. In order, however, that these statistics shall have any scientific value, they must cover large periods, embrace great numbers, include various races and countries, and be properly prepared and tested. For it is evident that there are a number of difficulties greatly invalidating the conclusions drawn from occupational mortality statistics. These are as follows:

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First, occupation, while playing an important rôle in human life, is, nevertheless, only one of the many factors influencing it, there being a great number of others, such as race, country, climate, heredity, geographical, economic, political, and other conditions, each of which undoubtedly affects the lives of operatives; and it is exceedingly difficult to differentiate the causative influences of occupation on longevity from those of all other factors.

Second, there are under the modern system of subdivision of labor several thousands of special branches of trades and industries, only a very few of which, however, and these the most general, being, as a rule, mentioned or tabulated in the mortality statistics. Thus there are about half a hundred occupations in Ogle's tables, not many more in Bertillon's; and in the last (twelfth) census of the United States there are 140 groups, 70 of which are further subdivided, making the whole number in the last census 303. It is obvious that each of the general groups of occupations may embrace a large number of minor trades, each of which will have a different bearing on health and life, thus greatly invalidating the deductions from the general tables.

Third, in our modern industrial production, there are very few trades which are hereditary, as the feudal guilds were, and in which the operatives remained during their whole lives. The greatest number of industries constantly change their *personnel*, most individuals pursuing several trades successively; and the occupation in which they happen to die gives little indication of the one in which they may have spent the greatest part of their lives, and where they perchance had received the injuries to health to which they subsequently succumbed.

Fourth, certain trades can be pursued only by very strong and healthy individuals; while others, being comparatively light, can be carried on by the physically weak and feeble. It is, therefore, manifestly incorrect to base deductions on occupational mortality statistics, seeing that the primary factors (*i.e.*, the workers) are not on an equal basis as to health. All the above considerations make it incumbent upon us to regard occupational mortality and morbility statistics with a certain suspicion, and to apportion them only such value as is warranted by the scientific deductions of the general and special characteristics of each trade, and its effect on health.

Ogle's statistics deserve the great credit attributed to them by hygienists, by reason of their careful elaboration and intelligent preparation. They have been quoted widely and are regarded as standards. I shall give Ogle's table, followed by more recent data from the last United States census, and from J. Tatham's recent morbility figures in Oliver's book.

COMPARATIVE MORTALITY OF MEN, TWENTY-FIVE TO SIXTY-FIVE YEARS OF AGE, IN DIFFERENT OCCUPATIONS, FOR THE YEARS 1881-83, BY W. OGLE, AS REPORTED IN A PAPER READ BEFORE THE SEVENTH INTERNATIONAL CONGRESS FOR HYGIENE, IN 1891.[1]

Occupations.	Comparative mortality.	Occupations.	Comparative mortality.
Clergymen*	100	Grocers	139
Gardeners	108	Fishermen	143
Farmers	114	Carpenters, joiners	148
Agricultural laborers	126	Lawyers	152
Paper-makers	129	Silk manufacturers	152

* The mortality rate of clergymen, being the lowest, is taken at 100.

OGLE'S COMPARATIVE MORTALITY TABLE.—*Continued.*

Occupations.	Comparative mortality.	Occupations.	Comparative mortality.
Drapers	159	Medical men	202
Coal miners	160	Stone & slate quarriers	202
Shoemakers	166	Bookbinders	210
Commercial travellers	171	Butchers	211
Corn millers	172	Glass workers	214
Bakers	172	Lead workers	216
Cabinetmakers	173	Cutlers	229
Masons, bricklayers	174	Brewers	245
Blacksmiths	175	Cab drivers	267
Clerks	179	Liquor dealers	274
Railway laborers	185	Filemakers	300
Gunsmiths	186	Earthenware workers	313
Wool workers	186	Cornish miners	331
Tailors	189	Costermongers, peddlers	338
Hatters	191	Inn, hotel service	397
Cotton workers	196		

OCCUPATIONAL MORTALITY TABLE ACCORDING TO THE (TWELFTH) UNITED STATES CENSUS FOR THE CENSUS YEAR OF 1900 (ONLY IN THE "REGISTRATION AREA"—TEN STATES[2]).

Occupations.	Mortality, per 1,000.	Occupations.	Mortality, per 1,000.
Mercantile and mechanics, average	12.1	Leather makers	12.3
Professional average	15.01	Tin workers	14.5
Laborers and servants	20.2	Marble & stone workers	14.9
Engineers, surveyors	8.2	Engineers, firemen	15.7
School teachers	12.2	Painters	16.2
Lawyers	17.2	Butchers	16.1
Medical men	19.9	Plasterers	17.0
Clergymen	22.5	Carpenters, joiners	17.2
Textile mill workers	8.8	Leather workers	17.5
Plumbers and gasfitters	9.1	Hat, cap makers	17.9
Shoemakers	9.4	Cabinetmakers and Upholsterers	18.0
Machinists	10.5	Blacksmiths	18.3
Iron and steel	10.7	Cigar, tobacco workers	18.7
Glass makers	10.8	Brewers, distillers	19.7
Tailors	11.8	Stone masons	19.9
Printers, pressmen	12.1	Coopers	23.8
Bakers, confectioners	12.3	Millers, flour, grist	26.6

The United States occupation-mortality statistics being only for ten States and only for one year do not have the value of Ogle's tables, which embraced several years and the whole of England and Wales.

COMPARATIVE MORTALITY FROM SPECIFIED CAUSES IN CERTAIN DUSTY OCCUPATIONS. (JOHN TATHAM.[3])

Occupations.	Comparative mortality, all causes.	Phthisis and respiratory diseases.		Mortality figure.	
		Mortality figure.	Ratio.	Phthisis.	Respiratory diseases.
Agriculturists	602	221	100	106	115
Earthenware	1,702	1,001	453	333	668
Cutlers	1,516	900	407	382	518
Filemakers	1,810	825	373	402	423
Glass workers	1,487	740	335	295	445
Copper workers	1,381	700	317	294	406
Gunsmiths	1,228	649	294	325	325
Iron and steel	1,301	645	292	195	450
Zinc workers	1,198	587	266	240	347
Stone quarriers	1,176	576	261	269	307
Brass workers	1,088	552	250	270	273
Chimney-sweeps	1,311	551	249	260	291
Lead workers	1,783	545	247	148	397
Cotton workers	1,141	540	244	202	338
Cooper and wood turners	1,088	526	238	250	276
Rope makers	928	486	220	219	267
Masons and bricklayers	1,001	476	215	225	251
Carpet workers	873	471	213	226	245
Tin workers	904	451	204	217	234
Wool manufacturers	901	447	202	191	256
Locksmiths	925	428	194	223	205
Blacksmiths	914	392	177	159	233
Bakers and confectioners	920	392	177	185	207

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"In this table the mortality of the several dust-producing occupations is contrasted with that of agriculturists, who have been shown to suffer the least from the effects of dust. The aggregate death rate from tuberculous phthisis, and diseases of the respiratory system, is shown in this table, as are also the figures relating to each affection separately. Columns 1 and 2 give the combined mortality from these diseases in comparison with that of agriculturists. In the third column the mortality of the latter is taken as one hundred, showing the proportional relation to other workers." [3]

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Diseases of Occupation.

Disease has been defined as an abnormal condition of the body, a perturbation in the state of the living organism; while life itself is a struggle of the organism with its environment. In the study of the pathogenesis of disease, we come to a complex phenomenon, which on closer study resolves itself into two main branches: First, the intrinsic constitution of the organism; and second, the external world, *i.e.*, the environment. Among the environmental conditions influencing life and health, one, not the least in importance, is that of occupation. In the mortality statistics we have seen that occupation does affect the longevity of man; at least, there is a strong array of figures, corroborating each other, from various races, countries, and localities, which persistently show that some occupations have a very large comparative mortality, and which therefore warrant the deduction that these occupations possess some elements or conditions capable of causing those disturbances in the organism which terminate life more rapidly than is commonly the case when the conditions in question are absent. If death itself, which is but the culmination of all abnormal conditions of life, can be, more or less directly, brought on by occupation, how much more likely is it that occupation will influence the daily life and cause the morbid states called *disease?*

As a matter of fact, since the time of Ramazzini, we do regard many morbid states as due to the influence of occupation, and we call them "industrial diseases," or "diseases of occupation," by which we mean such diseases as are superinduced directly or indirectly by one or more elements existing in occupation. There are, however, two points which we must note in the study of industrial diseases: individual susceptibility, and the relative importance of occupation in the causation of disease. Those who have made a study of the pathogenesis of disease know the remarkable rôle which is played in health and disease by the inherited constitution, personal vital resistance, and power of immunity of each individual. We frequently observe two individuals working in the same trade, side by side, influenced by identical conditions, subject to the same harmful elements, and breathing the same foul, dusty, and poisonous atmosphere; yet while the one, sooner or later, succumbs to these dangers of his trade, and becomes invalidated by the general or special maladies of his calling, the other continues to enjoy life, with apparent immunity from all injurious influences. It is evident that in industrial, as in other diseases, the personal element, the individual susceptibility must be taken into account. So far as the question of the relative importance of occupation in the causation of disease is concerned, there are those who totally deny that there are *any* diseases of occupation. They claim that we may just as well classify diseases by habitation, soil, sewerage; by races, localities, and countries; by monarchies, republics, and constitutional governments, inasmuch as each of these external factors undoubtedly bears some relation to conditions of health, and may, in some more or less remote way, cause disease. This position is, however, untenable; for occupation certainly exerts a greater comparative influence on health than do many of the other external factors; and there are some industrial diseases which may be directly traced to certain specific industries, while this can hardly be said of the other factors.

Among the industrial diseases there are some which can be shown to be directly due to the toxic elements or substances generated in each trade; others there are in which their connection with some particular industry is more remote; and still other diseases in which occupation plays only a predisposing rôle. It is impossible to give here the detailed description of all industrial diseases, nor is it necessary, as all of these diseases are at the same time common to all mankind, and are more fully treated in other parts of this Handbook. The diseases to be briefly alluded to here are only those which bear a direct etiological relation to occupation.

Diseases of the Respiratory System.—The organs of the respiratory system are the greatest sufferers from industrial conditions. The respiratory passages have been very aptly named "the entrance port" of the body where most of the infective agents land on their arrival. All impurities of air, if persistently inhaled for long periods, are liable to produce inflammatory changes in the respiratory passages, and so to weaken them that they readily become a prey to any infective organism. The most pernicious effects on the respiratory organs are produced by the inhalation of dust. In the divers industrial processes, all kinds of materials from animal, vegetable, mineral, and metal substances are undergoing various processes of transformation, with the inevitable result that a great quantity of dust is raised and fills the air of the places of work, and is constantly being inhaled by the operatives. A mere temporary inhalation of dust is followed by increased secretion from the mucous membrane of the respiratory passages, by which these try to get rid of the foreign matter. When, however, the action of the dust is persistent and continuous, the mucous membrane of the passages gets congested, inflamed, and denuded of its protective ciliated epithelia, and, with the weakening of the defensive forces, the entrance of foreign matter or infective materials into the parenchyma of the lungs is no longer prevented. The statistical tables of Hirt, Ogle, Tatham, Bertillon, Kummer, and of the United States census, all agree that the greatest burden of ills due to occupation falls upon the much-abused respiratory organs.

Bronchitis.—Of the diseases of the respiratory system, the most directly traceable to industrial influences is bronchitis. Among the principal causes of bronchitis, Hoffman [4] mentions: (1) catarrhal congestion, (2) inhalation of dust, (3) inhalation of gases. All these factors are preeminently those which are most frequently due to industrial conditions. Excessive muscular exertion, increased body heat due to hard labor, sudden chilling of body surface, exposure to varied and extreme temperatures, etc., are a few of the causes of catarrhal congestion in the bronchi, leading to subsequent chronic inflammatory changes. Inhalation of dust as a cause of bronchitis is easily understood when we remember the irritation which any foreign matter produces in the mucous membranes, and the special irritating qualities of a great many industrial dusts. Poisonous gases and fumes are direct irritants, and cause intense congestion of the bronchial mucous membrane and inflammatory changes which tend to become chronic if the inhalation of such fumes persists. The statistical data, as to the prevalence of bronchitis among workers, are not reliable, for the reason that the disease in its initial forms is hardly one for which the worker discontinues work or seeks medical aid, and certainly not one which would figure in mortality statistics. Hirt [5] gives the percentage of workers suffering from chronic bronchitis as from 11 to 69 per cent. Some dusts are more irritating than others. Thus Hirt found, in an investigation which covered 12,000 workers in a dusty atmosphere, that of those who experienced harmful effects therefrom in a greater or less degree, 11 per cent. were workers in mineral dust, 13.6 per cent. in animal dust, 14.8 per cent. in metallic dust, 18.4 per cent. in dust of a mixed character, and 19 per cent. in vegetable dust.

Emphysema.—Emphysema is a disease of the lungs in which a part of the tissue loses its normal elasticity and

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remains in a state of abnormal dilatation. Emphysema is caused by all conditions which interfere with the normal expiratory functions of the lungs. Among the causes of emphysema are: (1) Catarrhal conditions of the passages, leading to accumulation of mucus in the bronchi, to obstruction of the bronchioles and to violent fits of coughing; (2) the lodgment of foreign matter and dust in the bronchioles, and the obstruction of these channels resulting therefrom; (3) constrained attitudes, etc., leading to interference with respiration. Most of these conditions are present in many occupations. We have seen that chronic bronchitis is very prevalent among most workers, and consequently favors the production of emphysema among them. Hirt[5] says that from eight to ten per cent. of all who suffer from bronchitis have emphysema. The filling up of bronchioles with dust is a frequent condition in the lungs of coal miners and others who work in clouds of dust, and such obstruction will cause compensatory hypertrophy and dilatation of other alveoli, also dilatation of the right ventricle of the heart. Work in a constrained attitude, playing on wind instruments, glass blowing, lifting of heavy weights, severe muscular exertion, and alcoholism are among the other predisposing causes of emphysema among workers. According to Kubborn[6] 37 per cent. of miners suffer from emphysema, and according to Seltman[6] 50 per cent. According to Fueller[6] breathing foul air, deficient in oxygen and rich in carbonic acid, predisposes to emphysema; he quotes Seltman's figures to show that, among coal miners, of those who worked in pure air only 7.9 per cent. suffered from this disease, whereas of those who worked constantly in foul air, as many as 62 per cent. were so affected. Hirt[5] gives the following table of the relative frequency of emphysema among workers in dusty occupations: Of 100 cases of sickness there were among metallic workers 3.1 per cent., among those exposed to animal dust 3 per cent., to vegetable dust 4.7 per cent., to mixed dusts 5.1 per cent., and to mineral dusts, 9 per cent.

Pneumonokoniosis.—Zenker applied this term to affections of the lungs due to deposits of dust in their parenchyma. Several forms of pneumonokoniosis are distinguished according to the nature of the dust inhaled and deposited in the lungs. Dust particles are carried to the lung tissue by direct inhalation and also by the action of the lymph channels. These latter play an important rôle in the dissemination of the dust particles, as has been shown by the discovery of some dusts—for instance coal—not only within the lung, but also in the liver, spleen, and kidneys. Fueller[6] quotes the report of a French chemist who found in several samples of lung tissue, weighing respectively 1,800 gm., 2,860 gm., and 220 gm., the following quantities of coal: 85 gm., 140 gm., and 114 gm. According to Merkel[7] the following factors are determining in the etiology of pneumonokoniosis: (1) The state of health and individual susceptibility of the worker; (2) the vulnerability of the respiratory organs; (3) the duration and intensity of the exposure to dust inhalation; and (4) the quality and character of the dust. Quimby (see article on *Lungs, Diseases of: Pneumonokoniosis* in Vol. V. of this Handbook) gives the following more common vocations in which laborers are exposed for prolonged periods to a dusty atmosphere: Mining of various minerals, and the handling of coal in transit to its point of consumption; charcoal grinders and carriers, moulders and those who clean castings, metal and glass polishers, stone masons and plasterers, chimney-sweeps, laborers who tear down old buildings, potters and grinders on various forms of stone, bakers and pastry cooks, gilders and gold and tinfoil beaters, workers in mother-of-pearl and lead, jewellers and glass-cutters, file-cutters, millers, tobacco workers, grain shovellers, etc.

We shall refer to various pneumonokonioses when we come to the subject of dusty occupations and their influence on health.

Tuberculosis.—Pulmonary tuberculosis is a very frequent disease among all kinds of workers, especially among those who work in a dusty atmosphere. The etiological relation of occupation to pulmonary tuberculosis is not difficult to understand, although the connection is not always directly traceable. Occupation is more of a predisposing than an exciting cause of tuberculosis. All conditions of occupations, sex, age, foul air, overcrowding, variety in temperature, exposure, constrained attitude, inhalations of dusts, gases, fumes, and poisons, all tend to predispose the organism to fall a prey to the ravages of the tubercle bacilli. The infection may take place outside of the place of work, but generally happens within its precincts; for there is no better place for the cultivation, distribution, and dissemination of the bacteria than the foul, ill-ventilated, close, damp, overheated, dusty shops, where, if only one tuberculous patient expectorates, enough material may be spread to infect hundreds. The prevalence of pulmonary tuberculosis among various workers has been noted in the already cited table of Tatham on mortality due to this affection. The last United States census gives the number of deaths from pulmonary tuberculosis in the census year as 109,-750. Dusty occupations, as already noted, predispose to phthisis. All statistical data, from Hirt to Tatham, confirm the statement that tuberculosis is the most frequent disease among all occupations, and the frequency is directly proportionate to the amount of dust that is formed in the occupation.

Lobar Pneumonia.—It is difficult directly to connect lobar pneumonia with occupation, although Hirt claims that the largest number of cases of this malady occurs among the laboring class. Congestion and a catarrhal condition of the respiratory passages and exposure to bad weather, etc., are the main predisposing causes. Bronchitis and emphysema, so frequent among workers, predispose to infection with the pneumococcus, by reason of the fact that the normal pulmonary tissue has lost its power to resist infection. Exposure leads to chilling of the surface of the body and congestion of the lungs. The average frequency of pneumonia was found by Hirt[5] to be 7.3 per cent. in some workers, while in millers the percentage was 20.3. According to the figures of the last United States census the laboring class shows the greatest percentage of cases of pneumonia. Merkel[7] denies that dust has any effect on the etiology of pneumonia. In one hundred and forty dead, out of ten hundred and thirty-five cases of pneumonia, he failed to find any trace of dust in the lungs. If dust affects the lungs at all, it may do so by the wounding of the mucous membrane, thus presenting a solution of continuity, favoring bacterial infection. It was claimed that textile workers are prone to this disease, although this is denied by later investigators. According to Hirt's table those who are exposed to vegetable dusts suffer the most from pneumonia.

Diseases of the Nervous System.—The nervous system is the most abused part of the organism of the worker. Modern industry, with its complex mechanical development, enormous rate of speed, intensity of action, and the great demands on the nervous and mental forces of men, tends to overstrain the delicate nervous cells, and sacrifice them to the much-vaunted strenuousness of life. Some of the factors, more or less frequently accompanying all occupations, which lead to nervous disturbances are the following: Excessive cardiac action, intense muscular strain, overuse of an organ or group of muscles, prolonged mental labor, overwhelming responsibility, intense anxiety, mental worry, sudden and continuous shocks and jarrings, extremes of heat, cold, dampness, and variations of air pressure, inhalations of certain gases, and the ingestion of certain poisons.

Among the nervous diseases most frequent among workers are cerebral and spinal hyperæmia, peripheral neuritis, the fatigue neuroses, progressive muscular atrophy, various toxic paralyses, and insanity. According to the last census report, persons engaged in literary and professional occupations suffer relatively more from nervous diseases than do all the other classes. Thus medical men show the largest number of deaths due to nervous

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diseases. The nervous disturbances due to toxic influences will be treated later.

The Fatigue Neuroses.—These neuroses, also called "functional impotences," are directly due to various occupations. They manifest themselves in loss of motor, sometimes of sensory, power of some organs or groups of muscles; this loss being due to the continuous, prolonged, and excessive use of the same. Causes which predispose to these neuroses are weakness of the nervous system, alcoholism, excessive use of tobacco, mental anxiety, and trouble. According to Oliver[3] the primary seat of the disorder is situated in the cortex of the brain, and he adds that "altered nutrition of the cerebral nerve centres is in all probability responsible for the defective muscular movements; and that the spasm is only the initial fact in the illness." The most common fatigue neuroses are "writer's cramp" or "scrivener's palsy," telegrapher's spasm, as well as the spasms which occur in typesetters, milkers, hammermen, piano players, violin players, etc.

Eye Diseases.—The eyes frequently suffer from effects of occupation. Injury to the eyes may come from a too prolonged close application and straining; from exposure to excessive light or heat; from various dusts; from gases and poisons; from burns and accidents.

Overuse and close application and overstrain produce pain, asthenopia, myopia, presbyopia, and other changes in refraction. Clerks, copyists, engravers, draughtsmen, watchmakers, proof-readers, etc., are those who overstrain their eyes.

Certain occupations which compel very close application with accompanying constrained positions cause *nystagmus.* This disorder of the eyes is chiefly due to the constrained position which some laborers are compelled to assume during their work, and is very frequent in coal miners, five per cent. (according to some authorities, ten per cent.) of whom are afflicted with it; although workers in other trades, such as compositors, metal rollers, etc., are sometimes affected. The comparative frequency of nystagmus among coal miners is due to the unnatural positions assumed by them when undercutting in coal seams, lying on their sides, and straining the eyes in order to follow the pick.

Exposure to excessive light and heat is frequent among certain trades, as those of silver finishers, burnishers, furnace-workers, glass-blowers, electric welders, etc. In some of these occupations, notably in electric welding, the temperature may reach 3,000° F. and over. Conjunctivitis, hyperæmia, hyperæsthesia of the retina are common among this class of workers. Glass-blowers are said to be subject to cataract formations. Those who work in dusty trades very often suffer mechanical injuries to their eyes, owing to accidental and frequently unavoidable entrance of gritty, sharp dust particles into the eyes.

The effects of certain gases, fumes, and poisons on the eyes are well known, and cannot be gone into here. All strong irritants will affect the eyes and produce various diseases in them. Certain toxic substances cause various amblyopias.

Burns and accidental injuries are very common in many industries. Of 18,644 accidents to 25,000 workers, nearly 1,000 were injuries to the eye.[4]

Dermatoses.—Many affections of the skin are directly due to certain conditions in occupations. Thus, the skin is liable to scalds and burns, to the mechanical action of various dusts, to the action of poisons, of irritating gases. Constant pressure and friction will also cause abrasions or callosities. The dermatoses vary in their extent and severity from a simple erythema, to vesicles, pustules, and ulcerations. Occupational eczema is frequent. Scalds and burns are very frequent in some occupations. Dust, mixed with perspiration, will form crusts, which irritate the epidermis, causing itching and erythema, and leading to subsequent infection and more serious lesions. Flax workers very commonly suffer from severe eczema of the hands and fingers. Lead, arsenic, and other poisons produce severe skin affections. Certain workers who are obliged to scrape hides with their fingers suffer from a form of disease of the nails, called "furrier's nails."

The constant friction and pressure on circumscribed places of skin produce thickenings, callosities, and bursæ. These vary in location according to the special character of the work and the parts of body exposed to the pressure and friction. The hand and fingers are the most frequent places of callosities, the knees and olecranon the most frequent places for bursæ.

Cardiac and circulatory diseases owe their origin among workers to excessive strain and muscular effort, the lifting of heavy weights, the strain at too arduous tasks, excessive variations in temperature, etc. Cardiac hypertrophy and dilatation are frequent among athletes, professional pugilists, gymnasts, etc. Disorders of the circulation also depend on alcoholism.

Diseases of the digestive tract, unless caused directly by absorption of certain poisons, like lead, arsenic, etc., are mostly due not to the occupation, but to the poor hygienic conditions under which so many of the workers are compelled to live.

Of the *surgical* diseases, apart from wounds, fractures, and dislocations, occupations may cause hernias, varicose veins, aneurisms, etc.

Infectious Diseases.—There are a number of maladies which are frequently observed in certain occupations,—maladies which are due to infection by pathogenic organisms that happen to cling to the materials of work. All forms of microbes can be at times found in various substances and materials handled by workers. Thus, the microbes of scarlet fever or of typhoid fever may cling to the materials handled by the tailor; gardeners, who are obliged to handle earth, are more liable to contract tetanus; the men who care for horses are almost the only ones who become infected with glanders; the tunnel workmen are specially liable to anchylostomiasis, the wool workers to anthrax, etc. The infection by the last two has been regarded as closely connected with the occupation, although they can hardly be regarded as occupation diseases.

Anthrax.—This is a disease of cattle, induced by the action of the bacillus anthracis. As it forms the subject of an extended article in Vol. I. of this HANDBOOK, it is not necessary that I should enter into any further details in this place.

Anchylostomiasis (maladie des tunnels).—This is an infective disease from which many workers in tunnels of Belgium, Switzerland, Australia, and other places have been found suffering. In one pit in the province of Liège from fifty to sixty-nine per cent. of all workers, and in a Hungarian pit eighty per cent. of all workers, were affected. This malady, of which a pernicious anæmia is the most characteristic sequel, is caused by a minute parasite which fixes itself in the upper part of the small intestine by a number of hooklets and sucks the blood. The disease has been found in others beside tunnel workers. The infective parasite is found in the excreta, from which the infection recurs. Defective sanitary arrangement in the places of work and the lack of care and hygienic supervision are the causes of the spread of this disease, which will disappear whenever better hygienic conditions are established in tunnels.

Of the other industrial diseases, it remains to mention caisson disease and several minor affections, such as "shoddy fever," "glass-blower's mouth," "stamp-licker's tongue," etc.

Caisson Disease.—This term is applied to a group of symptoms the pathology of which is obscure, and which are met with in workers in compressed-air chambers in sinking mines, in excavating for piers for bridges, and in building foundations in boggy soil for large structures. The danger to the workers seems to be greater on going out of the compressed-air chamber into the decompression room than on entering or working in compressed air. The usual symptoms of the disease are vertigo, buzzing in the ears, vomiting, muscular pain, numbness in the legs, unconsciousness, followed, not rarely, by sudden death. The danger is greater the greater the air

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pressure and the quicker the entrance of the worker from the compressed air into the decompression chamber; also when the workers are compelled to climb stairs and undergo cardiac and muscular strain soon after coming out of the compressed-air chamber. Oliver[3] thinks that caisson disease is due to increased solution of gases in the blood and sudden liberation of them, and regards the symptoms as due to the increase in carbonic acid. Not all workers exposed to compressed air suffer equally, and there are some who entirely escape harm. In the building of the St. Louis bridge, where the pressure was sometimes as high as from four to six times the normal, there were twelve fatal cases. In the building of the Brooklyn Bridge the fatality was less.

"Shoddy fever" is an influenza-like infection which is met with in workers in rags and shoddy garments. It is due probably to infection with some bacterial organism.

"Glass-blower's mouth" is a swelling of the parotid gland extending from the angle of the mouth to below the ears, and is met with in glass-blowers.

"Stamp-lickers' tongue" is a stomatitis sometimes met with in those who lick labels and stamps, and is due to infection.

The Factors of Occupation.

The relative increase in the mortality and the greater frequency of disease in certain occupations are in a great part due to the complex group of phenomena which we call occupation, and which is composed of a number of factors, each of which has its own special bearing upon life and health. The primary factors of occupation are: the worker, the place of work, the conditions of work, and the processes of work. These primary factors are composed of several minor factors, each of which may play an important rôle in the causation of sickness and may influence the duration of life. A more or less detailed analysis of each factor is necessary to the understanding of the *modus operandi* of industrial influence on health.

The Worker.—The primary state of health, the hereditary "physiological wealth," the physical normal development of all organs of the worker, are fundamental elements in all subsequent influences of occupations on health. Some occupations can be followed only by the very strong and exceptionally robust, while others attract the weakling and the feeble only. The susceptibility of the worker to the injurious elements of his trade and his relative predisposition to succumb to the noxious elements or processes of occupation will greatly depend on his primary condition of health before entering the trade which he has chosen as his life profession. The greater the capital of health the worker takes with himself when starting on his vocation, the greater will be his resistance to the dangerous features of his work; the weaker the worker, the more surely will he be affected by any and all detrimental elements. A perfect eyesight, hearing, and other physical faculties are therefore absolutely paramount conditions of normal occupation. But not less than these are also the habits and the care the worker takes of his life and health while at work. Carelessness in the handling of machinery will result in accidents to limb and life; personal uncleanliness in mine, factory, and shop will be followed by the relatively sooner ingress into the system of deleterious dusts, etc. Similarly, the worker will be affected by too great addiction to alcohol. The excessive heat or cold, the relatively great dryness or too great humidity of the place of work, the foul and dusty atmosphere, the difficult tasks, the arduous labor, the strain and tension of machine work, the worry and fear of the relentless mechanical powers, and the thousand and one demands on the muscular and nervous functions of workers all tend to the creation of a special need and a craving for some stimulating and bracing drug, which is furnished by the ever-present and readily obtainable alcoholic beverages. The use, however, of alcohol leads very often to its abuse, and the excessive drinking of alcoholic liquors is bound, sooner or later, to produce pathological changes, and injuriously to influence the health of the worker. The state of the blood-vessels in alcoholics, and their relatively greater susceptibility to pneumonia and other acute diseases, as well as to chronic digestive and liver troubles, are well known. There are several special trades which are known by their tendency to favor alcoholism in the workers. Brewers, bakers, drivers, innkeepers, bartenders, glass-workers, workers in the iron and steel industry are notoriously addicted to alcohol.

Sex and Age.—In many industries child and female labor is very largely employed; and the effect of work on them is very detrimental to health. The injurious influences of female labor are due to the following factors: (1) The comparative physical weakness of the female organism; (2) the greater predisposition to harmful and poisonous elements in the trades; (3) the periodical semi-pathological state of health of women; (4) the effect of labor on the reproductive organs; and (5) the effects on the offspring. As the muscular organism of woman is less developed than that of man, it is evident that those industrial occupations which require intense, constant, and prolonged muscular efforts must become highly detrimental to their health. This is shown in the general debility, anæmia, chlorosis, and lack of tone in most women who are compelled to work in factories and shops for long periods.

The increased susceptibility of women to industrial poisons and to diseases, has been demonstrated by a great number of observers. The female organism, especially when young, offers very little resistance to the inroads of disease and to the various dangerous elements of certain trades. Hirt[5] says, "it must be conceded that certain trades affect women a great deal more injuriously than men," and he mentions, among others, the effects of lead, mercury, phosphorus, and other poisons. Even where there are no special noxious elements, work may produce, as already mentioned, harmful effects on the health of women; but when to the general effects of industrial occupation are added the dangers of dust, fumes, and gases, we find that the female organism succumbs very readily, as compared with that of the male. Shuler[9] found that the frequency of sickness in females, under eighteen, as compared with that of men of the same age, is as 174 to 100. Miss Mary E. Abrahams[9] found that out of 138 lead-poisoning cases in Newcastle, where the number of men and women workers was about the same, there were 94 cases among the women to 41 among the men. She also found that out of the 23 deaths from plumbism, in the years 1889–1892, 22 were women and only 1 was a man. The women were all between seventeen and thirty years of age. These figures are substantiated by Hirt, Arlidge, C. Paul, Tardieu, and others. The predisposition of women in industrial occupations to disease in general is greater than it is in men, as was proven by Hirt in his statistics of tuberculosis among workers. The effect of work on the physical development of women was found to be very detrimental, especially when they were young. Arlidge[3] says that in those who from their youth work in high temperatures, the bones and joints are imperfectly developed, and that they are liable to female deformities and to narrow pelves. Herkner[9] found in his studies of Belgian female workers that girls who are engaged in mines suffered from deformed joints, from deformities of the spinal column, and from narrow pelves.

It has been estimated that out of every one hundred days women are in a semi-pathological state of health for from fourteen to sixteen days. The natural congestion of the pelvic organs during menstruation is augmented and favored by work on sewing-machines and other industrial occupations necessitating the constant use of the lower part of the body. Work during these periods tends to induce chronic congestion of the uterus and appendages, and dysmenorrhœa and flexion of the uterus are well-known affections of working girls.

The effect of work on the offspring is known to be injurious in female workers. Abortion is very frequent

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among female workers, especially when they work in certain dangerous trades. Of one thousand pregnancies among lead workers, reported by Tardieu,[3] six hundred and nine ended in abortions. Arlidge also found the percentage of abortions among female workers in the pottery trade very high.

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As far as the effect of female work on infant mortality is concerned, it has been shown to be detrimental. The rate of infantile mortality among mirror workers is, according to Hirt, sixty-five per cent. Tardieu and C. Paul found, among lead workers, an infant mortality of forty per cent. According to Greenhow, the "infantile mortality is due to the unwholesome influence to which infants are exposed in the manufacturing town by the industrial employment of married women."[3] Traces of lead, phosphorus, copper, aniline, etc., have been found in the amniotic fluid.

What has been said about the influence of industry on young women can, in some degree, be applied to child labor in general. The effects of industrial occupation on children can be summed up as follows: injury to the weak organism; the stunting or arrest of growth and physical development; the production of deformities in bone, joints, and spinal column; a dulling of mental faculties; the acquirement of a predisposition to moral obliquity; a lessening of the normal powers of vital resistance; a general deterioration of the constitution and a shortening of life by various diseases. Child labor, beyond all doubt, is the greatest curse of modern industry. The influence of child labor on the general health of the community has been demonstrated by the figures of Layet (quoted by Tracy [10]), which show that out of 10,000 conscripts from ten agricultural districts 4,029 were rejected, while in selected manufacturing districts the rejections for rachitism and small stature reached 65 per cent. of the whole number of conscripts.

The Place of Work.—The place where work is done bears an important relation to the health of the workers. Work is performed either indoors or outdoors; the former being pursued in factories, workshops, and homes. It was Dr. Guy who classified all occupations into two primary divisions—"indoor" and "outdoor," and proved that the latter were much healthier.

There are, however, some special occupations which can be classed among dangerous trades. I refer to *mining* and *tunnel work*, which are dangerous to life, limb, and health by reason of the nature of the work, and also on account of the conditions under which they are carried on. The harmful conditions in mining and tunnel work are the following: absence of natural light, foul air, great heat, increased air pressure, too great humidity, dangers of the lifts, of haulage, and of the winding machinery, etc.; the use of explosives, the danger of cave-ins, falls of rocks, etc.; sudden inundations by water; danger of fires from the various gases; the constrained attitudes, the arduous toil, the tension, danger, and worry. All these conditions, apart from the processes of mining and the character of the ground, are potent factors in the great morbidity and high mortality rate among miners and tunnel workers. Surgical diseases are very frequent, owing to the great number of accidents; and among the general diseases favored by work underground are lumbago, rheumatism, diseases of the respiratory, digestive, and circulatory organs.

Factories are places where work is done by the aid of mechanical power; a *workshop* is a place where work is done without any mechanical power. Thus a tailor shop, where the sewing-machines are run by steam or electricity, is a factory; while one in which only foot and hand power are used is a workshop. The sanitary features of the work place, the lighting, ventilation, cleanliness, and the absence or presence of sanitary conveniences all affect the health of the workers. The proper light of workshops and factories is important to the eyesight as well as to the general health of the operatives. A dingy, dark workshop favors not only eye strain, but also general uncleanliness and ill health. The window area of the shop is also of consequence, as is also the nature of the illuminant at night. The air in workshops and factories is usually very foul, owing to the overcrowding of the places and to the lack of proper ventilation. A person at work needs more fresh air than one at rest, because he consumes more oxygen and exhales more carbonic acid and organic impurities. The constant inhalation of foul air acts detrimentally on health, superinduces lack of tone, muscular debility, and anæmia, as well as a predisposition to respiratory diseases and tuberculous infection.

According to Roth [11] the worst workshops are those of shoemakers and tailors. In an investigation made by him it was found that many shoemakers' shops had 7 cubic m., some even less than 3 cubic m. of air space. He also reports that von Rozahegi found in printing shops 4.2 per 1,000 of carbonic acid. In some cotton factories the percentage of carbonic acid was found to be 0.15 per cent. The sanitary care taken of the premises is important, when we remember the large amounts of dust, waste material, and noxious elements which are to be found in workshops. The absence of a proper water supply, of a sufficient number of plumbing fixtures, washrooms and lunch rooms, and of bath and toilet accommodations is also an important factor in rendering the place of work unhealthy for the operatives.

The effects of *home work*, or, as it is termed, "*sweatshop*" work, are due partly to the defective sanitary conditions of the homes where the work is done and partly to other causes. The special dangers of sweatshop work are the following: Increased tendency to child and female labor, the whole family commonly participating in the work; the constant breathing of a confined, foul atmosphere, without the beneficial changes of travel to and from outside places of work; living, cooking, and sleeping in the workroom; the tendency to prolonged and excessive work; the effects of dust, etc., on the children of the home worker; and the danger of infection by the material of work, as well as that of spreading infection from the homes of the workers into places to which the articles manufactured in these homes are sent. The health of sweatshop workers is below the average.

Conditions of Occupations.—To describe here all the possible conditions of various industries and occupations and their effect on health is obviously impossible, and I shall therefore confine myself to a brief consideration of a few of them, and especially of the effects produced upon the workers by such factors as climate, light, air pressure, strain, mental worry, etc.

The healthfulness of *rural* occupations compared to those carried on in *cities* is attested by the lower comparative mortality of agricultural laborers, fishermen, and other outdoor workers, and is due to the abundant clean air, the active life, and the absence of the evils of overcrowded cities. *Active* occupations are healthier than *sedentary*, on account of the greater muscular activity, the more vigorous processes of metabolism, and the unconstrained positions of the workers. Those who are compelled to engage in prolonged sedentary work suffer from digestive disturbances, congestion of the portal circulation, deficient oxygenation, weakness of the muscular system, predisposition to respiratory diseases, and a general low vitality. Among the sedentary workers showing large mortality and morbility are clerks, bookkeepers, literary persons, engravers, tailors, shoemakers, etc.

The evil effects of *exposure* to extremes in climate are attested by the many writers on life and industrial occupation in the tropics. Insolation, extreme muscular and nervous debility, predisposition to infectious diseases, etc., are some of the evils which are encountered in tropical countries. Soldiers, convict laborers, and others who are compelled to do arduous labor in hot climates are especially prone to become affected with these diseases, and their mortality is high. The effects of exposure to extreme cold and inclement weather, as well as those of exposure to extremely high temperatures, are well known. Boatmen, fishermen, drivers, motormen, and others are compelled to work in all kinds of weather,

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and are prone to congestions of internal organs, respiratory diseases, rheumatism, and catarrhal affections. Bakers, cooks, blacksmiths, engineers, firemen, stokers, sugar refiners, furnace workers, electric welders, and others suffer from the effects of too high temperatures. Muscular exhaustions, thermic fever, muscular debility, respiratory diseases are some of the effects of a prolonged exposure to great heat. Andrew[8] reports the case of a child who had almost universal paralysis after exposure to great heat in the railroad cars; and several cases of insanity (firemen's frenzy) have also been reported, due to the same causes. Blacksmiths are exposed to direct radiant heat, and are predisposed to respiratory diseases. Oliver[3] says that a great many blacksmiths die from phthisis. He quotes Ogle's tables, showing that "out of 872 deaths of blacksmiths, 194 died of consumption, 183 of other lung diseases, 108 of diseases of heart and circulation, and 85 of diseases of the nervous system." In a number of industries the processes employed expose the men to extremely high temperatures; this is notably the case in the drying rooms of chemical works, in the furnace rooms of the glass and iron trades, in certain deep mines, etc.

Overstrong, radiant, and *glaring light* is met with in the iron and steel industries, in glass furnaces, in engine and forge rooms, and in electric welding, and is very injurious to the eyes and to the general health.

The excessive *relative humidity* of many places of work, while not a direct cause of disease, predisposes to rheumatism, catarrhal conditions, and congestions of the internal organs, and to diseases of the respiratory apparatus. H. Wolpert,[12] after an exhaustive investigation of the effect of various degrees of humidity on the health of workingmen, came to the conclusion that "on the whole, the normal degree of relative humidity in a workroom is when there is no formation of perspiration,"—a degree which is hardly obtainable in most industries. The trades in which the relative humidity is very great are, among others, mines and tunnels, all underground work, textile factories, where steam is introduced in the "sizing" rooms, bath-houses, etc.

Variations in the normal *pressure* of the *air* are indispensable conditions in several occupations. Aëronauts and mountain miners and climbers breathe rarefied air, and suffer on account of the lack of oxygen and diminution of air pressure. Divers, tunnel workers, caisson workers are exposed to an increased air pressure, and are liable to suffer from caisson disease, described above. Those who are subject to violent jarring and concussions in air, such as boiler-makers, blasters, and workers with explosives, are subject to deafness.

The *position* maintained while at work and the *attitude* which the worker is compelled to assume in each trade are not without effect on health. Salesmen and saleswomen in stores and shops and operatives in factories are frequently compelled to be on their feet all the time of work, and as a result the men suffer from varicose veins, and hemorrhoids, and the women from congestion in the pelvic organs. The bending and constrained attitude assumed by shoemakers, copyists, tailors, seamstresses, etc., cause defective development of the chest, deficient oxygenation of the blood, and predisposition to respiratory and other diseases. The constrained attitudes which coal miners are compelled to assume while "kirking" or undercutting the coal seams result in nystagmus, described above.

The *duration* of work is a potent factor in the effects of occupation on health. The normal physiological activity of the body functions is conducive to health and longevity; but the overuse and abuse of one or more organs or the whole body are bound to produce general ill health or special injuries. The standard of normal activity varies with each individual, as well as with the different kinds of labor and conditions under which it is carried on. The most correct standard will be that which is based on the sense of fatigue experienced by the worker; and we may assume that, under normal conditions, work becomes harmful when the worker feels greatly fatigued, and very injurious if the fatigue is pushed to the point of exhaustion. When in a state of great functional activity our organs draw a relatively large supply of blood and produce, as well as eliminate, a greater proportion of waste matter, in the form of carbonic acid, urea, aqueous vapor, organic matter, etc. The result of overfatigue is a retention of waste matter and consequent auto-intoxication. Hence the injurious effects of too prolonged work and of a work day of too great length.

The effects of the duration of work will, in part, depend on the *tension* and effort with which the work is done. When the work requires too great effort and is done under special tension, the worker will sooner reach the state of fatigue than he otherwise would. Carrying heavy loads and lifting great weights require special muscular strain, and may produce hernias, and cardiac dilatation; they also predispose to aneurisms, rupture of tendons and muscles, dislocations, etc. The excessive use of one muscle, organ, or group of muscles leads to their eventual injury. Thus, engravers, watchmakers, writers, tailors, etc., suffer from eye-strain; athletes, gymnasts, hammermen, etc., from hypertrophy of muscles and cardiac affections; speakers, preachers, exhorters, etc., from vocal strain.

The *pauses* in the workday have a great deal to do with the fatigue effect of occupation, for the reason that periodical rest is needed for all organs in a state of activity. It is a fact, that more work is accomplished with several pauses in the working day than when work is continued without pauses. After a prolonged rest, more may be performed in one hour than in several hours at the end of the working day; and the work of the latter part of the day is, as a rule, not so good as that done during the earlier part of the day. In some countries, notably in Russia, the workday lasts for from fourteen to sixteen hours, but there are several pauses and they are quite prolonged (the dinner pause lasting one hour and a half); as a result the workingmen feel less fatigue than when the workday covers a period of nine hours, with only a half-hour's midday pause.

The practice of carrying on the work in mills and factories continuously, by means of a day shift and a night shift of workers, is harmful, first, by reason of the bad air that is to be found in a constantly occupied place, and, secondly, by the bad effects of night work on the general health. Night watchmen, clerks, and all those who are compelled habitually to work through the whole night and sleep during the day, are not, as a rule, in as good health as are the day workers.

A number of occupations are *hazardous* by exposure of the workers to the risks of accidents to life and limb. Roofers, painters engaged on the outside of buildings, bridge builders, etc., are liable to injury and death from falls. Furnace workers, chemical workers, etc., are exposed to the danger of burns. Miners, workers with explosives, etc., are liable to injury by the falling of rocks, by explosions, fires, etc. Factory and mill employees, working near or about machinery, are liable to injury from the engines, belts, running gear, cogs, shafts, etc. Altogether, many trades are pursued under conditions which are extremely dangerous to the worker.

There are a number of occupations which are characterized by the *mental worry* and nervous strain to which those engaged in them are subject. Thus, stock brokers, gamblers, merchants, superintendents, and heads of large industrial and commercial interests, etc., work under prolonged mental and nervous strain, and often break down in the midst of their work.

Compensation.—The wages received by the workers for their labor exercise great influence on their life and health. On the rate of compensation greatly depend the hygienic surroundings of the worker, his personal comfort, his habitation, his proper clothing, and the quality of his food. The physical health of the worker largely depends upon these factors, and they in turn depend on the rate of compensation. As a rule, workingmen who get better wages live better, enjoy better hygienic surroundings, and are in better health. Continen-

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tal workers, who receive only a paltry wage, and are unable to afford decent dwelling-houses and sufficient food, are in a bad state of health when compared with American workingmen, who receive higher pay.

The Processes Employed in Different Occupations.—The chief element of danger in most trades lies in the processes which they employ, these often evolving substances or fumes which are more or less dangerous to health. Hirt bases his classification of the different trades upon the three principal harmful elements—viz., dusts, poisons, and gases. This classification, while not without its objections, is still the best for our purposes.

Trades Dangerous to Health on Account of the Dust Produced.—There are a number of industries in which large quantities of dust are produced. This dust being inhaled by the operatives becomes a source of danger to their health, the respiratory organs being the greatest sufferers, although dust may also produce gastro-intestinal disturbances and certain eye affections as well as dermatoses. The various kinds of dusts act alike, in a general way, differing very slightly, according to the form and quality of each. The first effects of dust inhalation are irritation and inflammation in the respiratory passages, the nose, throat, and bronchi, and if the inhalation is allowed to go on for a certain length of time the inflammation is likely to become chronic (chronic bronchitis and emphysema). The deposit of dust in the small bronchioles, and frequently in the parenchyma of the lung, superinduces inflammatory reaction in the lung tissue, followed by connective-tissue formation and sometimes by consolidation in nodules and distinct areas. The later stages of the pneumonokonioses are characterized by degenerative changes in the nodules, and in the other areas where the dust is deposited. Indeed, modern pathologists are of the opinion that "coal-miner's phthisis," "grinder's asthma," "potter's rot," and the other pneumonokonioses are, in their last stages, but tuberculous infections.

Coal Industry.—Coal miners who commonly inhale large quantities of dust are subject to respiratory diseases—to bronchitis, emphysema, and anthracosis. Coal dust has been found in the lungs of miners, and the quantities are sometimes very great. The initial symptoms are those of a catarrhal inflammation of the respiratory passages, accompanied by cough, black sputum, dyspnœa, and in a large percentage of cases by symptoms of emphysema. A time comes, however, though not in all cases, when the symptoms become aggravated, and general constitutional disturbances are seen which are due to degenerative changes and processes in the lung tissue. Merkel, Arlidge, Rindfleisch, Olge, Oliver, and others are of the opinion that the later stages of anthracosis are not necessarily tuberculous, although the analogy seems characteristic. Indeed, it is claimed by them that coal miners are particularly free from tuberculosis. Coal miners are subject, during their work, to many insanitary conditions besides dust inhalations. To mention only a few of the dangers of coal mining would be to repeat all the conditions of work, the dangers of which have already been described in a previous section of this article. Burnt coal or soot seems to possess specially irritative qualities. At least, it is a fact that charcoal burners and chimney-sweeps are great sufferers from pulmonary tuberculosis. Chimney sweeps also suffer from cancer of the scrotum, "chimneymen's cancer," an affection quite frequent in chimney-sweeps in England, although rarer in the same workers in other countries.

Iron and Steel Industry.—The effects of inhaling iron dust are not quite the same as those which result from the inhalation of coal dust. In the first place, iron dust undergoes absorption and oxidation to a greater or less degree in the lung tissues. Thus Zenker and Merkel both found in the lungs of iron workers large deposits of iron oxide; in Merkel's case 7.1 per cent.[7] Then, in the next place, the particles of iron dust often wound, with their sharp corners, the delicate bronchial mucous membrane, and thus open the way for infection with pathogenic bacteria. The branches of the iron and steel industry, especially harmful on account of dust, are those in which polishing and grinding are done. Thus cutlery workers, needle makers, and grinders of steel articles are inhaling large quantities of metallic dust, and are very much subject to respiratory diseases, and particularly pulmonary tuberculosis. Dry grinding is the most injurious process in cutlery work. Lloyd[8] quotes Holland, who says "that the average age of grinders is only twenty-five and three-quarter years; and young men of seventeen to twenty years of age, strong and rough from the plough, who engaged in the work died from its effects, as a rule, before reaching the age of thirty." The general mortality ratio of grinders from respiratory diseases is, according to Tatham, five hundred and fifteen to one hundred and fifteen among agriculturists. The mortality figure from phthisis is very high.

Mineral Industries.—Workers who inhale mineral dust, as stonecutters, masons, plasterers, brickmakers, diamond grinders and polishers, porcelain makers, pottery and china workers, etc., are subject to chalicosis pulmonum, a term applied to the pathological condition which is produced by a deposit of mineral dust in the lung. The deposit of these dusts has been demonstrated by chemical analysis. Meinel and Malpert found that such lungs contained immense amounts of silica, silicic acid, phosphate of lime, and sand.[10] The quantity of dust in the above-named trades is very large. Thus Oliver[5] quotes Lamaister, who analyzed the air in the Limoges potteries, and found "that the dust is composed of earthy particles and fragments of granite, flint, glaze, soot, and charcoal. The atmosphere which the brushers-off, the finishers, and the porcelain makers generally work in contained 640,000,000 of dust particles to the cubic metre, while in some of the rooms the number reached 680,000,000 per cubic metre." That the breathing of air laden with such quantities of dust is injurious is self-evident, and the mortality rate of these workers from respiratory diseases is very great. Hirt found the average life of stone grinders to be forty-two and a half years. The mortality rate of potters is the highest; but this is due to the fact that potters are also subject to plumbism. The number of trades in which mineral dust abounds is very large.

Textile Industries.—Workers in textile industries are subject to inhalation of organic dust, animal and vegetable. Among the textile trades which are unhealthy on account of dust are those which deal in flax, linen, cotton, jute, silk, wool, and hair-working. The dust in each of these branches of the textile industry differs from that of any other industry in some of its features, but retains its irritating qualities in common with all dusts. Besides the effect on the respiratory system, these dusts seem to be very irritating to the skin, producing various dermatoses. Those who clean and work at the crude materials are compelled to inhale more dust than the spinners and those who work at the later stages of manufacture. Greenhow found that out of one hundred and seven flax spinners seventy were affected with respiratory diseases.

Cotton workers are said to suffer from "pneumonic cotoneuse," a form of pulmonary tuberculosis due to the irritating dust habitually breathed by the operatives. As in other textile industries, those who work at the crude material suffer the most from dust. Cotton dust is also said to be very irritating to the skin, producing dermatoses.

Silk workers are prone to tuberculous affections, and to all respiratory diseases. Thus, in one silk spinnery in Sagrado the percentage of respiratory disease was twenty. Netolitzky[1] quotes Combassedes, who on examination found 760,000,000 of particles of dust per cubic metre in the work-rooms of the silk mills. He says that silk workers suffer from respiratory and digestive diseases, and from anæmia, and that they present a very high death rate.

Wool workers are exposed to animal dust, and also to the danger of infection by any pathogenic organisms which may cling to the animal substances, such as hair, wool, hides, etc. Anthrax is the principal infectious dis-

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ease afflicting woolworkers. The effect of dust inhalation is seen in the large number of cases of sickness from bronchitis and other respiratory diseases. Furriers very frequently suffer from what is called "furriers' asthma," the symptoms of which, however, are due not so much to the effects of dust inhalation as to the various poisonous dyes used in coloring fur.

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The inhalation of *wood dust* is claimed to be without any effect, although Merkel states that workers in pencil factories, who inhale large quantities of dust formed in the processes of sawing the wood for the pencils, suffer very much from phthisis. Carpenters, sawmill workers, etc., are exposed to wood dust.

Tobacco dust, in tobacco, cigar, cigarette, and snuff manufactories, acts on the worker mechanically, also chemically, by reason of the nicotine contained in it. There is a tendency among writers on the subject to deny the evil effects of tobacco dust on the operatives. This is hardly true. There is abundant evidence that cigar, cigarette, and snuff workers suffer greatly from respiratory diseases, as well as from anæmia and digestive disturbances.

Flour dust has always been regarded as peculiarly injurious to those who are compelled to inhale it. Millers, bakers, and confectioners, but the first especially, have been stated as having the highest death rate among workers in non-poisonous dusts. Of 108 cases of sickness among millers, Shuler[3] found 34 cases of respiratory disease, 12 cases of tuberculosis, 19 diseases of the skin, 17 of the digestive organs, 4 eye diseases, and 3 of circulatory system. In the modern forms of flour milling the greatest part of dust production is done away with, and the effect of flour milling is not very harmful to the workers. Those who are exposed to the inhalation of *mixed dust*—for instance, street cleaners, carpet sweepers, carpet beaters, etc.—are liable to bronchial affections. In Hirt's tables mixed dusts show a larger percentage of all respiratory diseases than do most of the other dusts.

Trades Dangerous to Health on Account of Poisonous Substances.—There are a large number of trades, the chief element of danger in which consists in the poisonous nature of the materials and substances made in the processes of manufacture, etc. As the toxicology of most of these substances is dealt with in other parts of this HANDBOOK, only a very brief description of their effects upon the health of the workmen will be given here.

Arsenic.—Arsenic in its various forms is used in medicine and the arts for many purposes. It is employed for preparing dyes for textile fabrics and for coloring artificial flowers; it is an ingredient in many forms of wall paper, and is used in carpet manufacturing; it is sold as an animal and parasitic poison, and is used in many other ways and in combination with various substances. All persons manufacturing articles in which arsenic is employed are subject to arsenical poisoning. Arsenic affects the skin, gastro-intestinal tract, respiration, and especially the nervous system. On the skin the effects of arsenic are seen in the eczematous eruptions and various vesicular and pustular sores. On the respiratory passages arsenic acts as an irritant, and causes a catarrhal condition of the nose, throat, and bronchi. In the gastro-intestinal tract arsenic causes severe irritation, anorexia, diarrhœa, colic, gastritis; and among the nervous disorders which it produces may be mentioned a general diffuse multiple neuritis, progressive muscular atrophy, loss of tendon reflexes, local anæsthesia, trophic sores, and ataxia. Not all who are exposed to arsenic suffer equally from its effects. A large number of workers in arsenic seem to enjoy a peculiar immunity from its toxic effects. As an example of such immunity I can cite a patient of mine who for the last eight years has worked in a paint manufacturing establishment, packing Paris green in boxes, for from ten to sixteen hours a day, and seemingly he has good health all the time; while new men, who were engaged to assist him in his work, usually showed signs of toxic effects of arsenic within a very short period after exposure to the atmosphere full of arsenical dust.

Lead.—Lead is the most widely and largely used metal. The number of its uses can hardly be stated; indeed, the trades and arts in which lead is not employed, in one or another form, are not very many. Hence a very large contingent of workers are exposed to plumbism. The mode of introduction of lead into the system is through the lungs, digestive tract, and skin. Lead dust is prevalent in most places where it is used. Lead is ingested in the form of dust or through the medium of the particles which cling to the hands, fingers, and person of the worker. Its absorption through the skin is slight. Among the trades in which the workers are exposed to the danger of plumbism are the following: Lead miners, white-lead workers, lead-paint manufacturers, painters, potters, calico printers, compositors, pressmen, stereotypers, linotypers, printers, plumbers, filemakers, platers of iron and makers of hollow ware, solderers, makers of lead toys, vessels, etc., glazers of cards, paper, etc., and a very large number of other trades into which lead goes in some of its forms. The effect of exposure to lead is not the same on all workers. Women and children are especially prone to plumbism. The effects of lead poisoning are seen in the anæmia, cachexia, metallic taste in the mouth, vomiting, constipation, lead colic, bluish line along the margin of the gums, retraction and ulceration of the gums; but the most marked effects are those on the nervous system. There are a loss of motor power in the hands and feet, wrist drop, progressive muscular paralysis, multiple neuritis, temporary and sometimes permanent blindness, convulsions, insanity. The mortality of lead workers is very great. Tatham[3] says it is ninety per cent. above that of other workers, and three times greater than that of agriculturists. Of the total deaths which occurred among lead-workers, one-fourth were due to pulmonary tuberculosis, one-eighth to lead poisoning. Plumbism is especially frequent among those engaged in manufacturing white lead, printers, filemakers, and painters.

Stubler, of Berlin, taking his statistics from the reports of the sick-benefit societies, states that of 3,000 printers in Berlin, 313 were annually sick with lead colic."[3] The analysis of the dust in some printing shops gave nearly 15 per cent. of lead.[3] File-makers also suffer very largely from plumbism. Ogle gives the following statistics of the comparative mortality from lead poisoning, based on the death register for 1879–82, in males over fifteen years of age: File-makers, 466 per million living; painters, plumbers, glaziers, 224; earthenware-makers, 152; gasfitters, 62; printers, 27, and all other males, 4. According to Tatham, the comparative mortality from lead poisoning in the several trades is the following: Males occupied in one manner or another, 1, wool manufacturers 3, cutters 3, printers 3, leadmakers 5, gasfitters, locksmiths 6, coachmakers 7, copper workers 8, glassmakers 12, potters 17, painters and glaziers 18, plumbers 24, filemakers 75, and lead workers, 211.[3]

Mercury.—The effects of mercury upon workingmen who labored in cinnabar mines had been noted as far back as in 1665, when reference to the tremor caused by it was made by Dr. Walter Pope in the Philosophical Transactions.[3] Detailed accounts of the mercurial poisoning of operatives is also found in Ramazzini's work. The industries in which mercury is used, and in which the workers are exposed to the danger of mercurialism, are the following: Cinnabar mining, gold and silver mining, where mercury is employed to form amalgams; the manufacture of scientific instruments, such as thermometers, barometers, etc.; the manufacture of electric meters and lamps, where mercurial pumps are used to create a vacuum; the gilding and silvering of mirrors, etc.; the manufacture of certain paints; the making of pharmaceutical preparations; also the making of felt where the felts are brushed with a solution of the nitrate of mercury. The mode of introduction of mercury into the system is by inhalation of the fumes, or by ingestion of the salts of mercury through deposits on the hands, fingers, clothing, etc. Stomatitis, salivation, gastric disturbances, emaciation, cachexia, are symptoms of chronic mercurialism. The effects on the nervous system are

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marked tremors, paralysis, and psychical changes. The tremors and paralyses are noticeable especially in the muscles of the face, hands, and arms. Melancholy, depression, loss of memory, and hallucinations are some of the psychic forms. Kussmaul has shown that mercurialism acts very badly upon women, predisposing to abortions and to diseased conditions of the infants.

Phosphorus.—The danger of phosphorus poisoning is almost entirely restricted to the manufacture of matches from yellow phosphorus. The making of matches from red phosphorus (safety matches) is not accompanied by any dangers. The principal effect of phosphorus is its action on periosteum and bones, the maxillary bones being the most easily affected. A prolonged exposure to the action of phosphorus is necessary before the specific effects of it are noticeable. Some writers claim that phosphorus has no effect on healthy periosteum and bone and that only those who suffer from caries of the teeth and other affections exposing the periosteum of bones to the phosphorus fumes are affected. The disease manifests itself in necrosis and sequestration of the affected bone or of that portion of it which is diseased. The number of cases of phophorus poisoning in the United States is not large. Sweden is the country where most of the match factories are located, and where phosphorus poisoning is most frequently met.

Copper and Brass.—Copper is a metal which is found in a pure state, and which is also procured from various ores. Brass is an alloy of copper and zinc. The mining of copper and the manufacture of copper vessels, etc., are not considered as dangerous as the manufacture of brass and brass articles. It has been said that workers in copper have often found that their hair, urine, and skin turn green. The salts of copper are more poisonous than the metal. Arlidge thought that inhalation of copper dust produces the "copper colic," which is a form of digestive disturbance characterized by pain, purging, vomiting, and prostration. This is denied, however, by later investigators, who assert that the symptoms are due to a mixture of the carbonate of copper and lead.

Workers in brass-smelting and the manufacture of brass articles are subject to inhalation of brass dust and fumes. A general catarrhal condition of the respiratory passages and gastro-intestinal tract results from exposure to brass dust. What is known as "brassmen's ague," which is characterized by chills, fever, cephalalgia, nausea, depression, prostration, and collapse, is thought to be due more to the zinc in the brass than to the copper.

Noxious Gases and Fumes.—The occupations in which perceptible quantities of dust or definite poisonous substances are produced are few in comparison with the numerous industries in the processes of which noxious gases and fumes are evolved. The industrial processes in which chemical agents and gases are produced which, when absorbed or inhaled, may become dangerous to health, are so manifold and diverse that it is absolutely impossible to give even a brief description of them. Nor is it always possible to trace the harm done to health in these chemical industries to any one of the elements or gases prevalent in the process, for in most of these industries various and complicated processes are being simultaneously carried on, and the workers may be exposed to a number of agents and gases at the same time or successively. If we take, as an example the coal-tar color industry, there are several dozens of various agents produced, either together or as by-products, and each of them may be more or less injurious to health; and it is exceedingly difficult sometimes to determine which of them has produced the most harm in the case of any particular individual. So widely do chemical manufactures permeate the whole range of human industries that there is hardly an article or substance made in which chemical processes of some kind do not take place.

Some of the principal agents and gases evolved in chemical trades are the following: Sulphur and its compounds; carbon and its compounds; sodium, sodium chloride, chlorine gas; potassium and its salts, ammonia, ultramarine, carbon bisulphide, dynamite, nitroglycerin and other explosives; chromium, alum, iron and its oxides; lead and its salts; arsenic, copper, zinc, illuminating gas, coal tar and its products, nitrobenzol, the various drugs, india-rubber, turpentine, cyanogen compounds, and many others too numerous to mention.

Most of these agents are used, in one or another form, singly or in combination, in most of the human industries and arts; and many of them are also toxic to a large degree, and injuriously affect the health of those engaged in their production and in handling them.

The effects of the work with noxious agents and gases are either acute or chronic, and the dangers are from (1) the toxicity of the substances; (2) the danger of explosions, burns, and corrosions; and (3) the excessive temperatures which are necessary in most of the chemical processes. The mode of introduction of these noxious agents into the system is somewhat different from that of the dusts produced in other trades; and the effects are also somewhat different. While the inhalation of dust acts chiefly upon the respiratory system, the gases and other noxious agents of the chemical industries have each their own effect, each having specific action, but mostly of a toxic character. Moreover, while dusts affect the human system only after long exposure and continuous and prolonged inhalation, the effects of gases and chemical agents are produced after comparatively short exposures. Again, while the effects of dust inhalations may always be seen on the respiratory system, and at times pathologically demonstrated by the presence of the dust in the lung tissue, the effects of toxic agents and gases cannot, in most cases, be demonstrated, and, if at all, only in the blood, by chemical and spectroscopic examinations.

Roth cites Austrian statistics of mortality and morbility among chemical workers. He found the mortality to be 7 per 1,000. The diseases with which they were affected were distributed as follows: 25.7 per cent. for burns, contusions, and the like accidents; 17.9 per cent. for affections of the respiratory system; 14.7 per cent. for disorders of the digestive tract; 10.8 per cent. for diseases of the skin, and 10.5 per cent. for general constitutional diseases.

Prophylaxis.

Having briefly examined the various dangers of different trades, we now come to the most important phase of our subject, that of prophylaxis; the most important, for, after all, the aim and purpose of hygiene in general, and industrial hygiene in particular, is the prevention of disease and preservation of life. On a closer study of industrial conditions we find that many, if not most, of the dangerous elements in trades are preventable, and that there is no need for the terrible waste of health and vast destruction of life prevailing in modern industries, as shown in the mortality and morbility statistics.

In the endeavor to improve industrial conditions, and prevent unnecessary suffering in the dangerous trades, medicine and legislation are allied: the one to study and expound the rules of health, the other to enforce the laws based on scientific hygiene. Unfortunately, the ignorance of the workingmen and the cupidity and negligence of employers are the two stumbling-blocks to the general acceptance of the better laws of health.

In discussing the hygiene of occupations we propose to consider the subject under two heads—General Prophylaxis and Special Prophylaxis.

General Prophylaxis.—The first personal requirement for preventing the evil influence of occupation on health is the proper selection of a trade; this is commonly done by natural selection, or more frequently by accident; yet it is very important that certain trades be followed only by the best physically endowed constitutions. Were there a medical supervision and control of the selection of trade by individuals, persons of a scrofulous diathesis, with a tuberculous family history, would not be permitted to embrace indoor, inactive, sedentary occupations, and

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certainly not any in which large quantities of dust must be inhaled; nor would nervous, delicate, choleric persons be allowed to enter industries which subject the workmen to great nervous strain, mental worry, and responsibility, nor those in which they may be exposed to toxic agents which act specifically on the nervous system. Perhaps the proper medical supervision of the selection of a trade is as yet a dream of hygienists, but it is bound to be realized.

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Already there are legislative enactments in all civilized countries restricting, limiting, and partly prohibiting *child labor*, and the highest aim of hygiene is that no child under eighteen should be allowed, under any circumstances, to engage in any occupation except that of developing its physical and mental faculties.

Female labor is also largely restricted, and even prohibited in some trades; and in many States legal provision is made to limit the industrial activity of women during pregnancy, after childbirth, and in specially dangerous trades.

The *personal cleanliness* of the workers is an important condition in the general prophylaxis of the effects of occupations. It is a fact that in specially dangerous trades, such as printing houses, lead works, etc., and in all industries where poisonous substances are manufactured and manipulated by the employees, those workers who have the least regard for personal cleanliness, who are careless in washing themselves, and who eat their food with hands and clothing full of the toxic materials, are the readiest victims of industrial poisoning; while the more careful often escape all harm. Workers in dusty and poisonous trades should have their hair on face and head cropped short and they should be compelled to observe rigid rules of personal cleanliness, the compulsion being necessary on account of the ignorance of the workingmen and their contempt for the dangers lurking in their trade,—a contempt bred by familiarity.

The wearing of *proper clothing* is an important prophylactic measure in all trades. It must suit the kind of trade in which the individual is engaged. Those who are exposed to low temperatures should wear woollen sweaters or flannel underwear, while workers in high temperatures should wear light absorbing cloth. All who work in damp, moist, and wet places should have their footwear impermeable to dampness, and their clothing should be made of a material which will absorb moisture without letting it penetrate the undercloth. The wearing of rubber-impregnated cloths is inadvisable as it interferes with evaporation of perspiration; mackintosh capes, protecting from moisture and at the same time allowing evaporation, are recommended by some authorities. Persons working in dusty occupations should wear fabrics with smooth surfaces only, and, whenever possible, without any seams, folds, or pockets where dust may accumulate. But the most important prophylactic measure in this respect is that no clothes worn while at work should be taken out of the workplace, but must be exchanged for other clothes which are to be worn only outside the workshop. In some trades the employers are compelled to furnish the workers with two suits of overalls to be worn while at work. In those trades in which corrosive poisons and gases are likely to burn or injure clothing, the worker should wear leather cloth or other not easily destructible material; and wherever the hands come in contact with the same substances leather gloves should be worn. In dusty trades it is advisable to cover the head with closely fitting caps. There are some industries in which the cloth worn is the result of established custom and is usually consistent with hygienic principles. Thus the chimney-sweep's suit, so often seen on the Continent, is very appropriate to his calling, and protects him from contact with the irritating soot.

Duration of Work should be adjusted to the nature of the work and the standard of health of the operatives. Economists agree that there has been no loss of productive capacity since the work day was reduced from sixteen to eighteen hours to the ten-hour-day standard; and owners who frantically struggled against every attempt to reduce the working day, and prophesied the decadence of industry if it was done, have at last come to see that a shorter workday means actually a greater productive capacity and a better state of health in the workers. No universal workday can be established or is applicable to all trades and persons; the length of work should be carefully adjusted to the age, sex, and health of the worker, to the place of work, to the conditions under which it is carried on, and to the character and nature of the processes of each industry. The more unfavorable the conditions under which the work must be carried on, the shorter should be the workday. This is the rule followed in specially dangerous trades; thus, caisson workers are allowed to work for only from two to four hours at a time; furnace workers, or those who are exposed to fumes and gases in lead and other trades, work, as a rule, only in three- to four-hour shifts. The same rule should be applicable to all other trades.

The number and length of the *work pauses* bear an important relation to the health of the employees in each trade, for every physical or mental activity requires periodical relaxation. It has been proven that more work can be done in two hours at the beginning of the workday than in twice that time at the end of the day. In England forenoon and afternoon pauses are required for child workers, besides the usual midday lunch hour. This rule should be adopted for adults also, especially in the dangerous trades. The length of the midday lunch pause should not be less than one hour in any trade, as a shorter pause leads to carelessness and haste in cleaning up, to high speed of food consumption, and to failure of the worker to go outside of the shop for a short breath of fresh air.

Night work is more unfavorable to health than work during the day, and, whenever this is practicable, such work should be restricted; at any rate, the working hours should be comparatively shorter and the pauses longer and more frequent than in day work, and there should also be periodical changes between the day and night shifts, so that those who for one period are engaged during nights should at other times be working by day.

Overwork leads to ill health and to fatigue neuroses, and should be restricted if not entirely abolished. The prophylaxis of the fatigue neuroses can be accomplished only by due regard to the working capacity of the muscles and organs employed. The burden of work, whenever this can be avoided, should not be put on one group of muscles or on one organ. Thus writers, copyists, clerks, and others who have much handwriting to do should train themselves to employ both hands, and besides they should use them in such easy positions as not to overfatigue the muscles. The same principles may be applied to overstrain of other organs.

The proper *education* of the worker in general hygiene, and especially in the dangers of his specific trade, is an important factor in the prophylaxis of many of the occupational diseases.

The problem presented by the unhealthy condition of *sweatshop* work is a difficult one for legislators, but very simple to hygienists, who are unanimously of the opinion that all home work should be entirely prohibited; and that there should be a complete separation of the factory from the home. It is therefore merely a question of time when the economic obstacles to the abolition of the sweatshop method will be surmounted.

The *construction* of workshops, factories, mills, etc., cannot be gone into here, but there is one requirement which should not be overlooked in this respect, and that requirement is that industrial establishments should be constructed for the specific processes to be carried on therein, and that the plan of adapting any ramshackle, out-of-date building, unfit for any other purpose, to the uses of factory or workshop, as is frequently the case, must be absolutely prohibited. The size of the workplace should, of course, correspond to the number of employees, and to the needs of each establishment. The minimum of four hundred cubic feet of space for each worker, which is established by legislation in many places, is entirely in-

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adequate; there should be at least one thousand cubic feet of space for each individual, as a general rule, and this allowance should be increased in special dusty and otherwise dangerous trades. The walls, ceilings, floors, and all surfaces of each establishment should be constructed with due regard to the process of industry carried on within them. Thus, in all places where dust abounds, the walls, and especially the floors, should be made without any cracks, nooks, etc., where dust may accumulate, and should be constructed of smooth material, glass, tiles, or the like, which may easily be washed and scrubbed. In all workplaces where the humidity is relatively very great, the walls and other surfaces should be made of impervious materials. Whenever practicable, the floor should be made of asphalt, concrete, or cement, so as to be impermeable to moisture; it should also be properly graded and drained so as to be easily washed off. This precaution is especially to be recommended in mercury and lead work establishments where the poisonous substances are likely to collect on floor surfaces. Of the cleanliness of industrial establishments it is sufficient to say that it is an indispensable condition of the healthy workshop.

Lighting.—On the proper lighting of workshops depends not only the condition of the eyesight but also the general good health of the workers. The ideal of workshop lighting is the avoidance of anything but daylight as a source of light during work; and, if artificial illumination is absolutely required, the use of electricity only, whenever possible, as other illuminants produce many impurities and unduly raise the temperature of the workshop.

Bussing[14] gives the following requirements for the artificial lighting of factories: (1) The quantity of light should correspond to the normal requirements of the room space and the occupants, (2) the light should approximate the quality of daylight as much as possible, and be white, and in this respect the hygienic value of different lights stands in the following order: electricity, argand burners, open gas flames, and petroleum oil; (3) stability of flame, all flickering and jumping lights being injurious to the eyes; (4) low proportion of impurities given off; (5) low heating capacity. To these requisites may also be added proper distance from the persons at work, proper location of lights, uniform distribution, and shading of eyes when light is too glaring.

Ventilation is the corner-stone of industrial hygiene; for the greatest part of the dangers which threaten the workers are due to the impurities in the air of the places of work, impurities which can be done away with only by efficient methods of ventilation. The impurities in industrial establishments are the following:

I. Impurities caused by the workers: (*a*) decrease in oxygen; (*b*) increase in carbonic acid; (*c*) increase in amount of aqueous vapor; (*d*) increase in temperature; (*e*) increase in amount of organic matter.

II. Impurities due to the place of work: (*a*) detritus from walls, ceilings, floors, and other surfaces; (*b*) increased humidity, due to dampness absorbed and retained in the walls and materials of building; (*c*) moulds, fungi, and other low organisms.

III. Impurities due to artificial lighting and heating: (*a*) increase in amount of carbonic acid and other gases; and (*b*) increased temperature.

IV. Impurities due to presence of machinery, etc.: (*a*) increase in temperature from motion and friction of machinery, etc.; and (*b*) detritus and waste from tools, etc.

V. Impurities due to industrial processes: (*a*) waste and detritus from crude materials being crushed, torn, milled, ground, polished, etc.; (*b*) dust from organic and inorganic substances of manufacture; (*c*) poisons, gases, and fumes; (*d*) infective agents and bacteria. Without going into the detailed study of each of these impurities we shall only consider here how they are to be removed by ventilation. Ventilation is either natural or artificial, according to the natural or mechanical means employed to further it. The natural modes of ventilation are the following:

1. The porosity of the walls and other parts of the building.
2. The various openings made in rooms, such as windows, transoms, doors.
3. Special openings made in windows, walls, ceilings, etc.
4. Chimney flues and other ducts connecting rooms with external air.
5. Cowls and warming devices, made in chimney flues and other ducts.

The last three methods are regarded by some writers as belonging to artificial ventilation, although it is best to limit the meaning of this term to modes of ventilation which are accomplished by mechanical means only. The methods of artificial ventilation are two: extraction and propulsion. By "extraction" methods we mean the ventilation by which: (1) impure air of a room is extracted by means of exhaustors, fans, etc., without special means being provided for the substitution of fresh air; and (2) the extraction of the impure air by the same methods and the provision, at the same time, of special openings or ducts and inlets for the ingress of pure air from the outside. The propulsion method of ventilation consists in: (1) blowing in, propelling, and forcing in air from the outside into the room to be ventilated without making any other provision for the escape of the impure air from the room; and (2) the same methods, plus the addition of special means of escape for the impure air. A combination of the two methods is the best. The motor power for the ventilating devices may be compressed air, water, steam, or electricity. In the propulsion method of ventilation special means may be also provided: (*a*) for filtering the incoming air from its impurities; (*b*) for warming it to a desired temperature; and (*c*) for regulating its relative humidity. In the extraction method of ventilation provision may be made for: (*a*) collecting the impurities of the extracted air in proper receptacles; (*b*) cleaning it by precipitation, filtration, compression; and (*c*) for absorption of gases, etc., by chemical means.

For further details see special books on ventilation, also the works referred to at the conclusion of this article.

Provision should be made in all industrial establishments for artificial ventilation, for by natural ventilation alone it is hardly possible to remove all the impurities to be found in them. In small workshops, with a limited number of employees, with a minimum of waste matter and dust, with no machinery in use, no gases or fumes liberated, natural ventilation may be adequate. But in all other places, especially in large factories, mills, mines, and tunnels, no reliance whatever can be placed on natural methods of ventilation, mechanical means being absolutely indispensable. There is hardly an industry in which some of the above-mentioned motor powers are not used, and wherever there is motive power artificial ventilation need not cost more than the initial expense of the installation of the ventilating apparatus, and should be insisted upon and properly supervised by competent authorities.

In mines the air is full of impurities, and contains various deleterious gases, known as "black damp," "white damp," "fire damp," and "after damp,"—gases which are dangerous on account of either their toxic or their explosive nature. Here artificial ventilation must be provided for on a large scale, though even then much of the danger is difficult to avoid.

SPECIAL PROPHYLAXIS. *Dust.*—The following are the prophylactic measures to be observed in those occupations which are characterized by the production of large quantities of dust.

1. Separation, from all other processes, of those in which dust abounds.
2. Substitution of machinery for handwork, whenever this is possible.
3. Substitution of wet for dry processes of production.
4. Instant and continuous removal of formed dust by special ventilators.
5. Isolation of the worker from the dusty process.
6. Frequent change of air and frequent pauses.

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7. Special devices for preventing dust from entering the respiratory organs.

1. The processes in which dust is largely formed should be confined to special rooms, which should be kept isolated as much as possible from the other rooms of the establishment.

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2. The production of dust may largely be avoided by substituting for hand work carefully enclosed machines. Machine production requires comparatively few operatives, thus lessening the number of persons exposed to dust inhalation. Industries in which the dust has an economic value have already partly accomplished this. In flour and cement mills, and in sawmills provision is made for the collection of the valuable dust and its further utilization. Flour milling was once considered an unhealthy trade; but since the introduction of self-regulating machinery, enclosed in chambers, the formation of dust, from the crushing of the coarse grain to the packing of the finest flour, has been reduced to a minimum. What has been accomplished in a few industries may be repeated in others.

3. Dust is produced only when the industrial processes are performed by dry methods. Wherever possible, wet processes should be substituted by either wetting the material, or the implements, or the place of work, the wetting materially reducing the dust. Wools are sometimes oiled for this purpose. The wet methods are especially imperative in work with poisonous substances, and in the metal grinding industries. Needle, cutlery, stone, and other grinding and polishing can very well be done by wet methods, thus preventing dust formation.

4. The instant and continuous removal of dust can be done only by artificial ventilation and specially constructed devices for each trade. Dust is removed by precipitation, filtration, and absorption. Precipitation of dust is accomplished by the action of the specific gravity of the dust, by the action of water, a stream or shower of which is allowed to fall on the dust thus precipitating it, and also by centrifugal action. Filtration is accomplished by letting the dust filter through cotton, wool, or other material which may be kept dry or wet. The proper ventilating devices for removal of dust consist of the following several parts: (*a*) An expansion or hood, properly fitting or enclosing the tool, machine, or stand of each dust-producing process and worker. This hood must be so adjusted as to cover all surfaces or projections where dust is formed. (*b*) The tubes or ducts with which hoods or expansions are connected; the dust is drawn into the hoods, and conducted from these into the tubes. These latter must be tight, and should be provided with cleaning caps to facilitate periodical cleaning in case of obstruction, etc. (*c*) The *wetting* appliances are in the form of jets, rosettes, streams, showers of water which are applied to the dust in the hood, tubes, or receptacles. (*d*) The *fans*, exhaustors, and other means for aspirating the dust from the hoods and tubes by the creation of a vacuum within the same. The aspirating force must be nicely adjusted to the needs of each trade and process, otherwise the draughts may be too strong. (*e*) *Receptacles* which are connected with the tubes, etc., and in which the dust collects and settles by its specific gravity, by the action of water, or by centrifugal motion.

5. In those industries in which the dust, for one or another reason, cannot be removed, and in which there is great danger that it will impinge upon the face and get into the eyes of the operatives, special appliances have been devised for isolating the worker from his work by an intercepting window, put between him and the dust; or he is separated from it by a complete glass partition, in which openings are made for his arms to go through for the necessary manipulations; or, finally, the work may be done by means of long poles and other tools, manipulated by the workers from the outside of the closed chambers.

6. Wherever dust is produced in large quantities the workers should be given frequent opportunities for inspiring pure outside air, by making the pauses as frequent as possible, and by compelling the operatives to go outside of the shop during these pauses.

7. Workers in dusty trades very often stuff their nostrils and their mouths with flannel or cloth to keep out the dust. The appliances called "respirators" are an extension of the same principle. They consist of a framework made of vulcanite, wire, or metal, which is so constructed as closely to fit the lower part of the face, covering the mouth alone, or the mouth and nose together. Within this framework some filtering material is placed for intercepting and collecting the incoming dust, thus preventing its inhalation. There are a great number of more or less ingenious respirators on the market. One of these, devised by B. W. Richardson[15] consists of a mask in which a breathing tube is fitted, on the inside, with rolled feathers which are so arranged that during inspiration they will rise up and filter, while in expiration they will lie down, like a valve, against the wall of the tube. This is an example of the ingenuity spent on the construction of respirators. The respirators have, however, never been popular with workers; indeed, they are seldom, if ever, worn, unless by compulsion. The objections made by operatives against the wearing of respirators while at work are the following: they are clumsy, uncomfortable, and unsightly; they interfere with respiration; if the filtering material is thick and closely woven, respiration is very difficult—if not, the dust gets through; they interfere with talking, spitting, chewing, and smoking; they get wet by the moisture of the breath, and in general they are a great inconvenience to the wearers, who would rather inhale the dust than wear one of them. In trades where the worker is exposed to violent poisons or specially irritating gases, special masks, entirely air-tight, are provided, and are fitted with tubes to bring in air from the outside, and with complicated valves, etc., to let out the expired air. The objections against respirators already alluded to apply in greater force to those instruments which are used only in very exceptional cases.

The *prophylaxis* in industries where *poisons, gases, and fumes* are evolved and liberated does not differ in its essential features from the prophylactic principles laid down for dusty occupations, except that they must be more strictly and carefully enforced if they are to be effective in protecting the health of the workers. In specially dangerous trades the periodical medical examination of the employees goes very far toward remedying the evils of the trade. Wet methods of production should be insisted upon wherever toxic substances may produce dust. Certain poisons should be entirely prohibited from being used and for them should be substituted other materials less poisonous. Thus the use of any but red phosphorus should be prohibited in the match industry; no arsenic should be used in textile fabrics, on wall papers, etc.; the manufacture of lead toys and utensils should be prohibited, and so also should the employment of lead in pottery glaze and other manufactures. Mirrors may be backed by silver instead of by mercury; and in the place of the latter poison glycerin may be substituted in the manufacture of air pumps. The ideal will be reached when all toxic substances are replaced by non-toxic, and with time and vigorous agitation this ideal may be realized.

Wherever gases and fumes are in such abundance that toxic effects are feared, the wearing of proper protective clothing, respirators, and masks should be insisted upon in spite of the objections of the workers.

Other prophylactic measures, applicable to each industry, differ according to the nature of the toxic substance in each. No alcoholic beverages or acidulated drinks are allowed to arsenic and lead workers, but may be permitted in moderate doses to mercury workers. Workers in lead manufacturies are given from ten to fifteen minutes for washing their hands. Sapolio and ammonium tartrate are recommended for the hands, potassium permanganate for a mouth wash. As food, milk and pork enjoy special favor with lead workers, and are furnished by some employers. A number of so-called "sanitary"

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drinks have been proposed for lead as well as other workers. The value of potassium iodide as a prophylactic for plumbism, though high in the estimation of some, is doubted by Blum,[16] who made a special study of plumbism

Chromium workers should have their faces and noses protected with masks to prevent ulceration.

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Those who work in soda manufactories and come in contact with chlorine gas are advised to drink a two-per-cent. solution of dilute sulphuric acid

Phosphorus workers are to be examined periodically by dentists for caries of the teeth. Chalk, milk, saponified water are recommended for those who work in or are exposed to sulphur and its compounds

The use of common salt is interdicted to mercury workers on account of the danger of the formation of sublimate.

Each industry in which special toxic agents are being manufactured should be provided with special rules for the guidance of the employees, and should also be under the constant care and supervision of proper medical authorities.

The *prophylaxis of infection* from crude materials, or from manufactured articles, is important in the hair, wool, hide, and fur trades especially, on account of the danger of anthrax infection, but it is also important in all trades in which goods are imported from Oriental countries, where certain contagious diseases are endemic. The only effective prophylactic measure, under these circumstances, is proper and thorough disinfection of all suspected materials.

The *special prophylactic* measures against *accidents* to the *eyes* have already been spoken of to some extent in the section relating to the methods of removing dust and toxic materials Where the danger from flying particles, dust, etc., is very great, it is recommended to wear protective spectacles. A large number of special spectacles have been manufactured for persons whose eyes are thus exposed, but, as in the case of respirators, they are strongly objected to by the workers. The wearing of spectacles is made obligatory in some trades. Koenigshoefer[17] sums up the objections against spectacles as follows: they limit the field of vision, they may impair vision, they sometimes cause headache and pain in the eyes, they are apt to get dimmed by condensed moisture, the metal frame is apt to get hot, and finally, they are uncomfortable. All of these objections may be removed by a proper construction of the glasses.

Prophylaxis against Accidents by Machinery.—This is a science by itself, the study of which requires special technical training. In most countries laws are enacted to safeguard machinery and prevent accidents. Motor engines, flywheels, etc., must be fenced in and provided with proper guards and rails. Wheels, shafts, drums, belts, and all gearing must be provided with special protective appliances. Circular saws, planes, power looms, and other machinery and tools are all to be properly guarded with approved devices. Many machines and parts of them are at present provided with proper safeguards by their makers. Workers should be thoroughly drilled in the art of self-protection and educated to the dangers of machinery as well as to all other dangers of their calling. This remark applies with special force to workers in large electrical establishments, where a man may lose his life, by coming in contact with a wire carrying a powerful current of electricity.

Offensive Trades.

Thus far the effects of occupations have been considered only with reference to the health of those engaged in them—the workers themselves. There are a number of occupations, however, which affect not only their workers, but the community at large, or, at least, that part of it which lives in their immediate vicinity. These occupations have been named "offensive trades," also "public nuisances." Except in trades which allow poisonous substances or noxious gases to escape outside their precincts, and thus directly injure the health of the surrounding neighborhood, the dangers to health of the so-called "offensive trades" are not direct; at least, it is difficult to show the existence of any diseases or pathological lesions which owe their origin to those trades. Most of the harmful effects of these trades are due to the smoke, noise, and smell produced, which may give rise, in those predisposed to such ailments, to certain disorders such as anorexia, nausea, neurasthenia, anæmia, and kindred ills. The number of offensive trades is very large, and a classification of them has been attempted by the French Government, which divided them into three classes, according to the degree of their offensiveness. Tracy,[18] in his article on "Public Nuisances" in Buck's "Hygiene and Public Health," and S. A. Goldsmith in his article in the former edition of this Handbook, gave full lists of those trades, based on the French classification, as well as detailed technical descriptions of the various processes of the offensive businesses. The space here being limited, only the prophylactic part will be noted, and all technical details will be omitted. The following are the annoying factors in most offensive trades: *Noise*, *Smoke*, *Dust*, *Smell*, and *Noxious Gases and Fumes*.

Noise.—The number of businesses which are characterized by excessive noise is quite large, especially in populous towns. Surface and elevated railroads, driving of heavy wagons over rough pavements, machine shops, forge rooms, blacksmith shops, saw and planing mills, street venders, street music, etc., are a few of them. Excessive noises affect especially nervous, neurasthenic, and sick persons, causing irritability, sleeplessness, anorexia, and general disturbances. A New York physician gave to these symptoms the name of "Newyorkitis," but the malady, if there is such, could better be termed "urbantis," as it is characteristic of all large cities. The prevention of excessive noise is possible in a large degree by municipal action. Thus in New York it is not allowed to create unnecessary noises, especially at night, and near residential streets; street-band music is prohibited in the boroughs of Manhattan and the Bronx, railroad companies are compelled to remove "flat-wheel cars," street peddling is not allowed at night, etc.; with a wider introduction of asphalt pavement a fruitful cause of noises will also be largely abolished.

Smoke.—Among the many nuisances incident to city life is the black smoke belched forth from the chimneys of manufacturing establishments. The composition of the smoke as it leaves the chimney depends on the character of fuel burned, as well as on the methods of combustion and the care with which it is carried on. Black smoke consists of carbon mechanically suspended, and also of other gases, such as carbonic acid, carbonic oxide, and hydrogen sulphide. Wood and bituminous coal give off very abundant and black smoke, while hard coal gives off very little on account of its cohesiveness and complete combustion. When furnaces are of adequate capacity, with grates having a large area, with the coal spread in a thin continuous sheet, and with the requisite amount of air, the production of smoke is greatly diminished.[19] The other remedies, outside of using anthracite coal, are the providing of tall chimneys, so that the smoke shall be emitted above the windows of living houses; and the voluntary or compulsory introduction of smoke-consuming devices. There are a very large number of patented smoke consumers, most of them based on the principle of making a more thorough and complete combustion of all particles of carbon in the fuel.

Dust.—There are only a few businesses in which large quantities of dust may escape outside of the establishments and become a public nuisance. These are carpet-cleaning and beating works, sandblasting of glass, and street sweeping. Carpet-cleaning is now done in large establishments without producing dust. Proper methods have been devised for collecting the dust and preventing its coming outside. Sandblasting of glass is to be relegated outside of residential streets, the dust usually not falling farther than about three hundred feet from the establish-

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ments. Street sweeping may be done with comparatively little dust if the streets are previously well sprinkled with water and the cleaners are careful.

Smell.—The trades and businesses which are or may become offensive on account of their smells are very numerous indeed. They include the greatest bulk of generally offensive trades, as they are composed of all the numerous industries in which animal or vegetable matter is manufactured or stored, and which may at certain periods of the procedure give rise to offensive odors. We shall here allude only to the following: (1) The keeping of live animals and of animal matter. (2) Killing of animals. (3) Manufacture and utilization of animal substances. (4) Manufacture of vegetable substances, etc.

Keeping of Live Animals.—As in all offensive trades, the keeping of live animals becomes a nuisance only in populous towns. The nuisance created by the keeping of live animals, such as horses, cows, calves, swine, sheep, goats, birds, poultry, and rare and wild animals consists in: (1) the specific odors peculiar to each kind of animal; (2) the smell from the urine, excreta, and other organic matter from the animals; (3) the noises which are made by them and which disturb the rest of the neighborhood; (4) the flies and parasites which they attract to themselves; and (5) possible infective materials and germs likely to be transmitted to men.

Most municipalities have laws which are intended to abate the nuisances created by the keeping of animals. The remedies for the nuisance are the following: (1) total prohibition of the keeping of certain animals within the city limits, or at least in overcrowded neighborhoods; (2) restricting the building of new places for animals; (3) proper veterinary supervision and disinfection, to prevent disease of animals and infection; (4) proper construction and maintenance of the places where they are kept; (5) removal of all animal matter likely to give offensive odors, or to become putrefied. The rules and regulations of municipalities embrace all of the above-enumerated prophylactic measures. Thus in New York no cows, horses, calves, swine, sheep, or goats are allowed to be kept in tenement houses; no stables are allowed on the same lot with a tenement house; and the keeping of all kinds of animals, even pigeons and chickens, requires a permit from the Health Department. In Boston [19] stables are prohibited within two hundred feet of a church; in Chicago, in order to build a stable, it is necessary to get the permission of the owners living within six hundred feet of the proposed stable.

Most of the offence given by the keeping of live animals is given by horse stables, as comparatively few other animals are kept in cities. Stables should be specially constructed for the purpose. They should contain at least twelve hundred cubic feet of space and one hundred and twenty cubic feet of floor space for each horse; stalls should be at least six feet wide and nine feet long, and the stable should be well ventilated. The floors of stables should be of some impervious material, such as concrete, cement, bricks set in cement; no woodwork that cannot be easily taken off should be laid on flooring. There should be provision for an unlimited supply of water, and the floor should be properly graded and drained, and the stalls provided with longitudinal "valley drains," provided with adjustable covers easily taken up, and the drains should all be tightly connected with the sewer by a properly trapped, extra heavy drain. [19] No accumulations of manure are to be allowed; as soon as it is collected, it should be put into barrels or pressed into bales and daily removed. The removal of manure should be done within the stable, and the carts should be well covered before they start out from the stable. The removal hour should be at night or early in the morning. Thus in Boston manure can be removed only after 12 (midnight); in Jersey City between 6 P.M. and 7 A.M. The stables should be kept scrupulously clean and frequently disinfected with a solution of one pint of formalin to three gallons of water or a similar solution of carbolic acid; corrosive sublimate solution and creolin can also be used. There is no reason why, with such precautions, the keeping of horses should be attended with offence. The keeping of other animals may be made inoffensive by means of similar methods.

The Keeping of Animal Matter.—The storage or keeping of animal matter, manure, offal, bones, hides, horns, skins, fish, garbage, etc., may be attended with offence, on account of the tendency to speedy putrefaction and decomposition, when the decomposing matters may emit very offensive and sickening odors, unbearable by many, and causing headache, loss of appetite, and nausea in others. The prevention of their becoming nuisances can be summed up in the following measures: Immediate destruction, by burning all needless matter likely to decompose; immediate removal from habitations; scrupulous cleanliness; disinfection; keeping of matter in tightly closed vessels.

The Killing of Animals.—The killing of animals is one of the oldest industries of mankind, and has been always in need of state supervision and control from the time of Moses in ancient Egypt until the present. The nuisance created by slaughtering animals consists mostly in the odors peculiar to the slaughter-houses, although other things, such as the noise created by the animals, the flies and parasites attracted by the animal matter, as also the possibility of infection by animal diseases, all play their part in the creation of this nuisance. The offensive smell is due to the animals themselves, the fresh animal guts, blood and other products, and the decomposing animal matter within the buildings. The remedies for the nuisance are: prohibition of slaughtering in any but specified localities; the construction of special municipal abattoirs; the proper building and maintenance of the slaughter-houses, their supervision and inspection; the immediate removal of all by- and waste products; the refrigeration of meat; the absolutely clean condition of the places; the provision of special means for destroying foul- and ill-smelling matter, and the disinfection of the premises.

Municipal provisions about slaughter-houses were inaugurated in the United States as early as 1692 in Boston, [20] and are now found in nearly every community. In New York City slaughter-houses are located only in specified localities, of which there are only four or five. In Boston the slaughtering of animals is concentrated in the Brighton abattoir; and in New Orleans in the municipal abattoir. Cleanliness in the slaughter-houses is provided for in the various sanitary codes, the following being from a section of the New York law: "All those who are responsible for the places should cause such places and their yards and appurtenances to be thoroughly cleansed and purified, and all offal, blood, fat, garbage, refuse, and unwholesome or offensive matter to be removed, at least once in every twenty-four hours after the use thereof; and they shall also at all times keep all woodwork, save floors and counters, thoroughly painted or whitewashed." An unlimited supply of water is even more needed in abattoirs than in stables. Goldsmith quotes Tardieu as saying that in Paris (where the buildings are of iron and glass) ninety thousand litres are used daily in each of the five abattoirs, and adds that in New York a slaughter-house in Forty-fifth Street uses nearly five million gallons a day. [22] The slaughtering of poultry and smaller animals should also be controlled by the municipalities, and most of the prophylactic measures used in slaughter-houses of larger animals are applicable to them also.

Utilization and Manufacture of Animal Substances.—Modern industry does not allow anything to go to waste, and in animal trades there is hardly a substance which is not utilized in some way. Among the many branches of these utilization industries to be discussed here are the following: The rendering of fat and lard; bone and blood-boiling; gut-cleaning; manufacture of glycerin, soap, and glue, and the preparing and tanning of skins and hides.

Fat Rendering, Lard Refining.—Most of the rendering of fat is done by the action of heat, although there are several chemical methods in vogue. Since the trade be-

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came concentrated in large establishments, the old method of rendering fat in open kettles has become happily obsolete. The chief nuisance of fat rendering consists in the odors "which are all caused, partly by the storage of decomposing fat on the premises, but mainly by the distillation of portions of the fat, which produces certain ill-smelling substances, such as acrolein and allylic alcohol, with sometimes capric, caprylic, and caproic acids."[18]

The prevention of fat-rendering from becoming a nuisance is accomplished by the following measures: (1) The use of undecomposed animal matter; (2) the employment of a low temperature in rendering; (3) the boiling of fat in tightly closed vessels; (4) the use of condensers for the removal and destruction of the gases and odors. The New York Sanitary Code has the following section: "That no fat, tallow, or lard shall be melted or rendered except when fresh from the slaughtered animal; and taken directly from the place of slaughter, and in a condition free from sourness and taint, and all other causes of offence at the time of rendering; and that all melting and rendering are to be in steam-tight vessels; the gases and odors therefrom to be destroyed by combustion or other means equally effective." Hines[21] says: "The great secret in preventing nuisance is the avoidance of burning the materials, or even raising them to high temperature. The lower the temperature at which the work can be successfully carried on, the less is the risk of producing offensive smells. The temperature need not exceed 120° F." When steam methods of rendering are used, the need of condensers is imperative. "Condensers may be of several styles and shapes. The water may be introduced at the top, and broken by means of a plate, a short distance below, the shower may also be made by means of a rosette. The condenser itself may be made of iron, copper, or even wood. It should be made as high as possible, in proportion to the diameter. The gases should be introduced at the bottom, and passing up through the water shower, connect with the furnace fires by a pipe near the top." (Goldsmith.[22]) Of the chemical methods of fat-rendering D'Arcet's method is by separation of the fat from its membranes by the action of sulphuric acid. Lard refining differs little from the general rendering of other fats, and, being done mostly by the low temperature method, it is not offensive.

Bone and Blood Boiling.—In the processes of boiling these animal substances odors may arise which may be quite offensive. The following preventive measures are recommended by the Philadelphia Board of Health:[20] "The floors of all bone-boiling establishments and depositories of dead animals shall be paved with asphalt, or with brick or stone, well laid in cement, and shall be well drained. The boiling of bones, etc., shall be conducted in steam-tight kettles, boilers, or cauldrons, from which the foul vapors shall first be conducted through scrubbers or condensers, and then into the back part of the ashpit of the furnace fire to be consumed. When bones are being dried after boiling, they shall be placed in closed chambers, through which shall be passed, by means of pipes, large volumes of fresh air, the outlet pipe terminating in the fire-pit."

Gut Cleaning.—The utilization of the small intestines of animals for sausage skins and the manufacture of catgut is necessarily accompanied by a great deal of stench from the foul-smelling contents of the guts and the decomposition of animal matter. "The processes should be carried on away from habitations; the guts, etc., should not be allowed to come in a foul state, but must be utilized immediately, and proper precautions taken to let no foul matter cling to the floor or surfaces of the establishment. This may be accomplished by the use of plenty of water. The water in the tank where the intestines are macerated may be disinfected by a weak solution of chloralum or chlorinated soda."[18] Parent Duchatelet (Tardieu) denies that gut cleaning is harmful to health.

The Manufacture of Soap.—Soap is manufactured from fat and alkalies. It may become a nuisance: (1) On account of the large quantity of fat, tallow, and fat animal residue, which are collected from all animal waste matter, and which are, by the time they reach the soap factory, in a decomposing state. (2) By the processes inherent in fat rendering. (3) By the odors arising from the huge vats and tanks where the fat is being boiled with the alkaline lye. The prevention of the first nuisance is accomplished by insisting that only fat in a fresh state shall be allowed in the soap factories. The means of preventing fat-melting and rendering from becoming a nuisance have already been described. The nuisances caused by the odors arising from the boiling tanks can be prevented by fitting these with covers, and conducting the vapors either outside through a tall chimney, or, as in fat-rendering, through proper condensers.

Glycerin.—When the fatty acids of the fats in soap manufacture combine with the alkalies, the base left is a residue in the form of glycerin, which, before being fitted for the market, must be refined several times. During this process sweetish unpleasant odors are given off, which can be prevented by the same means as those which are used in treating odors from fat rendering.

Glue-Making.—All kinds of animal waste matter, hoofs, horns, skin scraps, leather scraps, etc., are used for the extraction of glue. As in the other processes employed for the utilization of all animal waste matter, the nuisance comes from the decomposing material, from the odors given out during boiling, etc., and from the offensive residue or "scrutch." The remedies are the same as in other kindred processes.

Treating and Tanning of Skins and Hides.—Animal skins, before they are converted into lasting leather, must go through a number of complicated processes. In the scraping, salting, hairing, brining, liming, puering, tanning, curing, and other processes very offensive and disgusting odors often arise; and in liming some sulphureted hydrogen may also be evolved. The process named "puering" consists in soaking the hides in a liquid composed of dog's dung. Tanning establishments should not be allowed in residential localities. The various manipulations may be done with little offence if the places are properly constructed and well kept.

Manufacture of Other Substances.—Among the other substances, the manufacture of which may become offensive, are the following: Illuminating gas, petroleum refining, distilling, brewing, vinegar-making, sugar-refining, boiling of oil, manufacture of varnish, cooking, etc.

Illuminating Gas.—The nuisance caused by the presence of gas works in populous localities is due to various gases and odors given off, during the many stages required, in the process of distilling gas from bituminous coal. The process especially objectionable is the "liming," or passing the gas through a closed chamber filled with quicklime, which is afterward deoxidized and gives off ammonium sulphide and sulphureted hydrogen. Oxide of iron has been substituted for quicklime, with a material lessening of offensiveness. Notwithstanding all the care employed and despite the modern inventions of condensers, scrubbers, and other means for destroying and absorbing offensive gases during the manufacture of illuminating gas, this business is still quite a nuisance to a neighborhood, and the best remedy is to remove it as far as possible from habitations.

In the processes of refining petroleum, offensive odors are given off. These are due to the escape of fumes during its distillation, as well as during the agitation of the refuse or "sludge" acid with alkaline solutions. Goldsmith recommends that the wash water from the agitators should be passed through a series of troughs furnished with cross slots, to retain all oily or tarry matter; and the treatment of the sludge should be carried on at a distance from crowded neighborhoods.

The nuisances caused in the processes of brewing, distilling, sugar refining, and other industries mentioned, consist in the odors given off at certain stages of manufacture and may be prevented by the same methods as those described in the section on Fat Rendering.

Tracy lays down the principles of controlling the nuisance caused by the odors and vapors which are given off

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during the manufacture of various substances as follows: (1) Conveying and storing in tight vessels. (2) Substitution of less offensive processes for the more offensive. (3) Proper construction of the places where nuisances arise. (4) The use of plenty of water, proper cleanliness, and drainage. (5) The destruction of all offensive odors by passing them through condensers, etc., and from there into the fire pits where they will be consumed.

Gases and Vapors.—The number of the trades which may become a nuisance to the community on account of the vapors, acid fumes, and gases which are evolved in their processes, and are allowed to escape into the surrounding air, is very large. Among the more important of these are all the chemical trades; the manufacture of alkalies, ammonia, bleaching powder, soda, and glass; assaying, smelting, and the manufacture of jewelry, lead paint, certain drugs, etc.

The nuisance created by all of these trades can be summed up in the following: (1) Odors offensive to the neighborhood. (2) Deleterious gases. (3) Destruction of vegetation in the neighborhood.

The remedies advised for the prevention, or at least mitigation, of the nuisances are: (1) Removal, whenever possible, from crowded localities. (2) Dilution of the gases and vapors by air. (3) Condensation of gases by cooling them with water, by passing them once, or several times, either through condensers filled with water or through scrubbers filled with wet coke. (4) Absorption through discharging all gases into fire-pits, where they are destroyed by the action of fire, or by passing them through neutralizing substances, which are of course different for each of the different gases.

George M. Price.

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OCCUPATION DISEASES. See *Caisson Disease; Hands and Fingers, etc.; Lead Poisoning; Lungs, Diseases of: Pneumonokoniosis; Siderosis; etc.*

OCEAN SPRINGS.—Jackson County, Mississippi. POST-OFFICE.—Ocean Springs. Hotels.

This is a station on the railroad between New Orleans and Mobile, eighty-three miles east of the former, and fifty-seven miles west of the latter. It may also be reached by coast steamers from either city. The name of the springs is derived from their proximity to the gulf, the beach being but half a mile distant. According to Walton the springs are most resorted to by citizens of New Orleans and Mobile. The following analysis was made by Prof. J. Lawrence Smith:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	47.77
Potassium chloride	Trace.
Calcium chloride	3.88
Magnesium chloride	4.97
Ferrous oxide	4.71
Organic matter	Trace.
Ammonia	Trace.
Iodine	Trace.
Total	61.33
Gases.	**Cu. in.**
Sulphureted hydrogen	1.28
Carbonic acid	9.79

The water is a potent chalybeate, the iron being no doubt held in solution in the form of a carbonate. The unusual combination of carbonate of iron, chloride of sodium, and sulphureted hydrogen especially adapts this water to the treatment of diseases of the skin in persons of a scrofulous diathesis. *James K. Crook.*

OCHEE SPRINGS.—Providence County, Rhode Island. POST-OFFICE.—Johnston.

The Ochee Springs are not properly a health resort, although there are many visitors in pleasant weather. There are a number of springs in the neighborhood, but only one is improved at the present time. The following analysis was made by Prof. John H. Appleton, of Brown University:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Magnesium carbonate	1.13
Calcium carbonate	3.20
Calcium sulphate	.44
Potassium sulphate	.88
Sodium sulphate	.41
Sodium chloride	.57
Iron oxide and alumina	.75
Insoluble mineral matter	.58
Organic and volatile matter	.87
Undetermined	.15
Total	8.98

This water is pure and wholesome, and is said to act as a mild cathartic and diuretic when used continuously. It has been accorded a considerable reputation as an auxiliary in the treatment of kidney, liver, and stomach troubles. The water is used commercially. *James K. Crook.*

OCHRONOSIS. See *Pigment, etc.*

OCONEE CHALYBEATE SPRING.—Putnam County, Georgia. POST-OFFICE.—Eatonton.

Lake Eaton branch of Central Railroad to Eatonton, and from thence by private conveyance to spring. This spring has had considerable local reputation for a number of years. The waters contain the following ingredients:

Iron carbonate.	Calcium sulphate.
Calcium carbonate.	Sodium chloride.
Potassium sulphate.	Silica.

The iron is insufficient in quantity to warrant us in placing the water in the chalybeate class. The flow is small but constant, the water issuing from a fissure in a granite rock. *James K. Crook.*

OCONEE WHITE SULPHUR SPRINGS.—Hall County, Georgia. POST-OFFICE.—Bowdre. Hotel and cottages.

Location, six miles from Gainesville and two miles from Sulphur Springs Station, on the Southern (Richmond and Danville) Railroad. Hacks meet all trains.

This is one of the most attractive watering-places of the South. Long before the war Southerners of wealth and fashion gathered there annually. A few years ago the property was purchased by Mr. Ferdinand Phinizy, of Athens, and many improvements were made. The old buildings were torn down and a large, well-appointed hotel and handsome cottages were erected. The excellent and liberal management has kept the place popular, and

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it now numbers among its guests visitors from far and near. No analysis is furnished, but the waters are said to be valuable in rheumatism, dyspepsia, and diseases of the blood. There are also bathing conveniences, including shower and plunge baths and a large swimming pool.

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James K. Crook.

ODONTOMA.—This term has been applied in a general sense to a great variety of tumors arising in connection with the teeth—from the tooth follicle, the dentine, the cement, the enamel, the tissue about the tooth, or from the tooth structure as a whole. Different names have been applied to these growths by various authors, and at present the classification of these tumors is in a confused state. The majority of the observations are rather old, very little study having been made recently of this subject. By most writers the term *odontoma* is limited to those growths which arise at an early period of development of the tooth before the formation of the dentine. Those developing during later life from the dentine, cement, or enamel of the mature tooth are classed as *odontinoids*. These are further divided into *dentinoids*, arising from the dentine; *emailloids*, arising from the enamel; *dentalosteoma*, arising from the cement. The *true odontomata* are rare, and for the greater part form soft growths corresponding to the stage of development of the tooth, and presenting such varied appearances as to justify the diagnosis of myxoma, cystoma, sarcoma, or fibroma. Dentine may develop later in the tumor, the growth becoming hard, and after complete dentification stationary in development. Occasionally they may reach such a size as to cause erosion of the jaw bone. They may be single or multiple. They are usually irregular or nodular; after dentification they resemble dentine in structure. The *odontinoids* are usually very small and unimportant excrescences of the teeth, which are more of the nature of inflammatory hyperplasias than of true tumors, and are found in pathological conditions of the teeth, particularly in association with diseased roots. In caries of the teeth there may arise from the exposed pulp masses of granulation tissue of a polypoid character, the so-called *pulp-polyps* or *pulp-granulomata*.

The *cystic tumors* found in the jaw are sometimes included with the odontomata, but by other writers are placed in a class by themselves. Three forms of these cysts occur: *follicular* and *periosteal cysts* and the *multilocular cystoma*. The *follicular cysts* are found only during the period of dentition. They are usually monolocular, rarely multilocular cysts, having a wall lined by cylindrical epithelium. With the exception of those arising from the wisdom teeth they develop at an early age and grow slowly, taking several years to reach an important size. They arise from the cystic degeneration of a normal tooth follicle, or from supernumerary follicles or Anlage. In the cyst cavities there are occasionally found imperfectly developed teeth. The *periosteal cysts* arise chiefly as a result of chronic inflammatory processes affecting the roots; they are termed accordingly *peridental, periodontal, subperiosteal,* or *root cysts*. A portion of these formations arise from collections of pus beneath the periosteum; others take their origin from granulation tissue growing about the roots. The inner side of the granuloma is lined with epithelium derived from the remains of the epithelium of the cement. The granulation tissue may become converted into a firm fibrous capsule forming the cyst wall, the root of the tooth projecting into the cavity of the cyst. Proliferation of the epithelium lining the cyst may lead to appearances similar to those of dermoid cysts. More frequently the cysts contain a clear, mucoid, or thick brown fluid. They occur most frequently in the upper jaw. Carcinoma may take its rise from the epithelium of the cyst wall. The *multilocular cystomata* of the jaw are very rare tumors, taking their rise from the follicle; epithelial proliferations from the follicle forming alveolar or gland-like structures, which become cystic. The cyst walls are usually very thin. The growths may reach a large size, and cause great destruction of the jaw bone. Though seldom becoming carcinomatous the cysts cause great enlargement and atrophy of the bone, the bony layer over the cysts being sometimes as thin as paper, or in other cases the bone may entirely disappear, leaving the cyst covered only by periosteum.

Sutton ("Tumors Innocent and Malignant") defines the odontoma as a tumor composed of dental tissues in varying proportions and different stages of development, arising from teeth germs, or from teeth still in the process of growth. He classes them, according to the part of the tooth germ concerned in their formation, as follows: (1) *Epithelial Odontoma*, from the enamel organ; (2) *Follicular Odontoma*; (3) *Fibrous Odontoma*; (4) *Cementoma*; (5) *Compound Follicular Odontoma*, all from the tooth follicle; (6) *Radicular Odontoma*, from the papilla; (7) *Composite Odontoma* from the whole germ. For a description of these varieties and for illustrations of cases the reader is referred to this work.

Aldred Scott Warthin.

ŒDEMA.—(Hydrops, dropsy.) An increase in the amount of lymph within the tissue spaces or serous cavities is known as *œdema* or *dropsy*. The fluid itself is often called a *transudate*; but at the present time the distinctions formerly held between œdema and inflammatory exudate, and transudate and exudate, are no longer emphasized, inasmuch as the essential etiological factors are common to both. Various specific terms are employed to denote the portion of the body affected by the condition of œdema, as, for example, *hydrops* is usually limited to the collection of fluid within the body cavities, *œdema* to the collection of fluid within the lymph spaces of the connective tissue or parenchymatous organs, *anasarca* or *hydrosarca* to an œdematous condition of the skin or subcutaneous tissues, *ascites* to the collection of fluid within the peritoneal cavity; while *hydrothorax, hydropericardium, hydrocele, hydrophthalmos, hydrocephalus internus, hydrarthros, hydrops bursarum*, etc., are used to designate the collection of fluid in the pleural cavity, pericardium, scrotum, eye, cerebral ventricles, joints, bursæ, etc., respectively. Localizations of œdema of great importance clinically are designated as *œdema of the lungs, œdema of the glottis*, etc. The œdematous swelling of the presenting portion of the fœtal head is known as *caput succedaneum*. Œdematous conditions of the conjunctiva are termed *chemosis serosa*. The term *dropsy* in strict use should be confined to the collection of fluid within the body cavities, but is applied in a loose way to any œdema or collection of fluid of such extent as to be evident by the ordinary methods of physical examination.

Lymph.—Since œdema is a pathological increase of the lymph, it follows that the production of the former must depend upon a disturbance of the normal mode of lymph production. The clear watery fluid which permeates the intercellular spaces of the tissues and bathes the serous surfaces is known as the lymph. Its chief source is the blood, and its constituents are passed through the walls of the blood-vessels by processes of diffusion, filtration, and specific secretory activity of the cells of the vessel walls. Under certain conditions the fluid of the cells and other constituents of the tissues may also pass into the free fluid of the tissue spaces. According to Heidenhain the lymph is composed of fluid derived from the blood, the lymph of the organ under consideration, and the water contained in the tissue cells and fibres. The ultimate source is, of course, the blood. Formerly regarded as a passive filtration from the blood-vessels, the formation of lymph is now considered by the majority of investigators to be of the nature of a secretion of the cells forming the capillary walls. In support of the view of the selective action of the blood-vessel walls are the facts that the composition of the lymph differs greatly from that of the blood plasma, and differs also in its composition in different parts of the body; further, under certain conditions it may contain more salts and extractives (urea and sugar) than the blood. The rapid passage of crystalloid substances from the capillaries into the lymph is also a strong point in favor of the view that the proc-

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ess is not one of mere diffusion, but is the result of a force inherent in the cells of the vessel walls. According to Heidenhain the specific function of the capillary walls plays a controlling part in the formation of lymph. Certain substances injected into the blood-vessels increase the production of lymph (extracts of leeches, mussels, crabs, peptone, etc.), and it is also possible that the capillary secretion is directly under nerve influence. It is very probable that certain œdematous conditions of the skin (urticaria, herpes zoster, etc.) are partly intoxications and in part due to nervous disturbances. The function of the lymph is the conveyance of nutrition to the cells and the removal of their waste products. From the lymph spaces the fluid is gathered into the lymph vessels passing to the lymph nodes, from which it is passed on to the veins by the larger lymph trunks. Not all the lymph is returned in this manner; a portion is undoubtedly taken up directly into the blood-vessels; or at least in some of the lymph nodes a portion is taken up by the capillaries of the lymphoid tissue.

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Etiology of Œdema.—It follows that as œdema is the result of an increase in the amount of lymph, such an increase may be brought about either by an increase in the amount of fluid passed out of the capillaries, or by some obstruction to the outflow of lymph through the lymphatics. In general, the causes of œdema are the various pathological conditions which may influence the process of lymph formation. The increased production of lymph may be due to an increase of the vascular secretion, or to an increased permeability of the vessel wall. These conditions may be brought about by increase of blood pressure, by pathological alterations in the vessel walls, or by the direct action of certain substances either upon the cells of the vessel walls or upon the nerves governing these, stimulating the capillaries to increased secretion. Within certain limits an increase in lymph production is equalized by an increase in lymph absorption through the lymphatics and also through the blood-vessels. Beyond this limit there arises a more or less permanent over-saturation of the tissues with lymph, and the condition of œdema is established.

According to etiology four general classes of œdema may be distinguished: *œdema from stagnation of the blood*, that resulting from *obstruction to the outflow of lymph*, that caused by *disturbance of capillary secretion*, and *œdema ex vacuo*. Clinically, a great number of varieties may be recognized: *toxic, thermal, traumatic, inflammatory, cachectic, infectious, hydræmic, anæmic, neuropathic*, etc., but all of these fall within the four etiological classes above named, the great majority belonging to the third class, namely, that produced by disturbance of the capillary secretion through alterations in the vessel walls.

Etiological Varieties of Œdema.—*Œdema of Stagnation.*—Following an obstruction to the onward flow of the blood, resulting from ligation or occlusion of the main venous trunks, or in general venous congestion, due to insufficiency of the heart, the capillary pressure rises and an abnormal secretion of lymph takes place. That the œdema is due directly to the increased blood pressure within the capillary cannot be said to have been definitely proved. It is probable that as a result of the increased pressure the cells of the capillary walls are stimulated to increased secretory activity. It is also probable that degenerative changes in the endothelium result from the distention of the vessel, so that as a consequence of an increased permeability of the wall serous transudation occurs. The fact that in many cases no changes in the vessel walls of an œdematous area can be found favors the theory of increased secretion. In chronic congestion the occurrence of œdema is also favored by the resulting loss of elasticity of the tissues about the vessels. An increase of arterial pressure does not give rise to œdema so long as the venous return is unimpeded, but in all cases of passive congestion there is an increased formation of lymph. This may be compensated for by an increased flow of lymph, but beyond a certain limit the fluid collects in the tissues. In cases of general passive congestion the œdema first shows itself in the most dependent parts of the body, the influence of gravity favoring the greatest increase of pressure in the vessels of these parts. As in general passive congestion there is some obstruction to the discharge of the large lymph trunks into the veins, the lymph of the tissues is not removed so rapidly as normally. Local passive congestion gives rise to local œdema; thrombosis of the femoral vein causing œdema of the lower extremity, occlusion of the portal circulation being followed by ascites, etc. The fluid in œdema of stagnation always contains but a slight amount of albumin. With increase of pressure the amount rises, and a varying number of red cells may escape from the vessels into the lymph.

Œdema Caused by Obstruction to the Lymph Circulation.—It has been shown by a number of investigators that obstruction to the current in the lymph vessels is not as a rule followed by œdema, on account of the numerous and universal collateral anastomoses, and also for the reason that the lymph may be reabsorbed by the blood-vessels. An actual obstruction to the lymphatic circulation can, therefore, hardly occur except in the case of the main lymphatic trunks. Even in these cases, if the production of the lymph remains normal, collateral channels may be developed, sufficient to carry off the lymph without causing œdema. According to Baldaert the total occlusion of all the lymph vessels of a part may give rise to a pure lymphatic œdema, which in the case of increased formation of lymph may develop into a tissue œdema. Obstruction of the thoracic duct by tumors, aneurisms, etc., is usually followed by chylous ascites. Even in this event a collateral circulation may be set up; but in other cases the rupture of the receptaculum chyli gives rise to a chronic chylorrhœa into the peritoneal cavity. In the case of œdema caused by stagnation lymphatic obstruction causes a great increase in the degree of the œdema present.

Œdema Caused by Disturbances of Capillary Secretion.—As the result of chemical changes in the blood, imperfect oxygenation, anæmia, infections, intoxications, long-continued passive congestion, trauma, effects of low or high temperatures, etc., certain pathological alterations in the walls of the vessels may be produced, of such a nature as to cause an increase in the secretion of the vessel walls and give rise to œdema. The exact nature of the changes we are at present unable to state; in some cases the endothelial cells appear granular, cloudy, and are exfoliated; in other cases no changes in the cells can be discovered. It is also possible that alteration of the cement substance between the cells favors an increased transudation of fluid. The forms of œdema produced by the above-named factors are known clinically as toxic, infectious, neuropathic, inflammatory, etc.

Œdema ex Vacuo.—After degeneration or necrosis of portions of the tissue of brain or spinal cord the necrosed material is absorbed and the defect becomes filled with fluid of a very low specific gravity and containing but a small amount of albumin. In atrophy of the brain and cord the subarachnoidal space and the ventricles may become enlarged and filled with a similar fluid. This process may be regarded as being of the nature of a compensatory attempt to restore the normal tension of the part.

Nature of the Transudate.—The fluid of œdema is usually colorless or pale yellow, clear, and of alkaline reaction. A few leucocytes and red cells are usually present. In cases with accompanying icterus the fluid may be yellow or even brownish. An excessive number of red cells may give it a reddish tinge. The collections of fluid in the serous cavities are more likely to vary in color in a noticeable degree, and usually contain flakes of fibrin. Occasionally they may contain large numbers of desquamated endothelial cells, leucocytes, or fat droplets. After rupture of chyle vessels the admixture of chyle with the fluid of an existing ascites may produce a milky turbidity of the ascitic fluid. In other cases the milky appearance of transudates may be caused by a precipitation of albumin. The chemical composition of transudates is closely related to that of the blood plasma.

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The amount of proteids, salts, and extractives is a varying one, and is usually less than that of the blood. Under certain conditions the salts and extractives may occur in greater amounts than in the blood, but the amount of albumin is always much less. The fibrin forming elements may be absent or present in small amount. Mucin is occasionally present. The proportion of albumin in pure transudates varies greatly in different parts of the body. According to Reuss, the proportion of albumin in pleural transudations is 22.5 *per mille*, in pericardial 18.3, in peritoneal 11.1, in the fluid of subcutaneous œdema 5.8, in that of cerebral and spinal cavities 1.4.

The following table of the specific gravity and albumin content of certain transudates is given by Thoma:

	Specific gravity.	Per cent. of albumin.
Ascitic fluid in nephritis	1.006	0.56
Ascitic fluid in portal obstruction (cirrhosis)	1.008	.97
Ascitic fluid in general venous congestion	1.012	1.96
Pleural effusion in nephritis	1.007	
Pleural effusion in general venous congestion	1.012	1.30
Transudates of varying origin	1.007-1.011	0.05-1.1

As a rule the specific gravity of a pure transudate rarely reaches 1.010, usually falling below, 1.006–1.008. In inflammatory œdema the specific gravity may reach 1.016–1.020. In inflammatory œdema the amount of albumin is much greater than in pure transudates. The presence of abnormal substances in the blood plasma (sugar, uric acid, bile pigments, potassium iodide, phenol, etc.) leads to the presence of the same in the fluids of the tissues and body cavities.

General Morbid Anatomy.—Œdematous tissues are usually pale, swollen, and as the result of the deficient circulation colder than normal. The degree of change varies with the part involved and the structure of the tissue. The skin and subcutaneous tissue may take up an enormous amount of fluid; the skin may become greatly stretched, and an extremity may swell to many times its normal size. As a result of the extreme distention the skin at first becomes greatly thinned, smooth, and shining, later presents linear lines of rupture from which spontaneous oozing of fluid may occur; in chronic œdema the skin usually becomes thickened, rough, scaly, and pigmented, and may show numerous lineæ albicantiæ. The most characteristic physical sign of œdema is that of pitting on pressure, indentations made with the fingers in œdematous tissues persisting for some time, because of the diminished elasticity of the tissues. The lymph spaces of the skin and subcutaneous tissues may become so dilated that incision into these allows the fluid to escape in a constant stream. The appearance of the incised tissue is that of a partial liquefaction, so great may be the saturation with fluid. Œdema of the skin usually appears first over the ankles and beneath the eyes. The loose integument of the penis and scrotum may show the most extreme degree of saturation.

Collections of fluid in the body cavities, when extreme and long continued, cause dilatation of the cavity and compression of neighboring organs. The serous surfaces become grayish and more opaque and usually present more or less desquamation. In œdema of mucous membranes the mucosa becomes swollen, pale, grayish, more or less translucent, and of boggy consistence. In the case of the lung the alveolar spaces become filled with fluid, the presence of the fluid causes a loss of elasticity and a partial atelectasis. On section a more or less abundant frothy fluid escapes from the cut surface. In marked pulmonary œdema the volume and weight of the organ may both be greatly increased. Solid organs like the liver and kidney from the nature of their structure rarely show a marked condition of œdema. When present, the cut surface of the organ is moist and glistening.

The microscopical examination of œdematous tissues shows enlargement of the tissue spaces, separation of the connective-tissue fibrillæ, vacuolization of cells and nuclei, and the presence of fine albumin granules in the spaces occupied by the fluid. In the alveolar spaces of the lungs large numbers of desquamated epithelial cells are also found. In chronic œdema hydropic degeneration of some of the constituents of the tissue may take place. As a result of the lowered resistance of œdematous tissues, and the mechanical injury caused by stretching, distention, etc., secondary inflammatory changes are of frequent occurrence in and about œdematous tissues.

Clinical Varieties of Œdema.—*Inflammatory Œdema.*—The œdema associated with inflammatory processes is not of the nature of a pure transudate, but is usually classed under the head of exudates. Its etiology is, however, to be sought in alterations of the vessel wall similar to those which give rise to transudates, though of a more marked character. It occurs as circumscribed or diffuse swelling of tissues, or as effusions into the body cavities. It differs from transudates in the character of its fluid, which contains much more albumin and greater numbers of red cells and leucocytes, and a much greater proportion of fibrin-forming elements. It may be caused by any of the factors—infectious, toxic, traumatic, thermal, etc.—that give rise to inflammation. The œdema often seen in the neighborhood of inflammations is known as *collateral œdema*. Inflammatory œdema is regarded by some writers as representing the transition stage between the vascular changes that give rise to pure transudates or œdema, and those which lead to inflammatory exudation.

Toxic.—Heidenhain found that intravascular injections of the enzymes of the salivary, pancreatic, and gastric secretions, peptone, egg albumen, decoctions of the muscles of crabs and crayfish, etc., produced a marked increase in the production of lymph. He explained this phenomenon as due to the stimulation by these substances of the secretory functions of the cells of the vessel walls. According to Hamburger bacterial products circulating in the blood may either increase the permeability of the capillary wall or stimulate the endothelial cells to an increased or abnormal secretory function. A changed chemical condition of the blood may have a similar action. It has been suggested that œdema may be caused by a lack of oxygen, the resulting chemical changes in the blood or tissues causing an increase in osmotic pressure in favor of the tissues over the blood or lymph. The œdemas formerly regarded as *cachectic* or *hydræmic* are most probably caused by the altered functional activity of the endothelium due to changes in the composition of the blood. The œdema of chronic nephritis is probably to be explained in the same way. The acute œdematous conditions of the skin, such as urticaria, are also due wholly or in part to intoxication. The injection of certain protective or curative serums (plague serum) may be followed by extensive urticaria, or even by a more generalized œdema.

Hydræmic or Cachectic Œdema.—It was formerly held that a hydræmic condition of the blood, due either to a diminution of the solids of the blood or to a retention of water, could be a direct cause of an increased transudation through the vessel walls. The latter were believed to behave as dead animal membranes, and the process of œdema formation to be one of pure osmosis. It was shown by Cohnheim that hydræmia was not the direct cause of œdema. Even when the blood is replaced to the extent of one half its volume by decinormal salt solution, so that there is produced a marked hypoalbuminosis, no œdema is caused. In extreme hydræmic plethora, œdema may supervene when the amount of water in the blood becomes very great; but it does not develop in the same regions where œdema ordinarily is found. Further, the occurrence of one-sided hydrothorax, or of bilateral hydrothorax with unequal amounts of fluid in the two pleural cavities, must be taken as strong evidence of differences in the structure and function of the capillary walls in the two sacs. In general it may be said that hydræmia does not produce œdema, but only favors its occurrence. The œdemas which occur in chronic anæmia, cachexias, chronic nephritis, etc., are, therefore, to be regarded as due to changes produced in the vessel walls

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by the altered condition of the blood or by poisons circulating in the blood. By Thoma and other writers it is believed that cachectic and hydræmic œdemas are due to sclerotic changes in the vessel walls (*angiosclerotic œdema*). A loss of elasticity of the tissues may also favor the formation of œdema in these conditions. The fluid of hydræmic or cachectic œdema contains but a small amount of albumin as compared to inflammatory œdema.

Neuropathic Œdema. Angioneurotic Œdema.—If the production of lymph is dependent upon a secretory function of the vessel walls it is very probable that such function is under nervous control, and that under certain nervous disturbances an œdema may arise which may properly be designated as neuropathic. This is borne out by many clinical observations. In hysterical individuals and in persons who have been hypnotized localized œdemas may occur that admit of no other explanation. In epilepsy pale or red areas of angioneurotic œdema are not infrequently seen, in the shape of wheals, general urticaria, etc. In Basedow's disease urticaria not infrequently occurs, as well as circumscribed, unilateral œdema localized in the hands or legs. Erythema nodosum and herpes zoster are also regarded as partly toxic and partly neuropathic. Œdema also occurs after spinal paralysis; and in hemiplegia the affected side shows a more or less well-marked œdema. According to Janowski the severing of the vaso-motor nerves in conditions of œdema is followed by a great increase in the amount of the exudate. Vaso-motor disturbances in myelitis, tabes, sciatica, etc., are also associated with the production of œdema. Toxic, thermal, or traumatic irritation of the nerves may also lead directly to œdema. It must be borne in mind, however, that many writers hold that the existence of a purely neuropathic œdema has not yet been proved.

Œdema Fugax.—Transitory œdema is designated by this term. The majority of the so-called neuropathic œdemas are of this nature. Transitory œdema is of not infrequent occurrence in Basedow's disease, chlorosis, severe anæmia, hysteria, etc. Such œdemas usually appear during the day and disappear after a night's rest.

False Dropsy (*Hydropsia Spuria*).—The distention of cavities, chiefly those of glands, following stenosis or obliteration of the gland duct. The fluid usually results from the retention of secretions; it may be a thin serous or a thickened mucous fluid. In this class belong hydronephros, hydrosalpinx, hydrops cystidis felleæ, hydrometra, hydrops processus vermiformis, hydrops sacci lacrymalis, etc.

Œdema Intermittens.—Intermittent œdema has been described in cases of malaria, and in febris intermittens larvata. The whole body surface may be involved, but often the œdema is confined to the extremities, thorax, etc. Intermittent ascites and intermittent hydrarthros have also been observed.

Œdema Neonatorum (*Sclerema* or *Scleroma Neonatorum*).—A condition of the skin of the new-born characterized by an infiltration of serum into the subcutaneous tissue, hardening of the skin, and lowering of the skin temperature. Many theories have been adduced in explanation of this condition, but it is probable that scleroma represents a symptom complex and not an independent disease. The majority of children affected are those born prematurely. The affection begins usually on the second to the fourth day. After the eighth day it is very rare. Congenital cases have been observed. In the majority of cases the condition is fatal. The œdema has not been satisfactorily explained, but is probably due to changes in the blood following cardiac insufficiency, deficient oxygenation, and changed chemical nature of the blood in some cases due to intestinal intoxication. D'Agata is of the opinion that the condition is of the nature of a vaso-motor and trophic vagus neurosis.

Occurrence of Œdema.—Œdema is of most frequent occurrence in all forms of cardiac insufficiency, especially failure of compensation in valvular disease, chronic nephritis, cirrhosis of the liver, chronic anæmias, and cachexia, conditions in the lungs favoring venous stasis, thrombosis of large veins, or obstruction of these by tumors. In cases of hæmophilia after repeated hemorrhages œdema often occurs. Myelitis with decubitus is often associated with œdema of the lower extremities. Mediastinal tumors, or growths arising in the lungs or bronchial glands, or aneurism may cause œdema of one-half the body through pressure upon the large veins. In chronic chloral poisoning general œdema of the skin occurs, and in chronic morphinism œdema of the face has been observed. In both acute and chronic rheumatism circumscribed or diffuse œdema often appears in various parts of the body; in chronic rheumatism it is not infrequently associated with arteriosclerosis, particularly of the arteries of the foot and of the tibialis posticus. Œdema is also often associated with arteriosclerosis dependent upon other causes, vessel walls which show sclerotic changes being more permeable than normal vessels. In cases of cancer and ulcer of the stomach œdema may occur after severe hemorrhages. In chronic tuberculosis it is of less common occurrence. In this disease it is more often confined to one of the lower extremities, usually the left, as the result of marantic thrombi in the crural vein or some of its branches. When double-sided the œdema is due to cardiac insufficiency or to the changed condition of the blood. The development of amyloid disease or tuberculous peritonitis usually leads to extensive or general œdema.

Œdema of the larynx occurs in laryngitis, nephritis, malaria, cardiac insufficiency, enlargements of the thyroid, aortic aneurism, pressure of tumors upon the jugular veins and their branches, after the use of potassium iodide, inhalation of hot air, in acute infections, variola, typhoid, etc., in leukæmia, and in tuberculosis, syphilis, and carcinoma of the larynx, etc. Œdema of the pharynx occurs in the same conditions, but most frequently in scarlet fever and in chronic nephritis. The œdematous mucosa is swollen, translucent, and pale, these changes being most marked over the soft palate and uvula. The latter organ may be greatly increased in length and thickness and may cause serious disturbances of respiration. Œdema of the lung occurs especially in cardiac insufficiency, chronic nephritis, in connection with inflammatory conditions of the lung, and also in association with cerebral disease. Marked œdema of the penis and scrotum is very common in cases of extensive general œdema. Local œdema of these parts occurs in cases of stricture, traumatic injury of the urethra, bladder and seminal ducts, in infiltrations of urine, in syphilis, and after operations upon the bladder or rectum as one of the first signs of a phlebitis in the plexus prostaticus. There appears also to be an idiopathic form of œdema of the penis. In chronic œdema of this organ there often results a marked phimosis and a thickening of the mucous membrane of the external meatus. Œdema of the external female genitalia occurs after difficult labor, in cases of ovarian or uterine tumors, in abnormal position of the uterus, prolapse, etc.

In cases of infection with the bacillus of *malignant œdema* there develops very rapidly a general subcutaneous œdema, in the fluid of which many bacilli are found. Only a few cases have been reported in man, some of these following the injection of musk in the course of typhoid fever, others occurring during the puerperium, and others arising apparently without external injury. It is very probable that some of the conditions reported under this head were not in reality cases of infection by this bacillus.

Prognosis.—The consequences of œdema vary with the etiology, location, and extent of the process. Collections of fluid in the body cavities may cause compression of important organs, lungs, brain, etc. As a result of œdema of the nerves, degenerations and loss of function may take place. Œdema of the glottis may cause sudden death from suffocation. Œdema of the lungs is very frequently the immediate cause of death in cardiac insufficiency, chronic nephritis, etc. Fatal intracranial pressure may be caused by acute transudation into the cerebral ventricles and submeningeal spaces. Serious in-

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terference with respiration and circulation may be produced by pressure upon the lungs or diaphragm or by pleural or peritoneal dropsies. In general it may be said that the prognosis in œdema is serious because of the important pathological conditions underlying its appearance.

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TREATMENT.—In general this is directed to the condition which gives rise to the œdema. Extreme distention of œdematous skin may be relieved by puncture and continuous drainage. Collections of fluid within the body cavities may also be removed by aspiration (see also *Ascites*). *Aldred Scott Warthin.*

ŒDEMA NEONATORUM, or œdema of the new-born, was long confounded with "scleroma neonatorum"—a distinct affection. Œdema may occur in infants prematurely born or in those born at term but of poor vitality; it differs in these subjects in no respect from œdema in older patients, and can hardly be considered more than a symptom, associated as it is with many different conditions of the body. As with œdema in general the parts are soft, waxy white, pit on pressure, and in the more dependent areas the swelling is greatest. Bad feeding, defective hygiene, exposure to severe cold soon after birth, feeble heart action, and atelectasis of the lungs are all causes tending toward the production of the symptom of œdema in new-born infants. The treatment is that of the general condition and should be directed toward the underlying causes. Artificial heat to maintain the body temperature is an important adjunct. *Charles Townshend Dade.*

ŒNANTHE. See *Poisonous Plants.*

ŒSOPHAGUS, PATHOLOGY OF.—The wall of the œsophagus consists of a mucosa, submucosa, inner circular and outer longitudinal muscular coats, and an external fibrous tunic. The mucosa is covered with stratified squamous epithelium, and contains sparsely scattered mucous glands and few lymph follicles. In the upper portion striped muscle is also present in the wall, in the lower portion only unstriped. The poor blood supply, the lack of mucous glands and lymph follicles, and the thick covering of stratified squamous epithelium render the œsophagus less liable to disease than the closely associated structures, the pharynx and the stomach. The independent part played by the œsophagus in affections of these organs is often strikingly shown in the sharply limited borders of inflammatory processes in the pharynx, the inflammation ceasing abruptly at the beginning of the œsophagus. Though œsophageal disease is relatively rare, it is nevertheless of very great clinical importance, not only from the fact that disease of the œsophagus may interfere with the proper passage of food into the stomach, and thus give rise to general impairment of nutrition, but also because of the proximity of this organ to such important structures as the trachea, lungs, and aorta. Further, the examination of the œsophagus is relatively difficult, and possible only through the use of special instruments or apparatus. (For methods of examination see *Stomach, Surgery of the.*)

CONGENITAL MALFORMATIONS.—Though relatively rare, these conditions are of practical interest, inasmuch as children so affected may live for some time after birth, or even reach adult age. The malformations may exist alone or in connection with other defects. The following forms have been described:

1. *Œsophago-tracheal Fistula.*—Abnormal communications between œsophagus and trachea may occur. The most common form is that in which the œsophagus at the upper third ends in a blind tube, while the lower portion opens at its upper end into the trachea or bronchus. The upper and lower ends of the obliterated œsophagus may be connected by a muscular band or a firm fibrous cord. This malformation may be due to primary disturbances of development, or may be acquired during intra-uterine life as a result of suppurative processes in the glands lying between the œsophagus and the trachea. The upper part of the œsophagus may be closed in this way by cicatricial contraction, while the lower part may be connected with the lumen of the trachea, or the reverse condition may occur. Children showing this malformation may be otherwise well developed; they die shortly after birth from inanition or aspiration pneumonia. In this connection should be mentioned also the rare occurrence of cysts lined with ciliated columnar epithelium, lying between the œsophagus and the bifurcation of the trachea. These cysts represent remains of the communicating canal between œsophagus and trachea. They may reach such a size as to cause compression of the œsophagus and secondary dilatations of the same, and are therefore of clinical importance. In other cases they may be discovered only accidentally, having given rise to no symptoms.

2. *Stenosis.*—Partial obliterations or narrowing of the lumen may occur as congenital malformations of either the upper or the lower portion of the œsophagus. The lower end of the upper portion may open into the trachea, or may form a blind sac. In other cases the œsophagus may be open as far as the level of the bifurcation of the trachea, at which point complete obliteration of the lumen may be found. In a few cases a membranous stenosis or obliteration has been observed, or the lumen has been closed by a ring-like fold of mucosa. Those cases of obliteration in which the continuity of the œsophagus has been completely broken have been explained by the development of the trachea and bronchi at the cost of the œsophagus; while those cases in which the continuity is not wholly lost, but in which the two portions of the œsophagus are connected by a muscular band, have been explained as the result of a fœtal pressure-atrophy. The conditions are rare; only the partial stenoses have clinical significance.

3. *Total absence* of the œsophagus is without clinical significance and is found only in acardiac monsters.

4. A *reduplication* of the œsophagus (*diœsophagus*) has also been very rarely observed. The reduplication may be complete or partial, and occurs in different degrees of double monsters. It is likewise without practical significance.

5. *Congenital Dilatations.* In very rare cases there has been observed just above the cardiac orifice a peripheral dilatation of limited extent, the so-called "fore-stomach" or "antrum cardiacum." Children presenting this anomaly usually show the clinical symptom of rumination.

CIRCULATORY DISTURBANCES.—*Active hyperæmia* occurs in the early stages of inflammatory conditions. It may be due also to the irritation of certain foods or drinks. *Passive congestion* occurs in all cases of general passive congestion, particularly in chronic heart and lung diseases, cirrhosis of the liver, etc. In chronic passive hyperæmia the mucosa of the œsophagus is dark bluish-red; the epithelium often shows plaques of thickening (leukoplakia). Local dilatations of the veins occur, the so-called *œsophageal hemorrhoids* or *varices* (see Fig. 3615). In the upper part of the œsophagus they are relatively frequent, forming small blue nodules or saccular elevations; these possess no clinical significance. In the lower portion of the œsophagus they occur even more frequently, particularly in the region of the cardiac orifice, or a few centimetres above this. The enlarged veins project above the level of the mucosa, and may form saccular papillomatous masses resembling rectal hemorrhoids. The dilated tortuous veins may be as thick as a lead pencil or even larger. They represent vicarious enlargements of the collateral branches connecting the portal circulation (through the vena coronaria ventriculi) with the vena azygos. They occur particularly in portal obstruction (cirrhosis, syphilitic hepatitis, pressure atrophy of the liver, obstruction or thrombosis of the portal vein), as well as in chronic passive congestion due to cardiac insufficiency. They are found in the majority of cases in connection with rectal hemorrhoids. Their presence is revealed clinically by hemorrhage, which may be fatal. As an early diagnostic symptom in cirrhosis of the liver bleeding from œsophageal hemorrhoids is of great im-

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portance. Preceding the hemorrhage there may be observed pain in the stomach, swelling of the spleen, and distention of the abdomen, severe pain radiating from the stomach region to the shoulders or extremities—these symptoms are followed by sudden hemorrhage from the œsophagus. Similar symptoms are often seen preceding hemorrhages from piles. The cause of the œsophageal hemorrhage may be due to increase of venous pressure or to ulcerative changes in the mucosa over the varices. Rupture of the varix has followed coughing, severe muscular exertion, dyspnœa, etc. In other cases no direct cause for the hemorrhage can be found. Repeated hemorrhages of small size may lead to severe anæmia. The relative frequency of hemorrhage from œsophageal varices makes the condition a dangerous one.

Œsophageal hemorrhages may be caused also by injury, ulceration, new growths, etc. The hemorrhages very often arise from the large vessels in the neighborhood of the œsophagus, rather than from its own vessels. Bleeding from the latter occurs particularly in cancer of the mucosa. An aortic aneurism may erode the wall of the œsophagus and rupture into the lumen; or, on the other hand, the œsophagus as a result of ulcerative or carcinomatous changes may break into the aorta, carotid, left auricle, etc. Such an event is most likely to happen in cases of œsophageal carcinoma. In whatever way produced, the entrance of arterial blood into the œsophagus makes itself known by the appearance of the blood vomited up, providing the hemorrhage is of sufficient volume to cause immediate vomiting. There may, however, be a continuous slight oozing from an eroded artery or arterial aneurism, and the blood passing into the stomach may be so changed that its arterial character is lost before vomiting takes place. In some cases the blood may be digested and passed on into the intestines.

Retrograde Changes.—*Œsophagomalacia* is in the great majority of cases a post-mortem digestion of the mucosa of the œsophagus by stomach fluids which have passed, after or during death, through the cardia into the œsophagus. The epithelium is macerated, desquamated, or liquefied; the musculature may also be liquefied and perforated, the stomach juices passing into the pleural cavity. In the lightest grades, which are present in the majority of cadavers, the mucosa of the organ shows longitudinal stripes of desquamation corresponding to the longitudinal folds of the contracted mucosa. An intravital œsophagomalacia is of very rare occurrence, but has been described as the *round* or *peptic ulcer* of the œsophagus, which corresponds in all particulars to the round ulcer of the stomach. An *agonal* œsophagomalacia has been observed in severe cases of cerebral disease.

Atrophy of the œsophagus wall occurs in cachexia. *Degenerations* of the œsophagus wall are of very rare occurrence and have been studied but little. *Necrosis* is the most important retrograde process found in this organ. The most common cause is pressure, either from foreign bodies lodged within the lumen or from the pressure of an aneurism or tumor from without. As a result of the local anæmia caused by the pressure there occur necrosis and ulceration. The *peptic ulcer* has been mentioned. *Decubital* ulcers may be found in advanced stages of severe cachexias. *Noma* of the cheek or pharynx, gangrenous tonsillitis, or gangrene of the lung may be associated with *gangrene* of the œsophagus. Corrosive poisons may cause more or less extensive necrosis of the œsophageal mucosa associated with inflammatory changes. Gangrenous œsophagitis occurs also in severe infections as a rare complication.

Inflammation.—*Acute catarrhal œsophagitis* is the most common form. It is caused chiefly by irritating foods or drinks, through extension of inflammation from the pharynx or stomach, or as a secondary phenomenon in some of the acute infections (measles, scarlatina, typhoid fever, variola). As a result of the small number of glands in the mucosa there is often but little secretion. The epithelium may be desquamated, and the mucosa beneath hyperæmic, or cloudy white, or yellowish. Small ulcers may be formed over the surface of the folds, and these may heal with the formation of small longitudinal scars. In the case of foreign bodies deeper ulcers may be produced. The symptoms of acute catarrhal œsophagitis are, pain in swallowing, regurgitation, thirst, raising of

Fig. 3615.—Esophageal Varices. (After Kraus.)

secretion, pain on moving the neck, tenderness on pressure in the deep cervical region. Spastic contractions of the œsophagus may also occur.

Chronic catarrhal œsophagitis occurs chiefly in smokers and drinkers, as well as in individuals suffering from chronic pharyngitis or, more rarely, gastritis. The condition is often secondary to the chronic passive congestion caused by cardiac or pulmonary disease. It is found also in the portion of the œsophagus above a stenosis. It may be associated with diverticula. In cases of chronic gastritis characterized by frequent eructations of irritating substances or by frequent vomiting of the same, there may be produced a chronic œsophagitis, which may be of a purulent or ulcerative character. This condition is not infrequently found in old men.

Chronic œsophagitis may not always give rise to symptoms. In severe cases there may be pain and discomfort in swallowing. The pain has usually the character of pressure, more rarely it is stinging or burning; when it is severe, spastic contractions and regurgitation may occur. Moderate quantities of mucus may be expectorated; this may occasionally contain streaks of blood. The differential diagnosis from the accompanying affections of pharynx or stomach is often very difficult. The symptom of dysphagia, less marked in the case of fluids than in the swallowing of solid substances, is the most constant and characteristic symptom. Examination with œsophagoscope or sound is usually difficult, but is necessary for the exact determination of the condition. This is of great importance, inasmuch as the symptoms of chronic œsophagitis and beginning carcinoma of the œsophagus are the same; and the differential diagnosis can be made only by means of the œsophagoscope.

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In chronic œsophagitis the mucosa is deep reddish-blue in color, and is thickened, often showing polypoid or papillomatous hyperplasias, or flattened plaque-like areas of epithelial hyperplasia (leukoplakia) (see Fig. 3616). The muscular coats are often hypertrophic. Over

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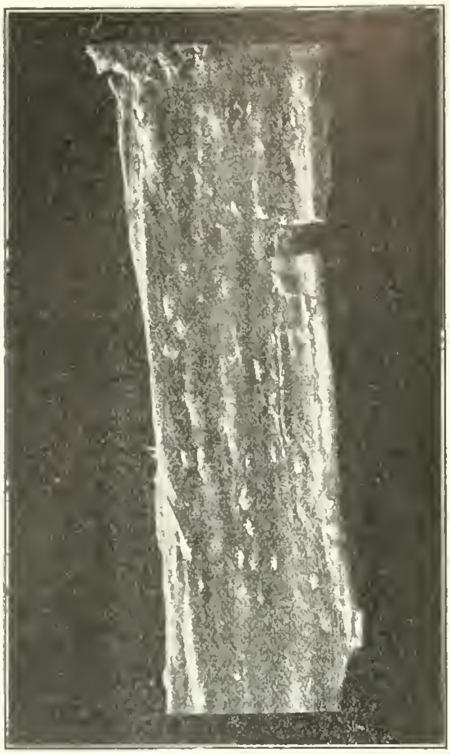

FIG. 3616. Leukoplakia of the Œsophagus. (After Kraus.)

the mucosa lies a layer of thin or thick, often very tenacious mucus, which at times is muco-purulent in character. Small or large erosions or ulcerations may also be present. The lumen is usually dilated, but may be narrowed either symmetrically or irregularly.

Abscesses may form in either acute or chronic œsophagitis, but are rare. In these cases the local symptoms are severe, chills and fever occur, blood or bloody purulent material may be expectorated. The course is usually prolonged; dysphagia may exist for many months. In very severe cases death may occur; but milder cases usually end in recovery after several weeks or months.

Follicular œsophagitis occurs when the glands of the mucosa become involved. The gland ducts are obstructed, there is extensive mucus formation, the gland lumen is dilated, and cysts filled with mucus are in this way produced. These rarely reach the size of a pea. About the cystic glands there is a small-celled infiltration; this may lead to suppuration and formation of ulcers. Occasionally a phlegmonous œsophagitis may be associated with the follicular form.

Phlegmonous œsophagitis is of rare occurrence. It may be caused by the presence of foreign bodies or corrosive poisons, but the most frequent cause is an extension from periœsophageal abscesses (purulent lymphadenitis, perichondritis cricoidea, spinal abscesses) or from phlegmonous processes in the pharynx, or more rarely in the stomach. It may also follow a follicular œsophagitis; through the confluence of the small follicular abscesses a diffuse purulent process may be produced. In advanced cases of pulmonary tuberculosis diffuse purulent œsophagitis or abscess formation in the œsophagus wall may occur without other evident cause.

Phlegmonous œsophagitis begins as a purulent infiltration of the submucosa, followed by a liquefaction of the tissue and the formation of circumscribed or extensive collections of pus. The mucosa may be extensively undermined; at the same time it may be reddened, and may present throughout its reddened surface numerous sieve-like yellowish apertures through which pus exudes. Large circumscribed collections of pus may cause bulgings of the mucosa into the lumen. The tissues about the œsophagus may be involved (periœsophagitis phlegmonosa), and the abscesses may rupture into the larynx and trachea, or more rarely into the mediastinum and pleura.

The symptoms of phlegmonous œsophagitis are usully obscure and offer few characteristics sufficiently striking to make the diagnosis from other conditions certain. Fever, chills, and dysphagia are the most constant symptoms. Pain may be felt behind the sternum or larynx; pressure upon the epigastrium may occasionally give rise to violent pain. Dyspnœa may be caused by pressure of an abscess upon the trachea or upon the bronchi. The dysphagia may increase to such an extent that fluids can no longer be swallowed. If the rupture of a large abscess into the œsophagus be followed by expectoration or regurgitation of pus, the diagnosis of phlegmonous œsophagitis is rendered more probable; but even in the event of such regurgitation the pus may come from an abscess in the neighborhood of the œsophagus, which has ruptured into its lumen. Only when foreign bodies are known to be lodged in the œsophagus can the diagnosis of phlegmonous œsophagitis be made with certainty. In the event of fistulous communication between the œsophagus and respiratory tract purulent pneumonia or gangrene of the lung usually results quickly. The prognosis is doubtful. Recovery may take place, the formation of cicatricial tissue in the submucosa and mucosa may give rise to stenosis, or in other cases intraparietal diverticula may be formed, the abscess cavities beneath the mucosa healing at the base but remaining open and communicating with the lumen of the œsophagus by wide openings in the mucosa having sharply cut undermined edges.

In connection with phlegmonous œsophagitis may be considered also the *periœsophageal abscess*. This has its origin most frequently in tuberculous lymph glands situated in the neighborhood of the œsophagus or in tuberculous caries of the vertebral column, or it arises in the course of a pyæmia. Further, purulent processes of the parotid or submaxillary may extend to the connective tissue about the œsophagus. Involvement of the œsophagus wall or rupture into the lumen of this organ may set up a phlegmonous œsophagitis. Rupture into the respiratory tract, pericardium, or pleura may occur. The periœsophageal abscess may reach a very large size, though often it is small. It is usually found between the fourth and seventh cervical vertebræ. The abscess arising in tuberculous lymph glands or tuberculous vertebræ is found most often in children, and its location is ordinarily between the vertebræ named. The symptoms are those of phlegmonous œsophagitis: fever, chills, dysphagia, pain on turning the neck, dyspnœa, etc. Children frequently become comatose; convulsions may occur; and finally the diagnosis may be made clear by the appearance of a swelling in the neck. In the case of tuberculous caries of the vertebræ the abscess may develop very slowly with few or no symptoms. The sound may be passed into the stomach without difficulty, but usually with more or less pain.

Œsophagitis pustulosa is the designation given to the changes in the œsophageal mucosa which occur in smallpox. Papules develop throughout the mucosa, these become cloudy and purulent, the epithelium over them is cloudy, thickened, and finally undergoes desquamation, leaving small ulcers.

Membranous Œsophagitis (*Œsophagitis Fibrinosa or Diphtheritica*).—True diphtheria of the œsophagus is rare; only in exceptional cases is there an extension from the pharynx into the œsophagus. Cases have been ob-

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served in which the œsophagus remained free when both pharynx and stomach were attacked; the œsophagus may, therefore, be said to possess a certain immunity in respect to diphtheria. A membranous or fibrinous œsophagitis accompanied by diphtheritic necrosis is of relatively frequent occurrence as a secondary condition in severe cases of smallpox, scarlet fever, measles, pyæmia, cholera, typhus fever, typhoid, chronic Bright's disease, pneumonia, tuberculosis, and in children as a frequent complication in intestinal catarrh. The process is rarely diffuse, but is circumscribed, and usually localized on the highest parts of the folds of the mucosa. Small ulcers may be formed at these places. Usually the symptoms of diphtheritic œsophagitis cannot be separated from the accompanying disease, but in certain cases the disease may manifest itself through hemorrhage or discharge of pseudomembranes from the œsophagus. The prognosis is very grave. When recovery takes place cicatrization of the diphtheritic ulcers may lead to stenosis of the lumen.

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Œsophagitis corrosiva is produced by the action of corrosive agents, acids, or the caustic alkalies, most commonly by concentrated lye, which have been swallowed either purposely or accidentally. (See Fig. 3617.) The change produced by the corrosive agent is of the nature of a necrotic inflammation; its severity depends upon the strength or concentration of the poison. In mild cases the superficial epithelium is necrosed, and is desquamated in grayish shreds resembling a croupous membrane. Alkalies may cause the cells to swell and form a soap-like mass. A more severe action of a corrosive agent may convert the entire mucosa into a dirty gray or black eschar; the vessels are injected; the submucosa contains numerous ecchymoses, and there is a line of demarcation separating the dead tissue from the inflamed tissues of the submucosa. Active suppuration occurs and the necrotic mucosa is desquamated. If healing results, the lumen may become greatly narrowed or gradually completely occluded. In the most severe cases the deeper layers of the œsophagus may be affected. The symptoms are severe burning pain beneath the sternum, dysphagia, intense thirst, hemorrhage, and collapse. Portions of the eschar, or masses of bloody mucus may be expectorated. In the mild cases the pain ceases after twenty-four hours, the dysphagia becomes less from day to day, until the symptoms finally disappear altogether. If much scar tissue is formed, difficulty in swallowing may be experienced again after several weeks. Severe cases may be immediately fatal from shock or from hemorrhage, or from perforation; in rare cases the covrse is prolonged, abscess formation, mediastinitis, pyopneumothorax, etc., occurring as complications. Patients recovering from severe corrosive poisoning are sure to suffer from cicatricial contraction of the lumen.

The diagnosis in the majority of instances is revealed by the history of the case and the evidences of corrosive action in the mouth and pharynx. It is of importance to discover the nature of the poison in those cases which are seen shortly after the poisoning has occurred. Litmus paper may be applied to the mucosa of the mouth or pharynx as a rough method of diagnosis as to whether acid or alkali had been used, in case the facts cannot otherwise be ascertained. The majority of such cases are caused by concentrated lye or sulphuric acid. According to von Hacker one-fourth of the cases of poisoning with concentrated lye are fatal as the direct result of the poisoning; in the case of sulphuric acid, about one-half. Of those living after poisoning with concentrated lye about one-half acquire severe stricture of the œsophagus; of those living after sulphuric-acid poisoning about a third show contraction of the lumen.

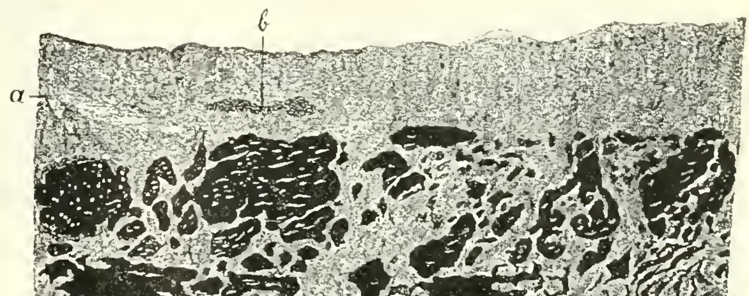

FIG. 3617.—Œsophagitis Corrosiva (after swallowing concentrated lye). *a*, The necrotic mucosa; *b*, bacteria embedded in *a*; *c*, upper portion of submucosa, infiltrated with homogeneous deeply staining masses (fibrin?); *d*, blood-vessel with necrotic wall; *e*, deeper portion of submucosa infiltrated with fibrinous network and leucocytes. (After Weichselbaum.)

Œsophagitis gangrænosa is of rare occurrence. It may follow the action of corrosive poisons, pressure of foreign bodies within the œsophagus or of tumors, aortic aneurism, etc., from without, or it may occur as an extension from gangrenous tonsillitis, pulmonary gangrene, etc. Decubital ulcers may occur in the upper part of the œsophagus or in the lowest portion of the pharynx. (See Fig. 3618.) Two small ulcers, one on the anterior wall, the other on the posterior wall, corresponding in position, shape, and size to each other, occur coincidently, so that one ulcer appears as the impress of the other. The condition occurs only in extremely cachectic individuals who have been confined to bed for a long time; it is due to the pressure of the larynx upon the œsophagus. The ulcers appear shortly before the death of the affected individual and cause difficulty in swallowing, in this way hastening the end.

Œsophagitis exfoliativa (Œsophagitis Desiccans Superficialis).—A number of cases of acute inflammation of the œsophagus, characterized by a rapid desquamation of the entire mucosa, have been described. The desquamated epithelium may form a hollow tube, 15–25 cm. long. The desquamation may be caused by subepithelial inflammation, action of chemicals, etc., but the exact nature of the disease is unknown. The majority of the patients were neurotic or hysterical.

Acute œsophagitis of young children occurs in nurslings as a result of a poor quality of mother's milk, soreness of the nipple, etc. It may be associated with gastro-intestinal irritation. Attempts at nursing are interrupted after a few seconds, the child cries, is restless, and regurgitates the greater part of the milk taken. Pressure upon

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the lower part of the sternum is apparently painful, the child often crying out. The disease is important in that it may pass over into an ulcerative or gangrenous inflammation.

Ulcus Pepticum Œsophagi.—Ulcers in all respects similar to the round ulcer of the stomach may occur in the lower portion of the œsophagus, and are regarded as due to the same causes: viz., a digestion by the gastric juice. In cases in which the resistance of the œsophageal mucosa is lowered, the repeated entrance of the stomach fluids into the œsophagus may be followed by the development of one or more round or oval ulcers. These vary in size and depth, their edges are smooth; and the bottom of the ulcer is covered with stringy brownish black masses. Occasionally the ulcers are very large and circular, extending ring like about the lumen. They all show a marked tendency to cicatrization, and lead to strictures, stenosis, or the formation of diverticula. Ulcers extending deeply into the œsophagus wall may perforate, and, following this, pyopneumothorax, mediastinitis, pulmonary gangrene, pericarditis, erosion of the aorta or other large vessels, liver abscess, etc., may result. Carcinoma may develop in the scar, as is frequently the case in the stomach. Not infrequently the round ulcer of the stomach and that of the œsophagus are coincident.

The symptoms caused by round ulcer of the œsophagus are chiefly burning pain and a sensation of pressure behind the lower part of the sternum during the act of swallowing. As a rule, the pain is more severe when solid food is taken than when fluid diet is given. At other times severe cardialgia may be present; also nausea, acid regurgitations, vomiting, and hemorrhage, bloody stools, etc. These symptoms cannot be separated from those of round ulcer of the stomach, which is frequently coincident. The absolute diagnosis may be made only by means of the œsophagoscope. Ulcers of slight extent may heal without complication; after cicatrization new symptoms may appear as the result of the narrowing of the lumen. Severe cases are very danger-

FIG. 3618.—Decubital Ulcers in the Upper Part of the Œsophagus (lower part of pharynx). (After Kraus.)

ous because of the important complications which may follow, and on account of the accompanying rapid emaciation and anæmia.

SPECIFIC INFECTIOUS DISEASES.—*Tuberculosis* occurs as a secondary process in severe tuberculosis of other organs, particularly of the larynx and lungs and the neighboring lymph glands. Primary œsophageal tuberculosis has not yet been reported. The infection of the œsophagus may take place by direct extension from neighboring organs, most frequently from the rupture, into its lumen, of caseating lymph glands; or from the swallowing of sputum in cases of pulmonary tuberculosis, and very rarely from the metastasis of tubercle bacilli in acute miliary tuberculosis. It has been noted that infection does not occur in case of rupture of vertebral abscess into the œsophagus. Infection is made more likely by preceding affections of the œsophageal mucosa, ulcerations, etc. The tuberculous ulcers are usually superficial, but may lead to perforation. The edges are covered by hyperplastic epithelium, scattered through which small yellowish or gray nodules are seen; the bottom of the ulcer is either smooth or papillomatous. Tuberculosis of the œsophagus may exist without any symptoms; when symptoms referable to the œsophagus occur, they consist in dysphagia and pain behind the sternum during the act of deglutition. Thrush may exist coincidently with tuberculosis of the œsophagus, but it is to be remembered that in cases of pulmonary tuberculosis thrush or carcinoma may be found in the œsophagus as an independent affection. The use of the œsophagoscope is necessary for the absolute diagnosis.

Syphilis.—Ulcerations of the mucosa of the œsophagus may be present during either the secondary or the tertiary stage, but on the whole they are rarely observed. They have been seen also in cases of congenital syphilis. The most frequent syphilitic lesion of the œsophagus is the gumma. This may lead to ulceration, perforation, cicatricial stenosis, hypertrophy of the œsophagus wall, etc. Difficulty in swallowing is the chief symptom. The differential diagnosis rests chiefly upon the anamnesis, evidences of syphilis elsewhere, therapeutic test, etc.

Actinomycosis.—A number of cases of primary actinomycosis of the œsophagus have been reported. Inasmuch as the entrance of infection in this disease is usually through the air passages, the œsophagus may be involved by extension from the peribronchial lymph glands or from the lungs, mouth, pharynx, etc. In a given case it may be difficult to decide whether the œsophageal condition is primary or secondary; but in the majority of cases it is likely that the primary seat is in the mouth. It is also probable that, for the infection of the mucosa of the œsophagus, some other lesion (erosion, ulcer, etc.) must be present as a factor favoring the entrance of the organism. The diagnosis of œsophageal actinomycosis rests entirely upon the finding of the parasite in the material expectorated or removed by means of the sound or œsophagoscope.

Thrush.—This is the most common and important parasitic disease of the œsophagus. It may be primary or may extend from the mouth and pharynx. It is most commonly found in poorly nourished children, and in adults suffering from continued fevers, particularly typhoid and sepsis, from chronic cachexias, and from chronic tuberculosis, nephritis, and diabetes, in their last stages. (See Fig. 3619.) Healthy children and adults may be occasionally affected; but the disease is by far most common in cachectic children suffering from chronic digestive disturbances. As a rule, the pharynx and mouth are affected at the same time. The appearance of the parasite upon the mucosa of the mouth, tongue, or pharynx is very characteristic and the diagnosis is easily made. The parasite develops in the upper layer of the mucosa, its filaments forming a dense feltwork among the epithelial cells. Slightly elevated whitish or grayish patches, which can be easily scraped off, leaving a bleeding or ulcerated surface, are seen over the mucosa. In the œsophagus small white, flattened, or nodular patches may be scattered over the mucosa, or the patches may be arranged longitudinally, corresponding to the folds of the mucosa. In other cases a more diffuse growth may be seen, the œsophageal lumen to a large extent or throughout being lined by the growth. In very severe cases the growth may be so extensive as to form thick-walled casts of the lumen or even

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solid cylinders. The growth may penetrate into the submucosa or even reach the muscle coats. Penetration into the blood-vessels may occur and metastasis of the parasite result. The reactive inflammation of the œsophageal wall is usually in proportion to the amount of infiltration, by the parasite, of the mucosa and underlying structures.

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FIG. 3619.—Lower Portion of Œsophagus Showing the Presence of Both Thrush and Tuberculosis. (After Kraus.)

Thrush of the œsophagus rarely gives rise to independent symptoms, except when the growth is extensive. Dysphagia followed by aphagia is the chief symptom, especially in the case of children. Occasionally hollow or solid cylindrical casts of the œsophagus may be regurgitated. In those cases in which the masses of the growth are firmly adherent to the mucosa death may result from the complete obstruction of the lumen of the œsophagus.

ANIMAL PARASITES.—In general trichinosis the encysted worms may be found in the striped muscle of the œsophagus wall. Their presence may be regarded as explaining the painful deglutition occurring in the course of trichina infection. Round worms (ascaris lumbricoides) may wander into the œsophagus from the stomach; and may be found occasionally in œsophageal diverticula. From the œsophagus they may reach the respiratory passages, and entering the larynx may cause severe or even fatal obstruction to respiration. Occasionally other forms of animal life may gain accidental entrance to the œsophagus (flies, bees, wasps, leeches, hair-worms, etc.); in the majority of cases no symptoms are produced, the intruder acting as a simple foreign body, except in the case of leeches and stinging insects. In the case of the former hemorrhage may be produced; and the sting of the latter may give rise to a severe œsophagitis.

PROGRESSIVE CHANGES.—*Hypertrophy* of the wall of the œsophagus occurs above a stenosis of a portion of the lumen or of the cardiac opening. In the latter case the lumen throughout its entire length may be greatly dilated.

TUMORS.—New growths of the œsophagus are on the whole not frequent. Metastatic growths are of rare occurrence. Of the primary tumors carcinoma is by far the most common. Benign tumors causing symptoms during life are very rare. The great majority of benign growths are small and clinically unimportant. Of these the most common are small *papillomatous warts* (œsophageal warts, verrucæ) (see Fig. 3620). These are usually about the size of a pinhead or bean, rarely larger, projecting above the mucosa, and are often multiple or confluent. They are found especially in old individuals. In structure these little growths consist of hyperplastic papillæ, covered with thickened epithelium resembling the condylomata. They rarely ulcerate, and only exceptionally may they offer slight obstruction to the passage of food. They are usually discovered only at autopsy, but their presence in the œsophagus could be revealed during life by means of the œsophagoscope, should they reach such a size as to cause symptoms.

Next in frequency occur *fibromata*, which usually take their rise in the connective tissue outside of the œsophageal wall, but, through pressure, are finally forced to occupy a position in the mucosa of this organ. The prevertebral fascia, the periosteum of the vertebræ, the perichondrium, the periœsophageal connective tissue, and less frequently the connective tissue of the muscle and submucosa of the œsophagus wall form the points of origin

FIG. 3620.—Papillomata of the Œsophagus. (After Kraus.)

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for these growths. They are usually diffuse thickenings, but may be polypoid or sharply circumscribed. The last is usually of very small size. Microscopically, the œsophageal fibromata present the appearance of a *fibroma molle* and are usually well supplied with blood-vessels. Their consistency is soft and elastic. The polypoid fibroma may reach a large size and may, during efforts at vomiting, present itself in the pharynx or mouth, where the tumor may be felt or seen. If the growth possesses a long pedicle it may, when situated in the upper part of the œsophagus, be caught at the entrance to the œsophagus, and pressing upon the epiglottis give rise to severe symptoms of dyspnœa and dysphagia. Large growths may more or less completely block the œsophagus and cause pressure upon the trachea. In these cases there is a constant feeling of pressure behind the sternum, increased on eating, progressive dysphagia, pain radiating to the shoulder blades, dyspnœa, etc. The growth is very likely to ulcerate and a spontaneous cure may result in rare cases from such ulceration, or from the twisting or tearing of its pedicle. The diagnosis of œsophageal fibroma is made certain by means of the œsophagoscope, by removal of a portion of tissue from the growth, and by microscopical examination. The prognosis is on the whole unfavorable. The patient usually dies of inanition or suffocation.

FIG. 3621.—Carcinoma of the Œsophagus. (After Kraus.)

Lipomata of the œsophagus occur very rarely in the form of sharply circumscribed or polypoid growths arising in the submucous connective tissue, most frequently in the neighborhood of the laryngeal and tracheal cartilages.

Myxoma of the œsophageal wall has been observed in the form of a polypoid tumor of small size.

Myomata of the œsophagus have been observed a number of times. They are usually leiomyomata, but a few cases of rhabdomyoma have been described. The former may develop from the muscularis mucosæ or from the muscular coats; these growths may be circumscribed or polypoid and occur most frequently in the lower portions of the œsophagus in the neighborhood of the cardia. They are found at any period of life, are usually small, and do not give rise to symptoms. In the one case of rhabdomyoma which has been carefully described, the microscopical appearances were those of a rhabdomyosarcoma; metastasis into the neighboring lymph glands had occurred.

Primary sarcoma of the œsophagus is very rare. Alveolar, spindle-cell, and round-cell forms have been observed in the upper part of the organ, less frequently near the bifurcation, apparently arising from the tissues of the œsophagus wall. In the majority of cases of sarcoma involving the œsophagus, the tumor has extended from some one of the neighboring structures. Lymphosarcoma of the bronchial lymph glands may thus compress and invade the œsophagus. Finally, a widespread lymphosarcomatosis of the œsophagus wall may occur as the result of such extension. Ulceration, hemorrhage, etc., may follow. The ulcer may be covered by a growth of thrush; secondary infection and gangrene may result. Only one case of primary lymphosarcoma of the œsophagus has been reported. The diagnosis of sarcoma of this organ rests upon the presence of symptoms of œsophageal obstruction, the use of the œsophagoscope, and the removal of a portion of tissue for microscopical examination.

Dermoid cysts are very rare. They have been observed in the upper portion of the œsophagus or lower part of the pharynx. The *congenital cysts* lined with columnar cells, which have been observed in the œsophagus wall, are to be classed as *simple teratoid cysts* due to anomalies of development. They represent remains of the original communication between œsophagus and trachea.

Carcinoma.—This is the most common and important of the œsophageal neoplasms. It is almost always squamous-celled in character (*epithelioma, cancroid*), arising from the squamous cells of the mucosa, and exhibiting more or less horny change and formation of epithelial pearls, as is the case with the epithelioma of the skin. Only in rare cases is the primary cancer of the œsophagus of the columnar-celled type (adenocarcinoma). In such cases the growth takes its origin from the cells of the mucous glands, or from congenital cysts lined by columnar cells and lying in the walls of the œsophagus. Occasionally the cancer arising from the gland cells may take on the appearance of a carcinoma simplex, a carcinoma medullare, or a scirrhous carcinoma, etc., but these forms are very rare.

Œsophageal epithelioma (Fig. 3621) is not an infrequent disease. It is found more often in males than in females. The level of the bifurcation is most often involved. It has a tendency to grow in ring shape about the lumen, and in this way gradually to cause stenosis. As the cancer increases in size it quickly ulcerates. In this way a large part of the tumor may be lost and the stricture reduced. About the ulceration, the mucosa shows carcinomatous infiltrations and small secondary nodules, which may also ulcerate. In other cases the edges of the primary ulcer may be nodular, greatly thickened, and firm, causing marked stenosis. The œsopha-

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geal wall above the cancer is usually hypertrophic and the lumen dilated. Proliferation of connective tissue about the ulcer may lead to the appearance of a scirrhous cancer. Very frequently a portion of the growth is soft, rapidly growing, and necrotic, while the remaining portion is very hard, composed largely of scar tissue. The greater the connective tissue formation the more marked the stenosis. In the majority of cases only one cancerous nodule of large size is present; only rarely are there multiple cancerous foci. The œsophageal mucosa about the cancer, and particularly the mucosa of that portion of the lumen which is situated above the stenosis, usually shows a marked chronic congestion or inflammation.

Œsophageal cancer occurs most often between the ages of fifty and sixty years. Cases have been observed in young individuals. The etiological factors are no better known than are those of carcinoma elsewhere. It is significant that the most common seat of the growth is at the narrowest portion of the lumen. The condition is more common in smokers and drinkers, and it is probable that chronic irritation here, as elsewhere, favors the development of the neoplasm. Foreign bodies, burns, healed ulcers, etc., have been regarded as etiological factors. The course of the disease usually extends over one year, often over a shorter period. Death takes place usually from inanition due to the stenosis, to a perforation or to hemorrhage, or from fatal complications due to metastasis or extension of the tumor.

Beginning in the mucosa from a proliferation of the epithelium the carcinoma cells infiltrate the submucosa and musculature as far as the outer fibrous covering. The wall first becomes thickened, its original elements undergo atrophy, and the affected portion of the wall is replaced by carcinoma tissue. Necrosis of the carcinoma cells follows, ulceration of the surface occurs, and there is a greater or less formation of scar tissue. As a result of the ulceration perforation into the trachea, bronchi, lung, mediastinum, pleura, pericardium, or large blood-vessels may occur. Erosion of the vertebral column may be produced. Perforation into the trachea, bronchi, or lung is of most frequent occurrence, death resulting from gangrene or purulent pneumonia. Occasionally the carcinomatous infiltration may involve the trachea and bronchi, or even the heart. Erosion of the aorta, carotids, or pulmonary vessels may cause fatal hemorrhages.

In many cases the cervical lymph glands and the connective tissue of this region show extensive carcinomatous infiltration, and the neighboring structures may suffer greatly from pressure. As a result of pressure upon one or both of the recurrent laryngeals, either by the primary tumor or by enlarged carcinomatous lymph glands, paralysis of one or both vocal cords may result. The changed character of the voice, in connection with obstruction to the passage of food through the œsophagus, is an important diagnostic symptom.

Metastases in distant organs occur first in the liver, lungs, and bones. Except in rare cases local metastases in the bronchial, tracheal, and epigastric lymph glands are always present.

The most extensive carcinomatous infiltration of the œsophagus wall may exist without the occurrence of symptoms directly referable to this organ. In some cases the only symptom is progressive emaciation and weakness. In the majority of cases the earliest symptom is dysphagia, which progresses rapidly so that the patient soon becomes emaciated. Regurgitation of food takes place immediately after swallowing if the cancer is situated in the upper portion of the lumen; after some time has elapsed, when the growth is in the lower part, particularly if the lumen above the stenosis is much dilated. The regurgitated food may contain pus, blood, or portions of necrotic cancer tissue. Pain may be constantly present or entirely absent; or present only when food is taken. It may be very severe, of a burning character, or there may be simply a dull pressure, located behind the lower part of the sternum, and radiating to the shoulder blades. Marked dyspnœa may result from the pressure upon the respiratory passages. The enlargement of the cervical lymph glands may occur early and indicate the nature of the disease. Pressure upon the recurrent laryngeals, causing paralysis of the vocal cords, is not infrequent. Disturbance of the sympathetic may cause oculo-pupillary symptoms (miosis, retraction of the lids, narrowing of the palpebral fissure, etc.). Erosion of the cervical vertebræ, pressure upon the brachial plexus, etc., may give rise to paralyses of the upper extremity. The occurrence of perforation into the respiratory tract, pleura, etc., is followed by characteristic symptoms on the part of the region involved. Emphysema of the skin of the cervical region and of the mediastinal tissue may occur. Trophic disturbances in the skin and nails have been observed. The urine usually contains albumin, indican, and phenol; in the late stages of the disease acetone, aceto-acetic acid, and oxybutyric acid.

FIG. 3622.—Spindle-Form Dilatation of the Œsophagus Above a Scirrhous Carcinoma. (After Kraus.)

The diagnosis rests chiefly upon the case history and the demonstration of a stenosis of the œsophagus. If in an individual past the age of forty years there occurs without evident cause a stenosis of the œsophageal lumen, with progressive emaciation, carcinoma is usually indicated. Cicatricial stricture or the presence of foreign bodies may be excluded by the history. Pressure from without, due to aneurisms or neighboring growths, must be eliminated. Carcinoma of the œsophagus has sometimes been mistaken for spasmodic stricture. The writer has seen two such cases, and was able to make the diagnosis of cancer in each case from bits of cancer tissue found adhering to the bougies used in dilating the stricture. In doubtful cases in which the stenosis is slight, the œsophagoscope should be used, and a bit of tissue removed for microscopical examination. The use of sounds, etc., should be attended with great care, from the possible danger of perforation. Auscultation of the œsophagus may also aid in the diagnosis. Gurgling sounds arising at the stenosis may sometimes be heard at a distance from the patient. The constant absence of the sound caused by the passage of food or drink through the cardia may be taken as evidence of the existence of a pathological process interfering with

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the normal function of the musculature of the cardia. In complete stenosis the food passed into the œsophagus may gradually accumulate above the stenosis and be regurgitated later. The absence of hydrochloric acid, pepsin, peptone, etc., may be taken as evidence that the food had not entered the stomach. The prognosis in all cases is hopeless. Death may be postponed by operative measures.

Fig. 3623. – Diverticulum of the Lower Third of the Œsophagus, with Dilatation. (After Kraus.)

Alterations in the Lumen. — *Dilatation* is usually secondary to stenosis. Primary dilatation of the œsophageal lumen is very rare. The dilatation in the acquired cases may be *general* or *partial*, either the entire œsophagus or only a portion of it, above the stenosis, being enlarged. The dilatation of a localized portion of the wall and not the entire circumference, is known as a *diverticulum*. *Primary or congenital* dilatation is usually general—the so-called spindle form. This may also be acquired, usually in chronic œsophagitis, or œsophagitis secondary to spastic contraction of the cardia. The musculature is usually thickened, and often shows fibroid areas. The ectasia may be enormous, the lumen measuring as much as 30 cm. or more in circumference—as large as a man's arm. At the same time the length is increased, and the organ becomes tortuous. *Secondary* dilatations develop above strictures, but are not present in all cases. (See Fig. 3622.) The dilatation may be fusiform or cylindrical. The muscular coats are usually hypertrophic in the dilated portion. Regurgitation is the chief symptom of œsophageal dilatation. Dyspnœa may be produced by pressure.

Diverticula are of two forms: *pressure diverticula* and *traction diverticula*. The first arises from pressure within the lumen, the latter from external traction pulling out the wall. Pressure diverticula are rare. They are found most frequently at the junction of the pharynx and œsophagus, on the posterior wall. They are also called *dorsal diverticula* in contrast to the *lateral diverticula* of the pharyngeal wall. They are rarely very long, and extend downward between the œsophagus and the vertebræ. The muscular wall is weakest normally at the point where these diverticula occur. Local bulging is first brought about by trauma, swallowing of large and firm pieces of food, etc. The bulging is increased by pressure of food, and gradually there is formed a saccular pouch, the mucosa and submucosa bulging out between the muscle bundles of the inferior constrictor of the pharynx (pharyngocele). In some cases muscle fibres have been found in the wall of the sac, and the condition has been regarded as an ectasia due to a disturbance in the closure of the fœtal cleft at this point. The latter view is probably more generally accepted than the former. In case the diverticulum becomes filled with food there may result difficulty in swallowing, gagging, and vomiting. Decomposition of the contents of the sac may take place, followed by maceration of the epithelium lining it, secondary infection, ulceration, and phlegmonous œsophagitis or periœsophagitis. If the sound is passed when the sac is filled, it is very likely to enter the dilated sac; when the sac is empty, the sound may pass by the opening of the sac without entering it. When passed down against the posterior wall, the sound is more likely to enter the sac.

Traction diverticula are not rare. They occur usually in the anterior wall, in the neighborhood of the bifurcation, rarely higher or lower. (See Fig. 3623.) They result from the extension of an inflammation of neighboring lymph glands with adhesion to the œsophageal wall and subsequent cicatricial contraction, pulling out the wall at the point of adhesion. The sac is usually short; at its tip the remains of a diseased gland are always to be found. The lumen of the diverticulum may point downward, horizontally, or upward. It communicates with the œsophageal lumen by a round, oval, or longitudinal opening of varying size. The mucosa about the opening is often puckered. Several diverticula may exist coincidently. In the majority of cases the lymph glands attached to the diverticula are tuberculous. The condition may have its origin in childhood. Usually traction diverticula exist without symptoms. Through perforation of the sac chronic purulent periœsophagitis may be set up, with extension to pleura, pericardium, lungs, etc. In this way the most severe symptoms may arise and the case reach a fatal termination.

Stenosis of the œsophagus may be *congenital* or *acquired*. In the latter case partial or complete obstruction of the lumen may result from foreign bodies, inflammatory swellings, phlegmon, growths of thrush, tumors; or cicatricial contraction of the wall following corrosive poisoning, syphilis, diphtheritic inflammation, trauma, etc.; or from changes in the neighborhood of the œsophagus, such as enlarged lymph glands, aneurisms, tumors of the lung or pleura, etc. A number of cases of œsophageal stricture following ulceration of the œsophagus in typhoid fever have been observed. The characteristic symptoms in all cases are dysphagia and regurgitation of food.

Rupture of Œsophagus.—This condition is rare. It may be due to trauma or to excessive internal pressure. It is reported as occurring in the healthy œsophagus as a result of prolonged vomiting; usually after a full meal, or in a condition of intoxication. It is probable that in some of these cases some pathological weakening of the wall was present. The condition is invariably fatal.

Foreign Bodies.—Among the foreign bodies reported as gaining entrance to the œsophagus are bones, leeches, needles, false teeth, etc. Needles may pass out through the wall and be found in other parts of the body. Sharp-pointed or rough bodies are most dangerous, as they may enter the wall of the organ and give rise to a phlegmonous œsophagitis, which may extend to the lungs, pleura, or pericardium. In other cases the foreign body may lead to erosion of the large vessels. Complete obstruction of the lumen may be caused by false teeth. Gangrene due to pressure usually results. The entrance of foreign bodies into diverticula may lead to perforation. The fungus of actinomycosis may gain entrance through the lodgment of bits of straw, chaff, etc., in the œsopha-

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geal mucosa. (For general treatment of diseases of the œsophagus, see *Stomach, Surgery of the.*)

Aldred Scott Warthin.

ŒSOPHAGUS. (SURGICAL.) See *Stomach, Surgery of the.*

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ŒSTRUS. See *Insects, Parasitic.*

OÏDIOMYCOSIS OF THE SKIN. See *Dermatitis Blastomycetica.*

OJAI HOT SULPHUR SPRINGS.—Ventura County, California. Access.—Viâ Southern Pacific Railroad to Ventura, thence fifteen miles by stage to springs.

This resort is beautifully situated in Waterfall Canyon, about five miles from the thriving village of Nordhoff. The altitude of this location is about one thousand feet above the sea level. The surrounding scenery is very fine, and the vicinity affords excellent hunting and fishing. The springs flow about fifty thousand gallons per hour, and have a temperature ranging from 60° to 104° F. Several of the springs are carbonated, and others are sulphureted. Among the well-known springs are the Fountain of Life, St. Jacob's Well, and the Mother of Eve Springs. These Ojai waters contain the carbonates and sulphates of sodium, potassium, and magnesium, the carbonates of iron and lime, silicates, and carbonic acid and sulphureted hydrogen gases. Many stiff-jointed, rheumatic, and gouty persons repair to these springs for relief, and it is stated that a fair percentage of them are not disappointed in their quest. Good accommodations are provided for visitors.

James K. Crook.

OJAI VALLEY, SOUTHERN CALIFORNIA.—This little valley, said to be one of the most beautiful spots in Southern California, is situated in Ventura County, about sixty miles northwest of Los Angeles, and about fifteen miles from the coast. It has an average elevation of from nine hundred to twelve hundred feet, the upper part of the valley being the highest.

It is about fifteen miles in length, and from two to four miles wide. It is "entirely surrounded by the San Rafael and Santa Inez ranges, which rise on the east to a height of six thousand feet. It is thus well sheltered from harsh winds and partly also from the sea fogs" (Solly).

Nordhoff is the principal town with a population of eight hundred or more, and is the terminus of a branch railroad from San Buena Ventura. The upper Ojai is noted for its orchards, while the lower Ojai is devoted to beans and grain. Fruits of various kinds also thrive here. The opportunities for camping and shooting are abundant, deer, quail, and other small game being plentiful. The horseback rides are very attractive in this "country of beautiful views."

The following table, compiled from data given by Solly ("Medical Climatology"), will indicate the character of the climate:

Climate of Ojai Valley, taken at or Near Nordhoff.

	Jan.	Feb.	March.	April.	May.	Dec.	Winter.	Spring.	Year.
Temperature for 1892. Average (degrees F.) mean.	52°	53°	54°	56°	62°	50°	1893. 51°	1893. 54°	1893. 58°
Average mean	...	...	...	...	....	...	1895. 52	1895. 57	1895.
Maximum for 1892	78	79	85	82	100	77	85	95	
Minimum for 1892	27	...	28	31	34	25	26	32	
Humidity— Mean relative (January and February)	...	...	...	...	....	...	66%	65%	
Fogs, mornings	...	...	...	...	....	...	4	28	
Rainfall, inches	...	...	...	...	....	...	12.82	9.23	27.84
Rainy days	...	...	...	...	....	...	11	8	

The climate, it will be seen, is a very mild, equable one in the winter and spring, with a comparatively dry air, and slight rainfall; in brief, it represents the well-known characteristics of the Southern California climate for resorts situated some distance from the sea, and, in addition, the modifications produced by the peculiar situation of the valley, shut in as it is by mountains.

This climate is said to be especially favorable for asthmatics, and is also to be recommended for cases of pulmonary tuberculosis, chronic bronchitis, chronic diarrhœa, and nephritis.

The accommodations are only moderate. According to Solly there are pleasant boarding-houses and cottages. Such a locality as the Ojai Valley is rather suited to those who are well enough to take up a permanent residence there, and occupy themselves with the various pursuits of an outdoor life.

Edward O. Otis.

OJO CALIENTE.—Taos County, New Mexico. Post-Office.—Ojo Caliente. Hotel.

Access.—Take Denver and Rio Grande Railroad to Barrancas Station; thence twelve miles by stage to springs.

These celebrated hot springs are located at an elevation of about six thousand feet above the sea level in the region of the ancient cliff dwellers, twenty-five miles west of Taos and fifty miles north of Santa Fé. There is now a commodious hotel at the resort, having accommodations for about one hundred guests. The surrounding country is broken and mountainous, and the climate of the usual delightful New Mexico variety. The hottest summer day recorded at the springs in recent times was 93° F., and the coldest winter day 20° F. The resort is kept open all the year round. The springs are fifteen in number, and vary in temperature from 90° F. to 122° F. Their flow has not been measured, but it is estimated by Congressman Antonio Joseph, the proprietor, at about forty-two hundred gallons hourly. The following analysis was made by Prof. O. C. Marsh:

One United States Gallon Contains:

Solids.	Grains.
Sodium carbonate	91.52
Magnesium carbonate	1.26
Iron carbonate	5.90
Lithium carbonate	.12
Sodium chloride	22.18
Calcium carbonate	2.42
Potassium sulphate	3.00
Sodium sulphate	7.92
Silica	1.22
Total	135.54

An analysis, made in 1892, of the "New Spring" by W. T. Hillebrand, acting chief chemist of the United States Geological Survey, showed the presence of large quantities of carbonate of sodium, besides salts of lithium, potassium, strontium, barium, magnesium, and iron, with a considerable proportion of carbonic acid gas. The waters here have a great reputation in the treatment of advanced syphilis, chronic induration of the lymphatic glands, gout, and rheumatism.

James K. Crook.

OLD AGE. See *Senility*, and *Death, Physiological Theories of.*

OLD POINT COMFORT, NEWPORT NEWS, AND VIRGINIA BEACH.—Old Point Comfort, Va., is situated at the southeastern extremity of Yorktown Peninsula, at the entrance to Hampton Roads, through which the James River empties into Chesapeake Bay. Situated thus it commands a view directly out to sea between Cape Charles and Cape Henry. Directly south of Old Point Comfort, at a distance of about eleven miles, is the city of Norfolk, Va. In a westerly direction from Old Point, seven miles distant, as one passes up through Hampton Roads to enter the James River, is situated Newport News. "All vessels coming down the James River from Richmond and Petersburg, and those entering and leaving the harbor of Norfolk (and the Portsmouth Navy Yard there situated) must pass close to Old

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Point Comfort, while the entire sea-going commerce of Chesapeake Bay passes it at no great distance on its way to and from the ports of Baltimore, Annapolis, and Alexandria."

Old Point Comfort is a government reservation, and here is situated the famous fortification of Fort Monroe, the largest of its kind in America, commanding the entrance to Hampton Roads and the approach to the navy yard at Norfolk. The very extensive marine view, the attractions of a large military garrison, combined with a mild climate a considerable portion of the year, render this resort one of the most popular ones in the country. Moreover, it is very easily and comfortably reached from the North, and affords excellent accommodations, though expensive.

The accompanying climatic table based upon observations taken at Norfolk, will serve also to illustrate the climate of Old Point and Newport News, for the three places are so near one another that there can be but little difference in their climatic elements.

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stable climatic conditions of a Northern spring during these months. One will find at this resort a large amount of sunshine, a comparatively mild temperature, no great amount of rain, and less wind than at Atlantic City. When one considers the ready accessibility of "Old Point" from the North, and its favorable climatic features, its value as a health resort must be regarded as very considerable. The sources of amusement and diversion are also many, and greatly enhance the value of the resort. They are the ever-shifting panorama of the ocean with the constant passing of various craft; the fascination of the military life, such a predominant feature here; the frequent visits of warships; the Normal and Agricultural Institute for colored people and Indians at Hampton, two and a quarter miles distant; and the National Soldiers' Home at the same place; the various shorter or longer excursions by water to Norfolk, Richmond, Virginia Beach, the York River, etc. The Hampton Golf Club and the Country Club are accessible to the guests of the hotels, and are said to be kept in excellent

Climate of Norfolk, Va., Latitude, 36° 51'; Longitude, 76° 17'. Period of Observation, Thirteen Years.

	Jan.	Feb.	March.	April.	May.	July.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
Temperature (degrees Fahrenheit)—														
Average or normal	40.8°	42.9°	48.0°	56.3°	67.1	79.6°	61.0°	49.6°	42.2°	57.1°	77.4°	60.4°	41.8°	59.2°
Average daily range	14.8	16.1	16.9	17.5	17.8	18.1	14.5	14.9	14.2	17.4	17.2	14.4	15.0	16.0
Mean of warmest	47.5	53.2	57.7	64.0	75.9	89.0	70.9	58.7	50.9					
Mean of coldest	32.7	37.1	40.8	47.5	58.1	70.9	56.4	43.8	36.7					
Highest or maximum	80.0	81.0	81.0	92.0	98.0	102.5	89.0	80.0	73.0					
Lowest or minimum	8.0	9.0	16.0	27.0	38.0	60.0	31.0	20.0	6.0					
Humidity—														
Average mean relative	75.5%	70.6%	66.4%	68.2%	68.8%	70.3%	74.7%	72.7%	71.8%	67.8%	71.8%	74.8%	72.6%	71.8%
Precipitation—														
Average in inches	3.89	3.85	4.35	4.29	3.54	5.39	3.96	3.58	3.80	12.18	15.65	12.77	11.54	52.14
Wind—														
Prevailing direction	N.	N. E.	N.	S. W.	S. W.	S. W.	N. E.	N.	S. W.	S. W.	S. W.	N. E.	N.	S. W.
Average hourly velocity in miles	7.5	8.7	9.5	8.9	8.0	6.7	7.2	7.7	7.5	8.8	6.8	7.2	7.9	7.7
Weather—														
Average number clear days	8.8	8.6	10.0	9.5	11.0	8.5	13.7	11.2	10.1	30.5	27.1	35.5	27.5	120.6
Average number fair days	11.2	10.9	10.8	10.5	12.3	14.5	9.6	9.8	11.8	33.6	40.9	29.8	33.9	138.2
Average number clear and fair days	20.0	19.5	20.8	20.0	23.3	23.0	23.3	21.0	21.9	64.1	68.0	65.3	61.4	258.8

Temperature and Rainfall at Fort Monroe, Va. Latitude, 37° N.; Long., 76° 19' W.

	Feb.	March.	April.	July.	Oct.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.
Mean temperature (degrees Fahrenheit)	41.81°	49.90°	55.99°	78.73°	61.90°	41.10°	57.34°	77.07°	61.92°	41.77°	59.52°
Maximum temperature	72.00	78.00	91.00	102.00	89.00	69.00					
Minimum temperature	4.00	13.00	31.00	61.00	30.00	17.00					
Mean precipitation in inches	2.72	3.30	2.98	5.34	2.92	4.58	10.17	15.32	10.18	10.67	47.04

A comparison is also given of the temperatures of Norfolk, New York, and Boston for the months of February, March, and April, the season at which "Old Point" is especially resorted to by visitors from the North.

shape. The links overlook the sea, and at the attractive club house there is a tea room and café, and music on Saturday afternoons. There are also sailing, driving, and bathing in the season. Attention should also be called to

Temperature (degrees Fahrenheit.)	February.			March.			April.			Season.		
	Norfolk.	New York.	Boston.	Norfolk.	New York.	Boston.	Norfolk.	New York.	Boston.	Norfolk.	New York.	Boston.
Average daily maximum	53.2°	40.1°	38.6°	57.7°	45.9°	43.2°	64.0°	56.3°	53.2°	58.3°	47.4°	45.0°
Average daily minimum	37.1	25.9	20.1	40.8	31.3	26.7	47.5	40.5	36.1	41.8	32.5	27.6
Average daily temperature	42.9	31.3	28.1	48.0	36.8	34.2	56.3	46.9	43.9	49.1	38.3	35.4

Like Atlantic City, Old Point Comfort is an all-year-round resort, frequented during the colder seasons of the year more especially by visitors from the North and during the summer by those from the South. As has been said, and as is the case with Atlantic City, the season of February, March, and April is the popular one for Northern visitors and invalids who desire to escape the unstable climatic conditions...

the great advantage of the beach as a playground for children. Such a climate and such a resort are especially to be recommended for those who with difficulty endure the rigors of a Northern winter, and at the approach of spring find themselves in a depressed condition, physically and mentally, without being seriously ill. It is also to be recommended for convalescents from various acute diseases,

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for those who are recovering from the effects of an operation, and for scrofulous children. For the aged, the feeble, the neurasthenic, and for weakly children it offers, for a portion of the year at least, a mild and pleasant asylum. It is said to be immune from malaria. It can hardly be recommended for those suffering from any serious disease of the respiratory organs or from renal disease.

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As a half-way station between the North and the more Southern resorts in Florida, Georgia, and South Carolina, "Old Point" proves serviceable in the late autumn and in the spring.

There are two large and well-appointed hotels at "Old Point," the "Chamberlain" and the "Hygeia," with enclosed sun piazzas, affording excellent accommodations the year round. It is probable, also, that in the vicinity private boarding-houses and cottages can be found for those desiring less expensive accommodations than these luxurious hotels offer. The methods of reaching this resort are many and good. One can go by rail to Cape Charles and from there by steamer across the bay, or by rail all the way viâ Richmond; or one can make the trip from Boston, New York, Baltimore, and Washington by water.

Newport News, while possessing a similar climate, has less in the way of attractions to offer than Old Point, and is not so popular a resort, though it possesses much of historic interest. Here is located an extensive ship-building plant, with an immense dry-dock. It is also a port of importance. The Hotel Warwick offers good accommodations, and for one who desires a quieter existence than that at Old Point, Newport News would appear to be the more attractive of the two. It is reached by boat from Norfolk.

Virginia Beach is situated eighteen miles east of Norfolk, with which it is connected by rail, and six miles south of Cape Henry. It has a fine and extensive beach, affording good surf bathing, and is protected landward by extensive pine forests. The average winter temperature is 54° F, and the extremes for the year 34° F.

The climate is equable and mild and the soil dry. The Princess Anne Hotel is well appointed and offers excellent accommodations and food. The attractions are boating, bathing, fishing, shooting, and horseback riding. This climate and resort "are adapted for cases of chronic nephritis, bronchitis, overwork, and neurasthenia." (Hinsdale.) *Edward O. Otis.*

OLD SWEET SPRINGS.—Monroe County, West Virginia. Post-Office.—Old Sweet Springs. Hotel.

Access.—Viâ Chesapeake and Ohio Railroad to Alleghany Station, where Concord coaches meet all passengers for the springs. The location of Sweet Springs is more open than is generally the rule in mountain districts. They issue up in a valley of great loveliness, but are surrounded by mountain scenery of surpassing grandeur. The elevation is two thousand feet above the sea level, and the climate during the summer months is of the usual delightful character found in this region. The buildings at the springs are of brick and of a very substantial character, and at the height of the season the place resembles a miniature city. Eight hundred guests are easily entertained at one time. The main building is about three hundred feet in length, and no expense has been spared to make it one of the best summer hotels in the country. The hotel property embraces a grass farm of two thousand acres, which guarantees an abundant supply of dairy products, while neighboring farms furnish the best of poultry, mutton, etc. The water of the Sweet Springs is not unpleasant to the taste, but its temperature (79° F.) renders it rather warm for general use in drinking. For bathing, however, it is very agreeable. Two pools have been provided—one for men, the other for women,—each seventy-five feet long, twenty-five feet wide, and from three to five feet deep. The water is so clear that moss-covered stones on the bottom are distinctly visible. There are also warm and hot steam baths of both mineral and freestone water. The following analysis of the mineral water here was made by Prof. William B. Rogers:

One United States Gallon Contains:

Solids.	Grains.
Calcium sulphate	13.16
Magnesium sulphate	9.37
Sodium sulphate	6.32
Calcium carbonate	30.05
Magnesium carbonate	.80
Calcium chloride	.15
Sodium chloride	.14
Magnesium chloride	.31
Iron peroxide	.15
Silica	.17
Earthy phosphates	Trace.
Iodine	Trace.
Total	60.62
Gases.	**Cu. in.**
Carbonic acid	85.86
Nitrogen	4.31
Sulphureted hydrogen	Trace.
Oxygen	Trace.

This is a very good alkaline-calcic water possessing tonic, diuretic, alterative, and mild cathartic properties. It is valuable in functional disorders of the stomach, and is said to be employed with signal benefit in chronic diarrhœa and dysentery. It has also produced good results in rheumatism and in some forms of neuralgia, as well as in renal and urinary disorders. *James K. Crook.*

OLEIC ACID.—Oleic acid ($HC_{18}H_{33}O_2$) is the acid product of the decomposition of olein, the fluid constituent of natural oils and fats. Under the title, *Acidum Oleicum*, Oleic Acid, the United States Pharmacopœia recognizes the acid "prepared in a sufficiently pure condition by cooling commercial oleic acid to about 5° C. (41° F.), then separating and preserving the liquid portion." Such grade of acid is an oily liquid, yellow or brownish-yellow in color, and having an odor and taste as of lard. On exposure to air it absorbs oxygen and darkens in color. Its specific gravity is about 0.900 at ordinary temperatures. It is insoluble in water, but dissolves completely in alcohol, chloroform, benzol, benzin, oil of turpentine, and the fixed oils. On cooling the acid first becomes semi-solid, and at 4° C. (39.2° F.) congeals to a whitish, crystalline mass.

The medicinally valuable property of oleic acid is that while retaining the physical properties of a fixed oil, the acid is yet of high diffusive power, and, accordingly, upon inunction passes through the unbroken skin into the general circulation, and leaves behind a smooth, soft, and supple, but not greasy condition of the integument. Being an acid it forms salts with salifiable bases, many of which salts are soluble in excess of oleic acid. Such solutions of oleates in oleic acid are found to permeate the skin as readily as the simple acid, and for this reason such solutions form a class of medicines defined as "oleates," and devised as means of medicating the general circulation through the unbroken skin. Oleic acid is used exclusively for the manufacture of these pharmaceutical "oleates." *Edward Curtis.*

OLFACTORY NERVE.—I. Anatomical Part.—The olfactory nerve is the simplest of the nerves of special sense; indeed in its peripheral relations it is in some respects the simplest and most primitive nerve of the body. Its central relations, on the other hand, are most intricate and cannot be understood without reference to its evolutionary history. In the larva of the lowest vertebrate, the amphioxus (Fig. 3624), the anterior end of the tubular central nervous system opens freely to the outer body surface by a distinct neuropore on the dorso-median surface of the head. In the adult this pore becomes closed, but there persists a pit like de-

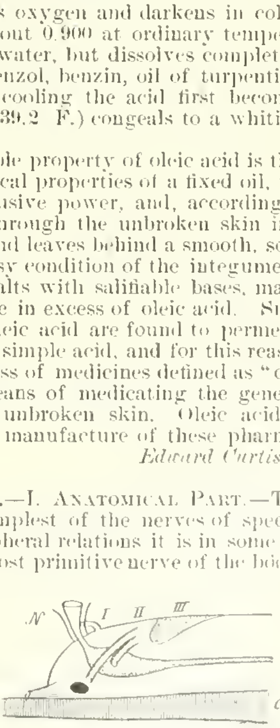

Fig. 3624.—Longitudinal Section Through the Brain of the Larval Amphioxus. *ch*, Notochord; *N*, neuropore, or sensory pit.

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pression of the outer skin, reaching in to rest in contact with the surface of the brain. This pit is lined with ciliated epithelium and at this stage of life it is displaced so that it lies on one side of the median line. The appearance of this structure, which is known as the "olfactory pit," is shown in the accompanying figure (Fig. 3625). From this simple beginning the entire olfactory apparatus of higher animals has been developed. The neuropore in embryos of other vertebrates does not actually open to the surface, but its position can sometimes be determined by the appearance of a pit-like forward projection of the brain wall in its most cephalic boundary at a point corresponding to the lamina terminalis of the adult (the lobus olfactorius impar of von Kupffer) (see Fig. 3626). Here, too, there is an invagination from the outer skin in the corresponding region. From this invagination there is produced not only the nasal fossa and the contained sensory epithelium, but also the hypophysis, the latter rotating ventrally through an arc represented by the arrow in the figure.

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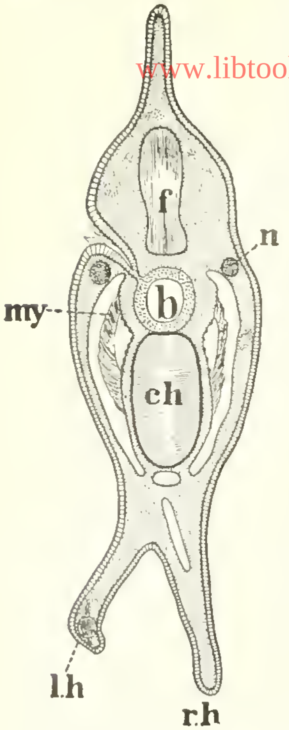

FIG. 3625.—Transverse Section Through Region of Olfactory Pit of Adult Amphioxus. (After Lankester.) The olfactory pit is seen as an ectodermic invagination at the left of the brain. *b*; *ch*, notochord; *f*, lymph space; *my*, first myotom; *n*, second cranial nerve.

The fact that the olfactory sensory thickening appears in the olfactory depression at a very early stage in its invagination has led to many attempts to homologize the olfactory organ with other sensory organs of ectodermal origin. In some of the fishes the adult olfactory mucosa is broken up into sensory patches resembling superficially the taste buds, and Blaue has assumed that these "olfactory buds" are the derivatives of one of the lateral line series of sense organs which has wandered into the olfactory fossa and there proliferated. In spite of the inherent improbability of this from theoretical grounds, his view has found its way into many of the current text-books of embryology. As a matter of fact, however, Blaue was ignorant of the development of the olfactory organ of these fishes, and the embryological history disproves his theory, for the olfactory sensory epithelium does not exhibit the "olfactory buds" until a very late stage in the ontogeny, showing that these are of secondary rather than primary significance. The truth is, that the phylogenetic origin and relationships of the olfactory organ must be left for future research to determine.

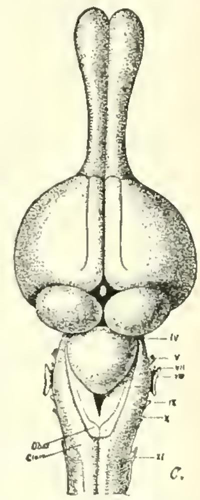

FIG. 3627.—Dorsal View of the Brain of a Young Alligator. (After C. L. Herrick.)

The later phylogenetic history is fortunately much clearer, and it is moreover of fundamental importance to our theories of the origin of the cerebrum, for the whole of the secondary prosencephalon in the lowest vertebrates seems to be related to this olfactory organ. As the optic lobes, geniculata, etc., have been evolved in response to the requirements of the organ of vision, so the olfactory bulbs and the earliest cerebral cortex seem to have been called forth by the necessities of the olfactory sense. Then later in the evolutionary process the prosencephalic roof, or pallium, became the seat of secondary connections for other nerve systems, until in man and other microsmatic mammals the olfactory function has been quite overshadowed by these secondarily acquired functions of a higher order. The distinction between the rhinencephalon and the remainder of the prosencephalon becomes more and more marked as we ascend the animal series.

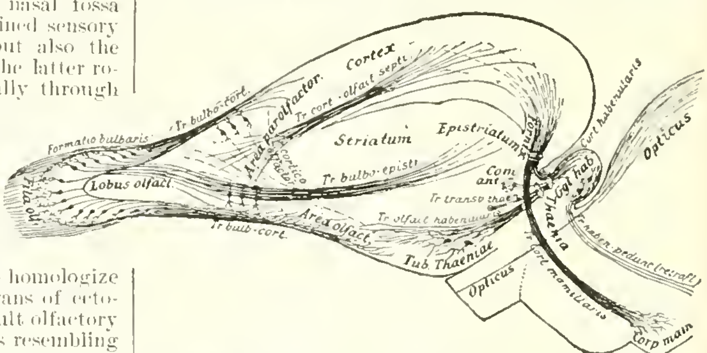

FIG. 3628.—Diagram of the Olfactory Connections of the Lizard, as seen in Sagittal Section. (After Edinger.)

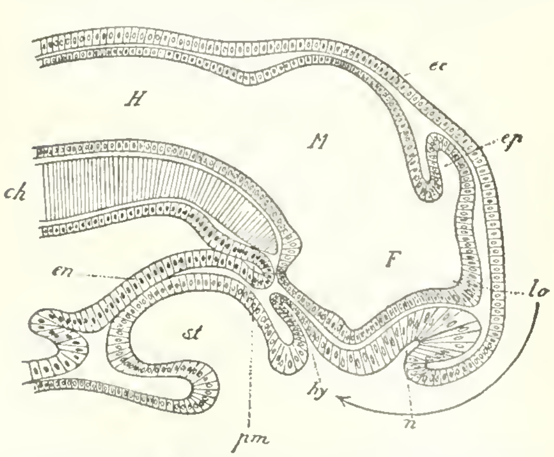

FIG. 3626.—Median Sagittal Section Through the Head of Ammocoetes. (After von Kupffer.) *ch*, Notochord; *ec*, ectoderm; *en*, entoderm; *ep*, epiphysis; *F*, primary forebrain; *H*, primary hindbrain; *hy*, hypophyseal invagination; *lo*, lobus olfactorius impar; *M*, primary midbrain; *n*, nasal invagination; *pm*, pre-oral gut; *st*, stomodeum.

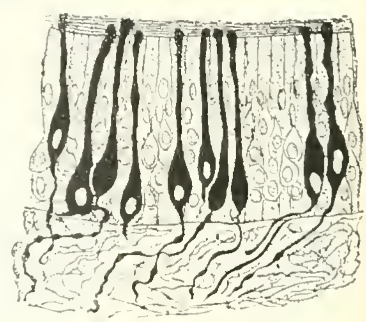

FIG. 3629.—Section of the Olfactory Mucous Membrane. (After von Brunn.) The specific olfactory cells are in black.

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Edinger and others have brought forth anatomical evidence to show that the first truly functional cortex, or pallium, to appear in the phylogenetic scale is the hippocampus, which is connected chiefly with the olfactory sense. With this is to be correlated the fact that the olfactory conduction path becomes medullated earlier in the development of the human cerebrum than that of any other special sense. Since the psychic functions in higher animals are associated, mainly, if not exclusively, with the cerebral cortex, it follows with great probability that the olfactory group of sensations was among the first to emerge into clearly defined consciousness. This olfactory cortex appears first in the Amphibia as a crescent of superficial nerve cells in the caudal and lateral border of the cerebrum. In the reptiles there is true cortex over the whole of the forebrain in addition to a simple but typical hippocampal formation. In these forms the olfactory nerve is the largest in the body and the whole system is enormous. It is, moreover, laid down according to the same general plan as in higher animals. The relations between olfactory bulbs and cerebrum in the reptiles are indicated by the accompanying figure of the brain of the alligator (Fig. 3627) and by the diagram of the olfactory connections in the lizard (Fig. 3628). This latter scheme applies also with no important changes save in the relative size of the parts, to all vertebrates above the reptiles in the zoological scale. In man, however, the sense of smell is relatively so unimportant and the higher cortical centres are so highly developed that it has proven a matter of the greatest difficulty to unravel the olfactory connections.

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Anatomically the olfactory nerve differs from all of the other nerves of the body in that its fibres arise from perikaryons, or cell bodies, lying in the sensory epithelium (Fig. 3629). In other words, the root ganglion for this nerve does not lie adjacent to the central nervous system, but its cells are in the periphery, diffusely scattered among the indifferent supporting cells of the sensory mucosa of the nasal organ. This condition we find in the case of no other nerve among the higher vertebrates, but it appears to be a survival of a primitive invertebrate condition. (See *Cranial Nerves*.)

The specific olfactory cells are distributed over a relatively small area of the nasal mucosa (about 2.5 sq. cm.) in the upper narrow part of the nasal sinus, partly on the superior turbinated bone, and partly on the nasal septum adjacent. Unlike the remainder of the nasal mucosa this portion is non-ciliated. It is yellowish in color and exceedingly vascular. The specific olfactory cells are commonly described as ending in a short stiff bristle.

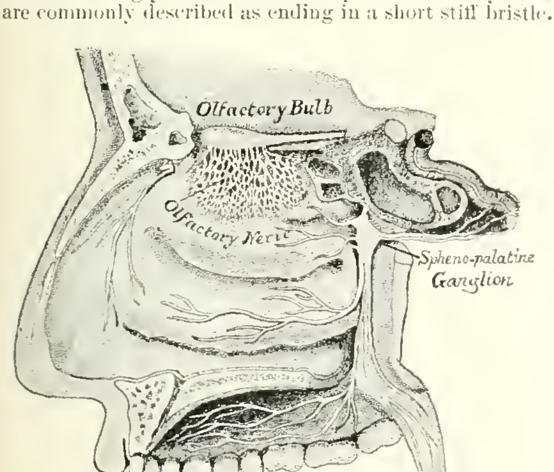

FIG. 3630.—The Right Olfactory Nerve on the Outer Wall of the Nasal Fossa. (Adapted from Hirschfeld.)

Recently Jagodowski has found (*Anat. Anzeiger*, vol. xix., p. 257) in the fishes that each of these cells is provided with a single long thread-like filament which projects outward into the mucus of the nose and which may be

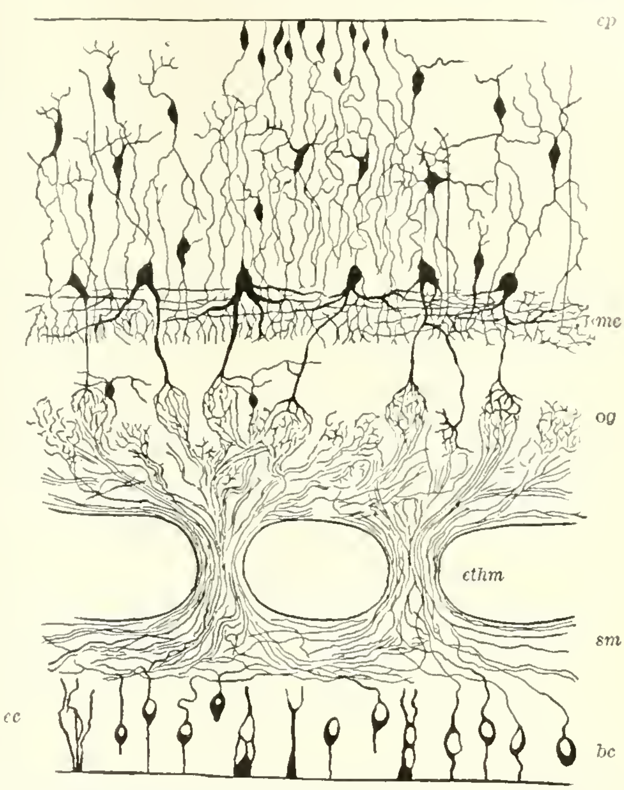

FIG. 3631.—Structure of the Olfactory Filaments and Bulb. (After Ramón y Cajal.) *bc*, Bipolar cells of the olfactory mucous membrane; *sm*, submucosa; *ethm*, cribriform plate of the ethmoid; *og*, olfactory glomeruli; *mc*, mitral cells; *cp*, epithelium of the olfactory ventricle; *cc*, epithelial cells of the olfactory membrane.

more than twice the length of the cell body from which it springs. The appearance of the fila olfactoria arising from these cells is indicated in Fig. 3630. These fibres passing from the olfactory mucosa to the olfactory bulb are commonly called the olfactory nerves, but it is evident that if the so-called specific cells from which they spring really correspond to the root ganglion cells of the other nerves, then the fila olfactoria correspond rather to root fibres. These fibres are non-medullated and are gathered into about twenty bundles, which enter the cranium by separate apertures in the cribriform plate of the ethmoid bone. The several strands enter the olfactory bulb and here terminate in peculiar arborizations in the glomeruli (Fig. 3631).

Jacobson's organ (a peculiar diverticle of the nasal sac) in some animals receives a special twig of the olfactory nerve, which rarely, as in Amblystoma, arises from the brain farther back (caudad) than the rest of the nerve and pursues a distinct course to its terminus.

The comprehension of the central relations of the olfactory nerves is greatly impeded by a confused and very inconsistent nomenclature. The term rhinencephalon was first used in neurology by Owen as a name for the olfactory bulb and its peduncle. It has since been extended by different writers to include various parts of the cerebrum which are concerned in the olfactory function, with, however, no uniformity in the extent of this application. The only logical course is (as pointed out by G. Elliot Smith, *Jour. Anat. and Physiol.*, xv., 1901) either to retain Owen's limited application of the term or

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to extend it to include all parts of the forebrain, which are directly connected with the olfactory function, viz., the olfactory bulb, tract (or peduncle), tuber, the area perforata, "paraterminal body" (a term introduced by Elliot Smith for the area extending backward from the olfactory peduncle, the gyrus subcallosus, paraterminalis and upward to fill the space between the callosum and the hippocampal commissure), and the whole pyriform lobe and hippocampal formation. This usage will doubtless commend itself to the majority of working neurologists, in spite of the fact that a part of that which is commonly reckoned as pallium is here included in the rhinencephalon. This difficulty is in large measure obviated by Elliot Smith in the paper cited above, by a reconsideration of the phylogeny of the pallium, from which he concludes that the olfactory portions of the pallium should be separated morphologically from the remainder of the cortex, which is of more recent origin and hence may be termed the "neopallium."

The classification of the rhinencephalon, according to Retzius, has been tabulated by Barker as follows:

1. *Bulbus olfactorius.*
2. *Tractus olfactorius.*

3. *Trigonum olfactorium* (gyrus tuberis olfactorii).	Stria olfactoria lateralis to gyrus olfactorius lateralis. Stria olfactoria medialis to gyrus olfactorius medialis.
4. *Gyrus olfactorius medialis.*	Area parolfactoria Brocæ.
5. *Gyrus olfactorius lateralis.*	Pars anterior—Eberstaller's gyrus transversus insulæ and the limen insulæ. Pars posterior. Extends from angulus lateralis to anterior extremity of gyrus hippocampi and terminates in the gyrus semilunaris rhinencephali and the gyrus ambiens.
6. *Gyrus perforatus (seu intermedius) rhinencephali.*	Anterior, much perforated, part of substantia perforata anterior.
7. *Gyrus diagonalis rhinencephali.*	Posterior, less perforated, part of substantia perforata anterior. Corresponds to the diagonal band of Broca, which extends from the gyrus subcallosus to the anterior end of gyrus hippocampi.

8. *Other portions of rhinencephalon.*
   (*a*) *Gyrus hippocampi.*
   (*b*) *Uncus*
   (*c*) *Gyrus dentatus.*
   (*d*) *Gyrus intralimbicus.*
   (*e*) *Gyrus fascioloris*
   (*f*) *Gyri Andreæ Retzii*
   (*g*) *Indusium griseum* (including the *striæ longitudinalis medialis et lateralis*).
   (*h*) *Gyri subcallosi.*

Reference to Fig. 3631 will render unnecessary a detailed exposition of the primary olfactory connections. The glomeruli are entangled knots of fibres, partly the terminal arborizations of the fila olfactoria and partly the dendritic tips of the neurones of the second order, whose nuclei lie in the zone of mitral cells. Each mitral cell usually sends a dendrite (in man) to but one glomerulus, where it receives the terminal arborizations of many fila olfactoria. The structures within the olfactory bulb are stratified, the following layers being encountered as we pass inward. First, a layer of fila olfactoria bounded within by the glomeruli arranged in a single series. Then, after an interval containing chiefly nerve fibres constituting the so-called molecular layer, are the mitral cells, arranged in a thin layer typically but one cell deep. Within this is the granular layer containing very many cell bodies of the olfactory granules. These are minute cells with feebly developed dendrites directed toward the ventricular surface, and much branched neurites passing out between the bodies of the mitral cells to arborize just within the zone of glomeruli. Their functional significance is unknown. Within this layer is the zone of nerve fibres, containing the tracts directed toward the cortex and composed chiefly of neurites of the mitral cells. Olfactory impressions entering by the fila olfactoria are transferred to the dendrites of the mitral cells and by the neurites of these neurones (the mitral cells constituting the primary intracranial centre) are carried to their secondary centres viâ the olfactory tracts. These secondary connections, which are very diverse and intricate, can be briefly summarized as follows:

The olfactory tract connecting the bulb with the secondary centres contains three sets of fibres, the lateral and mesial olfactory striæ superficially placed, and the deep, or ental, or precommissural tract. On their way part of the latter fibres terminate in the gray matter distributed along its course, while others run to the anterior commissure, forming its anterior or olfactory part, and terminate in various parts of the rhinencephalon of the opposite side. The mesial olfactory stria terminates in the area parolfactoria and other gray centres near the median line at the attachment of the crus olfactorius, effecting secondary connections with the hippocampus through the indusium griseum of the callosum and by other paths. Others of these fibres pass into the septum pellucidum and ultimately reach the hippocampus viâ the fornix. The larger portion of the secondary olfactory fibres pass back in the lateral olfactory stria to terminate in the cortex of the uncus, giving off collaterals on the way to adjacent gray centres.

The reflex connections between the cortical olfactory centres in the hippocampus and the lower regions of the brain are too complicated to be summarized here. The fornix is the chief pathway for these fibres, and their most important connections are the mammillary bodies (by way of the corpus fornicis, the *Tr. Cort. mammillaris* of Fig. 3628), and the nucleus habenulæ (by way of the stria medullaris thalami, marked *Cort. habenularis* on Fig. 3628). For the general relations of these tracts consult Fig. 3632.

One is at once struck by the peculiar way in which these olfactory tracts are distributed by widely divergent paths to secondary centres, which are far separated in space (though morphologically related). Upon comparison with the connections within the reptilian brain (Fig. 3628) the explanation is plain. There practically the entire forebrain is devoted to olfactory connections, and the cortical additions of higher types have been intercalated in such a way as to separate tracts and centres which were primarily juxtaposed.

II. Physiological Part.—The sense of smell in human beings, as compared with many of the lower animals, is very feebly developed, as will be made clear by even a cursory examination of the comparative anatomy and physiology of the organ. Animals are classified with reference to this sense as osmatic and anosmatic, and the former group is subdivided into macrosmatic and microsmatic divisions, depending upon whether the sense is highly developed or but feebly so. Man belongs to the microsmatic group, this sense playing a very subordinate rôle, either physiological or psychological, in our vital economy. Its unimportance is, however, more apparent than real and is to be explained, as Zwaardemaker points out, on psychological grounds.

As a matter of fact, olfactory sensations are always with us and our daily actions are profoundly influenced by them, though this influence is largely unrecognized as such. For these sensations are, in the case of human beings, intimately connected with the somatic and organic functions, and have a strong emotional content which obscures the process of ideation. This imperfect comprehension of olfactory impressions is reflected in our language, for our vocabulary of olfactory sensations is very limited and almost all borrowed from that of other senses. For our knowledge of the outer world we depend chiefly upon the other special senses, particularly sight. With the macrosmatic animals, on the other hand,

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the sense of smell is undoubtedly in some cases more potent in the elaboration of knowledge of the outer world than any other sense.

The physiology of the sense of smell is less perfectly known than that of any of the other special senses, and the same remark holds true of its psychology. While our knowledge of the anatomical arrangements of the paths of olfactory conduction to and within the brain has been greatly extended of late, we are yet ignorant of the means even by which the olfactory nerve termini are stimulated by the odorous substances. In particular, the physiological process underlying the difference between smell and taste is obscure. It is commonly stated that we taste substances in solution or in liquid form, while only gases are perceived by the sense of smell. While this is in general true, it nevertheless must be remembered that the odorous gases do not come into direct contact as such with the sensory end organs in the nose, either in fishes, where the nasal cavities are filled with water, or in air-breathing vertebrates, whose olfactory mucous membranes are always bathed with mucus in which the odorous substance must always be dissolved before it can irritate the sensory endings. Again, some sapid substances, such as hydrochloric acid, are also solutions of gases, and some solids in a state of fine division seem to give rise to distinct olfactory impressions. The fact that when the nostrils are filled with water carrying an odorous substance in solution the odor cannot be perceived does not necessarily imply that the failure is due to the fact that the substance is in solution, but rather to an irritating effect of the liquid upon the olfactory organ. This is indicated by two facts: First, that all olfactory sensation may be temporarily enfeebled or even entirely abolished for some time after the close of the experiment; and second, that if normal salt solution instead of water be used as a solvent, then the dissolved substance can in some cases still be smelled.

Tyndall discovered that odorous vapors have a considerable capacity for absorbing heat, and that very minute quantities of the odorous substance in the air experimented upon would produce surprising effects. At the close of a table giving the absorptive powers of different odorous vapors, he remarks: "We find that the least energetic in the list produces thirty times the effect of air, whilst the most energetic produces one hundred and nine times the same effect." The significance of these facts is still obscure. We certainly are not able to affirm as yet, with Ramsay, that the sense of smell is excited by vibrations of a lower period than those which give rise to the sense of light or heat, though it may well be that characteristic molecular vibrations give to various substances their distinctive odors. But in any case these movements seem to be incapable of transference to the receptive sense organ by the medium of ethereal vibrations, and direct contact of the odorous particles with the nervous organ seems indispensable. The ultimate stimulus is probably electro-chemical—a matter of ions.

Olfactory sensations are aroused with difficulty or not at all by irritation of the peripheral end organ by thermal, electrical, mechanical, or other stimuli than the normal gaseous media, though tumors or other irritants of the central olfactory apparatus may call forth vivid sensations of smell. It is hardly true, as often stated, that air containing odorous particles must be in motion in order to stimulate the olfactory organ. The truth is that in ordinary respiration the air currents do not strike the sensory surface directly, and hence olfactory impressions are called forth by such particles only as diffuse themselves upward from the respiratory portion into the olfactory fossa, while in sniffing the direction of the air currents is altered so as to pass more directly over the specific sensory area.

We are not as yet able to give a natural classification of smells, nor have we any secure basis for such a classification. Even the division into agreeable and disagreeable is subject to so great variation from one individual to another that it would be of small value, even if it were admissible on other grounds. Accordingly, the names of smells are usually taken from the objects which give rise to them, with little attempt at classification or correlation of similars.

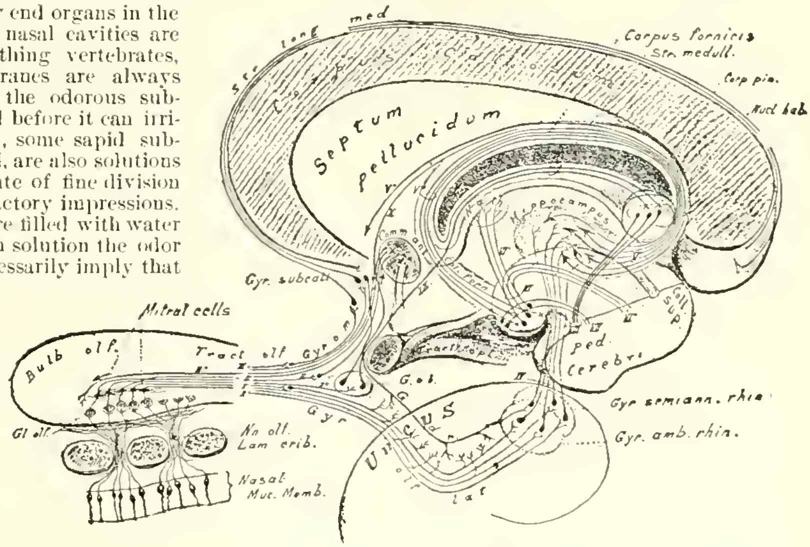

FIG. 3632.—Schematic Representation of Some of the Principal Neurone Systems of the Olfactory Conduction Path. Projected into sagittal plane. (After Barker.) *Bulb. olf.*, Bulbus olfactorius; *Col. forn.*, columna fornicis; *Col. sup.*, colliculus superior; *Comm. ant.*, commissura anterior cerebri; *Corp. mam.*, corpus mammillare; *Corp. pin.*, corpus pineale; *G. o.b.*, ganglion opticum basale; *Gl. olf.*, glomeruli olfactorii; *Gyr. amb. rhin.*, gyrus ambiens rhinencephali; *Gyr. olf. lat.*, gyrus olfactorius lateralis; *Gyr. o. m.*, gyrus olfactorius medialis; *Gyr. semiann. rhin.*, gyrus semilunaris rhinencephali; *Gyr. subcall.*, gyrus subcallosus; *Lam. crib.*, lamina cribrosa; *N. a. th.*, nucleus anterior thalami; *Nn. olf.*, nervi olfactorii; *Nucl. hab.*, nucleus habenulæ; *Ped. cerebri*, pedunculus cerebri; *Str. long. med.*, stria longitudinalis medialis; *Str. medull.*, stria medullaris; *Tract. olf.*, tractus olfactorius; *Tract. opt.*, tractus opticus; *I*, axones of mitral cells going to stria olfactorius lateralis; *I'*, axone of mitral cell terminating in gray matter of trigonum olfactorium; *II*, axone of mitral cell terminating in gray matter, whence axone goes to commissura anterior cerebri; *II'*, axones to anterior commissure; *II''*, centrifugal fibre terminating in bulbus olfactorius; *III*, axone of mitral cell terminating in gyrus olfactorius medialis; *IV*, axones of neurones connecting the olfactory portion of the uncus (gyrus ambiens and gyrus semilunaris) with the hippocampus; *V*, axones from hippocampus to fornix; *V'*, axone to commissura hippocampi; *V''*, axones from fornix to septum pellucidum; *V'''*, axones from fornix to corpus mammillare; *V''''*, axone from fornix to nucleus habenulæ by way of the stria medullaris; *VI*, fasciculus mammillaris princeps; *VI'*, fasciculus thalamomammillaris Vicq d'Azyri; *VI''*, fasciculus pedunculomammillaris, pars tegmentalis (*Haubenbündel* of von Gudden); *VII*, fasciculus pedunculomammillaris, pars basilaris (pedunculus corporis mammillaris); *VIII*, fasciculus retroflexus Mynerti extending from the nucleus habenulæ to the ganglion interpedunculare.

The number of smell qualities is very large. Some of those commonly recognized are compound, though authorities differ as to the extent to which such mixture is possible, or whether it is possible at all. If two distinct odors are mingled under experimental conditions, there often results, not a fusion of the two into a blended odor, as occurs with tastes, colors, and tones, but the stronger will supplant the other completely, or there will be an oscillation between the two. With some odors, again, there appears to be a true compensation. Thus, if two different olfactory stimuli of unequal strength are applied simultaneously, one will usually overpower the other completely; but if the stronger scent be diminished

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while the weaker is strengthened, a point may be found where the two blend into a single mixed odor. In other cases, however, a point is found where there is no sensation, *i.e.*, the odors are perfectly compensated. An increase of either stimulus results in the sensation appropriate to it and there is no mixture whatever. The olfactory organ is easily fatigued, more so by some odors than by others, and it is found that when completely fatigued for one odor it may be insensible to some other odors, partially so to another group and wholly unaffected in its sensibility with reference to still another group.

Such experiments suggest points of departure for the study of olfactory qualities, and enough progress has already been made to suggest that the modalities of smell can be grouped into several graded series. The number of such groups will quite certainly be greater than those known for taste, where we have simply the four primary qualities, sweet, sour, salty, and bitter. Zwaardemaker's nine smell classes are as follows:

(1) Ethereal scents: Fruit odors.

(2) Aromatic scents: Camphor and spicy smells, anise, lavender, etc.

(3) Balsamic scents: Flower odors, vanilla, gum benzoin, etc.

(4) Ambrosiac scents: Amber, musk.

(5) Alliaceous scents: Garlic, ichthyol, vulcanized rubber, asafœtida, bromine, chlorine, etc.

(6) Empyreumatic scents: Toast, tobacco smoke, naphtha, etc.

(7) Valeric, or hircine scents: Cheese, sweat, etc.

(8) Narcotic, or virulent scents: Opium, cimicine, etc.

(9) Nauseous scents, or stenches: Decaying animal matter, fæces, etc.

The ability to discriminate different intensities of odors is not highly developed; in general, the least observable difference between two smell intensities of the same substance amounts to about one-third of the original stimulus. On the other hand, the olfactory organ is sensitive to exceedingly small amounts of the irritating substance, or as Ladd states it: "The sense has a great degree of 'sharpness,' or power to be excited by small quantities of stimulus, as distinguished from 'fineness,' or power to distinguish minute variations in the sensations." There are many familiar illustrations of this "sharpness." It is stated, for example, that in a litre of air 0.000005 gm. of musk can be perceived, 0.000001 gm. of sulphureted hydrogen and 0.000000005 gm. of oil of peppermint. The sense is more delicate if the air containing the odorous substance is warmed.

It is learned by suitable tests that the sensibility of the organ of smell is much more acute than the perception of odors. It was found in one series of tests, for example, that upon the average 9 parts of camphor dissolved in 100,000 parts of water could be sensed by the nose, but without the perception of a definite odor, it requiring a solution of more than four times this strength before the specific odor could be recognized. Experiments made to determine the relative sensitiveness of men and women in this respect have thus far yielded conflicting results. With children it has been found that the sensibility (in the sense used above) increases up to the age of six years and then progressively diminishes. The delicacy of perception, on the other hand, measured by graded solutions of camphor, increases progressively with advancing age.

One source of perplexity in the classification of odors is the fact that some substances which have powerful odors in a state of great dilution are less effective in a state of high concentration. For some perfumes there appears to be an optimum vapor density below or above which the excitation is less strong. It has also been suggested that for unknown phylogenetic reasons some odors may have greater affective values than others, or it may be that fatigue of the sense of smell is *cæteribus paribus* less for those odors which have an element of utility to the species.

It must not be forgotten that some odorous substances affect the terminals of the trigeminus nerve in the respiratory part of the nasal passages, giving rise to tactile or other general sensation which may be combined with the olfactory sensations. This can be proven by plugging the olfactory sinus, when the trigeminal stimulus alone is perceived. Classification is further impeded by the universal confusion of tastes and odors. We say a substance "smells sweet," when as a matter of fact experiment shows that the modality sweetness can be perceived only by the sense of taste; and conversely most of the tastes of common experience are greatly affected by odors simultaneously sensed.

In the majority of persons (Toulouse and Vaschide) the left side of the nose is more sensitive than the right. With most of the other senses, on the other hand, there is an asymmetry in one-fifth of the cases in favor of the right side (van Biervliet). The difference is explained by the fact that the left side of the brain is more highly developed (in right-handed persons) and that the central olfactory tract does not cross before reaching its cortical centres, while those for the other senses do cross.

The measurement of olfactory sensations cannot easily be done absolutely in terms of the strength of the stimulus, though examples of the results of some attempts at the measurement of the threshold for smell in absolute terms are given above. To arrive at a relative measurement of olfactory values there are two methods chiefly in use. According to the method of Passy a number of flasks of equal size are provided and into each is put a measured quantity of the odorous substance, the quantities being arranged in a graded series. The substance may be allowed merely to diffuse itself through the air within the flask (which must be kept stoppered when not in use), or it may be dissolved in water or some other inodorous medium. By the use of a sufficiently extensive series, threshold values of different odorous substances may be determined and various other researches carried out.

The method of Passy is very laborious and for most purposes, particularly in clinical work, the olfactometer of Zwaardemaker is more convenient. In its simplest form it consists of a glass tube, curved at one end for insertion in the nostril and bearing a scale (preferably in centimetres), which slides with easy friction into a slightly larger tube which is lined with the odorous substance to be tested. The inner tube passes through a screen near its curved end. Now, when the outer tube is slipped completely over the inner tube so that its odorous lining is wholly covered by the latter, air drawn into the nostril through the inner tube will carry no odorous particles. If, however, the outer tube is slowly slipped off from the inner tube, the air current will pass over more and more of the exposed surface of the odorous substance before entering the inner tube, until a point will be reached at which the substance is just perceivable to the sense of smell. In this way the normal threshold can be determined for various substances and numerous tests of physiological and pathological interest carried out.

This simple apparatus has been modified in various ways. A very simple instrument which has the advantage of relative permanence of adjustment can be constructed by using a section of ordinary red rubber tubing for the outer tube. This should be slipped inside of a larger glass tube to prevent the odor from escaping from the outer side of the rubber, and the odor given off from the inner surface of the rubber tubing will remain quite constant for many months. For other odors the outer cylinder may be made of porous earthenware, whose pores may be filled with a solution of the odorous substance. Commonly the olfactometer is made double with a separate cylinder and breathing tube for each nostril, and for the study of the compensation of odors Zwaardemaker has constructed a very elaborate apparatus with two separate cylinders (one for each of the odors to be employed) connected with a single breathing tube and so adjusted that the amount of odorous surface exposed in each tube may be easily varied during the

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experiment. With the varying adjustments one odor or the other appears in consciousness alone until the proper compensation point is reached, when both odors vanish. The apparatus is provided with self-registering apparatus for recording on the kymograph the force of respiration in each cylinder and other data of the experiment.

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The unit in all of these experiments is the "olfactie," or the stimulus necessary to produce the least perceivable sensation. The position on the scale of the olfactometer having been determined for this minimal value, this value is taken as the unit, or olfactie, and other stimuli are measured in multiples of this.

For the fuller consideration of the subject of this article, see the work by H. Zwaardemaker, "Die Physiologie des Geruchs" (Leipsic, 1895), and the article by the same author entitled, "Les sensations olfactives, leurs combinations et leurs compensations," in *L'Année Psychologique*, vol. v., 1899, pp. 202–225. A complete bibliography of the organ and sense of smell up to January, 1901, has been compiled by Bawden, in *The Journal of Comparative Neurology*, vol. xi., No. 1, April, 1901.

C. Judson Herrick.

OLIBANUM.—*Frankincense. Thus. Gummi, resina olibani.*—A gum resin obtained from *Boswellia Carterii* Birdw. and other species of *Boswellia* (fam. *Burseraceæ*).

Olibanum is collected in northeastern Africa, chiefly by the Somali natives, and is mostly exported viâ India. It is produced by small trees similar to those which yield myrrh, and is chiefly obtained from incisions made for the purpose. It exudes as a thick milky juice, hardening into the tears described below, which preserve their white color much longer than those of other similar substances.

Olibanum occurs in irregularly oval or subglobular tears, separate, or occasionally somewhat agglutinated in the poorer grades, usually 1.25 cm. (0.5 in.) or less in diameter, from almost pure white to yellowish-white, occasionally reddish-brown when long kept, the surface powdery; breaking readily with a nearly flat, waxy, lustrous surface, translucent in thin fragments; odor balsamic, slightly like turpentine; softening between the teeth, aromatic and somewhat bitter. Triturated with water, it forms a white emulsion and is almost wholly soluble in alcohol. When burned, it emits a very strong and pleasant odor, on account of which it is used as incense.

Olibanum consists principally of resin, usually from 60 to 70 per cent., or occasionally 75 per cent., with from 30 to 35 per cent. of gum and from 3 to 8 per cent. of volatile oil. Its bitter principle has not been examined. The volatile oil, which is an article of commerce for perfuming purposes, combines a slight lemon-like odor with that of the drug, and is of complex composition. The resin is divisible into two portions, namely, *Boswellic* or *Boswellinic acid* and *olibano-resin*. The gum is more like acacia than like tragacanth.

From a medicinal point of view, the uses of olibanum are quite unimportant. It is no longer official in any leading pharmacopœia and is but little used in professional medicine.

Owing to its fragrant properties, it is with some a favorite ingredient of plasters and ointments, and it is elsewhere used for odorizing purposes. It has mild counter-irritant and disinfectant properties, leading to its use as a vulnerary. Internally, it possesses the ordinary stimulating diuretic and expectorant properties of the oleoresins, and it also has a considerable use, especially among the laity, based chiefly on religious fancy, as an emmenagogue. The dose is from 1 to 3 gm. (gr. xv.–xlv.). It is used chiefly, perhaps, in the form of the emulsion, although the tincture is to be preferred.

Henry H. Rusby.

OLIGÆMIA.—A decrease in the total mass of the blood. The term is often used incorrectly as a synonym for anæmia. The latter term is used to indicate a deficient supply of blood to a part, or a deficiency in the total amount of blood within the body, or, most commonly, to designate a decrease in the number of the red cells or a diminution of the hæmoglobin. The expression *general anæmia* may, therefore, be regarded as expressing the same idea as that conveyed in oligæmia. The decrease in the total mass of blood may be due to a number of causes, and the following varieties may be distinguished:

Oligæmia Vera.—True oligæmia is due to a sudden loss of blood through hemorrhage. A loss of half of the total mass of the blood is invariably fatal, and hemorrhages of even less degree may cause death. The red cells may drop after a single large hemorrhage as low as two million. After such a loss of blood there is a rapid fall in blood pressure, the pulse becoming very small, frequent, and irregular. In cases of hemorrhage of slight degree, but continued through a long period of time, the deficiency is partly made up by an increase in the fluids of the blood, the true oligæmia becoming thus converted into a hydræmic oligæmia.

Oligæmia Hydræmica or Serosa.—An oligæmia with increase of water in the blood, the red cells and albumin being diminished, occurs after all hemorrhages, particularly in the case of oft-repeated or prolonged hemorrhages of slight degree, as in bleeding piles, excessive menstruation, etc., also in conditions characterized by loss of albumin, as in chronic nephritis, dysentery, chronic suppurations, prolonged lactation, tumor cachexias, scurvy, malaria, etc. The hydræmic condition of the blood leads to pathological changes in the blood-vessel walls, favoring the passage of fluids and the increased production of lymph (œdema). Hydræmia is, however, not the direct factor in the production of œdema, but only a favoring one.

Oligæmia Sicca (Inspissatio Sanguinis, Anhydræmia).—A thickening of the blood through loss of water may lead to a decrease of the total mass. Such a condition may occur in cholera, dysentery, severe diarrhœas, excessive sweating, insufficient supply of water, etc. The highest degree of oligæmia sicca occurs in Asiatic cholera. As a result of the circulatory disturbances thus produced, and an insufficient supply of blood to the nervous centres, the characteristic symptoms of severe anæmia may arise, although the total number of red cells and total amount of salts and albumin in the blood are not decreased. The thickened blood becomes tea-like, the blood serum is richer in albumin and in salts. The body tissues become very dry, and non-encapsulated serous exudates are resorbed.

Oligæmia Oligocythæmica.—A decrease in the total blood mass due to a diminution in the number of red cells (see *Oligocythæmia*).

Oligæmia Hypalbuminosa.—A decrease of the blood mass due to a decrease in the albumin of the blood. As a result of such loss of albumin the blood becomes more watery; the condition is therefore practically a form of oligæmia hydræmica. (See also *Blood, Anæmia, etc.*)

Aldred Scott Warthin.

OLIGOCHROMÆMIA.—A decrease in the amount of hæmoglobin in the blood. This is one of the commonest changes in the blood, and may occur either when the red cells are normal in number or in association with an oligocythæmia. A simple loss of hæmoglobin is the chief change in chlorosis and the secondary anæmias. In chlorosis the number of the red blood cells may be nearly normal, while the hæmoglobin may be greatly reduced, even to twenty or twenty-five per cent. or less. In the secondary anæmias the number of red cells is also diminished, but the hæmoglobin is reduced to a relatively greater extent; thus, for example, if the number of red cells be diminished to 2,500,000, the hæmoglobin is usually found to be lower than fifty per cent. The individual red cells are, therefore, deficient in hæmoglobin. This is shown microscopically by the presence of a central clear area in the red cell. This area may be of varying size and shape; in severe cases the hæmoglobin-containing portion of the cell may be reduced to a narrow ring, enclosing a clear and transparent central area. In very extreme cases some cells may contain no hæmoglobin at all

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(the so-called blood shadows). In other cases the central clear area may not be enlarged, but small vacuoles occur throughout the cell protoplasm; the hæmoglobin may be preserved in the central part, and around this there may be a clear ring of varying width. Often the central portion stains very dark with eosin, and such cells are sometimes mistaken by inexperienced observers for nucleated red cells. Inasmuch as the darker central area takes the eosin and not the nuclear stain the mistake is inexcusable. In still other cases no definite vacuoles or clear spaces are seen within the cells, but their deficiency in hæmoglobin is shown by their lighter color and lighter staining. On the other hand, in pernicious anæmia the amount of hæmoglobin is relatively higher than the red cells; as, for example, if the red cells are 2,500,000 the hæmoglobin is fifty per cent. or higher. As a rule, however, both red cells and hæmoglobin are greatly decreased in this disease. The explanation of the relatively high hæmoglobin content is found in the presence of numerous large red cells (macrocytes) containing more hæmoglobin than the normal red cell. This may be regarded as of a compensatory nature. A pathological oligochromæmia occurs in all forms of anæmia, whether due to hæmolysis or deficient blood formation. In the latter case the individual red cells may contain a normal amount of hæmoglobin, or even a greater amount. In severe anæmias the hæmoglobin may be reduced to ten per cent. or less, but it must be borne in mind that the estimation of the low percentages is attended by a greater or less error. A physiological oligochromæmia occurs in the new-born during the nursing period, in the mature female after menstruation, and in the later months of pregnancy and the post-partum period. (See also *Anæmia*, etc.)

Aldred Scott Warthin.

OLIGOCYTHÆMIA.—A diminution in the number of the red blood cells, due either to lessened production or to an increased destruction of the same. The condition is of very frequent occurrence and may be due to a great variety of causes.

A physiological oligocythæmia occurs in hibernating animals during the winter sleep; observations made upon the marmot showed a diminution of the red cells from 7,000,000 to 2,000,000 during the period from November to February. There is also, according to some observers, a slight physiological variation in man, the number of red cells becoming slightly lower toward evening. According to Vierordt, Limbeck, and others, the red cells begin to diminish within one-half to one hour after the ingestion of a full meal, the number being reduced between 250,000 and 750,000 per cubic millimetre, remaining so for a short time, and after two to four hours gradually reaching normal again. The diminution is more marked after the ingestion of large quantities of fluids, and is therefore regarded as due to the dilution of the blood resulting from the absorption of fluid. According to some observers the red cells are increased in number during fasting or starvation, but Raum and Grawitz noted a definite diminution of red cells in healthy fasting men. Normal menstruation does not reduce the number of the red cells. After delivery there is usually found a diminution of red cells lasting for from ten to fourteen days. Under ordinary conditions the post-partum oligocythæmia is slight.

Pathological oligocythæmia occurs after hemorrhage, and in many infections and intoxications. It is found constantly in prolonged fevers, in leukæmia, cachectic conditions, malaria, syphilis, poisoning with mercury or lead, and in carcinoma, particularly of the stomach. A condition of oligocythæmia may also be produced by many poisons, the most important of which are: aniline, nitrobenzole, pyrogallic acid, toluylenediamine, potassium chlorate, amyl nitrite, phallin, helvellic acid, muscarin, arsenic, antimony, picric acid, carbon disulphide, sulphuric acid, glycerin, abrin, ricin, etc. In icterus the presence of the salts of the bile acids in the blood gives rise to oligocythæmia. The venom of poisonous snakes causes extensive destruction of the red cells. In yellow fever there is also a very marked destruction of red cells. Pernicious anæmia is characterized by marked oligocythæmia resulting from the destruction of the red cells by some poison as yet unknown. It is not improbable that the disintegration of red cells and the setting free of hæmoglobin may give rise to certain bodies or ferments having a hæmolytic action. In the oligocythæmia associated with infectious processes the specific poisons produced by the infecting organs have in the great majority of cases a decided hæmolytic action. In certain conditions of the bone marrow the formation of red cells may fall below the normal, hæmatopoiesis not keeping pace with hæmolysis. On the other hand, in cases of increased hæmolysis the bone marrow may present evidences of increased blood formation, and in very rare cases there is a probable similar compensation on the part of the spleen and lymph nodes. The diminution of red cells in the blood of man may be so great as a reduction to 500,000 or less per cubic millimetre. Such severe oligocythæmia is characteristic of the later stages of pernicious anæmia, but may be caused by poisons. (See also *Anæmia*, *Hæmolysis*, etc.)

Aldred Scott Warthin.

OLIVE OIL.—Oleum Olivæ. *Sweet Oil. Salad Oil.* —"A fixed oil expressed from the ripe fruit of *Olea Europæa* L. (fam. *Oleaceæ*)," U. S. P.

The olive is a small or medium-sized tree, with a much-branched trunk and numerous slender branches. The bark is gray, the wood compact, rather hard, agreeably scented, and susceptible of a high polish. Its fine yellow color, variegated with brown, in addition to the above qualities, make it a favorite material for small wooden ornaments and pieces of furniture.

The leaves of the olive tree are white underneath with a layer of stellate hairs. The fruit, the well-known olive, is an oval, pointed drupe, about 2 or 3 cm. (1 in.) long, consisting of a firm, very oily mesocarp, and a spindle-shaped, hard putamen, containing a single long and narrow, also oily, seed. Its color when ripe is dull blue or purple, its taste bitterish and oily.

This valuable tree is a native of Asia Minor, Palestine, and other parts of the Levant, where its cultivation is of the greatest antiquity, as the Old Testament and numerous ancient records show. It was introduced into the Mediterranean countries of Europe and Africa also at an early date, and has become thoroughly naturalized in some of them. In the course of time it appeared in the warmer parts of South America and elsewhere in the tropics, as well as in California in this country.

The fruit of the olive has been improved in form and size, as well as flavor, by cultivation, and there are several well-distinguished varieties. The olive is one of the most important products of Spain and Italy.

For the table, olives are gathered while still green, but fully grown, soaked in water or sometimes in lye to remove their natural bitterness, and finally pickled in a simple or sometimes flavored brine. For the oil they are allowed to ripen, and then are ground and subjected to pressure.

The quality of the product depends upon nicety in every stage of the operation; for the best table oil, fine fruits of good varieties must be taken, and the pressing done at once, without heat; this yields a moderate quantity of very clear, light-colored, generally slightly greenish, pleasant-flavored oil, generally called "Virgin Oil," which is sold for table use. The remaining cake is then broken up and heated or mixed with boiling water and more strongly pressed, when a further product of darker and stronger tasting oil is obtained. This grade of oil, which is called "foots," can be used for cooking or for fuel. An easy way, finally, for obtaining a large yield of oil is to lay the olives in heaps until decomposition begins, when a very strong-smelling oil (*huile fermentée*) results.

Composition.—No other fruit contains so large a proportion of fixed oil as this; it amounts generally to over one-half, and in good qualities to almost three-fourths. Besides, the fruit contains considerable *mannit*, diminish-

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ing as it ripens and the oil increases. Olive oil of the quality required for medicinal purposes is thus described: "A pale yellow, or light greenish-yellow, oily liquid, almost devoid of odor, having a nutty, oleaginous taste, with a faintly acrid after-taste, and a neutral reaction. Specific gravity, 0.915–0.918. Slightly soluble in alcohol, but readily soluble in ether. When cooled to about 10° C. (50° F.), it begins to be somewhat cloudy from the separation of crystalline particles, and, at about 5° C. (41° F.), it begins to deposit a white, granular sediment; below 2° C. (35.6° F.), it forms a whitish, granular mass." The principal part, more than two-thirds, of olive oil is the liquid fat *olein*, or triolein; nearly all the rest is *palmitin*, with a little *stearin*, *butin*, and perhaps also *cholesterin*. Of the so-called "olive oils" in the American market the cheaper ones, even bottled and labelled in French as "Pure Olive Oil from Nice," etc., are at present almost entirely better grades of cotton-seed oil, and some of the more expensive sorts are said to be adulterated with it. This oil and other cheaper ones are also used abroad extensively as substitutes for or adulterants of this delicious and much-prized substance.

Action and Use.—This can be disposed of quite briefly, so far as its medical use is considered. Given internally, it is chiefly a fatty food, and is emulsified and absorbed as other fats are. It is slightly, only very slightly, laxative, and has no other physiological action. Locally applied it is a neutral protective from the atmosphere, as are other fats; but in this application it has given place somewhat to cheaper ones—suet, lard, cotton-seed oil, etc.,—and especially to the various *petrolatum* products.

It is rather frequently given as an injection, but *castor oil* is preferable for this purpose. Like most other fixed oils, it is destructive to insect life, and rectal injections and applications are often efficient in the treatment of ascarides. Many reports have been published of the efficacy of large quantities of olive oil, two to four gills at a dose, in favoring the removal of gall stones. A little cocaine may be added if there is a tendency to reject it. Its most extensive employment in medicine is perhaps in the composition of several liniments and of the pharmaceutical soaps; in this field it has also of late been replaced in this country by the cheaper oil from cotton seed.

Administration.—As a laxative, three or four tablespoonfuls are required,—a dose that is apt to disturb the stomach of one unaccustomed to oils. This, as stated above, may often be prevented by the use of gr. ¼ of cocaine, given just before the administration of the oil. As an injection, one or two teacupfuls, injected warm, and retained an hour or so and then followed by soapsuds, make a very efficient composition for relieving an overloaded rectum.

W. P. Bolles.

OLIVER SPRINGS.—Anderson County, Tennessee. Post-Office.—Oliver Springs. Hotel.

Access.—From Knoxville viâ Southern Railroad (formerly East Tennessee, Virginia, and Georgia Railroad), thirty-five miles northwest to springs.

The Oliver Springs and the small village of the same name are situated on the southern slope of the Cumberland range of mountains, where the counties of Anderson, Roam, and Morgan join their boundary lines. The surroundings of the resort are very pleasing, and the climate is of a genial, attractive character. The average summer temperature at the springs is 72° F., and of the winter 38° F., showing an unusually low variation. It is said that malaria has never been known to exist in the vicinity. There are nine mineral springs within the ten acres occupied by the hotel grounds. They have not been fully analyzed, but are said to contain iron, manganese, lithia, magnesia, and sulphur. They are used considerably for medicinal purposes, and, joined with the beautiful scenery, the pleasant climate, and a comfortable, new hotel, they serve to render this location a very attractive one for the health or recreation seeker.

James K. Crook.

OLYMPIAN SPRINGS.—Bath County, Kentucky. Post-Office.—Olympian Springs.

Access.—Viâ Lexington and Big Sandy Railroad to Mount Sterling, thence by stage.

These springs are ten in number, and are of the saline-sulphureted variety. The waters are promptly diuretic in their action. Analysis was made by Dr. Robert Peter in 1858, and again in 1887. Following is the result of the former analysis of the salt sulphur spring:

One United States Gallon Contains:

Solids.	Grains.
Magnesium carbonate	7.20
Iron carbonate	Trace.
Lime carbonate	13.93
Potassium chloride	10.67
Sodium chloride	166.01
Magnesium chloride	55.39
Lime sulphate	Trace.
Iron and bromide	Trace.
Alumina	Trace.
Silica	1.04
Water and loss	78.60
Total	332.84

Gases: Carbonic acid, sulphureted hydrogen, not estimated.

A re-examination of the waters in 1877 showed essentially the same results. The following additional ingredients were found in minute quantities:

Baryta carbonate.	Sodium iodide.
Strontium carbonate.	Sodium sulphide.
Sodium carbonate.	Boric acid.
Calcium chloride.	Phosphoric acid.
Lithium chloride.	Manganese carbonate.
Sodium bromide.	

Examination of the two other springs showed the presence of sodium carbonate in the proportion of twenty grains per gallon. One of them contains a little less than two grains of iron carbonate to the gallon.

James K. Crook.

OMENTUM, PATHOLOGY OF.—The term omentum (epiploön) is applied to the folds of peritoneum which connect the stomach with its neighboring organs, the liver, colon, and spleen. In structure similar to the mesentery, each omentum may be regarded as a special mesentery connecting the stomach with the organs named. They are usually designated respectively as: *gastro-hepatic* or *lesser omentum* (*omentum minus*); *gastro-colic* or *great omentum* (*omentum majus or epiploön*); and the *gastro-splenic* omentum.

The *gastro-hepatic* (stomach-liver) *omentum*, or small omentum, extends from the lesser curvature of the stomach and the adjacent first part of the duodenum to the portal fissure of the liver, enclosing between its two layers the hepatic artery, portal vein, bile duct, and associated structures, bound together by loose connective tissue.

The *gastro-colic* (stomach-colon) *omentum*, or great omentum, connects the greater curvature of the stomach and the adjacent first part of the duodenum with the transverse colon. It is the largest of all the peritoneal duplications, and is composed of four layers of peritoneum; it is much more voluminous than is necessary for the mere connection of the stomach and colon, and hangs down in front of the small intestines like an apron.

The *gastro-splenic* (stomach-spleen) *omentum* is a double fold of peritoneum passing from the dorsal surface of the stomach, near its left border, backward to the hilum of the spleen. It runs below into the gastro colic omentum. It is often called the gastro-splenic ligament. It contains the splenic vessels.

In structure the omental folds are composed of either two or four layers of the peritoneal membrane, a basement structure of very loose connective tissue, containing a remarkable number of blood-vessels and lymphatics, and more or less adipose tissue, the whole being covered with endothelium. Small lymph nodes are not infrequently found in the great omentum, less frequently in

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the gastro-splenic, but are almost constantly present in the lesser omentum. These usually show the structure of ordinary lymphatic glands, but hæmolymph glands also occur. Accessory spleens are of common occurrence in the gastro-splenic omentum.

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The great omentum is by far the most important, both physiologically and pathologically considered. That its function is of great importance, in so far as the protection of the peritoneal cavity is concerned, cannot be doubted. It usually contains a large amount of fat tissue, and this fact, taken in connection with its "coverlet" investiture of the small intestines, has led to the view, advanced by both Aristotle and Galen, and commonly accepted even to-day, that the organ is of service in preserving the heat of the body and protecting the intestines against chilling. Such function, doubtful as it appears, is of slight importance compared with the protective function of the omentum against intraperitoneal infection. The remarkable richness of the organ in blood-vessels and lymphatics—far in excess of the needs of the structure itself, if intended only for a protective covering—is structural evidence of the chief omental function. The vessels form a rich plexus throughout the connective tissue beneath the endothelial covering, the vessels themselves in many cases being separated from the peritoneal cavity by the endothelium alone. Numerous clinical observations tend to show that the transudation of lymph into the abdominal cavity or the absorption of lymph from the cavity is an important function of the omentum. Many writers hold that the omentum is a modified lymphatic ganglion. It has been shown experimentally that, after the removal of the omentum, animals are much more susceptible to intraperitoneal injections of micro-organisms than control animals whose omentums have not been removed. The inference may be drawn that micro-organisms obtaining entrance to the peritoneal cavity are taken up by the omentum and there rendered harmless or are killed.

In local traumatism, or after operations involving the peritoneum, in beginning peritoneal infection, local peritonitis from whatever cause, etc., the omentum is quite commonly found attached to the affected area, entirely surrounding it and shutting it off from the remainder of the peritoneal cavity. This occurs particularly in appendiceal and tubal disease, following the beginning of a local peritonitis, but it is also of very frequent occurrence over the surface of liver, spleen, intestines, etc. It would appear that the omentum is attracted to the diseased area; the location of such adhesions deep in the pelvis or in parts of the peritoneal cavity not usually occupied by the omentum would indicate such a movement of the omentum to the affected part. The slightest irritation in any part of the peritoneum is apparently sufficient to cause the omentum to attach itself to the affected area, and to shut off the focus of infection from the remainder of the peritoneal cavity. Even when microscopic changes are not visible, alterations of the intestinal wall permitting the passage of germs or of their products, are sufficient to cause such adhesions. The plastic exudate thrown out by the omentum at the point of lesion no doubt offers some purely mechanical protection against the spread of infection; it is also probable that the secretion poured out from the omental vessels has some bactericidal or antitoxic action. Furthermore, the bacteria received into the lymphatics of the omentum are either rendered less virulent or are destroyed

Malformations.—The great omentum may be entirely absent, or only incompletely developed. Variations in size and shape are common; partial defects of large size are not infrequent. Misplacements of portions of the organ are found in connection with congenital hernias. Congenital cysts of the omentum are of very rare occurrence.

Circulatory Disturbances.—The vascular relations of the omentum are such as to make the circulatory conditions of this organ dependent upon that of the neighboring structures. Inflammations of the gastro intestinal tract, hernias, obstructions, tumors, disturbances of the portal circulation affect the vessels of the omentum to a more or less marked degree.

Active hyperæmia of the omentum occurs in the early stages of epiploitis, also after the sudden diminution of abdominal pressure after the removal of ascitic fluid or of a tumor of large size.

General passive congestion of the omental vessels follows portal obstruction, either as the result of hepatic disease or of pulmonary or cardiac affections. The vessels of the great omentum may be markedly congested in advanced stages of cirrhosis, or in failure of compensation in valvular disease of the heart. In such cases the congested omentum plays a large part in the production of the associated ascites.

Advantage has been taken of the dilated condition of the omental vessels in cirrhosis of the liver, and of the fact that the omentum readily forms adhesions with other structures, by an attempt to set up a collateral circulation between the portal and the systemic veins by means of "*Morrison's operation.*" This consists in the establishment of an anastomosis between the vessels of the omentum and those of the anterior abdominal wall through artificially induced adhesions. The peritoneum is first rubbed, and the omentum sutured to the area so treated. It is at present too early to speak of the value of this procedure; but very favorable results have been reported. In a case operated upon by Lens, venous channels were demonstrable in the adhesions that had formed between omentum and peritoneum. Animal experimentation shows the possibility of the establishment of such a collateral anastomosis. Similar results may be obtained by adhesions formed between the diaphragm and the liver or spleen.

Hemorrhage.—Small ecchymoses occur into the omental tissues in extreme active or passive congestion, in severe cases of the acute infections, in sepsis, in epiploitis, fat necrosis, secondary carcinoma, hæmophilia, etc. Large hæmatomata are rare; they may occur in association with fat necrosis in cases of acute pancreatitis, or in severe epiploitis associated with appendicitis or salpingitis, or very rarely in hæmophilia.

Infarction.—Incarceration or torsion of the omentum may, by shutting off the blood supply, give rise to an anæmic necrosis. Ligation or thrombosis of the epiploic artery will produce the same result. In cases of resection of the omentum in herniotomy a thrombosis may be induced in the omental vessels which may extend to the gastric arteries. In cases in which the ligations are near the epiploic artery, anæmic ulceration of the stomach or hepatic infarction may occur, as the result of the extension of thrombosis into the gastric and hepatic vessels.

Œdema of the omentum is of frequent occurrence. It may be due to general or local passive congestion, obstruction of the portal circulation, epiploitis, etc. In acute epiploitis associated with general peritonitis and ascites the omentum may be very much swollen. As a rule, œdema of the omentum is manifest in the resulting ascites; the free interchange of fluid between the lymph spaces of the omentum and the peritoneal cavity relieves the omentum, so that it does not become swollen through the accumulation of fluid in its tissue spaces, until the collection of ascitic fluid in the peritoneal cavity reaches a certain degree of tension.

Ascites.—The omental function of lymph production and lymph absorption is directly connected with the development of ascites. All conditions favoring an increased formation of lymph by the omentum, as well as those preventing the absorption of peritoneal fluids, lead directly to ascites. Malpighi was perhaps the first to suggest that ascites may be caused by a pouring out of fluid from the omental vessels. In a case reported by Landgraf, an ascites intractable after fourteen tappings disappeared after the sloughing of a part of the great omentum which presented itself in an omental hernia. Similar cases have been observed. Eitel reports an interesting case of marked ascites which had been repeatedly tapped. A large tumor was found to be present in the upper part of the abdomen. On operation this was dis-

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covered to be the great omentum tightly rolled upon itself, its veins constricted and its circulation impeded. It was unrolled and the ascites was cured. The cause was attributed to the fact that the patient, a worker in a quartz mill, was in the habit of carrying a heavy box of mill product pressed against his abdomen. Other cases of a similar nature point to the omentum as a direct factor in the production of ascites.

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Hydrops Omenti.—The collection of fluid between the layers of the great omentum is so designated. This condition occurs more frequently in cases of ascites in children than in old individuals.

Chylous Ascites.—In cases of secondary carcinoma of the omentum or in chronic fibroid omentitis, the ascitic fluid may be white or milky, due to fat or albumin in suspension. The presence of these substances may be due to the fatty degeneration of desquamated endothelium or tumor cells, or may result from the obstruction of chyle vessels. In the former case, when little fat is present in the fluid, the condition may be designated as *pseudochylous ascites.*

Retrograde Changes.—Atrophy of the omentum, as shown by total or marked disappearance of its adipose tissue, occurs in cachexias and wasting diseases as a part of the general marasmus. Atrophy of the fibrous trabeculæ may also occur. Cases have been observed in which the atrophy of portions of the organ gives rise to large open spaces between its coarser trabeculæ.

Necrosis of the omentum may be caused by incarceration or torsion, by ligation or thrombosis of omental vessels, or it may be associated with gangrenous conditions of the intestines.

Fat necrosis of the omentum occurs in acute pancreatitis, in pancreatic carcinoma, and in association with fat necrosis of the abdominal fat elsewhere. The necrosed areas are yellowish-white, slightly elevated and opaque, and usually circular in outline. The omentum may look as if it had been touched with a hot iron. The necrotic areas may be hemorrhagic. In cases of longer standing lime salts may be deposited in the necrosed cells.

Amyloid has been reported as occurring in the walls of the omental blood-vessels.

Hyaline change of the walls of the omental arteries is found in chronic fibroid omentitis, in association with omental tuberculosis, in the neighborhood of inflammatory adhesions, etc.

Calcification may follow fat necrosis, or occur in old tubercles. In two cases of splenic anæmia associated with hepatic cirrhosis (Banti's disease) numerous small nodules of calcification were found by the writer throughout the abdominal fat.

Inflammation (*Omentitis* or *Epiploitis*).—Inflammation of the omentum is essentially a part of a more or less general peritonitis in the great majority of cases; but in certain instances the omental inflammation preponderates, or appears to be primary; and further, as mentioned above, localized peritonitis is almost always associated with a localized epiploitis, the omentum adhering to and shutting off the inflammatory process (see *Peritonitis*). The character of the epiploitis is the same as that of the general or local peritonitis with which it is associated, viz., *fibrinous, purulent, gangrenous,* etc. The omental process is, however, in all cases characterized by a greater tendency to proliferation and formation of granulation tissue than is the case with the other portions of the peritoneum. This is especially true of the localized forms of epiploitis with adhesion; the inflammatory process is essentially plastic in character (omentitis adhæsiva). As a result of very active inflammations there may be formed such large masses of granulation tissue in the omentum as to produce tumors which may be mistaken clinically for neoplasms.

Inflammatory Tumors of the Omentum.—As the result of such excessive production of granulation tissue in the inflamed omentum, there is not infrequently found a tumor-like thickening of the omental tissues. This may occur in any part of the abdomen, but is most frequent in the appendix region. The thickening of the omentum may be diffuse or nodular, often limited to the portion adherent to the peritoneum about the primary focus. In other cases the omentum may be rolled up tightly above the level of the umbilicus, forming a firm cylindrical mass extending across the abdomen. The tumor mass may develop very rapidly in acute processes, but more gradually in chronic inflammations. After the inflammation has subsided the tumor may disappear through the resorption of exudates and the contraction of the granulation tissue, and the omentum may become detached. In other cases, after the inflammation has disappeared, the tumor remains and the omental adhesions become hard and organized. In purulent cases the inflammation may persist, and a chronic tumor then remains, composed of an inflammatory focus (abscess) surrounded by thick omental adhesions of granulation tissue. In other cases, after the termination of the inflammation, the omentum becomes detached, the granulation tissue is converted into fibrous tissue, and the omentum is greatly changed in form by the production of diffuse or nodular fibroid thickenings (omentitis fibrosa). If there is much retraction of portions of the new fibrous tissue the omental tumor may be very small and irregular (omentitis fibrosa retrahens).

Inflammatory tumors of the omentum also follow laparotomy, in which either the normal or the inflamed omentum has been ligated and in part removed. Torsion of the omentum may also give rise to an omental tumor. In some cases, after an operation for strangulated hernia, the omentum has become inflamed, though not involved in the strangulation. In all these cases the inflammatory tumor develops slowly; in one-half of the recorded cases the period of development varied from one to four months, and in some cases the interval was much longer. The tumor is usually on the same side of the body as that upon which the operation was performed, its location depending upon the amount of omentum removed. It may or may not be adherent to the abdominal wall. The tumor is usually about the size of an orange, but may be much larger. When adherent to the wall the tumor is immovable; if non-adherent it may be moved upward or laterally, but not downward. The surface of the mass is usually smooth, the consistence firm. It is tender on pressure. It usually does not move with respiration, or only slightly. Percussion gives a dull tympanitic note, often completely dull. In the centre of the tumor may be found the ligatures used to tie off the omentum, and it is believed by some that the use of silk ligatures in such operations plays an important part in the development of the tumor.

Clinically, the inflammatory tumors of the omentum may be mistaken for ovarian tumors, misplaced liver or spleen, malignant growth of the intestines, etc. In certain cases they have been regarded as malignant neoplasms (sarcoma) even after microscopical examination. Coley mentions a case in which a portion of the omentum had been excised on account of its presence in a left inguinal hernia. The stump became inflamed, withdrew, and gave rise to a mass in the region of the splenic flexure. Malignant disease was suspected, the abdomen was opened, and a portion of tissue removed for examination. The diagnosis was "probable spindle-celled sarcoma." The patient died after a radical operation. The autopsy showed that the inflamed omental stump had become attached to the splenic flexure, and the section for microscopical examination had been cut from the very abundant inflammatory tissue.

In two cases in the writer's experience there were found, in the region of the appendix, large tumor masses that clinically presented characteristics of malignancy. Microscopical examination of tissue removed for diagnosis showed a very cellular granulation tissue, rich in blood-vessels, having relatively thick walls. In one case the diagnosis of "omental granulation tissue" was given. The patient recovered, and the tumor completely disappeared. In the other cases the first sections examined were prepared by a quick method for immediate diagnosis. The

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section showed a sarcomatous-like structure of round and spindle cells grouped around blood-vessels, suggesting an endothelioma. Study of the sections showed large numbers of plasma cells present, and the fact that all of the blood-vessels had relatively thick walls. A diagnosis of omental granulation tissue was then given. A year afterward the tumor was reported as having entirely disappeared. There can be but little doubt that some of the so-called disappearing malignant tumors of the abdomen belong to this class. The microscopical appearances of small bits of tissue removed for diagnosis may on first glance strongly suggest a sarcomatous growth. In the relatively thick sections obtained by means of the freezing microtome or by quick embedding methods the finer points necessary to a differential diagnosis are usually not sufficiently clear for a safe diagnosis, and it is from such sections that the diagnosis of sarcoma is usually made. The writer holds that in carefully prepared sections the differential diagnosis between such forms of richly cellular granulation tissue and sarcoma may be made without great difficulty. The presence of numerous plasma cells, the prominence of the small vessels, both in number and in size, their relatively thick walls, the hypertrophic character of their endothelium, the marked endothelial proliferation, the typical character of the mitosis, the presence of fibrin and small pus collections, are all points establishing the diagnosis of subacute or chronic development of granulation tissue. The presence of adipose tissue and coarse trabeculæ of fibrous tissue are also of service in fixing the origin as omental.

Omental Abscess.—An acute omental abscess may develop without the association of a general peritonitis or of any discoverable local change. In the majority of cases, however, the appendix is the seat of primary infection. Omental abscess may be associated with salpingitis, and very frequently follows laparotomies or herniotomy. In those cases in which the omental abscess is apparently of cryptogenic origin, or overshadows the primary lesion, it may be inferred that the resistance of the omental tissues had been lowered, or that the organ, through circulatory disturbances or for other reasons, has been unable to overcome the virulence of the bacteria taken up. The abscess may be found in any part of the abdominal cavity, but as the omentum is commonly rolled up, it lies usually above the level of the umbilicus. It may develop around ligatures which are used in tying off the omentum. The organ is reddened, thickened, and is usually adherent to the abdominal wall by a fibrinous exudate, which is most marked over the abscess. The latter not infrequently forms an encapsulated pocket of pus between the omentum and the anterior abdominal wall, and may extend into the tissues of the latter. The clinical symptoms are those of sepsis, with local pain and tumor. In many cases the abscess becomes chronic, a large amount of fibrous tissue is formed about the encapsulated area, the adhesions become hard and firm, and a gradual healing of the abscess may take place. A more or less generalized peritonitis may accompany the abscess. Occasionally the pus may break through into the intestine and recovery follow. Rupture into the peritoneal cavity may cause a severe general peritonitis which may be fatal.

Sequelæ of Omental Inflammation.—As a result of inflammatory conditions of the omentum there may arise adhesions between the organ and the various abdominal viscera; these may cause stenosis, or snaring off of portions of the bowel, obstruction of the ureter, pressure upon the common duct or pylorus, abnormal position of the pelvic organs, etc.

Progressive Changes.—Either fibrous or fatty *hyperplasia* of the omentum may occur in the portion of the organ included in hernial sacs. The hyperplasia may take on the character of a lipomatous growth. Cases have been reported of such hyperplasias in hernial sacs which reached half-way to the knees.

The remarkable capacity for *proliferation* possessed by the omentum has been taken advantage of in plastic operations in the abdomen. (For further details in regard to this part of the subject, the reader should consult the article next beyond this.)

Tumors.—Primary neoplasms of the omentum are rare. *Fibroma* and *lipoma* have been described. In the former class of cases the actual disease may in reality have been a localized fibroid thickening resulting from an inflammatory omental tumor. The so-called lipomatous growths have been, in the majority of cases, localized or diffuse fatty hyperplasias.

Of the primary malignant tumors reported as occurring in the omentum *endothelioma* and *myxosarcoma* are the forms whose origin in this organ is supported by observation; but it must be observed that the rarity of such cases, and the imperfect descriptions given, leave us very much in ignorance as to the occurrence and nature of primary omental tumors. In the older literature there are occasional reports of "*primary cancer*" of the omentum, "scirrhus of the omentum," and "primary colloid disease," "vesicular degeneration," "hydatid disease," etc. The exact nature of this peculiar growth of the omentum, apparently primary in some cases, cannot at present be stated. Primary epithelial growths (carcinoma) of the omentum of course do not occur. In some cases the growth may have been secondary to colloid carcinoma of the stomach or intestine, or to cystocarcinoma of the testis or ovary. In typical cases the omentum is greatly thickened; its surface is uneven, flocculent, and shreddy, this appearance being due to the projection of rounded villus-like masses of gelatinous material attached by shreds of tissue. The appearance strongly suggests hydatid disease of the placenta. On microscopical examination the mass of the omentum has a finely spongy texture of connective tissue enclosing masses of gelatinous material. Swollen cells are occasionally found in the spaces. If we exclude the cases of true *colloid cancer* or *cystocarcinoma, secondary* to primary tumors in other organs, there still appears to be a peculiar myxomatous growth of the omentum, which according to the most careful reports (Eve and others) must be classed as a *myxoma* or *myxosarcoma.* No proof of its endothelial origin exists. Matas has reported a case of primary myxosarcoma of the omentum with secondaries in peritoneum and accompanied by a mucoid ascites.

The flat or warty growths, originating from endothelium, may be primary in the omentum as well as in the peritoneum. Microscopically, the primary endotheliomata of the peritoneum consist of cords or strands of cells in the connective tissue beneath the endothelial covering. The cords of cells appear to follow the lymph vessels. The growth may originate from the superficial layer, or from the endothelium of the lymph vessels.

Omental *cysts* have also been reported, and have been interpreted as "*simple serous cysts*," "*distended lymph vessels*," "*congenital multilocular cystoma*," etc. It is not improbable that the latter variety was a primary tumor of the ovary, which after becoming adherent to the omentum, had been freed from its original attachments. Such a process has undoubtedly occurred in the case of the so reported *dermoid cysts of the omentum.* Though primary dermoids of the omentum may occur, it is highly probable that those observed have originated from primary ovarian dermoids in the manner described.

Secondary malignant growths of the omentum are of very common occurrence; they represent most frequently carcinoma metastases from primary growths in stomach, intestine, gall-bladder, pancreas, ovaries, testis, uterus, and prostate. A number of cases of melanotic sarcoma of the omentum have been reported. While the growth, in several of these instances, was regarded as primary, it undoubtedly was metastatic from primaries in the skin or choroid.

Pseudomyxoma.—The omentum as well as the general peritoneal surface may be involved in the process known by this name. It is due to rupture of an ovarian cystoma, the discharge of mucoid or colloid material into the peritoneal cavity, and the organization of the latter by proliferation of the peritoneal tissues.

Parasites.—*Echinococcus* of the omentum has been re-

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ported. After rupture of a primary hydatid cyst into the peritoneal cavity the omentum may be secondarily involved in connection with the remainder of the peritoneum.

Tuberculosis of the omentum is of relatively common occurrence. In many cases the infection of the peritoneum appears to be primary in the omentum. The thickened omentum may be tightly rolled up, forming a tumor-like mass which may be mistaken for a neoplasm. In primary tuberculosis of the female genital tract, large tubercles may be found in the omentum. (See also *Peritonitis, Septic and Tuberculous.*)

Syphilis.—A fibroid omentitis has been observed in congenital syphilis, and in connection with syphilitic cirrhosis and fibroid splenitis.

Foreign Body.—A case is reported of an encysted needle being found in the omentum. Gauze, sponges, ligatures, or foreign bodies left in the peritoneal cavity during laparotomy may become included in omental adhesions.

Aldred Scott Warthin.

OMENTUM, SURGERY OF.—The omentum is composed of two layers of peritoneum which are derived from the anterior and posterior walls of the stomach. They pass downward in front of the abdominal organs into the hypogastric region, and are reflected backward upon themselves and pass upward until they reach the transverse colon. There they separate, and after covering this portion of the intestine they come into contact behind it, forming the transverse mesocolon. Thus the omentum is really made up of four layers, but in adult life the layers cannot be wholly separated, although this construction gives to the omentum a very loose and lobular character. In almost all persons the omentum contains a good deal of fat, and in individuals who are very stout the quantity of fat is proportionally large.

The function of the omentum under normal conditions seems to be to afford protection to the underlying coils of small intestine, and also to facilitate their movements. Under pathological conditions it has the further function of applying itself to any wounded surface of the peritoneum within reach, so that it may even be able to occlude a perforation and prevent fatal escape of intestinal contents. By reason of its large serous surface it doubtless aids materially in the resorption of extravasated fluids from the peritoneal cavity.

The lesions of the omentum which are of surgical importance are traumatic, inflammatory, parasitic, and neoplastic.

Traumatisms.—If the abdominal cavity is opened, for example, by a stab, the omentum will often be found presenting itself in the wound. It frequently serves a useful purpose by protecting other more important organs from exposure to infection and traumatism in an open wound. It may even protrude through a stab wound which opens both the lower part of the pleural cavity and the peritoneal cavity through the diaphragm. It is the most common content of a hernial sac. The omentum which is thus prolapsed into a wound may be uninjured, or some of its vessels may have been opened by the traumatism, or it may become inflamed, or it may become gangrenous either on account of the traumatism or secondarily through its becoming strangulated in the wound.

Intraperitoneal hemorrhage from a larger omental vessel may prove fatal because the thin walls of its vessels favor long-continued bleeding. In excising prolapsed or injured or adherent portions of omentum the surgeon should be careful to see that every bleeding vessel is secured by a ligature. If the omentum which presents itself in a wound is uninjured and the wound itself is clean, the omentum may be cleansed and replaced; otherwise it should be cut away.

Inflammation.—The simplest form of inflammation which can affect the omentum is of a traumatic character. This is most frequently seen in connection with an omental hernia, where repeated slight traumatisms give rise to local fibrinous peritonitis with the formation of adhesions. The hernia will then become partly or wholly irreducible and the omentum will be still more exposed to slight injuries. This condition is often seen in inguinal and umbilical herniæ. In operating upon such herniæ, it is customary to excise portions of omentum which are badly matted together by adhesions, or whose surfaces are deprived of their peritoneum when the omentum is torn loose from the hernial ring. The removal of more or less of the omentum does the patient no harm, but the stump of the omentum may give rise to serious trouble. It sometimes retracts, and becomes adherent to the abdominal wall or some portion of the intestine, while adhesions take place about it to such an extent that a mass is formed that has more than once been mistaken for a tumor. In one case within the knowledge of the writer a section of this new-formed fibrous tissue was removed and was pronounced by a well-known pathologist to be a spindle-celled sarcoma. In consequence an extensive resection of the descending colon, to which the omentum was adherent, was performed, and from the indirect effects of this operation the patient died. Such an inflammatory tumor in the omental stump will, like all ciatricial tissue, decrease in size in the course of time, but it may give the patient a great deal of trouble during the process, and the adhesions produced by it may continue to give trouble long after the inflammation has subsided.

Suppurative inflammation may develop in the omental stump, usually as the result of an infected ligature. If general peritonitis is avoided, an abscess may be produced within the omentum. The omentum under such circumstances will attach itself to the surrounding parts, including the anterior abdominal wall, so that it may be possible to open the abscess without entering the general peritoneal cavity.

The more chronic inflammations, such as syphilis, tuberculosis, and actinomycosis, may involve the omentum, usually in common with other portions of the abdominal cavity. Omental echinococcus is also known, and in very rare instances an echinococcus cyst of the omentum reaches a great size, although the lesions in other portions of the peritoneum are insignificant.

Tumors.—A few primary tumors of the omentum have been reported. They are for the most part lipomata, sarcomata, or cystic tumors of congenital origin. Dermoid cysts and teratomata are thus explained. There are also acquired cysts of the omentum of a serous or hemorrhagic character, the latter being secondary to hæmatoma. Thus the tumors of the omentum are similar to those of the mesentery.

In addition to these primary tumors of the omentum secondary nodules may develop on its surface and within it in case of malignant disease of other abdominal organs, while tumors of the transverse colon may grow downward into the omentum so that they simulate omental tumors. A careful examination after the abdomen is opened will usually show the starting-point of such a tumor.

An omental tumor is characterized by a great range of mobility as long as adhesions do not exist. For this reason a small cyst may easily be mistaken for a solid tumor. As tumors of the mesentery often have a great mobility, it will scarcely be possible to differentiate them from omental tumors before the abdomen is opened.

The removal of an omental tumor requires no special technique. On account of the thin walls of the vessels all bleeding should be stopped by ligature before the abdomen is closed. Mass ligatures cannot well be avoided, but the amount of tissue included in each ligature should be small. It is also worth while to approximate the peritoneal surfaces of the omentum by a continuous catgut suture so as to prevent the formation of extensive adhesions. If an echinococcus or epithelial cyst cannot be removed *in toto*, it should be sutured into the abdominal wound and drained.

Omental Grafts.—The omentum has occasionally been used to cover a defect in the peritoneum which could not be closed by direct suture or as an additional safeguard

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to cover a weak suture of the stomach or intestine. It is especially adapted for such a purpose because of its extensive peritoneal surface, its great mobility, and its free blood sepply. Furthermore, the omentum can be sacrificed without especial injury. The advantage of covering all wounded surfaces within the abdominal cavity with peritoneum has not been generally recognized, yet when this is done repair is hastened and the risk of sepsis is lessened as truly as is the case in covering wounded surfaces of the body with skin, while within the abdominal cavity a raw surface has a third disadvantage not possessed by external raw surfaces in that it gives rise to adhesions more or less dangerous, according to their situation. Such adhesions can be partly or wholly avoided if the raw surface is covered with peritoneum. The omentum has been used with success to supply peritoneal grafts, which may remain attached to the omentum, or may be wholly cut from it and stitched over the wounded surface like a skin graft over a raw external wound. The wound in the omentum itself should of course be closed by suturing the cut edges of the peritoneum.

Edward Milton Foote.

ONYCHIA. See *Hands and Fingers, etc.*

OPEN-AIR TREATMENT OF PULMONARY TUBERCULOSIS.—The so-called "open-air" treatment of pulmonary tuberculosis has been adverted to frequently in this Handbook, notably under *Falkenstein*, *Goerbersdorf*, and *Health Resorts*. It is the established treatment of pulmonary tuberculosis at the present day, and is most completely exhibited in the sanatoria. In a word, it consists in affording the patient pure outdoor air to breathe continuously, both night and day, keeping him out of doors by day and having his bedroom windows open by night, or in many cases and places having him sleep also out of doors. It is hardly necessary to add that at the same time due attention should be paid to diet, rest, hydrotherapy, and to all that pertains to the hygienic well being of the patient; hence this method is also, and perhaps more correctly, termed the "hygienic-dietetic" treatment. This treatment has been brought to such a degree of perfection that it may almost be said to be independent of climate, that is, it can be successfully carried out wherever there are pure air free from dust, protection from wind, and a moderate amount of sunshine—climatic conditions which are obtainable almost everywhere outside of large centres of population. It seems a very simple matter to conduct such a treatment, but experience has shown that constant supervision is necessary, aided by the example of others, in order to keep the patient up, day after day, summer and winter, to this treatment in all its strenuousness; hence the great value of sanatoria and their constant and rapid increase in number. Even though this treatment is in a measure independent of climate, it is not to be asserted that all climates are equally valuable, for it is obvious that the greater the number of favoring climatic elements, the more perfectly the treatment can be conducted, and the more successful it will be. Hence such resorts as Davos, Colorado Springs, Idylwild (California), Asheville, Aiken, and many others of superior climatic excellence are especially favorable for this mode of treatment, provided the other essential factors, such as diet, etc., are at hand. It may be thought that this treatment can be accomplished by simply instructing the patient to keep out of doors; nothing could be more fallacious than this. In the first place, the patient will not keep out of doors all day of his own volition. If he is out for a few hours each day, he is prone to think that he is fulfilling his instructions. Further, he is too often left to himself to determine whether he shall remain at rest or take exercise while in the open; generally he does the latter, sometimes from ignorance, sometimes for the want of any proper place where he can remain at rest. Here, again, comes in the value of the sanatorium where all these details are carefully looked after.

The theory of the outdoor treatment is, of course, evident; the object is so to improve the nutrition of the pulmonary tissue and general system, and so to harden the patient and thereby increase his resisting power that he will no longer present a favorable soil for the tubercle bacillus. It is also claimed for this treatment that it will increase tissue metabolism, so that fibroid transformation of tuberculous lung tissue may be hastened, or the encapsulation of caseous areas effected.

Are all cases of pulmonary tuberculosis suitable for the open-air treatment? Obviously not, for all cases are not susceptible of an arrest or improvement; and the object of this treatment is to *cure*. Although it is difficult, if not impossible, in many cases and in the various stages of the disease, to form a probable prognosis, still in general it may be said that advanced cases with mixed infection and septic symptoms—cases of very extensive disease, those in which the tuberculous process is accompanied by acute symptoms, or those in which the recuperative power seems to be lacking, and the whole system appears to have collapsed—are unfavorable cases and unfitted for the severe régime of the open-air treatment. Fresh air, of course, should be afforded all cases, as to everybody else, sick or well; but this can be done in a well-ventilated room, where the patient is made comfortable and kept at rest. If some of these apparently hopeless cases later exhibit more favorable symptoms and develop greater recuperative power, they then can more properly be subjected to the open-air treatment.

Lest there may be some misunderstanding, it is well again to state what may seem self evident, viz., that the open-air treatment in all its rigorousness means practically a continuous outdoor existence. Day after day in all kinds of weather one must be exposed to the open air, and the windows of his sleeping-room must be kept open day and night, summer and winter. This does not mean that one shall sit out in a rain or snow storm, but on a veranda for example, which affords shelter from the storm and wind and yet is open to the air. The writer, for example, had a patient at Rutland, Mass., who, during a New England winter, spent eight hours daily out of doors, always slept in a cool room, with open windows, and bathed his chest every morning with cold water.

In Colorado Springs it is quite generally the custom for consumptives to sleep out of doors, even in winter, with face and body well protected. This is more readily done in warmer climates, as in Phœnix, Arizona, for example, where the practice is quite general. It is also a practice, with some, to sleep with the head out of doors, well protected, while the body is within. As a rule, the vitality and bodily vigor of a consumptive are low, and hence the greater part of the time out of doors is spent at rest, best on a reclining or ship's chair. One of the common sights at the German sanatoria is the "Liegehalle" or piazza, where are long rows of patients in reclining chairs. Dettweiler insists upon almost complete rest in the open air, while other phthisio-therapeutists permit their patients who have no fever to take a limited amount of exercise. As has been said above, a well-equipped sanatorium affords the best opportunity for taking the open-air treatment, and medical supervision is always at hand to insist upon it; at the same time it is practicable, in very many cases, to devise at the home of the patient an arrangement for this treatment. A properly protected veranda, preferably facing the south; a tent with a wooden floor; a country barn with the large doors open; a shed or wooden chalet simply and cheaply constructed, serving also as a sleeping-room by night;—all of these afford opportunities for the "treatment." If the physician is at all ingenious he will readily invent some way by which this can be accomplished, for there is almost always something in or about the patient's house that can be utilized for this purpose.

It is hardly necessary to say that a patient used to an indoor life, as the great majority of them are, must be somewhat gradually accustomed to a constant open-air exposure, but it is marvellous how perfectly they establish the habit, and how complete is the endurance which they attain. Knopf ("Prophylaxis and Treatment of

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Pulmonary Tuberculosis") quotes Andvoid, of Tonsaasen, Norway, as saying that he leaves his patients on their chairs, wrapped in furs, for from five to nine hours a day at a temperature of 25° C. (– 13° F.).

The number of hours during which the patient remains out of doors depends largely upon the location and latitude of the resort. At Davos, for example, the sun rises late and sets early, on account of the surrounding mountains, so that a winter's day is only about four or five hours long. In Falkenstein the patients remain out of doors for from seven to ten hours a day all the year through; at Rutland, Mass., for about eight hours; at Colorado Springs for from seven to eight.

The effects upon the patient of this prolonged stay in the open air are striking. Appetite and weight increase; cough and expectoration diminish; and if there is any rise of temperature at any part of the day, this is likely soon to disappear. The patient also experiences a sense of well-being and invigoration, together with mental exhilaration. After a course of open-air treatment one is no longer content to live indoors or sleep with closed windows.

It may be pertinently asked if patients do not catch cold under this constant open-air exposure. On the contrary, experience has proved that they are less likely to do so than when they live under constant protection with the consequent unavoidable exposure to impure air. The constant exposure to pure germless air, however cold, when one is properly clad, does not render one susceptible to catching cold, as Nansen so strikingly proved on his Arctic expedition.

In conclusion, it is well to reiterate that the open-air treatment is not the whole treatment of pulmonary tuberculosis. In addition, there must be an abundance of nutritious and properly prepared food; rest; a most careful avoidance of over-exertion either mental or physical; moderate exercise under careful supervision, and in suitable cases; and due attention to the skin by the use of various hydrotherapeutic measures. In brief, all the hygienic measures conducive to the invigoration of the general system, must be adopted. *Edward O. Otis.*

OPHTHALMIA, PURULENT. See *Conjunctiva, Affections of.*

OPHTHALMOMETER.*—An instrument for measuring the curvature of the refracting surfaces of the eye.

Thomas Young (1801)[1] was the first investigator to attempt accurate measurements of the curvature of the cornea in the living eye. By measuring the diameter and the prominence of the cornea, he found the chord and versed-sine of an arc of a corneal meridian; from these data he calculated the radius of curvature. Young's estimate of the curvature of the cornea agrees very closely with the results which have since been obtained by more refined methods.

Kohlrausch (1840)[2] measured the image of a distant object viewed by reflection at the anterior surface of the cornea, as in a convex mirror, and thus laid the foundation of ophthalmometry in the modern sense. The object used by Kohlrausch was a pair of candle flames placed behind small openings in an opaque screen. The images of the two bright points were viewed through a small astronomical telescope, constructed for observing at a distance of from two to three feet, and their positions marked by two adjustable spider lines in the eyepiece. The length of the image (distance separating the images of the two points of light) was then read, through the telescope, on a finely divided scale placed as nearly as possible at the distance at which the image had been observed.

Now the object and the image lie at conjugate foci of the cornea, considered as a convex mirror, and the relations of the two focal distances is expressed by the equation

$$\frac{1}{f'} - \frac{1}{f} = \frac{2}{r};$$

or

$$r = 2f \cdot \frac{f'}{f - f'}; \qquad (1)$$

in which

r = the radius of curvature of the cornea;

f = the distance of the object from the surface of the cornea;

f' = the distance of the image from the surface of the cornea.

As the observing distance is taken at between two and three feet, and the object is stationed at as great or at a greater distance, f is quite large in comparison with f'; it is admissible, therefore, without sensibly affecting the accuracy of the equation, to disregard f' in the denominator of (1) and to write the equation in the simplified form:

$$r = 2f \cdot \frac{f'}{f} = 2f'.* \qquad (2)$$

Again, the length of the object is to the length of the image in the ratio of their respective distances from the centre of curvature of the convex mirror (cornea).

Designating these distances by g and g' respectively, we have

$$\frac{g'}{g} = \frac{\text{length of image}}{\text{length of object}}.$$

But $$g' = r - f'$$

and $$g = r + f'$$

whence $$\frac{r - f'}{r + f} = \frac{\text{length of image}}{\text{length of object}};$$

or $$r - f' = (r + f) \cdot \frac{\text{length of image}}{\text{length of object}}. \qquad (3)$$

In the right-hand member of (3) neglecting r, which is small compared with f, and in the left-hand member of (3) substituting for f' its value $\frac{1}{2}r$ derived from (2), we have, as a sufficiently close approximation, the simplified equation

$$r = 2f \cdot \frac{\text{length of image}}{\text{length of object}}.\dagger \qquad (4)$$

* The writer desires particularly to acknowledge his indebtedness to Dr. John Green, of St. Louis, for assistance most kindly rendered in revising the present article for the press.

* To test the error involved in the use of this simplified equation, compare the values of r derived from (1) and (2) in a special case. For example:

Let $f = 0.8$ metre = 800 millimetres,
Let $f' = 4$ millimetres,

then by (1)

$$r = 1600 \cdot \frac{f'}{796} = 2.01\,f';$$

and by (2)

$$r = 1600 \cdot \frac{f'}{800} = 2.00\,f'.$$

The value of r by (2) is therefore too small by $0.01\ f' = 0.01 \times 4$ millimetres = 0.04 millimetre, which is within the limit of error in observation.

† To test the error involved in the use of (4) compare the values of r derived from (3) and (4), in a special case. For example, as in the previous note:

Let $f = 0.8$ metre = 800 millimetres,
Let $f' = 4$ millimetres.

Then by (3) [using for r in the right-hand member and for f' in the left-hand member their values as given by (1).]

$$r - \frac{r}{2.01} = (800 + 8.04) \cdot \frac{\text{length of image}}{\text{length of object}} \text{ millimetres},$$

whence

$$r = 1608.08 \cdot \frac{\text{length of image}}{\text{length of object}} \text{ millimetres},$$

and by (4)

$$r = 1600 \cdot \frac{\text{length of image}}{\text{length of object}} \text{ millimetres}$$

The value of r by (4) is therefore too small by

$$\frac{8.08}{1600} = 0.005 = \text{about } \tfrac{1}{2} \text{ per cent}$$

It should be further remarked that the use of the equation

$$\frac{1}{f'} - \frac{1}{f} = \frac{2}{r}$$

is permissible only on the assumption that the diameter of the convex surface at which rays are reflected to form the virtual image is small

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The results obtained by Kohlrausch, also by Senff (1846),[3] who carried the investigation somewhat further, correspond very closely with measurements which are now generally accepted. The later development of ophthalmometry has been in the direction of perfecting the instrument for purposes of scientific investigation, and of adapting it to clinical use.

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The ophthalmometer was perfected, as an instrument of scientific research, by Helmholtz (1854).[4] With the addition of a large graduated circle, arranged to carry lamps, it was employed by Donders and Middelburg to measure the curvature of the cornea in different meridians.

The ophthalmometer of Helmholtz is essentially an adaptation of the heliometer of Clausen (1841).[5] A divided plate of thick glass with parallel surfaces is mounted in a cubical box fixed in front of the objective of a small astronomical telescope constructed for observing at a distance of from 0.5 metre to 1 meter, so that each half of the glass plate covers half of the objective. The two halves of the divided plate are arranged to turn in opposite directions on a common axis at right angles to the axis of the telescope, and the amount of rotation is read to tenths of a degree on a graduated disc fitted with a vernier. So long as the two halves of the glass plate are in the same plane, perpendicular to the axis of the instrument, an object seen through the telescope appears without displacement and single; but any rotation of either half of the plate gives rise to a displacement of the image formed by the corresponding half of the objective, and this displacement increases with the rotation. As the two halves of the plate are rotated simultaneously in opposite directions the displacement of the images is also in opposite directions, and the total displacement is double what it would be if either half of the plate were rotated separately through the same angle.

The object (three points of light disposed in a row) as seen by reflection at the surface of the cornea is focussed by the telescope through the glass plates in the zero position—*i.e.*, with both plates set at right angles to the line of vision. The graduated disc is then turned until the two images are seen touching each other, but not overlapping, in which position of the plates the displacement of each image is exactly equal to half the length of the image. The amount of displacement (x) of either image depends on the index of the refraction (n) of the glass of

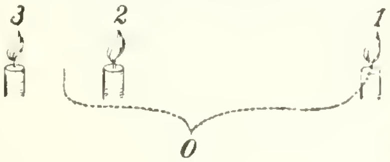

FIG. 3634.

which the plate is made, the thickness (h) of the glass plate, and the angle (ϕ) through which the plate has been rotated as expressed in the equation

$$x = h \cdot \frac{\sin(\phi - \phi')}{\cos\phi'},$$

the value of ϕ' being dependent on that of ϕ, as expressed in the equation

$$\sin\phi = n \cdot \sin\phi';$$

in comparison with the radius of the sphere. This implies that the image must be small in comparison with the radius of curvature of the cornea, or, what amounts to the same thing, that the object must be small in comparison with its distance from the observed eye.

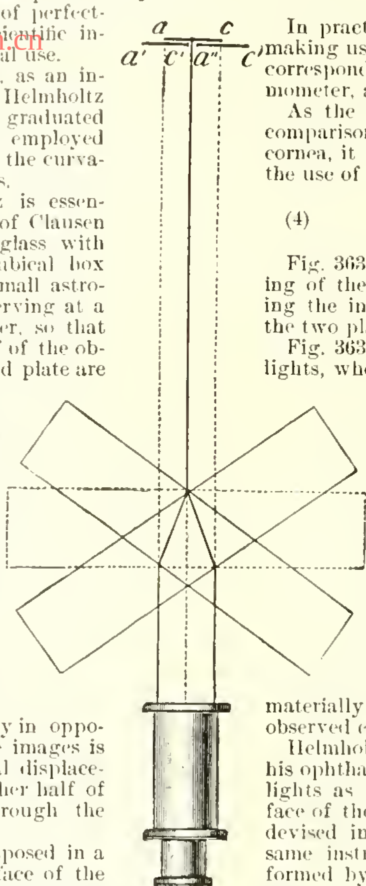

FIG. 3633.

as the displacement of each image is equal to half the length of the image, we have

$$\text{length of image} = 2x = 2h \cdot \frac{\sin(\phi - \phi')}{\cos\phi'}. \qquad (5)$$

In practice all calculation is dispensed with by making use of a table of successive values of $2x$ corresponding to different readings of the ophthalmometer, as ascertained by experiment.

As the distance of the object is quite large in comparison with the radius of curvature of the cornea, it is admissible to calculate the latter by the use of the simplified equation

$$(4) \qquad r = 2f, \frac{\text{length of image}}{\text{length of object}}.$$

Fig. 3633 shows the arrangement and the working of the glass plates, a' c' and a'' c'', representing the image a, c, as doubled by the rotation of the two plates in opposite directions.

Fig. 3634 shows the arrangement of the three lights, whose double images are viewed by reflection at the surface of the cornea; the image of 1 is brought by the rotation of the plates into a position midway between 2 and 3, as shown in Fig. 3634.

It will be seen from (5), also from inspection of Fig. 3633, that the size of the image is determined by the amount of rotation of the plates as indicated by the reading of the graduated disc, and is independent of the observing distance; also that, from the principle of construction of the ophthalmometer, the measurements may be made with great accuracy and without being materially impeded by slight movements of the observed eye.

Helmholtz also made direct measurements, with his ophthalmometer, of the real image of a pair of lights as seen by reflection at the posterior surface of the crystalline lens, and by an ingeniously devised indirect method he measured with the same instrument the much fainter virtual image formed by reflection at the anterior surface of the lens. By repeated measurements made upon the same eye in a state of accommodative relaxation and in accommodation for the near, he obtained the necessary data for calculating the radii of curvature of both surfaces of the lens in each of these two conditions. The measurements of Helmholtz were repeated with some modifications of the technique by H. Knapp (1860).[6] Knapp also measured the curvature of the cornea, mostly in the horizontal and vertical meridians, in a series of cases of astigmatism (1862).[7]

To adapt the ophthalmometer to the measurement of the curvature of the cornea in any required meridian,

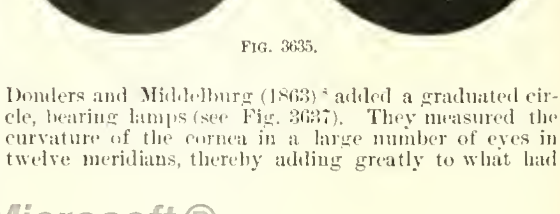

FIG. 3635.

Donders and Middelburg (1863)[8] added a graduated circle, bearing lamps (see Fig. 3637). They measured the curvature of the cornea in a large number of eyes in twelve meridians, thereby adding greatly to what had

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been previously known regarding the different forms of astigmatism.

Coccius (1867)[9] substituted a fixed plate cut from a doubly refracting crystal of Iceland spar for the movable glass plates used by Helmholtz. The amount of displacement of the image formed by the extraordinarily refracted rays is determined by the thickness of the plate, and is constant; the size of the object (distance separating the lights) is therefore varied, until the two images are seen to touch each other without overlapping. The radius of curvature of the cornea is found from the simplified equation:

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$$(4) \qquad r = 2f \cdot \frac{\text{length of image}}{\text{length of object}}.$$

The ophthalmometer of Javal-Schiötz (1881)[10] is especially designed for the clinical investigation of the curvature of the cornea in all meridians, and is admirably adapted to its purpose. Two strongly illuminated targets (*mires*) of white enamel replace the lights, and the doubling of the image is effected by means of a doubly refracting prism of Iceland spar, which is achromatized, and at the same time a little more than neutralized for the ordinary rays by the addition of a prism of flint glass turned in the opposite direction. With this construction of the prism, the two images of the pair of targets, formed, the one by the ordinary and the other by the extraordinary rays, are displaced equally in opposite directions; the aggregate displacement of the images for the distance at which the eye is observed is 3 mm. The two targets (*M M*, Fig. 3637), are arranged to slide on a graduated arc of 0.35 metre radius, turning with the tube of the telescope. The head of the patient is supported by the head-rest, so that the centre of curvature of the cornea shall lie approximately at the centre of curvature of the arc. A more exact adjustment of the distance is then secured by moving the telescope, with its stand, until the doubled images of the two targets are seen sharply defined by reflection at the surface of the cornea; the telescope is constructed for distinct vision at the distance of the image, which is formed about 4 mm. behind the centre of the cornea. The doubly refracting prism is in the part of the tube marked *C W*, and the meridian in which the arc and targets stand is read on the graduated disc at *E*. The eye under examination is directed upon the end of the telescope; the other eye is covered by the pivoted screen *P*.

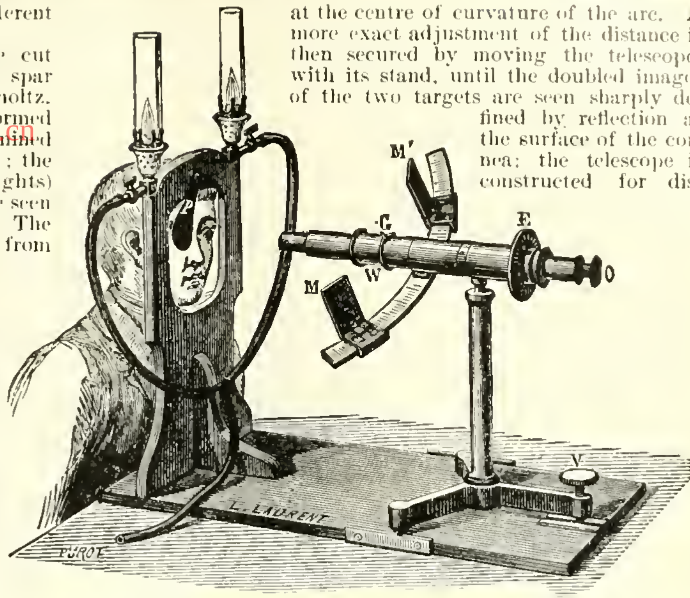

FIG. 3637.—Ophthalmometer of Javal-Schiötz, Original Model.

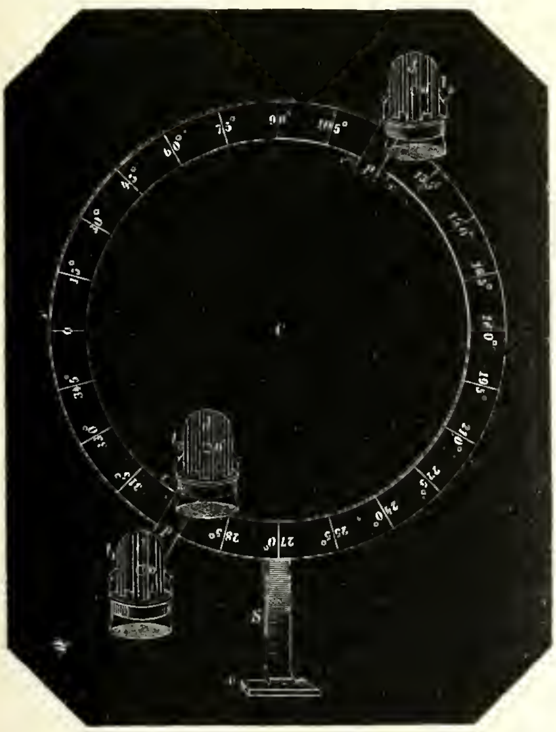

FIG. 3636.

As the effect of the doubly refracting prism (at the constant distance, $f = 0.35$ metre, of the targets from the eye) is to separate the two images exactly 3 mm., it is evident that when the length of the object (chord *M M*, separating the outer sides of the two targets) is so adjusted as to allow the two images to touch each other without overlapping, the length of the image must be just 3 mm. We have then, approximately,

$$(4) \qquad r = 2f \cdot \frac{\text{image}}{\text{object}} = 700 \cdot \frac{3}{\text{chord } M\,M} \text{ millimetres.} = \frac{2100}{\text{chord } M\,M} \text{ millimetres.*}$$

It will be observed that in this solution, $2f$ ($= 2 \times 0.35$ metre $= 700$ mm. and *image* ($= 3$ mm.) are constants.

* It will be remarked that, by the construction of the Javal-Schiötz ophthalmometer, the distance of the targets from the observed eye is rather small, and the image is rather large in comparison with the radius of curvature of the cornea (see page 363, footnote). In the use of equation (4) there is, therefore, a considerable margin of error, though not enough to detract from the usefulness of the instrument in clinical work.

It will be remarked that r, by this solution, is the radius of a circular arc whose chord measures 3 mm. which arc is assumed to be of the same curvature as a section of the corneal surface by a plane passed through the visual axis and the axis of the telescope. But the configuration of the cornea is approximately that of a segment of a prolate ellipsoid, and supposing the axis of this ellipsoid to coincide with the axis of the telescope, r will be the radius of a circle whose curvature is equal to that of the elliptical section of the cornea at the two points in which the direction of the reflecting surface determines the length of the image, *i.e.*, at two opposite points on the ellipsoid each 1.5 mm. distant from its axis. Under these conditions it is evident that r will be greater than the radius of curvature of the cornea at its centre.

As a rule, the visual axis does not coincide with the axis of the corneal ellipsoid, but makes an angle with it (angle α), which angle is sometimes as great as 12°. The axis of curvature of the cornea is, therefore, not ordinarily in a line with the axis of the telescope, and the two points in which the direction of the corneal surface determines the length of the image are not symmetrically placed with reference to the axis of the ellipsoid. As the curvature of the ellipsoid at these two unsymmetrical points is unequal, it cannot be represented by a spherical surface. In any case, however, the value of r by equation (4) is greater than the radius of curvature of the cornea at its centre.

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consequently r (the radius of curvature of the cornea) is an inverse function of the chord $M M'$. The length of this chord is read from the graduation on the arc. The radius of curvature of the cornea in different meridians

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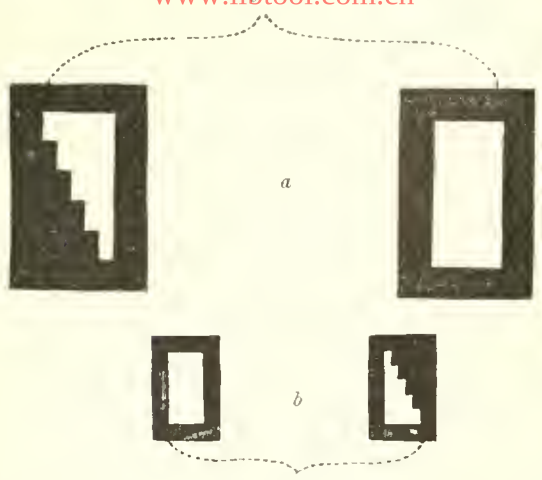

FIG. 3638.—*a*, The Targets; *b*, their corneal images as seen through the telescope without intervention of the prism of Iceland spar.

may be calculated from measurements of the chord $M M'$, made after turning the telescope, with the arc and targets, about its axis.

The great value of the Javal-Schiötz ophthalmometer is in its remarkable adaptation to the detection and measurement of corneal astigmatism, and for such examination it has won general recognition as indispensable to the ophthalmic practitioner. In astigmatism the essential thing to be considered is the difference in refraction in the two principal meridians, and it is for the measurement of such differences in the corneal curvature that the instrument has been especially designed. In the use of the ophthalmometer the length of the object (chord $M M'$) remains unchanged throughout the observation of the eye in its two principal meridians, and it is only the difference in the length of the image when the arc is adjusted successively for the corneal meridians of greatest and least curvature that is regarded. The observation consists in simply noting the amount of overlapping of the two images in the second position of the arc, after having first brought them into exact contact in the first position.

The device for reading the amount of overlapping of the images is shown in Fig. 3638, *a*. The outer side of one

FIG. 3639.—Corneal Images as Seen Through Telescope and Prism. Double images in touching position.

of the rectangular targets is cut in the form of steps of such width that each step approximately represents a difference of corneal curvature corresponding to 1 D of ocular refraction.* The number of overlapping steps is taken as the number of dioptries of astigmatism attributable to inequality of curvature of the cornea in its two principal meridians.

Fig. 3639 shows the doubled images of the targets in the position of contact; in Fig. 3640 the same images are shown with two steps overlapping, indicating 2 D of corneal astigmatism. It will be observed that in both these positions the images are rectangular, also that they lie exactly in the same line.

This rectangular form and linear direction of the images of the four targets is seen whenever the curvature of the cornea is symmetrical with reference to the plane of the arc. When the cornea is a surface of revolution, with its axis passing through the centre of the arc, this condition is fulfilled for all positions of the targets; but when the cornea is of a configuration approaching an ellipsoid of three unequal axes, the position of the arc

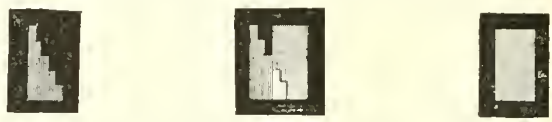

FIG. 3640.—Overlapping of Double Images — As = 2 D.

must be such that its plane shall bisect the ellipsoid in one or the other of its two principal planes. In all other positions of the arc the images of the four targets appear more or less distorted, and the images of the two pairs of targets are not in the same line (see Fig. 3641).*

This distortion and oblique displacement of the two images, in all but two positions of the arc, reveals at a glance the presence of corneal astigmatism. To find the meridian of greatest corneal curvature, the arc is turned until the images are seen in a line and most widely separated.† The two targets are then moved inward or outward on the arc until the images are brought into the position of contact. Lastly, the arc is turned through an angle of 90°, or until the images are again seen in a line, and the number of overlapping steps, which repre-

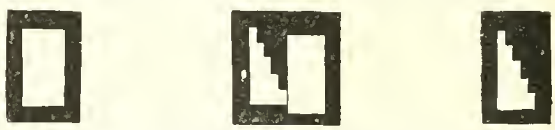

FIG. 3641.—Double Images not on a Level—Astigmatism Present. Arc not in a principal meridian.

sents the number of dioptries of corneal astigmatism, is noted. The examination of the two eyes need not consume more than two or three minutes.

The measurements of corneal astigmatism as made with the ophthalmometer agree remarkably, in most cases, with the results obtained by the use of methods which show the total astigmatism of the eye. The agreement in the direction of the principal meridians is especially close, so that in by far the greater number of cases the direction of the axis of the correcting cylindrical glass may be taken directly from the reading of the instru-

* Inasmuch as different eyes present considerable variation in corneal curvature, necessitating a corresponding variation in the separation of the targets in order to bring their images into exact contact, it is evident that a step on the target does not always represent the same fractional part of the chord $M M'$. In the case of a relatively flat cornea the targets must be set nearer together, and each step will then represent a larger fractional part of the chord $M M'$; conversely, when the cornea is of greater than average curvature the targets must be set wider apart, and each step will then represent a smaller fractional part of the same chord. It follows that in the former case each overlapping step in the image must represent somewhat more, and in the latter case, somewhat less, than 1 D of corneal astigmatism. It is well, therefore, always to note the length of the chord $M M'$, so that a correction can be made for it if deemed necessary.

* For an analysis of the phenomenon of distortion of the image formed by a mirror of asymmetrical curvature, also of the same phenomenon as it occurs in the case of a lens of asymmetrical refraction, see a paper by the writer: "Ein Beitrag zur Theorie der Cylinderlinsen," Graefe's Archiv, 1887.

† By interchanging the targets the images may be brought into the position of contact when the arc is set in the meridian of least corneal curvature, and the overlapping steps counted in the second position of the arc; in practice this is found to be more convenient, for the reason that the meridian of least curvature is, as a rule, approximately horizontal, and it is easier to adjust the targets in the horizontal and to observe the overlapping of the images in the vertical meridian.

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ment. In respect to the grade of astigmatism the agreement is less exact, for the reason that the observed corneal astigmatism is often modified by an astigmatism attributable to an oblique position of the crystalline lens, As a rule, the meridian of greatest corneal curvature is

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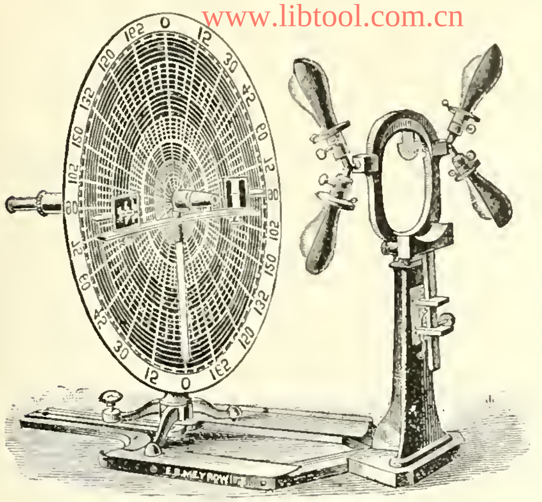

Fig. 3642.—Javal's Ophthalmometer with Attachment for Electrical Illumination of the Targets.

approximately vertical, and the meridian of greatest lenticular refraction is approximately horizontal; the total astigmatism is therefore generally somewhat less than the corneal astigmatism when the meridian of greatest corneal curvature is approximately vertical, and greater when, contrary to the rule, it is approximately horizontal.

In a comparatively small number of instances the total astigmatism is found to vary very widely from the corneal. For example, a relatively high grade of lenticular astigmatism may so far dominate a corneal astigmatism as largely to control both the direction of the principal meridians and the grade of the total astigmatism. Again, it is not uncommon to find a low grade of astigmatism, oftenest with the meridian of greatest refraction horizontal or nearly horizontal, in the absence of corneal asymmetry. Lastly, the ophthalmometer occasionally reveals an anomalous condition in which the corneal meridians of greatest and least curvatures are not at right angles to each other.

Not only has the Javal-Schiötz ophthalmometer greatly advanced our knowledge of astigmatism, but it affords, also, most important special information in every case of investigation of the refraction of the eye.

The instrument-maker Kagenaar (Utrecht, 1887)[11] has somewhat cheapened the original Javal-Schiötz ophthalmometer by substituting a pair of weak glass prisms, turned in opposite directions, for the doubly refracting prism of Iceland spar. Leroy and Dubois (1888)[12] have also produced a low-priced ophthalmometer, in which the doubling of the image is effected by means of two plates of thick glass as used by Helmholtz. In a second and newer model[13] (see Fig. 3642) the shape of the targets has been somewhat altered; and the direction of the meridians of greatest and least corneal curvature is read on the reflected image of the large disc which now constitutes the most conspicuous feature of the instrument.

Carl Koller.

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OPHTHALMOSCOPE; OPHTHALMOSCOPY.—from ὀφθαλμός, eye, and σκοπέω, to view. The ophthalmoscope, German, *der Augenspiegel*, is an optical device by means of which the interior of the eyeball is rendered visible.

Ophthalmoscopy, in its wider meaning, includes whatever pertains to the objective examination of the eye; in a narrower sense, it is restricted to the examination of the interior of the eye by the aid of the ophthalmoscope.

The anterior segment of the eyeball, comprising the cornea, the anterior chamber filled with the aqueous humor, the front of the iris, and so much of the anterior capsule of the crystalline lens as corresponds to the area of the pupil, is accessible to direct inspection by the naked eye, or through a magnifying glass. Even when the pupil is strongly contracted, a central opacity of the

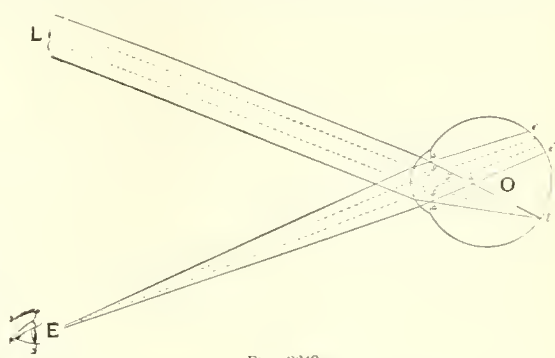

Fig. 3643.

lens capsule or of the immediately subjacent lens substance reveals itself by a characteristic white or gray appearance. When the pupil is widely dilated, we may look deeply into or through the crystalline, and may obtain glimpses of a detached and displaced portion of the

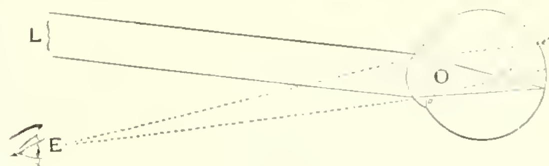

Fig. 3644.

retina, of a blood clot or other large foreign body in the vitreous, or of the surface of a very prominent tumor arising from the retina or choroid.

Let *L* (Fig. 3643) represent a pencil of parallel rays emanating from a distant source of light and entering the dilated pupil *a a* of the eye *O*, so as to light up a

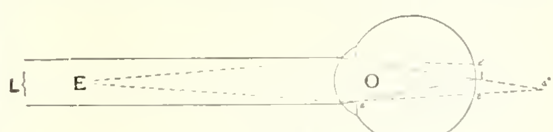

Fig. 3645.

path through the vitreous, indicated by the cone *a a l*. The eye of an observer at *E* will receive rays from any object which may happen to lie within that portion of this cone, near its base, which is bounded by the line *a a′′*. Outside of the limits *a a′ a′′*, the whole interior of the eye is either in comparative darkness or is shut off from view by the iris at *a, a*. If the pupil is contracted

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to the diameter *b b'*, only such part of the pencil *L* as is included within the dotted lines can enter the eye, and only such objects as happen to lie within the smaller

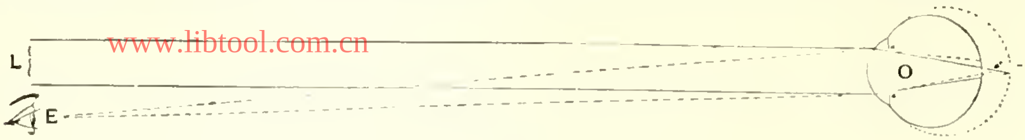

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FIG. 3646.

cone *b b' l* will be illuminated; of this smaller cone the greater portion is shut off from view by the iris at *b*, *b*, so that nothing can be seen outside the narrow limits *b b' b'*. If we take the angle *L O E* smaller (Fig. 3644), the point *a'* will fall farther back in the vitreous, and it will be possible to see more deeply into the eye.

When the angle *L O E* is taken very small, approaching zero (Fig. 3645), the illuminated point *l* falls within the area *e e*, which represents the field of view commanded by the eye of an observer at *E*; luminous rays from *l* will then enter the eye *E*, and the pupil of the eye *O* will be seen lighted up—*das Augenleuchten*. The particular case indicated in Fig. 3645 is, however, impossible, for the reason that, in the assumed position of the observer's eye, his head is necessarily interposed between the source of light and the observed eye. For this reason, when two persons look each into the eyes of the other, the pupils of all four eyes appear black.

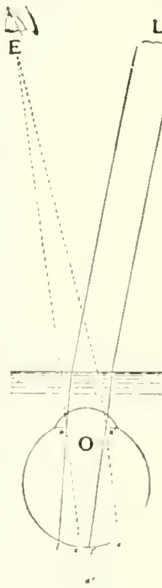

FIG. 3647.

When the refraction of the observed eye *O* is hypermetropic, the illuminating pencil is cut by the retina before reaching a focus (Fig. 3646), thus lighting up an area at the fundus which will be larger or smaller according as the pupil is more or less dilated and the pencil is cut by the retina at a greater or less distance from its focus. An observer looking into the eye, at a very small angle to the axis of the illuminating pencil, may receive rays of light from this illuminated area, and will then see the pupil of the observed eye illuminated. To develop this phenomenon by daylight, the pupil of the observed eye must be somewhat widely dilated, in order both that the illuminated area may be as large as possible, and that the iris at *a*, *a'* may cut off as little as may be of the view into the eye. The appearance of a shining pupil is best produced when the observer, with his back to a window, looks into the face of another person, a few feet away, whose eyes are directed toward a strongly illuminated surface, such as a bright cloud in the sky. Shining of the pupils is also very conspicuous, under particular conditions, in animals with eyes of hypermetropic construction whose fundus is clothed by a strongly reflecting layer—the tapetum. A familiar instance is the glowing of the eyes of the cat, when the gaze of the animal, with pupils widely dilated, is encountered by a person entering a dark room with a lighted lamp. In persons with congenital or acquired absence of the iris—*aniridia*, *irideremia*—the eyes may similarly be seen to shine by lamplight. The vivid red color of the pupils of albinos is independent of the refractive condition of the eye, and is a result of the lighting up of the whole interior of the eyeball through the unpigmented and abnormally translucent iris and choroid; when the eye of an albino is shaded by an opaque card, the pupil, viewed through a hole in the card, appears black, as in a normally pigmented eye (Donders).*

If we annul the refraction at the cornea by plunging the head of an animal under water (Fig. 3647), the eyes will be rendered very strongly hypermetropic, and the pupils may be seen to shine brightly by ordinary daylight. In this experiment it is also possible to see some of the details of the fundus through the widely dilated pupil.*

If the observed eye is strongly myopic, the illuminating pencil will converge to a focus (Fig. 3648) at some point in the vitreous humor, and, continuing on its course, will light up an area *l' l* where it is cut by the retina. As in the case of the hypermetropic eye, a portion, *e' l*, of this illuminated area will fall within the field of view commanded by the eye of an observer at *E*, who will then see the pupil of *O* lighted up.

If we take as the source of light a small incandescent electric lamp *L* (Fig. 3649), darkened at the back and sides, the retina of the (unaccommodated) emmetropic eye *O* will intercept the illuminating pencil before it reaches its focus, and a small area, *l l*, of the fundus will be lighted up. In this case, as in the cases assumed in Figs. 3646 and 3647, a considerable portion, *e l*, of the illuminated area, *l l*, falls within the region *e e*, from which rays of light can enter the eye of an observer at *E*, behind and a little to one side of the lamp. Under these conditions the pupil of *O* is seen strongly illuminated.†

If we move the lamp *L* nearer to the eye *O*, the angle *L O E* will become larger and larger, and the portion *e l'* of the illuminated area *l l'*, falling within the field *e e'*, will become smaller and smaller; whenever the angle *L O E* becomes so large that no part of *l l'* coincides with any part of *e e'*, the pupil will cease to appear luminous. If, however, we fit a small refracting prism *P*, to the incandescent lamp (Fig. 3650), we may so change the direction of the illuminating pencil as to turn it upon the eye *O*, as if emanating from *L'*, thus permitting an observer to look into the eye from *E*, at a very small angle to the axis of the illuminating pencil, even though he approach to a distance of only a few centimetres from the cornea of the observed eye.

The most convenient and effective way of lighting up the fundus of the eye is by making use of a reflector. This reflector may be made of unsilvered transparent glass, in which case it may be set at an angle of about forty-five degrees to the direction of the axis of the illuminating pencil (Fig. 3651). Of the incident rays, some are

* The shining of the eyes of certain animals in the dark was, for a long time, attributed to a supposed power of generating light. Prevost (1810) showed that the phenomenon is observed only when the eyes are illuminated by light falling directly upon them. Rudolphi (1810) called attention to the fact that it is necessary to look into the eye in a particular direction. In aniridia in the human eye Beer (1839) saw the pupils red and shining when he looked at the eyes in nearly the direction from which the light fell upon them; W. Cumming (1846) and Brücke (1847) discovered, independently of each other, that the pupils of the unmutilated human eye may be made to shine under the same conditions of illumination and inspection (cited from Helmholtz: "Handbuch der physiologischen Optik," first edition, S. 189).

* Mery (1704) first described this experiment, in which probably the first view of the blood-vessels of the retina of a living animal (cat) was obtained. The visibility of the details of the fundus in this experiment was correctly ascribed by La Hire (1709) to the alteration in the conditions of refraction, of which, however, he failed to give an exact explanation (cited from Helmholtz, *op. cit.*, S. 190). By the aid of the orthoscope of Czermak, a little trough of glass, fixed to the cheek and nose with wax, and filled with water, the observation of Mery may be repeated upon the human eye.

† This arrangement of the light represents essentially that employed by Brücke (1847). Brücke used a lamp or a candle as the source of light, and shut off the light from the eye of the observer by means of a small opaque screen.

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transmitted by the transparent glass, and lost, while other rays are regularly reflected, and may be directed upon the pupil of the observed eye *O*, as if they had emanated from

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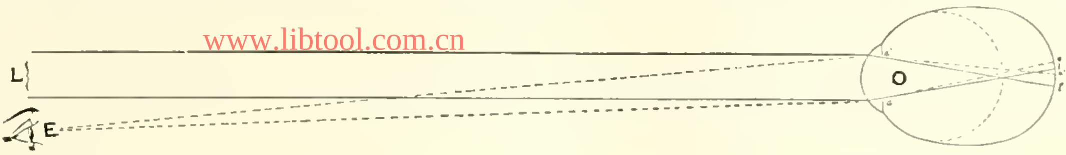

FIG. 3648.

L'. So, also, in the case of the efferent pencils, some of the rays are lost by reflection in the direction of the light *L*, while others are transmitted by the glass, to be re-

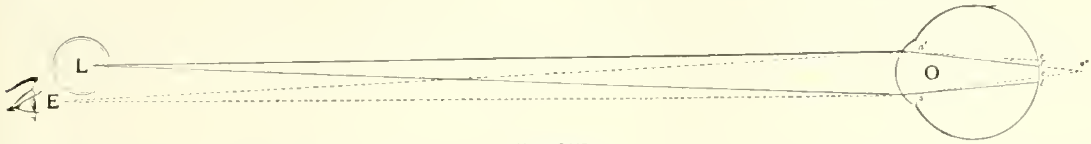

FIG. 3649.

ceived by the eye of an observer looking through the transparent mirror directly in the axis of the illuminating pencil.*

A plane mirror of silvered glass, or of polished metal,

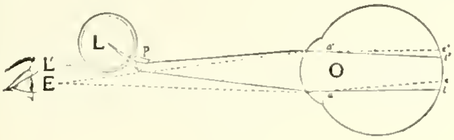

FIG. 3650.

may be substituted for the mirror of transparent glass, with the double advantage of reflecting a much stronger light into the eye and of permitting the lamp to be placed by the side of and at any required distance behind the patient's head (Fig. 3652). An observer looking past the side of the mirror, or, more conveniently, through a small central perforation, sees the pupil of the eye *O* more strongly illuminated than when an unsilvered glass mirror is used. The farther the plane mirror is held from the observed eye the smaller is the portion of its reflecting surface from which rays of light can enter the pupil and the weaker the illumination (Fig. 3653).

By making use of a concave mirror held near the eye, we may reproduce very nearly the same conditions of illumination as when the plane mirror is used (Fig. 3654), or, increasing the distance of the mirror or of the lamp, we may throw at will a parallel (Fig. 3655) or a convergent pencil (Fig. 3656) into the eye. If we increase still further the distance at which the mirror is held from the eye, and from the lamp (Fig. 3657), a very large convergent pencil, reflected from the entire surface of the mirror, may be thrown into the observed eye, and when the lamp and the pupil of the eye, *O*, come to lie in conjugate foci of the mirror (Fig. 3658), the size of the illuminating pencil is limited only by the diameter of the mirror, and the illumination at the fundus is correspondingly intense. A concave mirror of very thin, silvered glass, of a diameter of 33 mm. and a focal length of about 23 cm., with a central perforation of about 3.5 mm. diameter, is found to be, on the whole, most convenient, as serving both for such examinations as are required to be made with the mirror held near the eye (Figs. 3654 and 3656) and for those in which it is required to reflect a

large convergent pencil from a greater distance (Figs. 3657 and 3658).

If the illuminating pencil is made to pass through a strong convex lens held in front of and at somewhat less than its principal focal distance from the cornea of the observed eye, a very large convergent pencil may be thrown into the eye and focussed at any desired distance behind the cornea. With a convex lens of about 20 dioptries (5 cm. focus), held at a distance of about 4.5 cm. in front of the cornea (Fig. 3659), the focus will lie in the vicinity of the nodal point of the eye, and a large area of the fundus, limited only by the angular diameter of the convex lens, will be strongly illuminated.

If a weaker lens is employed, or if the lens of 5 cm. focus is held nearer to the observed eye (Fig. 3660), the focus of the illuminating pencil will lie at some point in the vitreous humor, and the illuminated area at the fundus will be larger or smaller according as the focus lies farther from or nearer to the retina. When the focus lies at a certain depth in the eye the diameter of the illuminated area is further limited by the size of the pupil, so that only a part of the illuminating pencil, corresponding to a larger or smaller central portion of the convex lens, can gain entrance into the eye.

If a stronger convex lens is used, or if the lens of 5 cm. focus is removed to a little more than its focal distance from the observed eye (Fig. 3661), the focus of the illuminating pencil will lie a little in front of the cornea, and the fundus will be illuminated in an area which, as in the case assumed in Fig. 3659, is limited only by the angular diameter of the convex lens.

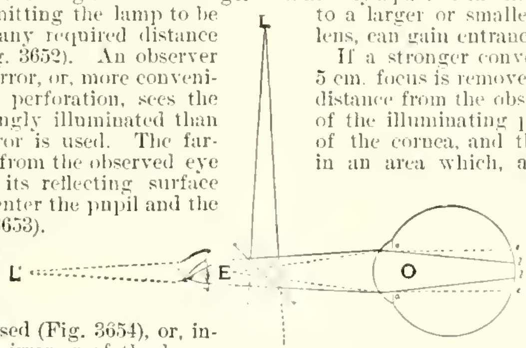

FIG. 3651.

In all three positions, as shown in Figs. 3659 to 3661, nearly the whole of the illuminated area of the fundus falls within the field of view commanded by the eye of an observer at *E*, so that rays emanating from a large area at the fundus may enter the eye of the observer.

By combining the perforated concave mirror, of about 23 cm. focus, with a convex lens of 5 to 6 cm. focus (Fig.

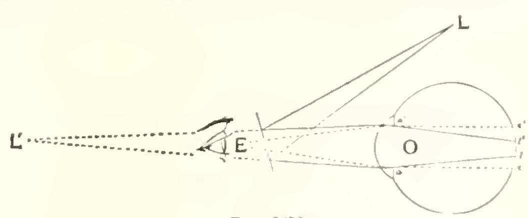

FIG. 3652.

3662), the maximum useful degree of illumination is attained, together with the ability to regulate the diameter of the illuminated area at the fundus by varying the dis-

* The arrangement shown in Fig. 3651 is essentially that originally employed (1851) by Helmholtz, the inventor of the ophthalmoscope.

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tance at which the lens is held from the eye. The observer looking through the central perforation in the mirror, directly in the axis of the illuminating pencil, is also in the most favorable position for receiving rays from the illuminated area at the fundus.*

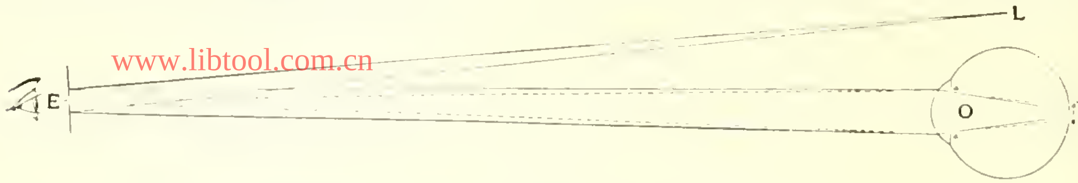

FIG. 3653.

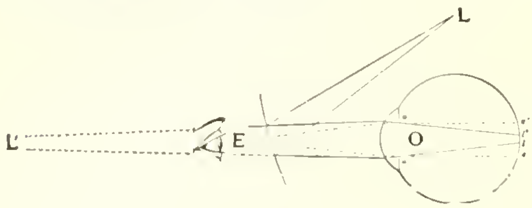

FIG. 3654.

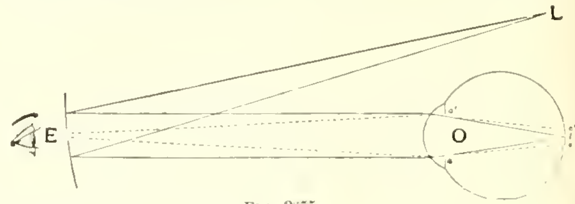

FIG. 3655.

We have thus far, for simplicity of demonstration, considered the source of light as a luminous point, which we have taken either at an infinite distance (Figs. 3643–3648), or at some short distance, as indicated by the position of the small electric lamp (Figs. 3649–3662). In practice, however, we ordinarily make use of an oil lamp or gas burner, in which case the area of illumination at the fundus corresponds to the inverted image of the flame (Fig. 3663). The maximum intensity of illumination is attained when the illuminating pencils are focussed exactly in the retinal image and the pupil is widely dilated.

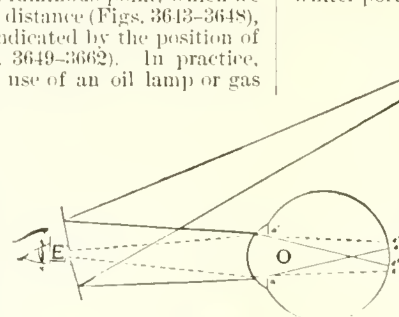

FIG. 3656.

The lamp ordinarily used in ophthalmoscopic work is an Argand oil lamp (the so-called student's lamp—Figs. 3675–3677), or an Argand gas burner, with some arrangement for adjusting it to the height of the patient's head. A petroleum lamp with a broad flame, or a bat-wing gas jet, may also be used. There is some advantage in surrounding the flame by an opaque screen, of metal or of asbestos, with an opening

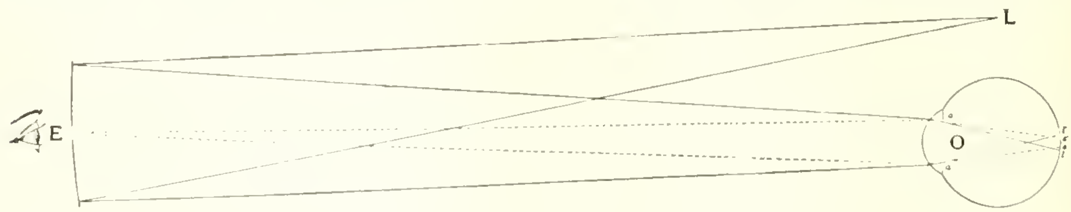

FIG. 3657.

of 2.5 or 3 cm. diameter. Many attempts have been made to utilize different forms of electric lamps as substitutes for oil or gas burners; a rather powerful incandescent lamp with the bulb of ground glass, fitted with a special rheostat for controlling the intensity of the light, has found favor with some good observers. Other inventors have employed a very small electric bulb and mirror, both attached to the handle of the ophthalmoscope, or have suppressed the illuminating mirror altogether.

A minor disadvantage in using oil or gas illumination is the yellow color of the flame, which imparts to the whiter portions of the fundus a somewhat unnatural tint. The true color of the fundus is best observed by indirect sunlight, either from a bright cloud or admitted into the darkened room through a hole in the window shutter which may be glazed with ground glass or covered with thin white paper. Direct sunlight is by far too intense to be safely thrown into the eye, even when reflected from an unsilvered glass mirror; the light of the full moon is insufficient, unless it be concentrated by reflection from a very large concave mirror.

The size of the bright image of the flame is in an inverse ratio to the distance (*LO*, *L'O*, *L''O*, Fig. 3663) of the lamp from the nodal point of the observed eye, or, when the plane mirror is used, to the distance $LE + EO$ (Figs. 3651–3653); when the illuminating pencils are imperfectly focussed, the image is spread out, at its borders, in a width equal to the radius of the circle of confusion in which any single pencil is cut by the retina. When a concave mirror is used, and the distance from the observed eye is large (Figs. 3657 and 3658), the illuminated area is practically the image of the mirror.

The extent of the area at the fundus, which falls within the field of view of the observer in the direct method of examination—*i.e.*, without the interposition of the convex lens—varies directly as the size of the pupil of the observed eye, and inversely as the distance from the eye at which the observer is stationed; a fairly large pupil and a near point of observation are therefore essential to the enjoyment of an ample field. To secure a near

* The illumination by means of the perforated concave mirror, conjoined with the employment of the convex lens to form an inverted image of the fundus at or near its anterior focus (Ruete, 1852), constitutes an invention second only in practical importance to that of Helmholtz. Figs. 3659 to 3661 illustrate a development of Brücke's experiment, by Helmholtz (1852).

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point of observation, we hold the ophthalmoscopic mirror as near as possible to the observed eye, and to prevent contraction of the pupil under the stimulus of the light reflected into the eye, we may instil a drop of a weak mydriatic solution, or we may make use of a mirror which reflects light of the minimum intensity compatible with sufficient illumination. If we employ a mydriatic we choose, by preference, a solution of cocaine (1 to 50), of euphthalmin (1 to 50), or of cocaine and euphthalmin (1 to 100 each), either of which will sufficiently dilate the pupil in the course of from ten to twenty minutes, without subjecting the patient to the inconvenience incident to the prolonged mydriasis which follows the instillation of a strong solution of atropine, duboisine, or hyoscyamine. To reflect a weak light into the eye, we may use a perforated plane or convex mirror made of darkly tinted glass, or, still better, the original form of mirror devised by Helmholtz, which is made up of three or more plates of thin, unsilvered glass. This compound mirror reflects more light than a single plate of glass, and also polarizes the reflected pencils; by its action as an analyzer, it also extinguishes most of the rays reflected from the surface of the cornea, which often interfere with the view of the parts within the eye.

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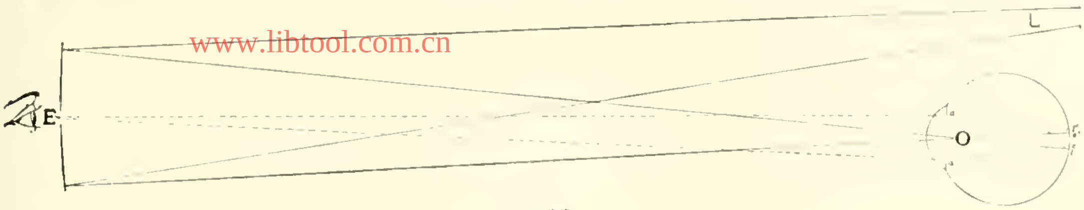

Fig. 3658.

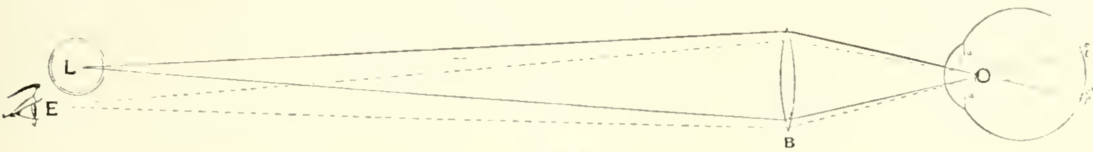

Fig. 3659.

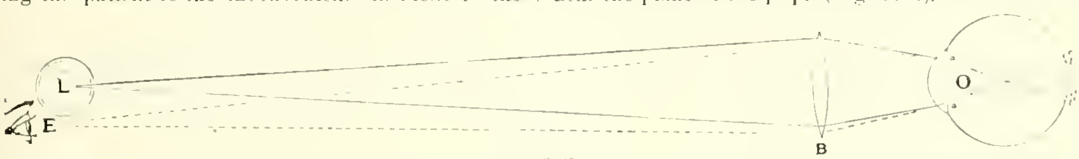

Fig. 3660.

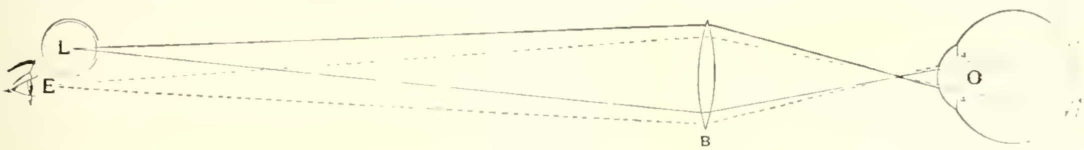

Fig. 3661.

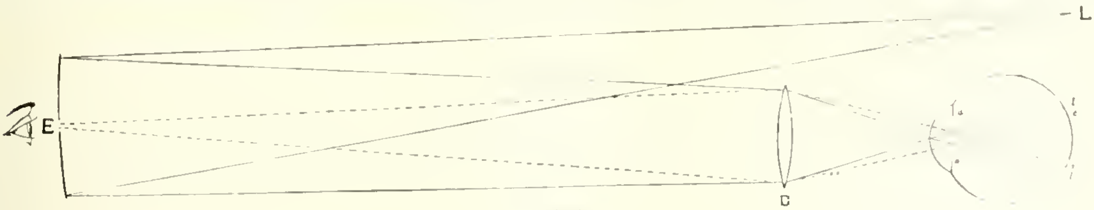

Fig. 3662.

In the indirect method of examination—*i.e.*, by the use of the convex lens of about 5 cm. focus held at about its focal distance in front of the observed eye—the size of the pupil plays a much less important part than in the examination by the direct method, and in certain positions of the lens it is almost completely eliminated as a factor in determining the intensity of the illumination and the amplitude of the field of view. This is practically the case whenever both the focus of the illuminating pencils and the intersection, within the eye, of the lines which defined the limits of the field of view lie in or very near the plane of the pupil (Fig. 3662).

Whenever the inverted image of the flame, at the fundus of the observed eye, is smaller than and lies wholly within the field of view commanded by the eye of the observer, the form of the image may be seen more or less distinctly outlined, according as it is itself sharply defined and as the refractive condition of the observed eye is such as to admit of the efferent pencils being accurately focussed upon the retina of the observer. Outside of the limits of this bright image, the fundus appears dark by contrast, although in fact dimly lighted through the faint general illumination of the interior of the eye by the bright image

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itself, and also by a little light reflected from the face of the observer.

When the image of the flame is larger than, and includes the field of view, the entire visible area of the fundus appears strongly illuminated.

When the (plane) mirror is slightly rotated, in any direction, the inverted image of the flame moves across the

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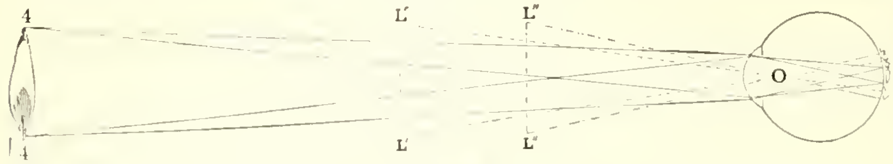

FIG. 3663.

fundus of the observed eye in the same direction. When the observed eye is hypermetropic, or is focussed for a distance greater than that of the eye of the observer, the apparent motion of the image is in the same direction as its real motion; but when the observed eye is focussed for a distance notably less than that of the eye of the observer, the image appears to move in the opposite direction. Upon the observation of the direction of the apparent motion of the illuminated area at the fundus, is

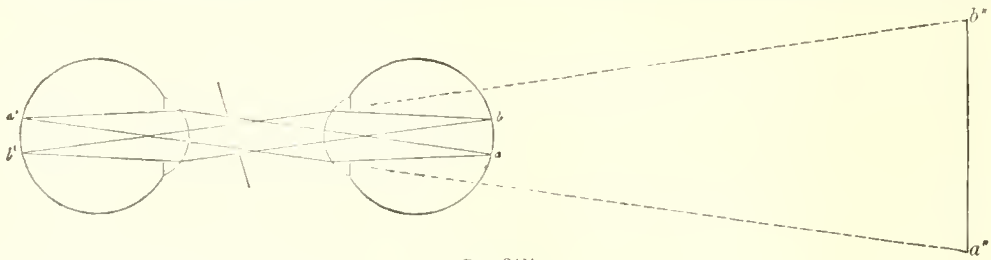

FIG. 3664.

based a ready and very useful method for the diagnosis and measurement of ametropia (see *Shadow-Test*).

In the living human eye the fundus appears ordinarily of a vivid red color, which is the expression of the color of the blood of the choroidal circulation showing through and more or less modified by the layer of hexagonal pigment cells.* This color is most intense in albinos, very bright in persons of blond complexion and light blue eyes, conspicuously darker in brunettes with deeply pigmented eyes, and least intense of all in the black races, in whom the illumination of the fundus is often so faint as to give off but little light, except from the white disc of the optic nerve and from the blood-filled vessels of the retina. Under normal conditions the red color is almost wholly due to the blood circulating in the capillary layer of the choroid, immediately underlying the layer of hexagonal pigment cells and hiding the more deeply seated choroidal arteries and veins. On this red background, which appears of a finely granulated texture, the retinal arteries and veins show conspicuously, branching from the central artery and vein on the nearly white optic disc (Pl. XLVII.).

Under favoring conditions of refraction in the observed and in the observing eye, the minuter details of the fundus are distinctly visible, both directly, in the erect

* After death the red color of the human fundus is lost.

image, and indirectly, in the inverted image. In the direct method of examination the eye of the observer is brought very near to the observed eye, in order that the field of view, as determined by the area of the pupil, may be as large as possible (Figs. 3651, 3652, 3654, and 3656; *cf.* Figs. 3653, 3655, 3657, and 3658). In the indirect method the observer is necessarily stationed at a much greater distance, say 20 cm. or more, beyond the position of the inverted aërial image (Figs. 3667–3672).

In the direct method of examination the visibility of the details of the fundus is affected in different ways according as the refraction of the observed eye is normal (emmetropic) or abnormal (myopic or hypermetropic). These three principal cases must be considered in order, the observing eye being assumed to be emmetropic.

(*a*) The observed eye is emmetropic, and with relaxed accommodation (Fig. 3664). Let *a* and *b* represent the origins of two efferent pencils, at two points within the illuminated area at the fundus of the observed eye. As both eyes are assumed to be emmetropic, the rays composing these pencils become parallel after refraction at the cornea of the observed eye and, entering the eye of the observer, are focussed at *a'* and *b'* upon its retina, where they form an inverted image *b' a'*, equal in size to *a b*. The observer looking through the pupil of the observed eye sees the portion *a b* of its illuminated fundus in the erect position, and magnified as indicated by the dotted lines drawn toward *a"* and *b"*.

(*b*) The observed eye is myopic (Fig. 3665). Let *a* and

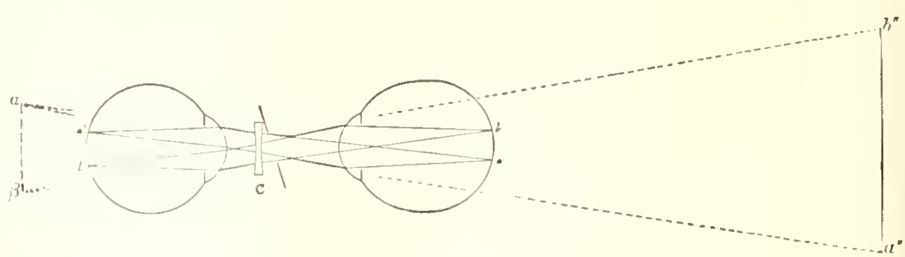

FIG. 3665.

b again represent the origins of two efferent pencils. As the observed eye is myopic, the rays composing these pencils become convergent after refraction at its cornea and would, if continued, converge to foci at *α* and *β*. Entering the eye of the observer they take on increased convergence, to cross at focal points in the vitreous, from which they again diverge to be cut by the retina as circles of confusion, thus forming a blurred image. By the interposition of the concave lens *C*, of a negative focal length equal to the distance *a C*, the convergent pencils are rendered parallel before they enter the observer's eye, so that they can be focussed accurately in the points

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OPHTHALMOSCOPIC VIEW OF THE NORMAL FUNDUS OCULI.

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a' and *b'* at its retina to form a sharply defined image, somewhat larger than the object *a b*. The concave lens *C*, placed at the anterior focus of the observed eye—about 13 mm. in front of its cornea—exactly corrects its remains adjusted for parallel rays, we may interpose the convex lens *C*, of a focal length equal to the distance *a C*, and thus render the divergent rays parallel before they reach the eye. The convex lens *C*, placed at the anterior

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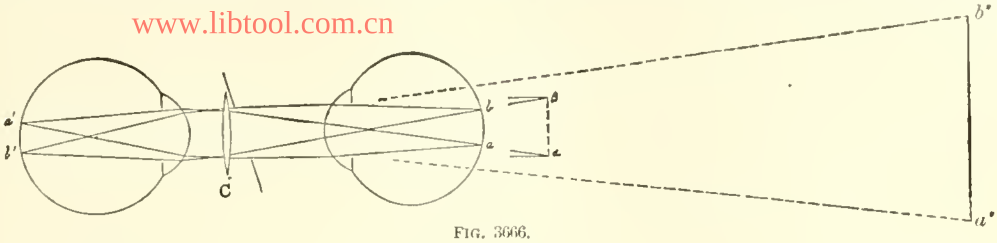

FIG. 3666.

myopia, and is, therefore, equal to the concave spectacle glass needed in distant vision. If the lens *C* is held a centimetre or more in front of the principal anterior focus of the observed eye, as is generally the case in ophthalmoscopic examinations, the negative focal length of the concave lens thus selected will be less than that of the required spectacle glass, by just its distance from the anterior focus of the eye. In low grades of myopia the error arising from a variation of 2 or 3 cm. in the distance of the concave lens is inappreciable, but in the higher grades (of 4 dioptries or more) the distance of the concave lens from the anterior focus must be added to its focus of the hypermetropic observed eye, exactly corrects its hypermetropia; if placed at a greater distance from the eye than its anterior focus, this excess of distance must be subtracted from the focal length of the convex lens. In low grades of hypermetropia small variations in the distance of the convex lens from the eye may be neglected.*

The details of the fundus of the hypermetropic eye, viewed through a convex lens placed behind the ophthalmoscopic mirror, are seen somewhat less magnified than in the case of the emmetropic eye.

In viewing the details of the fundus in the erect image

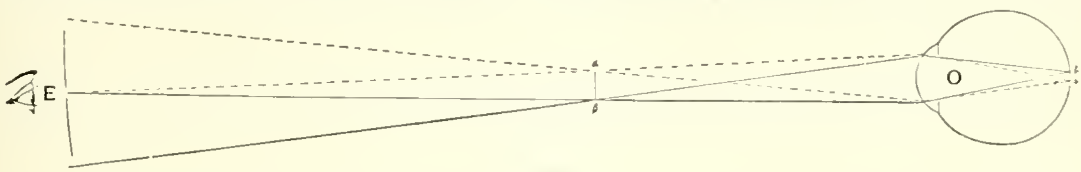

FIG. 3667.

(negative) focal length, in order to insure the highest degree of accuracy of which this method of examination is capable.*

The details of the fundus of the myopic eye, viewed through a concave lens placed behind the ophthalmoscopic mirror, are seen somewhat more magnified than in the case of the emmetropic eye.

(*c*) The observed eye is hypermetropic, and with relaxed accommodation (Fig. 3666). Let *a* and *b* again represent the origins of two efferent pencils. As the observed eye is hypermetropic, the rays composing these pencils emerge from the eye divergent, as if emanating from points *α* and *β* behind the eye, and, entering the eye of the observer, are rendered convergent, but not the cornea and lens of the observed eye perform the function of a simple microscope. If we adopt the conventional rule of referring the magnified virtual image to a distance of 8 Paris inches (about 217 mm.), the enlargement will be represented very nearly by the ratio 217 : 15, or about 14.5 diameters, in the case of an emmetropic eye of average dimensions (Helmholtz).

Ametropia in the eye of the observer plays an important part in affecting the distinctness of the view of the fundus in the erect image. Thus a myope who, with the unaided eye, can focus only divergent rays upon his retina, does not see the details of the fundus unless the observed eye is hypermetropic to a degree equivalent to or somewhat in excess of the measure of his own myopia.

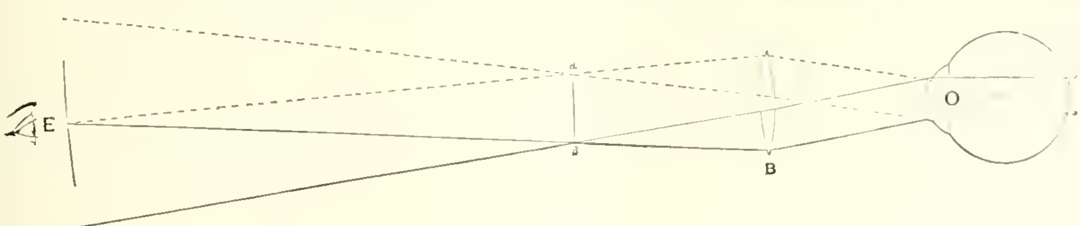

FIG. 3668.

sufficiently to focus them at its retina. An imperfectly defined image is therefore formed at *b' a'* of somewhat smaller size than the object *a b*. Here, however, the accommodation of the observer's eye may come into action, consciously or unconsciously, to focus the image upon its retina, and thus a distinct view of the fundus at *a b* may be obtained. Assuming that the eye of the observer A hypermetrope, on the other hand, can, with relaxed accommodation, obtain a clear view of the fundus of a

* The use of a concave lens behind the mirror, of a negative power sufficient to correct, or somewhat to overcorrect, the sum of the myopia of the observed and the observing eye, is a part of the original invention of Helmholtz (1851).

* The principle underlying the method of measuring the refractive condition of any eye, by means of a concave or convex lens placed behind the ophthalmoscopic mirror, is clearly set forth in the first publication of Helmholtz (1851), but the practical employment of the method on an extensive scale began with E. Jaeger (1856). It was also early cultivated by Donders, and especially by Mauthner (1867). Its general adoption, as a part of the daily work of the ophthalmic practitioner, dates from the introduction, by Loring (1869), of an instrument provided with a series of especially selected correcting lenses arranged to admit of easy and rapid changes.

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myopic eye in which the myopia does not exceed the measure of his own hypermetropia, and, by exerting his accommodation, he may be able to see the fundus of an emmetropic or even of a hypermetropic eye. A hypermetropic observer enjoys, therefore, a certain advantage in respect of the facility with which he can adjust his accommodation so as to see clearly under different refractive conditions of the observed eye, but he labors under a special disadvantage when he attempts to measure its refraction, and this for the reason that it is generally impossible for him either to estimate the degree to which he exerts his accommodation, or to control its exercise so perfectly as to hold it with even approximate accuracy at the point required to make him virtually emmetropic. To obtain trustworthy measurements of the refraction by means of the ophthalmoscope by the direct method, the hypermetropic observer should first neutralize his manifest hypermetropia by means of the appropriate convex glass, or else should subtract a quantity equal to the measure of his Hm from the value of the strongest convex glass, or add the same quantity to the value of the weakest concave glass through which he is able to see the details of the fundus distinctly. Similarly, the myopic observer should first correct his myopia by means of a neutralizing concave glass, or else should subtract a quantity equal to the measure of his myopia from the value of the weakest concave glass, or add the same quantity to the value of the strongest convex glass, through which he is able to see the details of the fundus. If the observer is astigmatic in any notable degree, he will see the fundus in the erect image under the same imperfect definition as if astigmatism were present in the observed eye. It is, therefore, essential to the highest accuracy, in measuring the refraction by this method, that the observer correct any astigmatism that may exist in his own eye by means of the appropriate cylindrical glass.

In the indirect method of examination the observer does not view the fundus itself, but an inverted aërial image of the fundus. The myopic eye forms such an image at its far-point (*punctum remotissimum, r*). Let *a* and *b* (Fig. 3667) represent two points taken within the illuminated area of a strongly myopic eye, and within the field of view of the observing eye at *E*. Inasmuch as the points *a* and *b* lie behind the principal posterior focus of the observed eye, the pencils originating from these points emerge, respectively, from the eye as pencils of convergent rays, to be focussed at the distance of the far point *r*, where they enter into the formation of an inverted real image *β a*. An observer stationed at *E*, about 20 cm. beyond *β a*, may accommodate for this real image, and see the finest details of the fundus sharply defined and magnified, but in the inverted position. The practical application of this method is greatly restricted by the fact that it is adapted only to cases of myopia of high grade, and that, at the best, the field of view is very small. Moreover, the image is seen under very different degrees of enlargement, according as the myopia is of a lower or a higher grade.

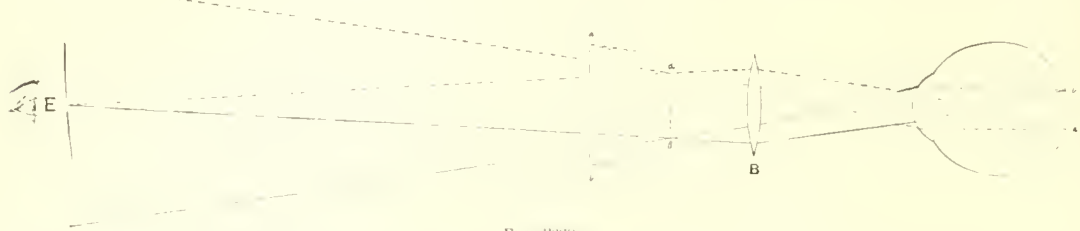

FIG. 3669.

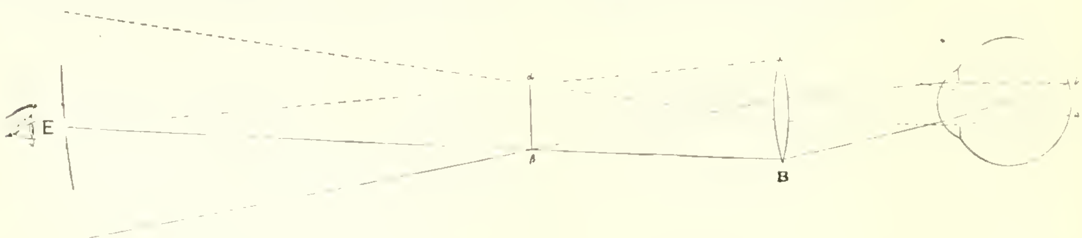

FIG. 3670.

The indirect method is extended to the examination of all eyes, irrespective of the state of the refraction, by making both the illuminating and the efferent pencils pass through a strong convex lens, placed at about its principal focal distance in front of the observed eye (Figs. 3668 to 3670; *cf.* Figs. 3659 to 3662). The efferent pencils, whether parallel (Fig. 3668), convergent (Fig. 3669), or divergent (Fig. 3670), are focussed by the convex lens either at its principal focus (in emmetropia), a little within the principal focus (in myopia), or a little beyond the principal focus (in hypermetropia). An inverted image is thus formed at or near the principal focus of the convex lens, and may be viewed from a station *E*, taken at a distance of from 20 to 25 cm. beyond the position of the principal focus.

The degree of enlargement of the picture of the fundus in the inverted real image, when the convex lens is placed at exactly its principal focal length in front of the nodal point of the observed eye, is found by dividing the focal length of the lens by the distance of the nodal point of the eye from its retina (= 1.5 cm. in the emmetropic eye). With a lens of 4 cm. focus the amplification is, therefore, 4 : 1.5 = 2.6; with a lens of 5 cm. focus it is 5 : 1.5 = 3.3; with a lens of 6 cm. focus it is 6 : 1.5 = 4; and with a lens of 8 cm. focus it is 8 : 1.5 = 5.3. In ametropia of the observed eye the second term in these several ratios is either greater (in myopia) or less (in hypermetropia) than the normal measure of 1.5 cm., so that the amplification of the inverted image is less in myopia, and greater in hypermetropia, than it is in emmetropia.

In very high grades of myopia, in which an inverted image of its fundus is formed by the eye at a very short distance in front of its cornea, the convex lens must be held very near the observed eye in order that it may take part in the formation of the image. This implies the use either of an excessively strong lens, in which case the details of the fundus will appear but little magnified in the inverted image, or of a weaker lens, held at a distance notably less than its focal length from the observed eye,

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Ophthalmoscope.

in which case the boundaries of the field of view will be greatly narrowed. In the highest grades of myopia a modification of the indirect method of examination is, therefore, to be preferred.

Fig. 3671 shows a greatly elongated eye, representing a myopia of about 25 dioptries, and, therefore, forming an inverted image of its fundus at a distance of about 4 cm. in front of its nodal point. A convex lens of about 10 dioptries power (= 10 cm. focus) is held at about its principal focal length in front of the observed eye, and, therefore, at a distance greater than that of the inverted image. The observer, at *E*, views the image *β a* through the convex lens, and consequently sees it magnified by the lens. In this position of the convex lens neither the intensity of the illumination nor the extent of the field of view is materially influenced by the size of the pupil. A convex lens of a focal length a few centimetres greater than the distance of the image from the nodal point of the observed eye, held at about its principal focal distance in front of the cornea, gives a fairly ample field of view, together with a convenient enlargement of the inverted image. If the lens is moved nearer to the observed eye —*i.e.*, nearer to the place of the image—the field of view will be more extensive and the amplification less; if, on the other hand, the lens is moved farther from the eye, the field of view will be less extensive and the amplification greater.

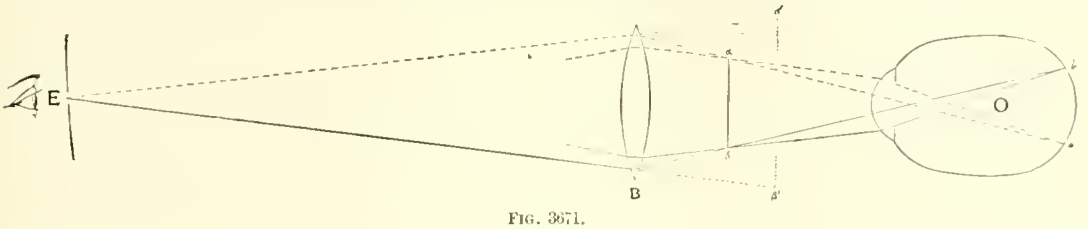

FIG. 3671.

In emmetropia of the observed eye the efferent pencils, of parallel rays, are focussed by the convex lens at its principal focus, irrespective of the distance at which the lens is held in front of the eye. The amplification of the image remains, therefore, constant for any particular lens, whether the distance of the lens from the eye be taken greater or less than its principal focal length. Only the size of the illuminated area at the fundus and the extent of the field of view are affected by the change in the position of the lens.

In ametropia, on the other hand, any change in the distance of the convex lens from the observed eye is attended, also, with some change both in the distance at which the inverted image is formed in front of the lens and in the amplification of the image. In hypermetropia, if we move the lens farther from the eye, the amplification of the image will be somewhat diminished. Conversely, in myopia, any increase in the distance of the convex lens from the eye is attended with some increase in the amplification of the image.

This change in the size of the inverted image in ametropia gives rise to a characteristic phenomenon in astigmatism, namely, a change in the apparent form of the disc of the optic nerve, according as the convex lens is held at a greater or less distance in front of the observed eye. In mixed astigmatism (Ahm or Amh) the eye is virtually myopic in the principal meridian of greatest refraction, and hypermetropic in the principal meridian at right angles to this meridian. It follows that, in moving the convex lens farther from the eye, the size of the inverted image increases in the direction corresponding to the ocular meridian of greatest refraction, and diminishes in the direction of the meridian of least refraction, so that the optic disc is seen as an oval of progressively varying form. In simple hypermetropic astigmatism (Ah) and in simple myopic astigmatism (Am) the change in the form of the inverted image of the disc is the same as in mixed astigmatism, but the variation is confined to the direction corresponding to the ametropic meridian. In compound hypermetropic astigmatism (H + Ah) and in compound myopic astigmatism (M + Am) the same change in form is observed as a result of unequal increase or decrease in the two principal meridians.

This change in the apparent form of the inverted image of the optic disc in astigmatism is necessarily attended with some indistinctness of outline, but this practically adds to, rather than detracts from, the conspicuousness of the phenomenon. In the case of the retinal vessels, the definition varies according as they happen to lie approximately in the direction of one or the other of the principal diameters of the oval. Both the distortion of the inverted image of the disc, and the inequality in the definition of the vessels which lie in the direction of the two principal meridians, may be made to disappear by the simple expedient of rendering the convex lens itself astigmatic by holding it more or less obliquely to the visual axis, according to the grade of astigmatism to be overcome.

The ample field of view, conjoined with as strong an illumination as can be utilized, the convenient degree of enlargement of the retinal picture, the fact that the conditions of visibility of the fundus are not materially affected by hypermetropia, or by any but the highest grades of myopia, and the facility with which the disturbing influence of astigmatism may be annulled by giving an oblique position to the lens, all combine to render the indirect method particularly available whenever we wish to obtain a general view of a large area of the fundus. On the other hand, for the examination of the details of the fundus under a greater magnifying power, and especially for measuring the refraction of the observed eye, the direct method offers advantages which are entirely its own. The two methods are, therefore, to be cultivated side by side, each supplementing the other; the two together affording the means of studying the fundus with a thoroughness not so perfectly attainable by the use of either method alone.

In order to be able to use both methods equally well, so as to obtain from each the best service of which it is capable, it is of the first importance that the observer eliminate any sources of error growing out of the uncontrolled exercise of his own accommodation. This can be

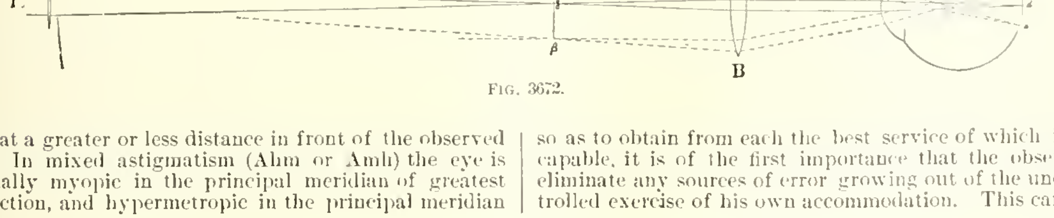

FIG. 3672.

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attained only by the observer training himself to make all examinations, as well by the indirect as by the direct method, under the uniform condition of complete accommodative relaxation. And here the learner has, first of all, to suppress an instinctive tendency to accommodate for the short distance at which he knows that the object,

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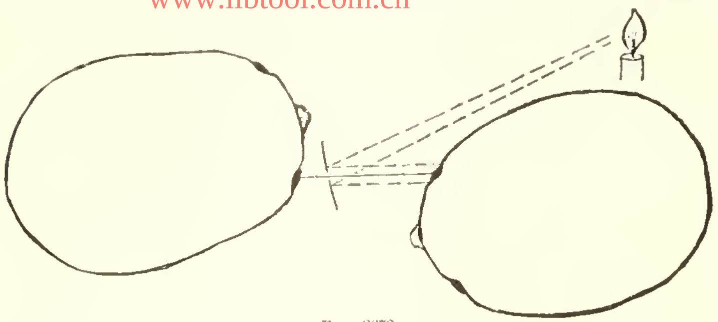

Fig. 3673.

or its image, actually lies. Hence, in practising the direct method, the learner should be made to feel that he must look not so much into the observed eye as through it, as if viewing an object lying far away. If myopic, he should accustom himself always to use the weakest concave correcting glass, or if hypermetropic, to use the strongest convex correcting glass through which he can obtain a distinct view of the details of the fundus; if emmetropic, he should learn to observe the fundus of an emmetropic eye without a correcting glass, and, in examining a myopic or a hypermetropic eye, to find and make use of the particular concave or convex correcting glass which exactly measures its myopia or hypermetropia. In practising the indirect method the learner should also acquire the habit of viewing the inverted image with relaxed accommodation, which he will accomplish, if emmetropic, by looking through a convex lens of about 5 dioptries power (20 cm. focus) placed immediately behind the hole in the mirror; or, if hypermetropic, by substituting for this lens such other lens, of greater power, as shall, in addition, correct his manifest hypermetropia; if myopic, he should similarly employ the convex or concave lens which accurately adjusts his own far point (r) for the distance of 20 cm.; and only in the particular case in which his far point lies at this distance (M = 5 dioptries) should he practise the indirect method without a correcting glass.

The use of a convex correcting glass in the indirect method of examination is shown in Fig. 3672; for the use of a concave or convex correcting glass in the direct method of examination see Figs. 3665 and 3666.

A fairly large pupil is always desirable in ophthalmoscopic examination, and in employing the direct method it is often indispensable. Nevertheless, it is not always either necessary or advisable to make use of a mydriatic. As the pupils contract both under the stimulus of strong light and in connection with the exercise of the accommodation, it is best to conduct all ophthalmoscopic examinations in a completely darkened room of considerable size, and preferably with walls of a dark color. The general darkness of the room is favorable to the dilatation of the pupils, and the consciousness that he is in a room of some size makes it easier for the patient to relax his accommodation when he is asked to direct his gaze toward a large and faintly lighted object upon the opposite wall. By observing these precautions the causes which incite to contraction of the pupils are in a great measure eliminated, with the exception of the direct influence of the light reflected into the eye by the mirror. The light of a student's lamp, reflected from the concave mirror of silvered glass and concentrated upon the region of the optic disc, ordinarily excites but little pupillary contraction, and, in fact, most of the routine examinations by the direct method may be made by the aid of this mirror without having recourse to artificial mydriasis. In searching for minute changes in the region of the macula lutea it is, however, not infrequently advisable to make use of a weak mydriatic, such as cocaine or euphthalmin. If, for any reason, it is judged inexpedient to instil a mydriatic solution into the eye, the plane mirror of Helmholtz, made up of several layers of unsilvered glass, may often be made to render excellent service.

In order to permit the patient to direct his gaze upon a somewhat distant large object, it is important that his view, with the eye not under examination, be not cut off by the head of the observer. Hence the very useful rule, of general application, that the observer accustom himself always to use his right eye in examining the right, and his left in examining the left eye (Figs. 3673 and 3674).

The ophthalmoscopic armamentarium, in its simplest effective form, includes (1) a perforated concave mirror, of about 33 mm. diameter and 23 cm. focus, mounted on a handle of about 13 cm. length, and fitted with a rotating disc or other mechanism by which any required concave or convex correcting glass may be easily brought into place behind the hole in the mirror; (2) a convex lens, of a diameter of about 3.5 cm. and a focal length of 5 or 6 cm.; and (3) a good lamp, which should be so mounted as to admit of the easy adjustment of the flame to about the height of the observed and of the observer's eye. This simple apparatus, used in a well darkened room, affords the means of exploring the eye, from the anterior epithelium of the cornea back to the retina and optic disc.

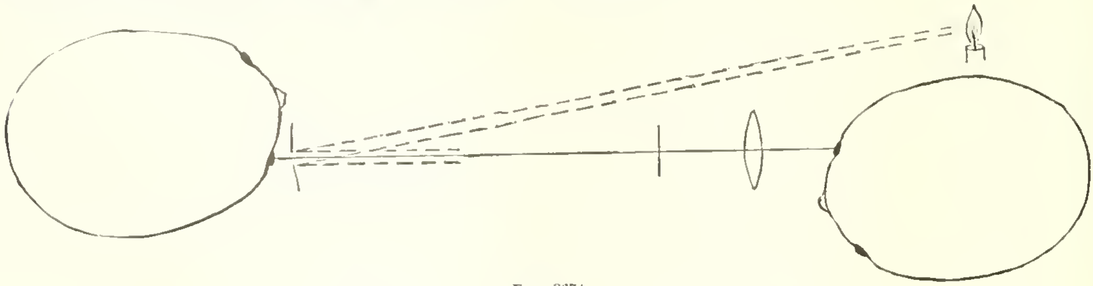

Fig. 3674.

If we place the lamp a little in front of the plane of the patient's face, and concentrate a cone of light upon the cornea by means of the convex lens (Fig. 3675), the conditions of illumination are very favorable to the detection and observation of any slight irregularities or opacities in the cornea, whether superficial or more deeply seated, and also of finely punctate deposits such as often occur in or upon the lining membrane of the cornea (membrane of Descemet). If we change very slightly the

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position of the lens, so that the cone of light shall fall upon the iris, we may note slight changes in its texture, and also any irregularities in the contour and pigmentation of the pupillary margin. By concentrating the light upon the region of the pupil, we may similarly detect thin deposits of lymph obscuring the anterior capsule of the crystalline lens in the pupillary field, specks of brown pigment detached from the posterior surface of the iris and adherent to the lens capsule, and also such opacities as have their seat in the capsule or in the anterior layers of the crystalline. If we have previously brought the

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FIG. 3675.

eye under the influence of a mydriatic, we may detect and carefully study any adhesions (synechiæ) which may have been formed between any part of the pupillary border and the lens capsule, whether recent or of indefinitely long standing. If the pupil is widely dilated, we may look deeply into the crystalline lens (*cf.* Fig. 3643) and thus detect and observe the various forms of opacity incident to different types of cataract, or we may even look through the crystalline into the vitreous, and obtain glimpses of a mass of effused blood or lymph, or of a very prominent tumor growing from the fundus. In many cases it is desirable to make use of a magnifying glass in connection with this lateral or oblique focal illumination, for which purpose there is nothing better than an ordinary doublet of about 3.5 cm. focal length. By the method of lateral illumination all objects are seen by the light which they reflect from their surface, and, therefore, in their actual color.

In using the mirror, the lamp is placed a little behind the plane of the patient's face, and, preferably, on the same side as the eye to be examined. Having placed a convex glass of about 5 dioptries (20 cm. focus) behind the mirror, we throw the light upon the eye from a distance somewhat less than the focal length of the lens. Looking through the mirror, we see the field of the pupil brightly illuminated, and of a vivid red color, whenever the media are of unimpaired transparency and the fundus is of its normal hue. In the presence of diffuse clouding of the cornea or crystalline lens, or a turbid condition of the aqueous or vitreous humor, the red color of the pupil may appear conspicuously dulled, or may not be seen at all. A circumscribed opacity, on the other hand, whether in the cornea, on the anterior lens capsule, or in the substance of the crystalline, appears black against the red background of the fundus. Motes and shreds in the vitreous appear, also, as a rule, under the aspect of black specks or threads, intercepting the red light from the fundus, but in rare instances, as in the case of crystals of cholesterin, they may reflect so much light as to sparkle brilliantly (*synchysis scintillans*). If a fixed opacity has its seat at or very near the centre of rotation of the eyeball (about 13.5 mm. behind the vertex of the cornea), it will undergo little or no change of position when the observed eye is turned in different directions; if in front of this centre, it will move in the direction in which the eye is turned; if behind the centre, it will move in the opposite direction. The greater the distance at which the body lies in front of or behind the centre of rotation, the greater will be the range of its excursions. Thus a spot in the cornea will move through a larger arc than an opacity at the depth of the anterior lens capsule, and this in turn will move through a larger arc than one situated at or near the posterior capsule. Inasmuch as the pupil and the anterior lens capsule lie at the same depth within the eye, an opacity situated at the front of the lens maintains a nearly constant position with reference to the bright field of the pupil, while a spot on the cornea, or in the deeper layers of the lens,

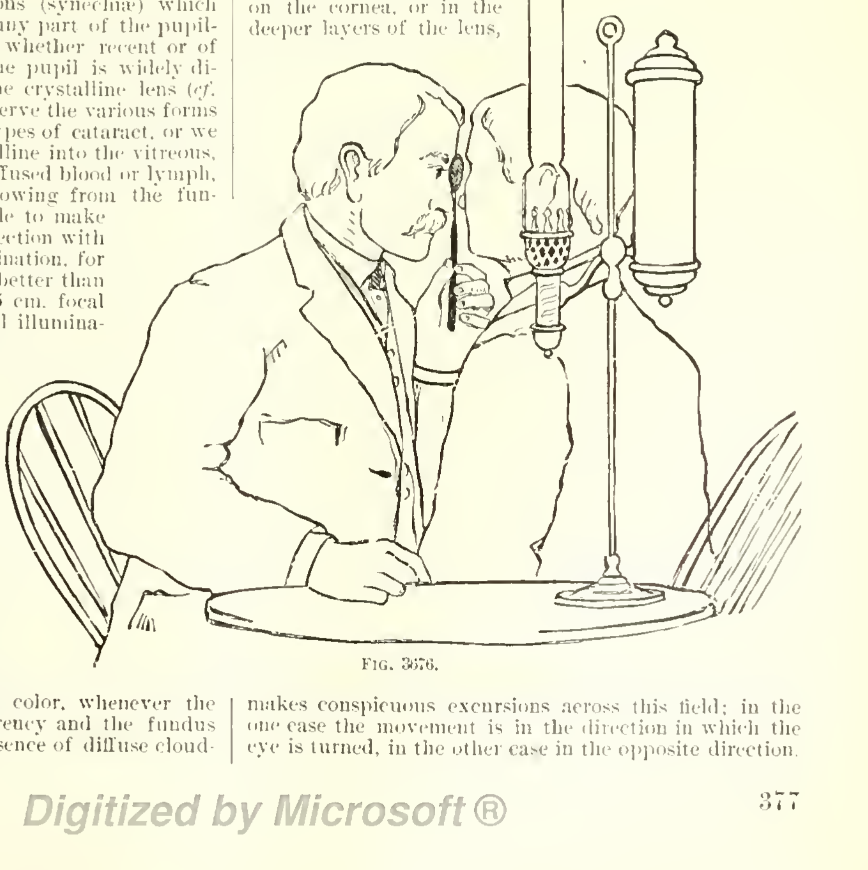

FIG. 3676.

makes conspicuous excursions across this field; in the one case the movement is in the direction in which the eye is turned, in the other case in the opposite direction.

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Another point to which the motion of a visible body within the eyeball may be referred is the bright image of the flame as seen reflected at the front of the cornea. This bright reflex is always seen at the point on the cornea which lies nearest to the eye of the observer, and affords, therefore, an approximately fixed point of reference.

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Still holding the mirror at a distance of about 20 cm. from the observed eye, it may happen that we obtain a distinct view of the details of some part of its fundus. This can occur only in myopia of a very high grade, in which the observed eye forms an inverted image of its fundus at some point within a few inches of its cornea, or in a somewhat high grade of hypermetropia. In such a case we may make a slight rotary movement of the handle of the mirror, and so change the position of the image of the flame at the fundus; as this image passes across the field of view in the direction in which the mirror is turned, its inverted image, in front of the eye (in myopia), will move, across the pupil, in the opposite direction; in hypermetropia the movement of the virtual image of the flame will be in the direction in which the mirror is rotated. If, while looking at the inverted image, we bring the mirror nearer to the eye, we presently reach a point at which the details of the picture are lost. We next advance the mirror to the usual position for the observation of the fundus in the erect image, about 5 cm. from the observed eye (Figs. 3673 and 3676). At this short distance the field of view is much enlarged (see Figs. 3651, 3652, and 3654; *cf.* Fig. 3653), and the conditions are at the best for the detection and observation of fixed or floating opacities lying deep in the vitreous, as well as for the observation of a detached retina, or a tumor growing from the fundus. It may also happen that on approaching the observed eye the details of its fundus are seen sharply defined, indicating the presence of hypermetropia of a grade in excess of the power of the convex glass behind the hole in the mirror. In such a case we may at once measure the degree of hypermetropia, by bringing progressively stronger convex glasses into position behind the mirror. If, on approaching the eye, the details of the fundus are not seen, or are seen but indistinctly, through the convex glass of 5 dioptries, we may change to successively weaker convex glasses, or to concave glasses of progressively increasing power, until, by noting the particular glass which first affords a perfectly distinct view, we have obtained a definite measurement of the refraction. If, in the course of successive observations with glasses of different power, we at first get a distinct view of only such of the retinal vessels as correspond in direction to one of the ocular meridians, and with some other glass we obtain an equally distinct view of the vessels corresponding in direction to the meridian at right angles to the former, we have both established the presence of regular astigmatism and obtained the data for the determination of its type and the measurement of its grade. If, as sometimes happens, we see the same vessels, or parts of vessels, under different degrees of definition, according as we view them through different parts of the cornea, we have to do with a case of irregular refraction (irregular astigmatism) dependent probably upon some irregularity in the contour of the cornea. In such a case the bright reflex from the cornea may show variations in size and in shape, dependent on differences in the contour of the reflecting surface. In keratoconus (conical cornea), of even low grades, the distortion of the retinal picture and the changes in the form and size of the corneal reflex are especially characteristic.

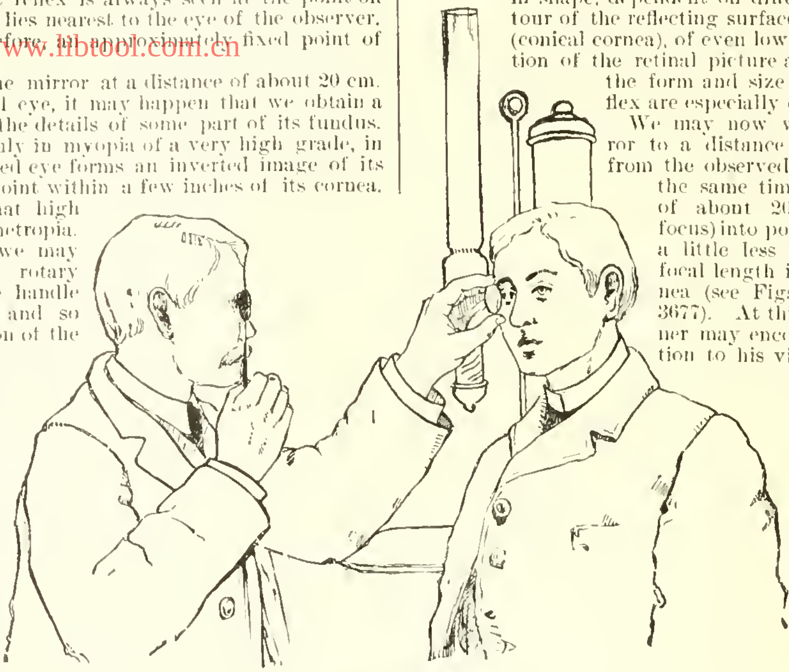

FIG. 3677.

We may now withdraw the mirror to a distance of about 40 cm. from the observed eye, bringing at the same time the convex lens of about 20 dioptries (5 cm. focus) into position at a distance a little less than its principal focal length in front of the cornea (see Figs. 3672, 3674, and 3677). At this stage the beginner may encounter an obstruction to his view of the interior of the eye arising from the bright reflex images of the flame or mirror formed by the two surfaces of the convex lens, the one virtual, behind the lens, the other real, in front of the lens. When the lens is held exactly concentric with, and at right angles to, a line connecting the pupils of the observing and the observed eye, the two reflex images lie also in this line, and may thus completely cut off the view into the eye. Both images are, however, easily got out of the way, either by moving the convex lens a little to one side, or by slightly rotating the lens so as to displace the two images in opposite directions. The strong convex lens, held at somewhat less than its focal distance in front of the eye, considerably magnifies a spot in the cornea, or in the field of the pupil, as seen from behind the hole in the mirror, and the conditions are favorable, generally, to the inspection of these parts

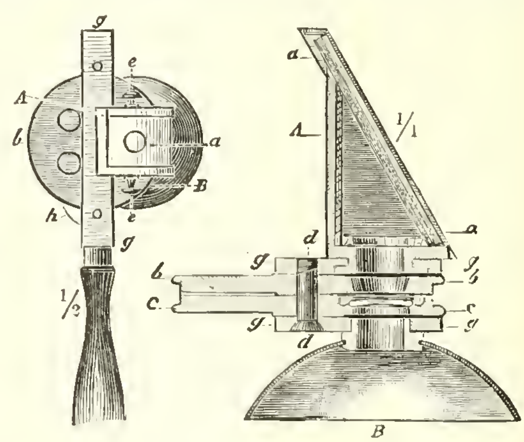

FIG. 3678.

of the eye. We may next turn our attention to the details of the fundus as seen in the inverted image, at about the position of the anterior principal focus of the convex lens, looking at it, for reasons already given, through the

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convex glass of about 5 dioptries (20 cm. focus), placed behind the hole in the mirror. Having got rid of the two reflex images formed by the convex lens, either by moving it a little to one side or by turning it a little obliquely to the line of sight, we may encounter a further obstacle in the reflex image formed by the anterior surface of the cornea. This will, however, give no serious trouble, except in the particular case in which the vertex of the cornea of the observed eye is directed exactly toward the hole in the mirror; a slight turning of the eye in any direction sufficing to displace the bright reflex from the central region of the pupil. Inasmuch as the inspection of the region of the macula involves the turning of the observed eye exactly in the direction of the eye of the observer, the indirect method is not favorable to obtaining a good view of this part of the fundus. Nevertheless, we may often succeed in eliminating much of the disturbance from the corneal reflex by making lateral movements of the convex lens in different directions.*

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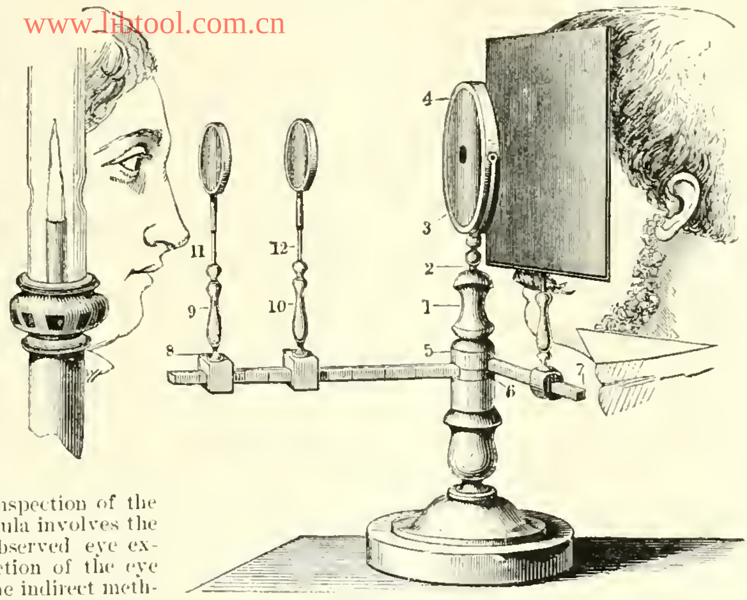

FIG. 3679.

It happens not infrequently that in moving the convex lens in a lateral direction a loop of a retinal blood-vessel appears to change in form. This is an effect of parallax, and is dependent on the fact that, by the lateral movement of the lens, the line of sight is considerably deflected, so that we see the vessel as from a different point of view. A loop of a retinal artery or vein, lying in a plane perpendicular to the general surface of the fundus, may thus appear as a straight line when viewed directly from in front, but will show something of its actual curvature when viewed from either side; the amount of the apparent curvature depending on the actual height of the loop and the extent of the lateral excursions of the lens.

For the inspection of the fundus generally, in the inverted image, including the disc of the optic nerve, the conditions are altogether favorable. To see the optic disc, which is situated to the nasal side of and a little below the posterior pole of the eye, the patient must turn his eye in the same direction, which he will most easily and surely accomplish by looking a little to the temporal side and slightly downward with the eye not under examination. To obtain a view of the peripheral regions of the fundus, the patient must turn his eye in the direction corresponding to the part to be examined, the details of which, as seen in the inverted image, will appear to move in the same direction.

If the concave ophthalmoscopic mirror is taken of very long focus (about 75 cm.), and held at a distance from the lamp and from the observed eye about equal to its radius of curvature (1.5 metres), the illuminating flame and the observed eye will be nearly at conjugate foci of the mirror, and the pupil of the latter will appear strongly illuminated. If, now, the observed eye is myopic in any degree in excess of one dioptrie, it will form an inverted aërial image of its fundus at a distance of 1 metre or less and some details of this image will be visible to an observer looking through the hole in the mirror. Inasmuch as, at the great distance of the mirror, the visible portion of the fundus is very small the patient may have to turn his eye slightly in different directions in order to bring one of the retinal vessels into view. The observer looking through a convex lens of 5 dioptries (20 cm. focus), placed behind the hole in the mirror, may calculate pretty accurately the distance of the image from the observed eye by noting the distance at which he sees the blood-vessel sharply defined. In simple myopic astigmatism (Am) and in mixed astigmatism (Amh or Ahm), only those retinal vessels whose direction is approximately at right angles to the principal ocular meridian of greatest refraction are visible in the inverted image; in hypermetropia (H), and in simple or compound hypermetropic astigmatism (Ah or H + Ah), the image is virtual, and the method is inapplicable.[1]

A plane mirror, at the distance of 1 metre, gives but a very small image of the flame at the fundus, and the field of view is also very small (see Fig. 3653). Neglecting entirely the details of the fundus, and regarding only the image of the flame, the distinction between hypermetropia and myopia may be made by simply observing the direction in which the image appears to move when the direction of the illuminating beam is changed by slightly rotating the mirror. This test turns on the fact that in hypermetropia the image which we see is virtual, and is situated behind the observed eye, while in myopia it is a real image, and is situated in front of the observed eye. Hence, in hypermetropia the image is seen to move into, across, and out of the field of view in the direction in which the (plane) mirror is rotated; in myopia the apparent movement is in the opposite direction. As the details of the image are disregarded, it is unnecessary to use a correcting glass behind the mirror, unless it be needed to correct a very high grade of ametropia in the eye of the ob-

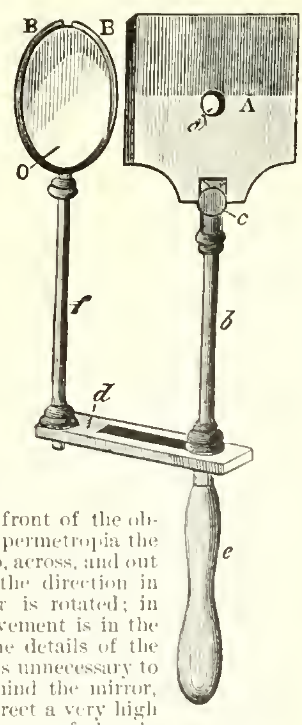

FIG. 3680.

* The geometrical axis of the cornea does not exactly coincide with the line of sight, the latter cutting the cornea a little to the nasal side of its vertex. Hence the corneal reflex does not, as a rule, exactly cover the image of the fovea. The angle which the axis of the cornea makes to the line of sight is known as the angle α (Donders); it is greatest in hypermetropic eyes, and least, sometimes even negative, in myopic eyes.

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server. In this test it amounts practically to the same thing whether we speak of the movements of the bright image, or of the border of the unilluminated area surrounding it. It happens, however, that the writers who have especially cultivated this method have directed attention rather to the dark border (shadow) than to the image of the flame; hence the name, *shadow-test*, by which this method is commonly designated (see *Shadow-Test*).

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As a rule, an eye under ophthalmoscopic examination relaxes its accommodation. Hence measurements made with the ophthalmoscope not infrequently show a somewhat higher grade of hypermetropia, or lower grade of myopia, than is revealed by subjective tests made with test letters without the resort to artificial mydriasis. In the case of certain careless or obstinate patients, of some illiterate persons, and especially of young children, the ophthalmoscope is indispensable in the diagnosis of ametropia in all its forms.

Two principal types of the ophthalmoscope are to be distinguished, namely, those adapted to the examination of the fundus by the direct method, and those in which an inverted real image of the fundus is formed by the aid of a convex lens. The former type appears in a practically perfect form, in the original invention of Helmholtz (1851); the latter type was evolved in its essential features by Ruete, in the course of the following year. The invention of Helmholtz consists essentially in the discovery of the fundamental fact that the fundus can be seen by looking through a mirror from which light is reflected into the eye; Ruete, by the combination of a concave mirror and a convex lens or lenses, demonstrated the practicability of viewing the fundus in a strongly illuminated real image. Helmholtz, in turn, by a development of the experiment of Brücke (see Figs. 3659 to 3661), showed that it was possible to see the details of the fundus, in the inverted image, by direct illumination, and with no other apparatus than a screened lamp or candle and a convex lens. The subsequent development of the ophthalmoscope has been confined essentially to changes in details, and to modifications designed to facilitate certain special uses.

It is entirely practicable to illuminate the fundus by direct light, and view its reflected image in the mirror. Thus in the arrangement shown in Fig. 3651, it is possible, though less convenient, to place the lamp at L', and to view the image, as reflected on the mirror, from L. With the lamp (preferably a small electric incandescent bulb) at L or at L', it is possible for two observers, sta-

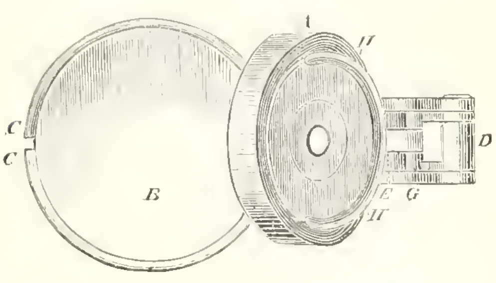

FIG. 3681.

tioned at L' and L, to view the fundus of O at the same time. Demonstrating ophthalmoscopes for two observers are based on this principle.*

Again, the efferent pencils emanating from different parts of the illuminated area at the fundus may be severally divided behind the mirror, so that each half, after two reflections, shall enter the corresponding eye of the observer. The binocular ophthalmoscope, like the binocular microscope, gives some degree of stereoscopic effect.*

Fixed ophthalmoscopes, as distinguished from ophthalmoscopes in which the mirror and the convex lens are held each in the hand, have been devised in considerable number; they have been used in measuring the details of the fundus, in making drawings of the fundus in normal and pathological states, and, especially, in demonstrating the ophthalmoscopic picture to a number of persons in succession.† Their prototype is to be found in the original ophthalmoscope of Ruete (Fig. 3679). The camera lucida may be used with any fixed ophthalmoscope.‡

Ophthalmoscopes have also been constructed with a combination of mirrors, by means of which an observer may, with one eye, see the fundus of his other eye. By a different arrangement of mirrors an image of the optic

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* In every reflecting ophthalmoscope there are two points of view at which the eye of an observer may be stationed so as to receive rays of light from the illuminated fundus, namely, the usual and most favorable position immediately behind the mirror, and a less favorable position close by the side of the lamp. The use of an electric lamp makes it possible to see the details of the fundus from a station in its immediate vicinity whenever the efferent rays reflected from the mirror are parallel or divergent, as is ordinarily the case when a plane or a slightly convex mirror is used. With a concave mirror of a focal length less than its distance from the place of the inverted image, a twice inverted (*i.e.*, erect) image of the fundus may be seen at some point between the mirror and the lamp. A third point of view may be obtained by deflecting a part of the efferent rays at some point between the observed eye and the mirror. This is effected in the "ghost" ophthalmoscope of Laurence ("Klinische Monatsblätter für Augenheilkunde," S. 534, 1863) by interposing a sheet of polished transparent glass, set at an angle of 45°, in the path of the illuminating and the efferent rays; the latter are in part transmitted by the sheet of glass, and in part reflected at right angles to their original course. Some of the rays which have entered into the formation of the inverted image may be deflected to one side by reflection from a small plane mirror in front of and partially covering the central opening of the illuminating mirror; or some part of the same rays may be similarly deflected by a small reflector, preferably a totally reflecting right prism, placed just behind the illuminating mirror. Demonstrating ophthalmoscopes of this construction have been devised by De Wecker and Roger ("Bulletin de l'Académie des Sciences," 1870), and by Sichel *fils* (Annales d'Oculistique, 1872). By slightly separating the two totally reflecting glass rhombs in the binocular ophthalmoscope of Giraud-Teulon, and cutting them off square at their ends, an ophthalmoscope for three observers has been constructed (Monoyer: Revue médicale de Nancy, 1874); a fourth observer may see the fundus reflected on the illuminating mirror in the direction of the light.

* Coccius was probably the first to construct a binocular ophthalmoscope; a small perforated plane mirror, set, at an angle of 45°, behind the hole in the illuminating mirror, deflected a part of the efferent rays in a direction at right angles to the line of sight, and a second plane mirror, parallel to and about six 6 cm. distant from the other, reflected these rays into the second eye of the observer. The two retinal pictures were necessarily of unequal size, but notwithstanding this defect, the instrument is said to have given a somewhat better view than when but one eye was used (Snellen und Landolt; Graefe-Saemisch, "Handbuch der gesammten Augenheilkunde," iii., i., S. 160). The first binocular ophthalmoscope of good construction is that of Giraud-Teulon, in which the rays which have traversed the right half of the hole in the mirror are reflected to the right, and the other half to the left, and both are again reflected, at right angles, to enter the two eyes of the observer. All this is very simply accomplished by total reflection at the two obliquely cut ends of two rhombohedra of glass enclosed within a small metallic box behind the mirror (Annales d'Oculistique, xlv., 1861). By a slight change in the construction of this instrument, by Laurence and Heisch, it is made of a little lighter weight, although more fragile and more costly. A further modification, by Coccius, consists in the application of the principle of the common opera-glass, by which the image is seen considerably magnified (Report of the Fourth International Ophthalmological Congress, London, 1873). The latest change in this ophthalmoscope is by its inventor, who has notched the proximal ends of the two rhombohedra so as to make a small central opening, behind which he has placed a very small electric lamp, thus dispensing with the mirror (Giraud-Teulon: Annales d'Oculistique, xcvi., December, 1886).

† Th. Ruete: "Der Augenspiegel und das Optometer," Göttingen, 1852. The Epkens-Donders ophthalmoscope (1853) is a fixed ophthalmoscope designed for the measurement of the details of the fundus as seen in the erect image. Ulrich (Henle und Pfeuffer's Zeitschrift für rationelle Medicin, 1853) combined the mirror and object lens in a short metal tube, to the side of which a candle was attached. Hasner (Prager Vierteljahrsschrift, 1855) made the tube longer and used a separate lamp. R. Liebreich (Archiv für Ophthalmologie, 1855) constructed his larger ophthalmoscope by mounting an instrument essentially like Hasner's upon a standard and fixing the head of the patient by means of a special rest. With this ophthalmoscope he made the elaborate colored representations of the fundus figured in his "Atlas der Ophthalmoscopie" (Berlin, 1863). Burke ("Ophthalmoscope réflecteur," Havre, 1871) constructed a fixed ophthalmoscope in which a second concave mirror, of 19 cm. focus, was substituted for the usual object lens in examinations by the indirect method. Carter (Report of the Fourth International Ophthalmological Congress, London, 1873) mounted the several parts of the ordinary hand ophthalmoscope, all on an enlarged scale and with correspondingly increased radii of curvature, upon separate standards resting on a table four feet long.

‡ The camera lucida was used with the Epkens-Donders ophthalmoscope and with the large ophthalmoscope of Liebreich: Noyes (Transactions of the American Ophthalmological Society, 1873) also applied it to the fixed ophthalmoscope of Carter.

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disc is formed at the macula of the same eye. These are curiosities of ophthalmoscopy.*

The ophthalmoscopes which have won a permanent place in the armamentarium of the ophthalmic practitioner are all based directly upon the simple reflecting ophthalmoscope of Helmholtz and the compound ophthalmoscope of Ruete. A few typical forms must be briefly noticed.

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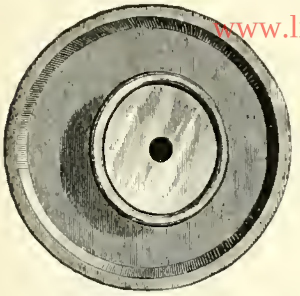

FIG. 3682.

The ophthalmoscope of Helmholtz (1851), perfected in some of its details by the instrument maker Rekoss, is shown in Fig. 3678. The two revolving discs, at the back of the mirror, have each five openings, in four of which are mounted concave glasses, giving twenty combinations ranging from — 3 dioptries to — 13 dioptries. The mirror, made up of three layers of very thin glass, is set at an angle of 56° to the plane of the revolving disc. The lamp is placed a little behind the plane of the observer's face, necessitating the use of a screen, to shade the observed eye from the direct light. The purpose of the concave glasses, in the two discs, is to permit the details of the fundus to be distinguished notwithstanding the presence of myopia of the observing or of the observed eye, and also to neutralize any disturbing effect arising from the possible exercise of the accommodation in either eye.[2]

The ophthalmoscope of Ruete (1852) consists of a perforated concave mirror and two vertical standards for holding lenses, all mounted in line on a fixed horizontal bar (Fig. 3679). With a convex lens of 4 cm. focus, mounted on the first standard at a distance of about 3 cm. in front of the cornea of the observed eye, an inverted image of its fundus, magnified about two and a half diameters, is formed about 4 cm. in front of the lens, and is viewed by the observer looking through the hole in the concave mirror. A second convex lens, mounted on the second standard at a distance somewhat beyond the position of the inverted image, affords the means of viewing this image under an increased amplification. A concave lens, mounted on one of the standards, is used in the examination by the direct method.[3]

FIG. 3683.

Coccius (1853) attached a convex lens to a plane mirror in such a position that the illuminating rays pass through the lens before impinging upon the mirror (Fig. 3680). The conjoined effect of the convex lens and plane mirror is essentially that of a concave mirror.[4]

Ruete's fixed ophthalmoscope becomes an ordinary hand ophthalmoscope when the mirror and the convex lens are dismounted, and are held in the two hands of the observer.

* Helmholtz ("Beschreibung eines Augenspiegels," Berlin, 1851) described a simple method by which an observer may, by looking in a mirror, see the illuminated pupil of one of his own eyes with the other eye. Coccius ("Ueber Glaukom, Entzündung und die Autopsie mit dem Augenspiegel," Leipzig, 1859) devised an arrangement of light and mirror by which an eye may receive a defined picture of its own optic disc. Heymann ("Die Autoskopie des Auges," Leipzig, 1863) combined a perforated plane mirror, a reflecting prism, and three convex lenses in such a manner that with one eye a view is obtained of the fundus of the other eye in a twice-inverted (*i.e.*, erect) picture. Similar arrangements have been devised by Giraud-Teulon (Annales d'Oculistique, xlix., 1863) and by Coccius.

Zehender (1854) substituted a convex mirror of 16 cm. radius of curvature for the plane mirror in the instrument of Coccius, thus making it possible to obtain from a single convex mirror the effect also of a plane, or of a concave, mirror (Fig. 3681).[5]

A convex mirror offers a slight theoretical advantage over a plane mirror, as does the latter over a concave mirror, in examinations by the direct method, and the instruments of Coccius and of Zehender have been especial favorites with some excellent observers. They are, however, more difficult to manage than the concave mirror, and are at present but little used. In practice the perforated concave mirror of 23 cm. focus suffices for most examinations, whether by the indirect or the direct method; in a few special cases the polarizing plane mirror of Helmholtz maintains its superiority over all rival inventions.

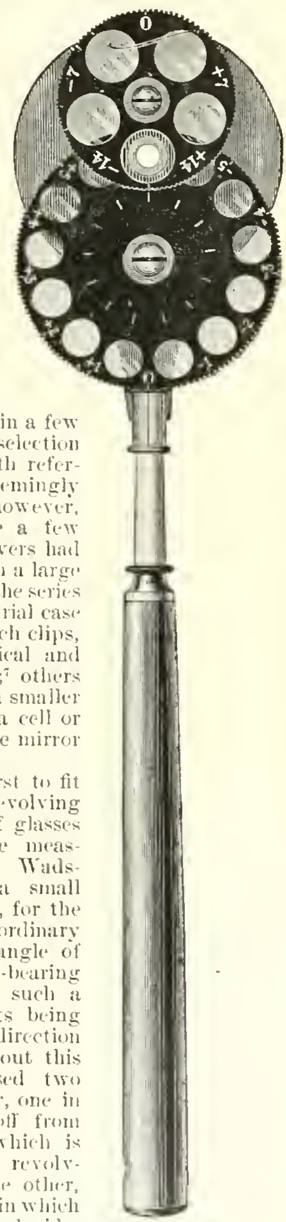

FIG. 3684.

The ophthalmoscope of Helmholtz, with the two Rekoss discs, includes all that is required for the convenient measurement of the refraction by the direct method, provided only that the discs are made larger, so as to contain a few more glasses, and that the selection of the glasses is made with reference to this use. This seemingly obvious development was, however, long deferred. Meanwhile a few exceptionally careful observers had ophthalmoscopes made with a large clip, to receive any one of the series of glasses in the oculist's trial case (Donders),[6] or with two such clips, intended to hold a spherical and a cylindrical glass (Noyes);[7] others contented themselves with a smaller series of glasses, fitted to a cell or small clip at the back of the mirror (Jaeger).[8]

Loring (1869) was the first to fit the ophthalmoscope with revolving discs containing a series of glasses sufficient for the accurate measurement of the refraction.[9] Wadsworth (1876) substituted a small mirror, of 15 mm. diameter, for the larger concave mirror in ordinary use, setting it at a fixed angle of 20° to the plane of the lens-bearing disc, and mounting it in such a manner as to admit of its being turned in any required direction (Fig. 3682).[10] Following out this suggestion, Loring devised two modifications of the mirror, one in which a segment is cut off from one side of the mirror, which is hinged at this border to a revolving setting (Fig. 3683); the other, the so-called tilting mirror, in which a segment is cut off from each side, and the mirror is swung on pivots at the two extremities of its vertical diameter (Fig. 3687).[11] The ophthalmoscope of Loring, as perfected by its inventor, is the type of a thoroughly good instrument for all practical uses; as made under his direction, by Mr. H. W. Hunter, of New York, it has not been surpassed as a model of good construction and fine workmanship.

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The essential points in the construction of a good ophthalmoscope are few and simple. The best material for the concave mirror is silvered glass, which should be very thin, in order that the margin of the central perforation may encroach as little as possible upon the effective area of the opening when the mirror is turned obliquely to the line of sight; any excess of thickness above 0.3 mm. is both unnecessary and injurious. The central hole should be about 3.5 mm. in diameter,* and its unpolished margin should be coated with a dull black pigment; the alternative expedient of removing the silvering from a small central area of the mirror is not to be commended. A mirror made of polished metal is more difficult to keep in order, and, unless in very perfect condition, reflects much less light than a mirror of silvered glass. The focal length of the mirror should be about 23 cm.; this is a convenient focal length for examinations by the indirect method, and in the direct method the effect is not very different from that of a plane mirror (*cf.* Figs. 3652 and 3654). The mirror should be so mounted as to admit of its being inclined about 25°, to the plane of the correcting glass, and it is very desirable that it be so arranged that it can be turned in its cell. For the latter reason, and also because the mirror, when lying flat in its cell, is in closer proximity to the correcting glass, the writer prefers the hinged mirror of Loring (Fig. 3683) to his tilting mirror (Fig. 3687).

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Fig. 3685.

Fig. 3686.

The correcting glasses should be so mounted as to admit of their automatic centration, and of the easiest possible change from one glass to another without interrupting the observation by removing the instrument from the eye. The series of lenses should be sufficiently large to include the entire range of hypermetropia and of myopia, with intervals as small as can be taken note of by the observer; a common interval of 1 dioptrie will suffice for most practitioners, others may be able to utilize an interval as small as 0.5 dioptrie. A combination of a larger and a smaller Rekoss disc, or of a full disc with a quadrant of another disc, is sufficient to meet these requirements; the glasses in the principal disc should be of somewhat greater diameter than the hole in the mirror (about 5 mm.); those in the second disc or quadrant should be a little larger (about 7 mm. in diameter). The two discs should be as thin as the curvature of the glasses will permit, and they should be mounted in the closest possible proximity to each other and to the back of the mirror.

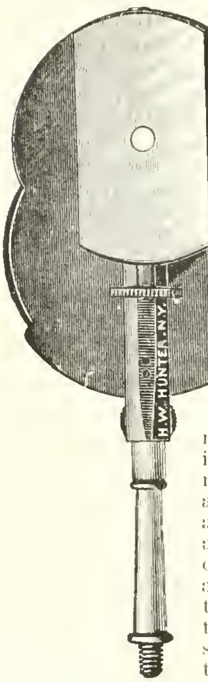
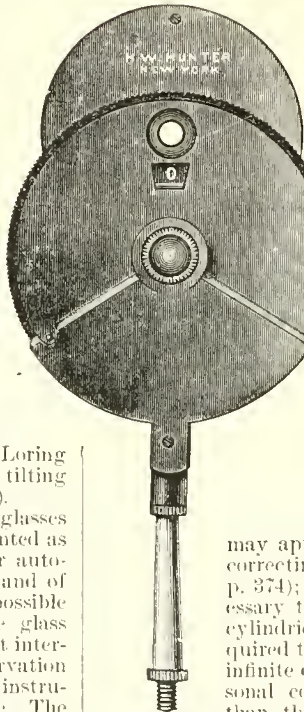


Fig. 3687.

The handle of the ophthalmoscope should be not less than 14 or 15 cm. in length, measured from the centre of the mirror, and it should be large enough to admit of its being easily and firmly grasped by the hand. As, with this length of handle, it is somewhat difficult to reach the edge of the principal disc with the finger, a rack-and-pinion mechanism (Crétès), a cog-wheel (Loring), a train of cog-wheels (Noyes), or a cog and cam device (Meyrowitz), has been added; a very full series, of no less than seventy-four glasses, has been mounted, after the manner of an endless chain, in the place of the usual revolving disc (Couper);[12] a smaller series, similarly mounted, is used in the ophthalmoscope of Morton.

If the observer is simply hypermetropic or myopic, he may apply his personal correction to the correcting glass found by observation (see p. 374); if he is astigmatic, it may be necessary to add to the ophthalmoscope such cylindrical glass or glasses as may be required to correct his vision in either eye for infinite distance. The glasses for this personal correction should be a little larger than those in the second disc (about 9 mm. in diameter) and should be mounted immediately behind it; in astigmatism, of even as low a grade as 1 dioptrie, its correction adds appreciably both to the sharp definition of the picture and to the observer's quickness of perception.



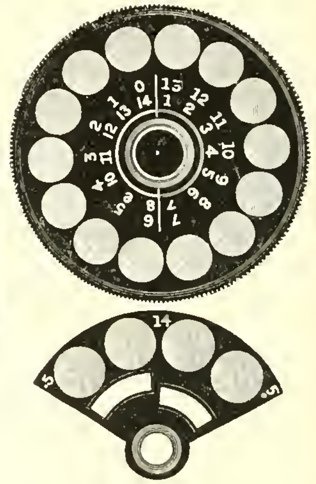


Fig. 3688.

Fig. 3684 shows the back of an ophthalmoscope made for the writer, in 1876, by Hunter.[13] It is, in fact, one of Loring's smaller ophthalmoscopes, with the addition of a second smaller disc—a construction adopted, a little later, by Badal, in France. Substituting + 13 and − 13 for + 14 and − 14, the order in which the glasses are brought into use becomes precisely the same as in the ophthalmoscope of Badal and in the later ophthalmoscopes of Loring; with +0.5 and −0.5 in the place of + 7 and − 7, as figured, an interpolation of 0.5 dioptrie may be made between the limits + 6.5 and − 6.5. A third disc, with two glasses, serving also as a cover to the smaller disc (Fig. 3685), or a setting of the form shown in Fig. 3686, affords the means of applying such correction as an astigmatic observer may find advantageous. The ophthalmoscope of Loring, with the tilting mirror, in the construction finally adopted by its author, is shown in Figs. 3687 and 3688.[14]

John Green.

* H. Knapp (Archives of Ophthalmology and Otology, iv., i., p. 41, 1874) made comparative trials of a number of mirrors with holes varying from 1 to 5 mm.; "the best illumination is obtained by an opening in the mirror of 3.5 or 3.75 mm. in diameter."

Plate XLVII., by Jaeger, shows the fundus of a normal eye as viewed by means of the ophthalmoscope.

[1] Couper: Report of the Fourth International Ophthalmological Congress, London, 1873.

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[2] Helmholtz: Beschreibung eines Augenspiegels. Berlin, 1851.
[3] Th. Ruete: Der Augenspiegel und das Optometer, Göttingen, 1852.
[4] A. Coccius: Ueber die Anwendung des Augenspiegels nebst Angabe eines neuen Instrumentes, Leipzig, 1853.
[5] W. Zehender: Archiv für Ophthalmologie, I., i., 1854.
[6] F. C. Donders: On the Anomalies of Accommodation and Refraction of the Eye. The New Sydenham Society, p. 106, London, 1864.
[7] H. D. Noyes: Transactions of the American Ophthalmological Society, 1869.
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[8] Ed. Jaeger: Oesterreichische Zeitschrift für practische Heilkunde, 7. März, 1856.
[9] E. G. Loring: Transactions of the American Ophthalmological Society, 1869.
[10] O. F. Wadsworth: Boston Medical and Surgical Journal, January 25th, 1877.
[11] E. G. Loring: Report of the Fifth International Ophthalmological Congress, New York, 1877.
[12] Couper: See description of Couper's new Ophthalmoscope, with illustration, in Juler's Handbook of Ophthalmic Science and Practice, London, 1884.
[13] J. Green: Transactions of the American Ophthalmological Society, 1878, p. 476.
[14] E. G. Loring: Transactions of the American Ophthalmological Society, 1878, p. 489.

OPIUM.—(U. S. P.; B. P.; P. G.) *Succus Thebaicus, Lachryma Papaveris, Extractum thebaicum, Meconium, Laudanum.*

Definition.—Officially considered, under the authority of the United States Pharmacopœia, opium is "the concrete milky exudation obtained by incising the unripe capsules of *Papaver somniferum* L. (*P. officinale* Gmel.; *P. album* Mill., fam. *Papaveraceæ*), and yielding, in its normal moist condition, not less than nine per cent. of crystallized morphine" when assayed by the United States Pharmacopœia process. This definition is to be read in connection with the description given below, which more closely delimits the article. It is also to be considered in connection with the provisions for *Opii Pulvis* (see the section on Preparations), which has a different alkaloidal standard, and with those for the alkaloidal standardization of the preparations made from the latter.

Fig. 3689.—The Opium Poppy (var. nigrum). Plant much reduced. (Baillon.)

The definitions of other pharmacopœias differ considerably from that of ours. The German requires, as ours formerly did, that opium be produced in Asia Minor; also that it contain from ten to twelve per cent. of morphine and not more than eight per cent. of moisture. The British Pharmacopœia requires different amounts of morphine for the opiums used in the different preparations; not less than seven and a half per cent. for the tincture and extract, and between nine and a half and ten and a half per cent. for other uses. For diluting a higher with a lower grade, the United States Pharmacopœia requires that the morphine percentage of the latter be between seven and a half and ten per cent. In view of the standardization of the preparations, it would at first thought appear superfluous to impose rigid standards for the drug, but important commercial and tariff considerations are involved, aside from the fact that large downward variations in morphine percentages are liable to be accompanied by important upward variations in the percentage of other, perhaps undesirable, alkaloids.

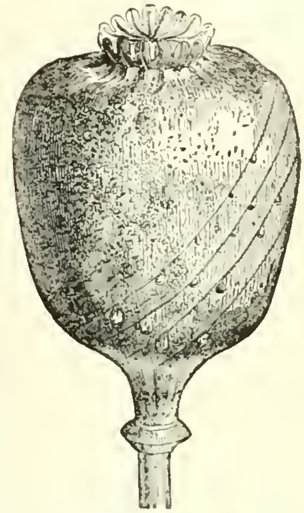

Fig. 3690.—White Poppy, showing the incisions made in the green capsule for the extraction of opium. (Baillon.)

Origin.—All opium is now regarded as the product of the one species named in our definition, though some botanists have been inclined to regard its varieties as distinct species. Although the plant grows abundantly in a wild state about the eastern Mediterranean, and in adjacent regions, opium is wholly the product of cultivated plants. Although the *var. glabrum*, having red flowers and usually dark seeds, is preferred and more largely grown in Turkey, and the *var. album*, with white flowers, is more commonly grown in Persia, such distinctions are not rigid, since flowers of all intermediate colors may usually be seen in a Turkish plantation. The opium plant here figured (Fig. 3689) is an annual herb, nearly a metre (a yard) high, somewhat branched above and bearing from five to twenty large flowers and capsules (see Fig. 3690). The latter is about as large as a small apple, and yields the opium by the process described below. (See section on Production.)

Almost every country possessing a suitable climate has yielded opium of fair to good quality, including Europe as far north as Sweden and North America as far north as New England, though most of these operations have been purely of an experimental character. Financial success in opium production requires a special combination of conditions affecting soil, climate, population, and cost of labor, and has been attained, to a noteworthy extent, only in Turkey, Persia, India, China, and Egypt. Of these products that only of Turkey answers perfectly to the official description, and it supplies practically the entire medical demand, except for purposes of morphine manufacture. For this, any product rich in morphine and easily worked is selected, the most of it, with the exception of Turkish opium, being Persian, so far as United States manufacturers are concerned. All other opium is consumed in the vicious practices of smoking and chewing. Of this, the Egyptian product is probably somewhat greater than the whole of the Turkish product, though smaller now than formerly. That of India is probably from ten to twenty times as great as that of Turkey, and that of China at least double that of the

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rest of the world, including even the Indian. It will thus be seen that the vicious use of opium is about fifty times as great as its medicinal use, in connection with which it must be remembered that probably more than half of that usually classed as medicinal is in reality vicious.

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Production and Preparation.—The best climatic conditions for poppy culture are those which prevail in the warmer wheat-growing sections—conditions under which it is practicable to sow in September, to trust to a covering of snow for the protection of the young plants through the winter, and to gather in the crop late in the following summer. More precarious, and generally less successful, is the production of a crop during the summer of the same year, the sowing being done in February or March. The capsules are ready for incision when just beginning to turn yellow, at which time the dense network of milk tubes ramifying through the entire thickness of the pericarp is charged with a thick milky juice. In Turkey the incisions are made in a somewhat obliquely or spirally transverse direction (Fig. 3690), in India vertically. In both cases the knife possesses two or three blades set near to one another, and the incision is made as deeply as possible, care being taken that it shall not penetrate the central cavity. This work is performed in the late afternoon, *i.e.*, at a time when the sun will not interfere with the flow of juice. In the morning, the exudation will be found to have thickened sufficiently to admit of its collection. It is considered that the quality of the Indian product is injuriously affected by the prevalence of very heavy dews. The opium is removed by a blunt scraping instrument, to which it is prevented from adhering in a troublesome degree by various devices; in Turkey, by the use of the saliva of the collector, in Persia by the application of a small quantity of oil. Owing to slight differences in the use of the scraper, portions of the epidermis of the capsule may or may not be removed with the opium. The collection of the Smyrna product naturally adds from five to eight per cent. to the weight of the opium from this source, and this amount is usually very largely added to. (See section on Adulteration.) As gathered, the opium is transferred to a poppy leaf held in the left hand, and the mass, when of convenient size, is laid away in the shade for a day's drying, which, if it has not advanced too far, will permit of the moulding of the product. When sufficiently dry it is enwrapped in the poppy leaf, and such masses may then, without further modification, be packed in Rumex capsules, to prevent their adhesion to one another, and marketed. They may, on the other hand, be subjected to very varied processes for various purposes. Considerable of the Persian opium is subjected to a long-continued kneading or beating process, with exposure to the atmosphere, so as to cause it to assume a resemblance in appearance to Constantinople opium. The latter variety is said to be similarly beaten up, so as to make it of a more homogeneous and finer structure. Much of the high-grade Turkish opium, and almost all of that of similar grade of other countries, is beaten up with that of lower percentage, to increase its bulk and weight. It is even said that some medicinal Turkish opium has thus mixed with it that of other countries. None of the operations above considered, though designed to reduce the morphine strength, can be regarded as acts of adulteration, so long as they do not result in reducing the morphine strength below official standards. Persian and Indian opium, instead of being wrapped in the poppy leaf, are usually wrapped in paper, and, since they are designed chiefly for exportation to China, they frequently bear inscriptions in Chinese characters. The masses are of varied forms, being in squares, cakes, cylindrical sticks, balls, or in masses similar to those of the Turkish article. Instead of being packed, like the Turkish, in Rumex capsules, they are usually packed in "poppy-trash," consisting of the chopped, dried capsules and other parts of the plants.

Adulteration.—The dilution of a high-grade, by the addition of a low-grade opium has been already considered. That by the addition of an excessive amount of the epidermis of the capsule or of the chopped capsules, or possibly of other parts of the plant similarly chopped, sometimes amounting to a third of the weight of the opium, or of an extract of the capsules, or of starchy substances, all of which are in themselves practically inert, may be considered, when they do not reduce the morphine strength below the official standard, as on the borderland between dilution and adulteration. The use of an extract made from the herbage of the plant is clearly adulteration, and is rather common, as is that of various gummy substances of an extraneous nature, and of earthy substances, some of them effervescing with acids. The use of such heavy bodies as stones, nails, and bullets, now less common than formerly, scarcely requires mention. The custom still prevails, to a greater or less extent, of diluting opium, after arrival in this country, so that it barely meets the official requirement, the product being known as *Pudding* or *Boston Opium.*

DESCRIPTION.—In irregularly globular, usually more or less flattened masses, weighing from 250 to 1,000 gm. (½ to 2 lbs.), the surface marked with the impression of a poppy-leaf used for wrapping, and frequently bearing fragments of this, with some rumex fruits; of a chestnut-brown or reddish-brown, changing to dark or blackish-brown with long keeping; plastic and rather soft, or gradually hardening from without inward, with age; fractured surface exhibiting more or less tissue fragments, together with small tear-shaped particles of opium and, under the microscope, some acicular crystals, especially visible after moistening with benzene; of a heavy narcotic odor and taste, the latter disagreeable and bitter.

The required morphine percentage has been stated under Definition. Although the official definition would permit the employment of the higher grades of opium from any country, it will be seen that the description, in view of what has been said concerning the different methods of wrapping and packing, would exclude all but the Turkish variety. Persian opium is light-colored and characterized externally and internally by an oily appearance. Egyptian opium is packed much like the Turkish, but is dark-colored and is almost if not quite invariably below the official standard in morphine yield. Indian opium is also dark-colored, usually possesses a peculiar odor, said to be due to fermentation during the long process of curing required by the peculiar conditions to which it is subject, and is commonly encased in coverings made by glueing together poppy leaves or petals by a substance made partly from a dark-colored exudation from the curing opium and partly from an extract of the plant. Very little of it is exported, except to China (*Provision Opium*), and this small quantity is restricted almost wholly to the Patna product. Chinese opium is mostly of very low grade, though of late some of much better quality has been produced. It is not of interest in materia medica.

Since it is required that the determination of the morphine percentage be accomplished by the official method, it is important that this process be here given:

Assay of Opium.

Opium, in any condition to be valued.. 10 gm.
Ammonia water .... 3.5 c.c.
Alcohol,
Ether,
Water......... of each a sufficient quantity.

Introduce the opium (which if fresh should be in very small pieces, and if dry, in very fine powder) into a bottle having a capacity of about 300 c.c., add 100 c.c. of water, cork it well, and agitate frequently during twelve hours. Then pour the whole as evenly as possible upon a wetted filter having a diameter of 12 cm., and, when the liquid has been drained off, wash the residue with water, carefully dropped upon the edges of the filter and the contents, until 150 c.c. of filtrate are obtained. Then

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carefully transfer the moist opium back to the bottle by means of a spatula, add 50 c.c. of water, agitate thoroughly and repeatedly during fifteen minutes, and return the whole to the filter. When the liquid has drained off, wash the residue as before until the second filtrate measures 150 c.c. and finally collect about 20 c.c. more of a third filtrate. The second filtrate, placed in a tared capsule, is first to be evaporated until it represents only a small volume; then to this is to be added the first filtrate; and, finally, after rinsing the vessel with the third filtrate, the evaporation is to be continued until the residue weighs 14 gm. Rotate the concentrated solution about in the capsule until the rings of extract are redissolved, pour the liquid into a tared Erlenmeyer flask having a capacity of about 100 c.c., and rinse the capsule with a few drops of water at a time, until the entire solution weighs 20 gm. Then add 10 gm. (or 12.2 c.c.) of alcohol, shake well, add 25 c.c. of ether, and shake again. Now add the ammonia water from a graduated pipette or burette, stopper the flask with a sound cork, shake it thoroughly during ten minutes, and then set it aside, in a moderately cool place, for at least six hours, or over night.

Remove the stopper carefully, and, should any crystals adhere to it, brush them into the flask. Place in a small funnel two rapidly acting filters, of a diameter of 7 cm., plainly folded, one within the other (the triple fold of the inner filter being laid against the single side of the outer filter), wet them well with ether, and decant the ethereal solution as completely as possible upon the inner filter. Add 10 c.c. of ether to the contents of the flask, rotate it, and again decant the ethereal layer upon the inner filter. Repeat this operation with another portion of 10 c.c. of ether. Then pour into the filter the liquid in the flask, in portions, in such a way as to transfer the greater portion of the crystals to the filter, and, when this has passed through, transfer the remaining crystals to the filter by washing the flask with several portions of water, using not more than about 10 c.c. in all. Allow the double filter to drain, then apply water to the crystals, drop by drop, until they are practically free from mother-water, and afterward wash them, drop by drop, from a pipette, with alcohol previously saturated with powdered morphine. When this has passed through, displace the remaining alcohol by ether, using about 10 c.c., or more if necessary. Allow the filter to dry in a moderately warm place, at a temperature not exceeding 60° C. (140° F.), until its weight remains constant, then carefully transfer the crystals to a tared watch-glass and weigh them.

The weight found, multiplied by ten, represents the percentage of crystallized morphine obtained from the opium.

Constituents.—Not all of the alkaloids of opium here described occur in all the varieties of opium, the presence or amount of some of them depending upon varying conditions of production or preparation. Of the twenty naturally occurring alkaloids, the identity of which has been established, morphine and codeine, as well as their derivatives, apomorphine and apocodeine, and also narcotine, are considered under those titles. Although several of the others are somewhat used in medicine, they are not sufficiently employed to be entitled to separate consideration, and they are briefly discussed here and in the section on Properties and Uses. Besides these, quite a number of alkaloids have been obtained artificially by treatment of the others.

Morphine occurs in opium of different kinds and grades in amounts varying from a small fraction of one per cent. up to nearly twenty-five per cent. Its ordinary percentage varies from six or seven to twelve or fourteen per cent. In the medicinal Turkish opium, probably as the result of manipulation with that object in view, it occurs almost uniformly in from nine and a half to ten and a half per cent. It occurs in the drug as a compound with sulphuric acid or as one with meconic acid. *Codeine*, which exists similarly, rarely if ever reaches one per cent. in amount and sometimes does not exceed one-fifth of one per cent.

Narceine ($C_{23}H_{29}NO_9 + 2H_2O$) resembles narcotine in appearance, though the crystals are finer and more slender and are slightly bitter. It melts at 145.2° C. (291.6° F.), is insoluble in ether, but is somewhat soluble in water and in alcohol. Nitric acid colors it yellow, though the color is evanescent; iodine, in small amount, gives it a blue color; Erdmann's reagent produces a deep yellow tint, becoming brownish, then orange; finally, Frohde's reagent produces a brownish green color which first turns yellow and then red. Like narcotine, narceine is but weakly basic. Its salts are crystallizable and are mostly incompatible with water, being precipitated or decomposed by it. Its hydrochloride is mostly employed and is strongly basic.

Thebaine ("paramorphine," $C_{19}H_{21}NO_3$) usually occurs in strongly lustrous scales, but sometimes in prismatic crystals. It is soluble in alcohol, benzene, and chloroform, and to a considerable extent in ether, and is insoluble in water. Its melting point is 193.4° C. Sulphuric acid colors it blood red, changing to yellow, nitric acid colors it red, Erdmann's reagent orange-red, Frohde's orange-yellow, slowly disappearing. It is decomposed quickly by diluted acids, with a production of the two isomeric uncrystallizable alkaloids *thebenine*, and *thebaicine*. It yields readily crystallizable salts.

Papaverine ($C_{20}H_{21}NO_4$) occurs in colorless acicular or prismatic crystals, soluble in hot alcohol, chloroform, and benzene, only slightly so in ether and cold alcohol, and insoluble in water. Its melting point is 147° C. (296.6° F.). It is colored purple or violet by warm sulphuric acid, violet-blue, becoming blue, yellowish, and colorless by Frohde's reagent. It yields salts readily and these are somewhat soluble in water.

The remaining alkaloids occur only in very minute amounts, and are merly objects of curiosity in materia medica. They are:

Codamine ($C_{20}H_{25}NO_4$), *Cryptopine* ($C_{21}H_{23}NO_5$), *Gnoscopine* ($C_{22}H_{23}NO_7$), *Hydrocotarnine* ($C_{12}H_{15}NO_3$), *Lanthropine* ($C_{23}H_{25}NO_4$), *Laudanine* ($C_{20}H_{25}NO_4$), *Laudanosine* ($C_{21}H_{27}NO_4$), *Meconidine* ($C_{21}H_{23}NO_4$,) *Oxynarcotine* ($C_{22}H_{23}NO_8$), *Protopine* ($C_{20}H_{19}NO_5$), *Pseudomorphine* ($C_{34}H_{36}N_2O_6$ "Phormine" or "Oxydimorphine"), *Rhoeadine* ($C_{21}H_{21}NO_6$), *Tritopine* ($C_{42}H_{54}N_2O_7$), and *Xanthaline* ($C_{37}H_{36}N_2O_9$).

Next to the alkaloids, the most important constituent of opium is about four per cent. of meconic acid ($C_7H_4O_7$), occurring free and in the alkaloidal salts. It can be extracted by the addition of lime, as calcium meconate. It occurs in colorless scales or prismatic crystals, soluble in alcohol and in hot water. It is colored deep red by ferric salts, the color not being destroyed by hydrochloric acid or by chloride of mercury or gold. It is tribasic and is decomposed, by boiling, into *comenic* and *pyrocomenic acids*.

A variable amount of lactic acid occurs in opium. *Meconin* and *Meconoisin* are neutral principles. The former ("opianyl") is in colorless, odorless, shining, bitter prismatic crystals, melting in the air at 110° C. (230° F.) and is soluble in alcohol and ether, slightly in water. It gives a green color when evaporated with sulphuric acid, with the addition of a little water. The latter has a somewhat higher melting point and yields a red, changing to a purple color, on similar treatment with sulphuric acid.

Among the less important constituents of opium neither starch nor tannin occurs. There is a varying amount of resin, a caoutchouc-like substance, gum, pectin, fixed oil, wax, glucose, coloring matter, and a volatile odorous principle.

Action and Uses.—A consideration of the actions of the more important constituents must precede those of opium. Those of morphine, codeine, and narcotine have already been considered under these titles. Of the minor constituents, the odorous principle of opium is often objectionable to the senses, and is removed in the *Opium Deodoratum* or *Deodorized Opium* (*Opium Denarcotisatum*, United States Pharmacopoeia, 1880) by repeatedly washing with ether, and adding to the dried residue enough

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sugar of milk to restore the product to its original weight. This treatment is supposed to remove also the narcotine, and probably most of the thebaine, the latter result greatly affecting its physiological action.

Thebaine.—This alkaloid is to be regarded as the principal constituent antagonistic to morphine, and hence to the general action of opium. It is a powerfully poisonous irritant of the spinal centres, producing convulsions. Therapeutical uses for it have not been developed.

Narceine acts very similarly to morphine, but is much weaker; its employment is vaguely stated to be free from the disagreeable after-effects of the latter drug, while others regard it as practically inert. Probably much of that used has been contaminated with morphine, yet the use of its numerous salts with organic and inorganic acids, has fully demonstrated that it does possess activity. Its dose is about the same as that of codeine 0.025–0.05 gm. (gr. ⅓ to gr. ⅔). None of the other alkaloids is known to be of importance in medicine.

Meconic Acid, though of no importance physiologically, has been considerably employed in compounding salts of alkaloids, under the impression that these, being the natural forms of occurrence in opium, were more diffusible and active than other salts. In this view, it was long official in the British Pharmacopœia, but the idea has now been abandoned and the substance is little used.

Opium.—From the foregoing it would appear that the action of opium should be that of morphine, except for the slight modification due to the presence of its thebaine. In the main, this is true, yet practice demonstrates differences which cannot thus, nor in any positive way, be accounted for. Doubtless the difference is partly due to the substitution of primary effects, when used in one form, for secondary effects when used in the other. In opium, as in most nervines, such primary and secondary effects are more or less antagonistic, as specially exemplified in its effects upon intestinal excretion, where a dose, relatively very small or very large, in consideration of the condition of the patient, is liable to increase peristalsis and discharge, while the characteristic effect of a moderate dose is to constipate. That opium should be less promptly hypnotic, producing more of a preliminary excitation of the spinal and lower cerebral centres, commonly with irritable pulse, can be readily charged to the action of its thebaine. It is difficult, however, thus to explain its greater intestinal astringency or constipating effect or its peculiar diaphoretic properties.

From a therapeutical standpoint opium can be used for all the purposes for which morphine is employed, though the dose should be relatively somewhat larger; that is, a dose of opium should contain more morphine than would be employed as a salt for the same purpose. Even with this proviso opium is not to be selected in preference to morphine for ordinary somnifacient purposes, since its action cannot be so accurately estimated, nor is it so prompt. On the other hand, there are cases in which it is to be preferred, even for such uses, since its after-effects are not so disagreeable or lasting as those of morphine. For checking intestinal discharges, opium is greatly to be preferred, though its continued use is not so constipating as that of morphine; often, in fact, it tends to looseness of the bowels. When it is necessary to maintain for some time an equable analgesic effect, as in relieving abdominal pain in peritonitis, for instance, opium is usually to be preferred, though it is sometimes desirable first to get the patient under its influence by the use of morphine. Subject to the above modifications, the specific actions and uses of opium should be sought under *Morphine*.

Special Uses and Doses of the Preparations.—(It is to be remembered that the doses of opium and its preparations are subject to the same enormous special variations as are those of morphine.) Of opium itself there is but one official preparation, namely, the *Opii Pulvis* or powdered opium, from which all the other preparations are made. This discrimination is of practical importance, since powdered opium must contain between thirteen and fifteen per cent. of morphine, about a half more than the lowest allowable (and usual) content in opium. It is specified that powdered opium of too high a percentage may be reduced to the proper strength by mixing in due proportion with that of a lower grade. Whenever the dose of opium is stated, it is powdered opium, which is to be understood. For ordinary purposes, this is 0.066 gm. (gr. i.). The substance is often given without change, much oftener in the form of the pills (*Pilulæ Opii*), each containing the above mentioned amount, with a little soap, or in the deodorized form, mentioned at the beginning of our paragraph on Actions and Uses, its strength and dose being equal to those of powdered opium. Crude, undried opium is occasionally given in pill form when slow solution is desired, as in cases of relaxed intestine, diarrhœa of phthisis, and chronic dysentery. Old and hard pills are sometimes written for (and many apothecaries keep them on hand for the purpose), in the hope that they will pass the stomach undissolved and exert a local continuous influence upon the intestine. This result is, however, not exactly within control, and may be better attained by coating pills with keratin. More often still, when the effect of solid opium is desired, the extract (*Extractum Opii*) is given, its morphine strength being eighteen per cent., and the dose from half as large to as large as that of powdered opium. The above-named are favorite forms for the administration of opium when it is desired to produce a constipating effect, to restrain intestinal peristalsis and relieve the pain dependent thereon, to relieve irritation dependent upon extreme purgation and irritant poisoning, and to stay nearly all forms of abdominal inflammation. In these cases the grain of opium is often combined with three or four grains of lead acetate. In this connection, the external employment of the "lead and opium" wash must not be forgotten. Its effect in relieving pain and averting or reducing inflammation in and underneath the skin are sometimes magical. It is made by dissolving one hundred and twenty grains of lead acetate in about ten ounces of water, adding one-half a fluidounce of tincture of opium, and water enough to make sixteen fluidounces. It should be shaken well before using.

The simple liquid preparations are the tincture (*Tinctura Opii*), or laudanum, the deodorized tincture (*Tinctura Opii Deodorata*), the vinegar (*Acetum Opii*), and the wine (*Vinum Opii*), all containing ten per cent. of powdered opium and between 1.3 per cent. and 1.5 per cent. of morphine, and exhibiting no important difference in physiological action, the selection being based chiefly on the basis of odor and flavor, and the ordinary dose of each being ten minims. Laudanum contains its opium in a mixture of equal volumes of alcohol and water. The deodorized tincture bears the same relation to laudanum that deodorized opium does to powdered opium. It is made from powdered opium, the deodorizing process being part of its manufacture. The vinegar contains three per cent. of nutmeg and twenty per cent. of sugar in dilute acetic acid. The wine is made with a mixture of white wine and fifteen per cent. of alcohol, and contains one per cent. each of cloves and cassia cinnamon. The action and uses of laudanum may be taken as the type of those of this group. It is used in cases similar to those in which opium is itself employed, but where a more prompt effect is desired. It is a favorite preparation for relieving the convulsions of puerperal eclampsia, as much as a fluiddrachm being often given and repeated once or twice if necessary. In some forms of hemorrhage connected with pregnancy or delivery, large doses are also commonly employed. Laudanum constitutes a favorite addition to poultices, for relieving superficial pain, and it is frequently rubbed in with liniment or applied with lime liniment to relieve pain when not deeply seated. In spite of the fact that absorption of morphine by the skin is slight, such treatment is of undoubted value. Laudanum is very commonly applied on pledgets of cotton to aching teeth or ears, though the latter treatment is not always to be recommended.

There are several mixed preparations of opium which

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are of great importance, paregoric (*Tinctura Opii Camphorata*) being perhaps the most so. This preparation contains only 0.4 per cent. of opium, with the same amount each of benzoic acid, camphor, and oil of anise, together with four per cent. of glycerin in diluted alcohol. It has no alkaloidal standard. Paregoric constitutes a most excellent combination of a carminative with an analgesic, and is of the greatest value in relieving abdominal pains which present such indications. It is pre-eminently the form of opium for administration to children; but it is to be borne in mind that its continued administration, through the inattention rather than the direction of the physician, has frequently been the means of leading to the formation of an opium habit. The dose of paregoric is 4–15 c.c. (fl. ʒ i.–iv.).

The brown mixture or compound mixture of liquorice (*Mistura Glycerrhizæ Composita*) contains twelve per cent. of the camphorated tincture of opium with six per cent. of wine of antimony, three per cent. each of the extract of liquorice and the spirit of nitrous ether, five per cent. of syrup, and ten per cent. of mucilage of acacia. The dose is about 16 c.c. (fl. ℥ ss.). This preparation is in its nature somewhat similar to the Dover's powder, being a much used expectorant and diaphoretic, with distinct diuretic properties also.

Dover's powder (*Pulvis Ipecacuanhæ et Opii*) contains ten per cent. each of powdered ipecac and powdered opium in sugar of milk, the dose being 0.66 gm. (gr. x.), and the corresponding liquid, often spoken of as liquid Dover's powder (*Tinctura Ipecacuanhæ et Opii*), consists of ten parts of the fluid extract of ipecac in one hundred parts of the deodorized tincture of opium (corresponding to ten per cent. of opium), the whole reduced by evaporation to one hundred parts; the dose is ten minims. The last-mentioned two preparations constitute a remarkably useful combination of a diaphoretic with an analgesic and somnifacient action. In this diaphoresis both elements play their own peculiar part. An approaching "cold" can frequently be averted by a full dose of either, with a few hours' rest. An irritable cough, preventing rest, is relieved by the hypnotic effect, while the condition itself is benefited by the diaphoresis. The troches of liquorice and opium (Trochisci Glycyrrhizæ et Opii) each contain 0.15 gm. (about gr. ij.) of extract of liquorice, 0.005 gm. (gr. $\frac{1}{12}$) of powdered opium, with sugar, acacia, and a little oil of anise to flavor. They are very useful in allaying throat irritation and mildly promote expectoration. By adding a little ipecac or tartar emetic the effect of Dover's powder may be simulated in mild degree.

The following table exhibits the preparations of our Pharmacopœia and the proportion of opium in each:

OPIUM (NOT LESS THAN NINE PER CENT. MORPHINE).

- Powdered opium (thirteen to fifteen per cent. morphine).
  - Deodorized opium (fourteen per cent. morphine).
  - Deodorized Tincture ($\frac{1}{10}$ P. opium).
    - Tincture of ipecac and opium ($\frac{9}{10}$ deod. tincture opium, $\frac{1}{10}$ fluid ex. ipecac).
  - Pills of opium (1 grain in each).
  - Camphorated tincture. ($\frac{4}{1000}$ P. opium, camphor, etc.).
    - Compound mixture of liquorice ($\frac{12}{100}$ camphor. tincture opium, $\frac{6}{100}$ wine antimony).
  - Tincture of opium ($\frac{1}{10}$ P. opium).
  - Wine of opium ($\frac{1}{10}$ P. opium and aromatics).
  - Vinegar of opium ($\frac{1}{10}$ P. opium and nutmeg).
  - Powder of ipecac and opium ($\frac{1}{10}$ P. opium, $\frac{1}{10}$ ipecac).
- Extract of opium (eighteen per cent. morphine).
  - Plaster of opium ($\frac{6}{100}$ ex. of opium).
  - Troches of liquorice and opium (ex. of opium, $\frac{1}{20}$ grain each).

Henry H. Rusby.

OPIUM HABIT. See *Insanity: Drug Habituation and Intoxication.*

OPIUM, POISONING BY.—The poisonous nature of opium, and of the poppy, was known to the ancients as early as the time of Nicander (185–135 B.C.), who gives a clear description of the toxic effects of a "drink prepared from the tears which exude from poppy heads." Dioscorides, three centuries later, refers to the lethal effects of the poppy, and describes the method by which opium was then obtained, a method which does not sensibly differ from that which is practised at present. Pliny (A.D. 70) speaks of the toxic powers of opium, and cites the instance of Post. Licinius Cæcina, who, disgusted with life, terminated his existence with opium—an instance which was by no means singular, as the narrative concludes with "item plerosque alios."

In modern times (since 1600) we can find mention of but twelve cases of homicidal poisoning by opium or its preparations or derivatives, of which two were by laudanum and the remainder by morphin. Suicidal and accidental poisonings by the opiates are of very frequent occurrence. Probably thirty to forty per cent. of non-homicidal poisonings in the United States and in Great Britain are caused by these poisons. The widespread use of "soothing syrups" and other similar nostrums containing opium is unquestionably a factor in the high percentage of infant mortality.

SYMPTOMS.—The symptoms produced by opium and its preparations, and by morphin—acute meconism—are practically the same, whatever preparation of opium or salt of morphin may have been used. Other things being equal, however, morphin and its salts are more rapid in their action than opium or the preparations made from the crude drug.

The *time* at which symptoms manifest themselves is usually from half an hour to one hour after the poison has been taken. Frequently this period is much shortened. In children who have received large doses the poison sometimes begins to produce its effects within a very few moments or almost immediately. When the poison has been introduced by hypodermic injection, it acts more rapidly than when taken by the stomach. Opium in solution acts more promptly than the same substance in the solid form, and the salts of morphin are more rapid in action than the alkaloid itself. Opiates administered by the rectum are more rapid in their action than when given by the stomach. The symptoms appear earlier when the poison is taken while fasting than when it is taken upon a full stomach. In exceptional cases the interval between the taking of the poison and the appearance of its effects is very much shortened even in adults. Thus, 45 c.c. of Liquor opii sedativus has caused total insensibility in fifteen minutes, and death in an hour and twenty minutes. Cases have also occurred in which the action of the poison has been much retarded, although taken in solution. Thus, instances are recorded in which no symptoms were produced in nine, twelve, fourteen, and eighteen hours by 45, 15, 60, and 45 c.c. of laudanum.

The clinical history of acute morphin or opium poisoning may be divided into three stages.

The first period, that of increased nervous excitability,

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is usually of short duration in the acute form of poisoning, although cases are recorded in which it has lasted fourteen and eighteen hours. It is frequently entirely absent, when large doses have been taken. This stage is marked by restlessness, great physical activity, loquacity, greatly increased imaginative power, frequently to the extent of hallucinations, always of a pleasing character, and by increased cardiac action. In adult males priapism sometimes occurs during this stage. Vomiting is also of occasional occurrence and greatly improves the patient's chances of ultimate recovery.

The condition of excitation passes, sometimes rather suddenly, into an intermediate stage of diminished excitability. The patient becomes weary, incapable of physical exertion, dull, and drowsy. He complains of a sense of weight in the extremities and an irresistible desire for sleep, to which he finally yields if not kept awake. The sleep is at first seemingly normal, though profound. The pulse and respiration are normal. The patient may be roused and sometimes kept awake by shaking him, by the infliction of pain, or by loud talking. The face is pale, the lips are somewhat livid, the surface is covered with perspiration, and the pupils are contracted. During this period the patient frequently experiences a violent itching of the skin, which is sometimes followed by the appearance of an exanthem which may be papular, red, bluish, or almost colorless, or resembling those of urticaria or of scarlatina.

The condition of somnolence is of short duration, and passes quickly into the stage of narcosis. The patient can no longer be roused, even by the most violent means. He lies motionless and senseless, with eyelids closed or partly closed. The surface is bathed in profuse perspiration, which exhales the odor of opium in opium cases. The face is pale, the lips are blue, the lower jaw is dropped, and the muscles are completely relaxed. The pupils are insensible to light, and contracted to the size of pinheads until death occurs, when they dilate. A few cases are, however, recorded in which the pupils were said to be dilated. At first the superficial arteries, temporals, and carotids are seen to pulsate fully, strongly, and rapidly, while the respiration is slow and shallow (eighty pulsations in the minute to four respiratory movements have been observed). Later, the pulse becomes feeble, slow, irregular, and easily compressible. The respiration becomes slow, shallow, stertorous, and accompanied by mucous râles. Retention of urine occurs early in the history, and continues until death or recovery.

From this period, if the case do not yield to treatment, the poisoning usually proceeds rapidly to a fatal termination. The surface of the body and even the expired air become cold. The skin is cyanosed and covered with a cold clammy perspiration. The pulse becomes slower, more feeble, and gradually imperceptible. The respiration is more shallow and feeble, while the râles become more pronounced. Individual muscles, or groups of muscles, are agitated by short clonic twitchings, and occasionally convulsions and tetanus occur. Later, the muscles become completely paralyzed, the respiratory movements are made at longer intervals and finally cease; the circulation continues after the cessation of respiration. Finally, the action of the heart is arrested and the patient dies quietly. Sometimes epistaxis and other hemorrhages occur toward the end; and in some instances death results from cerebral hemorrhage.

Should recovery follow after the stage of narcosis, the respiration gradually becomes more frequent and more natural, the pulse becomes first perceptible and then gradually passes toward the normal, while the condition of coma passes into one of deep sleep, which may continue for from twenty-four to thirty-six hours longer, although the patient can be roused.

In the great majority of cases in which recovery has progressed so far that the patient may be roused it will be complete. Nevertheless, occasional instances are recorded in which the victim has relapsed into a deeply comatose condition and has finally died.

In cases of recovery the patient, on awakening, is weary, giddy, and uncertain in his movements. He may also suffer for some hours from nausea and headache, and for a longer time from loss of appetite and derangement of digestion. In two cases Dr. Edes (*British Medical and Surgical Journal*, 1881, cv., 251) has observed the presence of casts in the urine; in one case, accompanied by albumin.

Duration.—In cases of fatal poisoning by the opiates death usually follows in from twelve to eighteen hours after the poison has been taken. Of 48 fatal cases, death followed within twenty-four hours in 43; within eighteen hours in 39; within twelve hours in 26, and within nine hours in 20. The minimum duration of the poisoning was forty-five minutes; and the maximum, fifty six hours.

Cases are recorded in which the symptoms of narcotism have disappeared and the patient has died at a greater interval of time than the above maximum. In such cases, although the death may have been accelerated by the action of the poison, the fatal result is immediately due to other causes. Thus, in a case quoted by Taylor, a patient suffering from disease of the heart took, in four hours, two hundred drops of laudanum, and was bled to the extent of thirty ounces. On the sixth day he was sufficiently recovered to undertake a journey, and died on the eleventh day. In this case the cause of death was failure of cardiac action, aggravated at least as much by loss of blood as by opium.

In cases of death in which the patient has suffered from a disease whose symptoms resemble those of opium poisoning, and has also received a large dose of an opiate, the question of duration may become one of considerable medico-legal importance. In a case which came under the author's observation a physician had given a child of four months gtt. x. of the Tinct. opii deodorata by mistake for Tinct. opii camphorata. The patient suffered from well-marked symptoms of opium poisoning, but under immediate treatment improved, and in forty-eight hours had apparently recovered. Death followed, however, in ninety hours from acute hydrocephalus.

Obviously, the same causes which influence the rapidity of action of the poison, and those which modify the effects of unusually large or small doses, will also influence the duration of the case, whether it terminate in death or in recovery.

Lethal Dose.—As the action of the opiates is much modified by conditions, such as age, habit, state of health, form of administration, and idiosyncrasy, it is impossible to fix a lethal dose applicable to all conditions. It may be said, however, that 0.065 gm. or gr. i., of morphin, or 0.1 gm. or gr. vi. of opium, would cause symptoms of poisoning in an adult not habituated to the drug, and possibly would cause death. Several instances of death from 0.2 to 0.26 gm (gr. iij.-iv.) of morphin (or laudanum equivalent) are reported. In other cases death has followed after doses as small as 0.032 (gr. ss.), but in these other causes were also operative or the report is unsatisfactory (see Witthaus and Becker, "Medical Jurisprudence," iv., 730).

On the other hand, numerous cases are on record of persons, not addicted to the opium habit, who have recovered from very large doses. The largest quantity of morphin certainly thus recovered from was 3.89 gm. (gr. lx.) of the acetate (Wood, *Boston Med. and Surg. Journal*, 1876, 82). Although the relative immunity in these cases of very large dose may be ascribed in some degree to an idiosyncrasy of the patients, their escape has been probably more largely due either to non-absorption of the poison or to rejection of the major portion by vomiting.

Infants and children are peculiarly susceptible to the poisonous action of opiates, even in very minute doses. Cases of death from small doses of laudanum are cited as follows: Gtt. iv. (equivalent to gr. $\frac{1}{6}$, 0.011 gm., of opium) in a child of nine months; the same quantity in a child of five weeks; gtt. v. (= gr. $\frac{1}{5}$, 0.013 gm.) per rectum in a child of eighteen months; gtt. viij., during eighteen hours, in four doses (= gr. $\frac{1}{3}$, 0.022 gm.),

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in a child of six weeks; gtt. iij. (= gr. $\frac{1}{4}$, 0.008 gm.) in an infant of two weeks; ♏iss (= gr. $\frac{1}{10}$, 0.0065 gm.) in an infant of three days; gtt. ij. (= gr. $\frac{1}{12}$, 0.0054 gm.) in an infant of five days; the same quantity in another of four days, ♏ i. (= gr. $\frac{1}{13}$, 0.005 gm.) in an infant of seven days; and gtt. i. (= gr. $\frac{1}{25}$, 0.0026 gm.) in an infant of six days. A dose of gr. iv. pulv. ipecac. et opii (= gr. $\frac{2}{5}$, 0.026 gm., of opium) has caused the death of a child of four and a half years. Huseman and Taylor refer to a case (Edwards) in which the amount that caused the death of a four-weeks-old child was as low as 0.006 gm. (= gr. $\frac{1}{10}$) of opium, taken in the form of the camphorated tincture.

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Even during this early period of life occasional instances of recovery from relatively large doses are met with. A case is reported by Dr. Corbet, in the *Lancet*, August 29th, 1857, p. 220, in which an infant of one day received ♏ xxx. (= 2.3 grains, 0.15 gm. of opium), yet recovered within ten hours. This case is of interest, as the age of the infant precludes the possibility of its having become accustomed to the drug, as was probably the case with a child of six months who recovered from a dose of a teaspoonful of laudanum (= 4.6 grains, 0.298 gm. of opium) (Simmonds), although treatment was delayed for an hour; and with another of nine months who recovered from a dose of two teaspoonfuls (= 9.2 grains, 0.596 gm.) of the same tincture.

The dosing of infants and young children with officinal or proprietary preparations of opium by mothers and nurses is widely practised. One of the results of the practice is the large percentage of deaths from opiates among young children. A tabulation of 144 cases of opium poisoning, taken chiefly from English and American journals, gives this result:

	Total cases.	Children less than one year.	Children less than five years.	Children less than ten years.
Laudanum	79	24	25	26
Opium	18	9	10	11
Morphin	34	3	5	5
Patented opiates	13	10	12	12
Totals	144	46	52	54
Percentage of total		32	36	37.5

From which it appears that about one-third of the reported poisonings by the opiates occur in children less than one year old.

The poisonous action of the opiates is very greatly diminished by habit, probably more than that of any other poison. The amounts taken by adult opium-eaters, laudanum-drinkers, and morphin-injectors are sometimes enormous. Cases in which the consumption reaches 2 gm. (grs. xxx.) of opium, or one-half, one, or even two ounces of laudanum (= 0.5, 1, 2 gm.), in twenty-four hours are of by no means uncommon occurrence. Such cases sink into insignificance when compared with that of De Quincey, whose daily draught of laudanum at one time reached nearly nine fluidounces (= about 20 gm. of opium). Krüger-Hansen relates the case of a patient who consumed in one year over 300 gm. of opium, a daily average of over 0.8 gm. (about gr. xiij.). Zeviani cites the case of a woman who, in thirty-three years, had taken over 100 kgm. of opium, equivalent to a daily average allowance of 8 gm. (= nearly gr. cxxv.); and as the dose is gradually increased by opium-eaters, the daily consumption in this case must have been much greater in the later years. Headland and Myers refer to instances in which gr. xviij. (= 1.16 gm.) of morphin were taken daily; and the author met with the case of a young man of twenty, of profligate habits, who had reached the same quantity, when he terminated his career with a large dose of potassium cyanid.

It is not to be inferred from these large amounts that an opium-eater can take an unlimited quantity of the drug without experiencing its poisonous action. It is simply a question of quantity—a quantity necessarily varying in each case,—and instances are of frequent occurrence in which the opium-habitué has experienced the symptoms of acute poisoning, and has even died from the effects of an overdose.

The tolerance of opiates acquired by habit is not confined to adults; it is also produced in quite young children. A remarkable case in point was published by Dr. J. L. Little (*American Journal of Obstetrics*, 1878, xi.). A male infant, suffering from acute inflammation of the knee-joint, followed by an abscess, began at three weeks of age with small doses of paregoric, gradually increased to a teaspoonful. Subsequently Tinct. opii was substituted, and then Magendie's solution of morphin, in doses gradually increased, until, when nearly eight months of age, the child took in one day two fluidounces of Magendie's solution (equivalent to 2.07 gm., gr. xxxij.) of morphium sulfate.

Treatment.—The treatment in cases of acute opium poisoning should be directed, first, to removal of unabsorbed poison from the stomach; and, second, to prevention of death by coma and cessation of respiration, until the processes of elimination have removed that portion of the poison which has been absorbed.

In the earlier stages of the poisoning, emetics are of value—zinc sulfate or ipecacuanha; or, if the patient be an obstinate suicide, apomorphin, hypodermically. On no account should tartar emetic, or any antimonial, be used as an emetic in this or any other form of poisoning. Stomach lavage is to be preferred to the exhibition of an emetic; particularly in the later stages, when, the patient having lost the power of swallowing, a hypodermic injection of apomorphin usually fails to provoke emesis. The siphon is to be preferred to an emetic, not only on account of its more certain and rapid action, but also because its use does not tend to increase the cerebral congestion as does the exhibition of the emetics. On the other hand, in some exceptional cases, in which opium in substance has been taken, an emetic may be necessary to remove masses too large to enter the pipe. In cases likely to lead to litigation, the material removed by the siphon should be preserved. The stomach having been emptied of its contents, the viscus is next to be well washed out, preferably with a solution (1 to 1,000) of potassium permanganate, about 500 c.c. of which are finally left in the stomach. This procedure is to be followed even when the poison has been taken hypodermically, as it is eliminated by the stomach.

If the case be seen before the stage of sopor has been established, it should be prevented, if possible, by keeping the patient in motion—walking him between two sufficiently robust assistants, preferably in the open air, if location and weather permit, but not in the direct sunlight. This "ambulatory treatment" has been beneficially prolonged in some cases for from six to eighteen hours. Under its influence sometimes the action of an emetic which has remained inert is brought about.

If the patient be already in a lethargic condition, he is to be roused without delay. This is best accomplished by cold affusions to the head, the body being kept warm and dry, flagellation to the palms and soles, or to the back with damp towels, or the use of the faradic current. When roused, the patient is to be kept awake as above.

Should the respiration have ceased or become very slow, it may frequently be stimulated by the application of the induced current, the positive pole being applied to the root of the neck over the point where the phrenic nerve crosses the scalenus anticus muscle, while the negative pole is carried laterally over the anterior attachments of the diaphragm. If the faradic current be not obtainable, or if it fail, artificial respiration is to be performed. To be of service this must be persisted in, in some cases, for many hours, and until normal respiration is again established. Dr. W. F. Cheatham has published (*North Carolina Medical Journal*, 1886, 20) a case in which this was the sole method of treatment. The respiration had ceased and the pulse was barely perceptible. Artificial respiration was applied. In thirty-seven minutes

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the patient made an effort of respiration; in an hour and forty minutes the respiration was five per minute, though stertorous. In nine hours consciousness returned, and recovery followed.

If the case be at all prolonged, distention of the bladder and possibility of reabsorption are to be prevented by the use of the catheter. If this be done in a case in which there is www.libtool.com.cn of litigation, the urine so removed should be carefully preserved.

Little can be said in favor of the different drugs that have been used as so-called physiological antidotes. Atropin, which is so frequently administered as an antidote to opium poisoning, unquestionably dilates the pupils, but has little, if any, effect upon the respiration. Cases are recorded in which, although atropin has been given until the pupils were widely dilated, the respiration has ceased, and the patient has subsequently recovered by means of artificial respiration (see paper of Dr. Cheatham, quoted above).

Tinctura belladonnæ, strong infusion of coffee by the stomach or subcutaneously, extract of coffee, caffein, brandy, digitalin, chloral hydrate, veratrum viride, and jaborandi have been used as antidotes. The last named, or pilocarpin, may be of value to increase the elimination, and thus lessen the duration of the poisoning.

Post Mortem Appearances.—The autopsy reveals no lesions which are characteristic of opium poisoning, except, possibly, the odor of the drug. Obviously, if morphin have been the substance taken, or if other more powerfully odorous substances be present, this will not be observed. The surface of the body is livid. Rigor mortis is said to be of shorter duration than usual, although an autopsy is reported by Tardieu at which rigor mortis was well marked sixty-two hours after death. Putrefaction is said to be more rapid than usual. The blood is fluid and dark. The vessels of the brain and meninges are gorged with blood, and the cut surfaces of the brain substance present numerous dark red spots. The veins of the scalp are also filled with blood. Serous effusions are frequently met with between the membranes, more rarely in the ventricles. The lungs are usually congested. The stomach and other viscera are normal, so far as the action of the poison is concerned. The bladder is generally full of urine.

The congestion of the cerebral vessels and of the lungs are the most noteworthy appearances. Yet, as they may be absent in opium poisoning, and may be present when death has resulted from other causes, they are only of value as confirmatory evidence of the cause of death.

Analysis.—To detect the presence of morphin in the viscera after death, or in articles of food, it is necessary to separate that alkaloid in a condition of as near purity as possible. In cases of opium poisoning it is further necessary to search for meconic acid, and, if possible, for other of the opium alkaloids.

If the facts of the case do not point very distinctly to opium or morphin as the poisonous agent, the process of Dragendorff should be followed for the separation of the alkaloids (Dragendorff, "Ermittl. v. Gitten." 4 Aufl., 1895, 149-153).

If the indications of opium or morphin poisoning be sufficiently direct, the following simplified method for the separation of morphin and of meconic acid may be followed. The substances, if solid, are finely hashed and extracted several times with water containing one per cent. of hydrochloric acid at the ordinary temperature (if the materials be alkaline, the proportion of acid is to be increased to such an extent that the liquid, when in contact with it, retains its acid reaction). The aqueous extracts are filtered and shaken with amyl alcohol three or four times, and oftener if necessary, until the amylic alcohol is no longer colored, and the alcoholic layers separated. If the substances under examination be liquid, they are to be rendered acid with hydrochloric acid, filtered, and the filtrate treated with amyl alcohol. The amylic solution now contains meconic acid, if present in the objects examined; and the watery solution, the alkaloids as chlorids. To separate meconic acid the amyl-alcohol solution is shaken with successive portions of water, which are separated, until the water is no longer colored. The alcohol is evaporated over the water-bath; the residue extracted with hot water; the solution filtered hot; the water evaporated over the water-bath; the residue extracted with alcohol; the solution filtered, and the alcohol evaporated. The tests for meconic acid are finally applied to a portion of the last residue. During this treatment a small portion of the meconic acid is converted into comenic acid, which does not, however, interfere with the tests.

To separate morphin from the aqueous liquid above mentioned, the hydrochloric acid is neutralized completely with ammonia, and the liquid rendered distinctly acid with acetic acid, and evaporated over the water-bath to the consistency of a syrup. The residue is extracted with four or five volumes of ninety-per-cent. alcohol and filtered. The filtrate is freed from alcohol by distillation. The residue, diluted with a small quantity of water, if thick, is heated to 50° to 60° C., an equal volume of amyl alcohol* is added and then sufficient ammonium-hydroxid solution to render the solution distinctly alkaline. The mixture is next strongly shaken at intervals for half an hour, the amylic alcohol separated, and the extraction of the aqueous liquid with amylic alcohol repeated three times. The united amylic solutions are evaporated to dryness; the residue is extracted several times with warm (not hot) water slightly acidulated with sulfuric acid, and the solution filtered. Upon the acid filtrate is floated a mixture of ten parts absolute ether and one part (ninety-five-per-cent.) alcohol; ammonium-hydroxid solution is added to alkaline reaction, and the whole strongly agitated. The ether-alcohol layer is separated; the extraction of the, now alkaline, aqueous liquid is similarly repeated several times, and the ether-alcohol evaporated in a number of small watch glasses. To portions of the residue so obtained, either dry or dissolved in a few drops of water, as the nature of the test may require, and now sufficiently freed from coloring and other foreign substances, the tests for morphin are to be applied.

Tests.—I. *Morphin.* 1. With the general reagents for the alkaloids, the morphium salts give reactions as follows, the fractions indicating the maximum of dilution in which the alkaloid is capable of reacting: With *phosphomolybdic acid*, yellowish, amorphous precipitate, $\frac{1}{5000}$; with *iodin in potassium-iodid solution*, red-brown, amorphous precipitate, $\frac{1}{5000}$; with *potassium and bismuth iodid*, amorphous precipitate, subsequently changing to silky needles, $\frac{1}{5000}$; with *auric chlorid*, lemon-yellow precipitate, becoming darker; with *phosphotungstic acid*, flocculent precipitate, $\frac{1}{1000}$; with *potassium iodhydrargyrate*, yellowish, amorphous precipitate, $\frac{1}{1000}$; with *platinic chlorid* slowly, yellow, crystalline precipitate, $\frac{1}{100}$; with *picric acid*, bright yellow, amorphous precipitate, $\frac{1}{100}$; and with *tannic acid*, a faint cloudiness, becoming somewhat thicker on standing. For the above tests the solutions of the alkaloidal residue are to be made with very dilute sulfuric acid, and the reagents should be as nearly neutral as their natures will permit.

2. Morphin dissolves in concentrated nitric acid with an orange-red color, which gradually changes to yellow. Addition of stannous chlorid solution does not change the color of the yellow solution to violet, as it does with the similar color obtained with brucin. Limit, 0.01 mgm.

3. Morphin dissolves in concentrated sulfuric acid, forming a colorless solution. If this solution be heated over the water-bath for an hour, and allowed to cool, or, preferably, if it be allowed to stand in a desiccator twenty-four hours, and then treated with a trace of nitric acid or a minute granule of saltpetre, a beautiful violet color is produced, which soon changes to purple-red, and then gradually fades. Limit, 0.001 mgm. (A. Husemann).

A further portion of the sulfuric-acid solution, if

* It is absolutely essential that the amylic alcohol used should be purified, *shortly before use*, by repeated redistillation, until a portion, on evaporation, yields no residue capable of reducing iodic acid.

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treated, after warming and subsequent cooling as above, with a small fragment of potassium dichromate, assumes a mahogany-brown color (J. Otto).

4. A fragment of solid morphin moistened with a solution of ferric chlorid, as neutral as possible (best obtained by dissolving the chlorid obtained by the dry method in water), assumes a brilliant blue color.

For the success of this test it is essential that the morphin salt be as free from impurities as possible, that little or no free acid be present, and that but a small quantity of the reagent be used. The color gradually changes to green and brown (Robiquet). Limit, 0.1 mgm.

5. A fragment of morphin moistened with Fröhde's reagent (a freshly prepared and colorless solution of 5 mgm. sodium or ammonium molybdate in 1 c.c. sulfuric acid) colors the reagent violet in a short time. The color changes to blue, and then to dirty green, and, finally, to faint reddish. Addition of water discharges the color instantly. Limit, 0.005 mgm.

6. Dissolve a small quantity of iodic acid in a few drops of water, in a small test tube, and agitate with a few drops of chloroform; the latter must remain colorless. Add the solution to be tested, and again agitate. The chloroform, which settles to the bottom, has a violet color, in the presence of morphin, while the aqueous layer is yellowish. Now float upon the surface of the liquid dilute ammonium hydroxid, with as little mixing of the liquids as possible; a brown band is formed at the junction of the ammoniacal and aqueous liquids (Serullas, Duflos, Lefort). Limits: For the violet color of the chloroform, $\frac{1}{7000}$; for the dark band with ammonium hydrate, $\frac{1}{10000}$.

This reaction is also produced by reducing agents other than morphin.

7. Dissolve the solid in warm, concentrated hydrochloric acid containing a little concentrated sulfuric acid, and heat in an air oven at 110° to 120° C. In the presence of morphin a purple color is produced, still visible in the presence of the accompanying carbonized matter. After evaporation of the hydrochloric acid, a further quantity of the dilute acid is added, and the mixture neutralized with sodium bicarbonate in slight excess; a cherry red color is produced, which changes to a dirty-greenish hue as the point of neutrality is reached. On addition of a few drops of a dilute alcoholic solution of iodin, the color changes to green, and the pigmentary substance now dissolves in ether with a purple color (Pellagri).

The reaction is due to the formation of apomorphin, and is consequently also observed with codein.

Many other tests for morphin are in use; the above are, however, sufficient. No one of them is in itself characteristic.

II. *Narcotin.* The reactions of the alkaloids of opium other than morphin are at present of but little toxicological interest, as they are substances which are not commonly met with, and hence are unlikely to cause poisoning. For the purpose, however, of distinguishing between morphin and opium poisoning by analysis (a distinction which may be of medico-legal importance), the reactions of narcotin and of meconic acid (see below) are taken advantage of. Narcotin is chosen from among the other opium alkaloids for this purpose, partly because it is more abundant in opium, and partly because of the sharpness of its reaction with sulfuric acid.

If the Dragendorff method have been followed, narcotin should be searched for in the residue of evaporation of benzene from the alkaline solution.

1. Of the general reagents for the alkaloids, phosphomolybdic acid, potassium iodhydrargyrate, iodin in potassium iodid, and picric acid give precipitates in solutions of $\frac{1}{1000}$ to $\frac{1}{3000}$.

2. Moistened with concentrated sulfuric acid at the ordinary temperature, narcotin produces an intensely yellow solution, which, on gradual heating, changes to orange, then, beginning at the borders, blue-violet, and, when the heat has been raised to the point of volatilizing of the acid, dark red. The colors are presented more slowly, but more purely, by dissolving the residue in dilute sulfuric acid and evaporating quite slowly (Couerbe, Husemann). Limits: $\frac{1}{2000}$, very evident; $\frac{1}{10000}$, faint carmine only.

3. Dissolve in concentrated sulfuric acid, let stand an hour, and add a trace of nitric acid; a red color, which for some time increases in intensity.

III. *Meconic Acid.* 1. Crystallizes in white, glistening prisms, either single and large, or small and arranged in bundles, which at 100° C. lose their water of crystallization and become opaque. If heat have been applied to the solution in the presence of acids, the shorter, prismatic crystals of comenic acid will be also observed.

2. Meconic acid, or a meconate in solution, gives white or yellowish precipitates with lead acetate, silver nitrate, mercurous nitrate, and mercuric nitrate.

3. The characteristic reaction of meconic acid is the formation of an intense red color when the acid or one of its salts is moistened with a solution of ferric chlorid (Sertürner). The color does not disappear either on warming or on the addition of hydrochloric acid, or of auric chlorid, or of mercuric chlorid.

Comenic acid gives the same reaction. It can only be present as a product of decomposition of meconic acid. Acetic and thiocyanic acids and their salts also give a red color with ferric chlorid. The former may be present as a normal food constituent, and the latter is present in the saliva in quantity sufficient to give the reaction without any preliminary purification. The red color, however, produced by acetic acid is discharged by heat or by the addition of hydrochloric acid, and that due to the thiocyanate disappears instantly on addition of auric chlorid or of mercuric chlorid solution.

FAILURE OF DETECTION.—As morphin is oxidized to oxydimorphin in the body, more or less completely according to the magnitude of the dose, it is usually eliminated in cases of poisoning as a mixture of oxydimorphin and morphin, both of which respond to the reactions given above. This elimination is principally by the alimentary canal and only in traces by the urine, whatever may have been the channel of introduction. Therefore the stomach and intestinal contents, or the product of stomach lavage, are the situations in which the poison will most probably be detected, and we may expect to find it in the urine only when very large doses have been taken. It has also been detected in the liver and kidneys in several instances, but very rarely in the brain. The detection of morphin is by no means certain, and carefully conducted analysis may fail to show its presence in the cadaver after undoubted poisoning by it, even when the stomach has not been washed out and vomiting has not occurred.

Although morphin is more subject to decomposition than strychnin, it still withstands the influence of putrefaction quite well. In a case cited by Woodman and Tidy it was detected four months after death; and Stas gives an account of a case in which he detected morphin in all the organs of a body after thirteen months of burial.

In cases of long burial, caution is required that ptomaïns be not mistaken for morphin, as occurred in an Italian case, in which Selmi showed that what a careless analyst had taken for morphin was in reality a ptomaïn (Selmi, "Sulle Ptomaïne," 1878). Such a mistake is impossible, if the tests described above are carefully applied (see Witthaus and Becker, "Med. Jur.," iv., 760–769).

Rudolph A. Witthaus.

OPTIC NERVE. See *Eye.*

OPTOMETRY—from ὀπτ-, root of ὄψομαι, fut. of ὁράω, to see, and μέτρον, measure—signified, in its older use, the measurement of the range of vision (*die Gesichtsweite*). With the attainment of broader and more accurate knowledge of the physiology and pathology of vision, quantitative methods have been applied to the investigation of other visual functions, and we now recognize, as parts of one general subject, the measurement

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Optometry.

(1) of the acuteness of the visual perception of form (eidoptometry),[1] (2) of the perception of light (photoptometry),[1] (3) of the perception of colors (chromatoptometry),[1] (4) of the extent and limitations of the visual field (perioptometry),[1] (5) of the accommodative and refractive states of the eye (dioptometry),[1] and (6) of the position and movements of the eyeballs (ophthalmostatometry and ophthalmotropometry).[1]

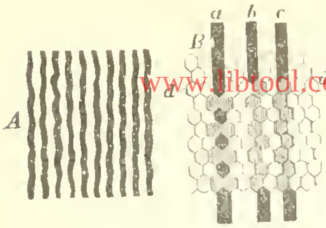

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FIG. 3691.

Eidoptometry—from εἶδος, form—deals with the measurement of the acuteness of the visual perception of form—*visus*, V.; German, *Sehschärfe*, S. Assuming an adequate illumination and a sharply defined retinal image, the physiological limit of the acuteness of vision is determined by the fineness of the mosaic formed by the cones of the retina at the fovea centralis. Let *d d* (Fig. 3691, *B*, from Helmholtz) represent the mosaic of retinal cones at the macula, and *a*, *b* and *c* the images of three vertical bars of a grating for which the eye is accurately accommodated. When the grating is removed to such a distance from the eye that the image of each bar does not much exceed the diameter of one of the retinal cones the several images appear more or less distorted or beaded, according as they happen to fall upon one or another, or perhaps upon two, of the cones lying nearest to their tracks. With the bars and interspaces of the grating each of a width of 0.4167 mm., the appearance shown at *A* begins to be manifest when the grating is removed to a distance of 1.1 to 1.2 metres (Helmholtz). This corresponds to a width of about 0.005 mm. in the retinal image for each bar of the grating, and to a visual angle of about 1.2′; it also indicates a very close approximation of the width of the image to the diameter of the retinal cones at the macula (0.0045 to 0.0054 mm.). Observations on the smallest angular distance at which two fixed stars of lesser magnitude (Hooke) or the bars of a grating (Helmholtz) can be positively distinguished by the naked eye, point also to an angle of about 1′ as the normal limit of distinct retinal perception.

The first serious attempt to apply a system of exact measurement to the clinical determination of the acuteness of vision was made by E. Jaeger. Jaeger's *Strichscale*[2] consists of a series of lines diminishing in length and in width from No. 1, with a width of 0.4597 Vienna inch, to No. 80, with a width of 0.0037 inch; the measure of the acuteness of visual perception is the narrowest line which can be positively distinguished at the distance at which the observation is made. Thus a normally acute eye sees No. 5 at 100 feet; No. 30 at 20 feet; No. 80 at 1 foot, etc. Unfortunately, the ratio of gradation adopted by Jaeger is such that the numbers do not indicate the relation of individual measurements to the normal. Moreover, the determination turns entirely on the unchecked statement of the person examined, that he sees the lines down to a certain place in the scale. The results of numerous and characteristically careful measurements made by Jaeger with this scale point to a visual angle of about 1′ as the limit of distinct recognition of the individual lines by a normal eye.

Snellen[3] was the first to work out a system of measurement adequate to the needs of the ophthalmic practitioner. Assuming a visual angle of 1′ as the average limit of distinct vision in the normal eye, Snellen constructed, upon this basis, a number of capital letters of sizes corresponding to seventeen different distances, ranging from 200 Paris feet (No. CC.) to 1 foot (No. I.). Each square letter, viewed from its appropriate distance, subtends a visual angle of 5′, and each letter is made up of lines subtending each an angle of 1′. The ultimate elements from which the several square letters are constructed are small squares, each subtending an angle of 1′; and twenty-five of these smaller squares are equal in area to the larger square in which the letter is inscribed. Only such letters are used as can be drawn approximately within the compass of a square, and even of these scarcely any two are of absolutely equal legibility; still, the difference is not so great as to impair the practical usefulness of the method, and the recognition of only a part of the letters in any line affords the means of making a finer discrimination than if only the more easily recognizable letters of the alphabet were used. Furthermore, certain of the letters often appear under characteristically modified forms when viewed by an astigmatic eye; D sometimes looking like B, O like the numeral 8 or like S, H like N, V like W, etc. The test of perfect recognition of form is the correct naming of all the letters at the distance corresponding to the number. Representing the greatest distance at which all the letters in any given line are recognized by *d*, and the greatest distance at which the same letters are seen by a normally acute eye by D, the measure of the acuteness of vision in any particular case is expressed in the fractional form $\frac{d}{D}$. The adoption of this simple and very convenient system was immediate and general; it remains the only method suited to the daily requirements of the practitioner.

The system of Snellen admits of but little further development; simple geometrical figures[3] and representations of familiar objects of characteristic outlines[4] are of use in examining children or illiterate persons. The substitution of a scale based on distances taken in metres instead of in Paris feet was made by Snellen in 1875.[5] The simpler form of letters known to printers and sign painters by the inappropriate name of "Gothic"[6] has been tried instead of the "block-letter" used by Snellen, and a regular ratio of gradation in geometrical progression[7] has been employed in the place of his somewhat arbitrarily selected series of numbers* (see Plate XLVIII.); a notation expressed in tenths of the normal, and therefore capable of being expressed in decimal form,[8] has also been somewhat extensively used.

For testing the perception of form at short distances, printed texts are in general use; such texts were first published by Jaeger[9] in a great number of different languages and in various kinds of type. Jaeger's smallest type (No. 1, = "gem" or "brilliant"), read fluently at a distance of one foot, is a pretty severe test of normally acute vision conjoined with good power of accommodation for the reading distance. Jaeger's numbers have no definite significance, beyond the fact that the higher numbers indicate the larger sizes of letters; still it is more convenient to employ even an arbitrary standard than to use the somewhat uncertain nomenclature of the type-founders.

Photoptometry—from φῶς, light—is comparatively little employed in the ordinary routine of ophthalmic practice, yet it is not without positive value in the diagnosis of impaired function of the retina. Two principal types of photoptometers have been used, each of which has its special applications.

A rapidly rotating disc, upon which a smaller or larger sector (Masson),[10] or a row of short lines arranged along a radius (Donders),[11] is depicted in black upon a white ground, or in white upon a black ground, presents the appearance of a shaded surface, or of a number of concentric shaded rings diminishing in intensity toward the periphery of the disc. Whenever the width of the black line is less than $\frac{1}{360}$ of the circumference of an imaginary

* The card of test-letters shown in Plate XLVIII. is constructed on the basis of a constant ratio of gradation, $\sqrt[3]{2} = 1.26$; the Arabic and Roman numerals denote, respectively, the distances in metres and in feet at which the letters should be distinguished by a normal eye. For convenience, the foot has been taken as equal to one-third metre, which is a little more than the Paris foot. In the arrangement here reproduced only a single letter is given for each number of the scale. The construction of the individual letters is slightly altered from that adopted by Snellen, with a view to somewhat more uniform legibility of the different letters.

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circle drawn through it, the shaded ring is ordinarily so faint as to be no longer perceived by a normal eye in average daylight within doors (Helmholtz).[12] The acuteness of light perception, in any particular case, is indicated by the number of the concentric rings seen when the disc is rapidly rotated.

The photoptometer (*Lichtsinnmesser*) of Förster[13] is a closed box one foot long, eight inches wide, and six inches high; at one end are two openings for the eyes, and a window, about two inches square, covered with translucent white paper. Behind this paper diaphragm is a small lantern, enclosing a candle of standard illuminating power. The quantity of light which enters the box is determined by the area of the paper diaphragm, and this is regulated by means of two notched plates of metal sliding over each other so as always to leave a square opening whose area may be read off from a graduated scale. At the opposite end of the box is placed the test object, a card showing alternate black and white stripes of from 1 to 2 cm. in width. The measure of the acuteness of the perception of light (L) is the quotient of h, the smallest area of the window required for the recognition of the stripes by a normal eye, divided by H, the smallest area which suffices for the recognition of the same stripes by the eye under examination. According to Förster's observations, made with an instrument of the construction just described, $h = 2$ sq.mm., giving the value, $L = \frac{2}{H} = \frac{1}{\frac{1}{2}H}$.

Chromatoptometry—from χρῶμα, color—as applied to the diagnosis of defective color perception, has been discussed under the title *Color Perception*, Vol. III., pp. 208–217. Approximate measurements of the acuteness of color perception may be made with Snellen's test letters, printed in vivid colors on a black ground; or similar white letters on a black ground may be strongly illuminated by colored light.

The principle of simultaneous contrast may be utilized as a qualitative test of color perception. Thus the shadow cast by any small opaque object upon a white ground appears of a color complementary to that of the light. The test may be made in the dark room appropriated to ophthalmoscopical examinations, by placing a sheet of colored glass in front of the lamp and directing the attention of the patient to the color of the shadow cast by a pencil, or by a small opaque card, upon a white screen.

Perioptometry—from περί, around—is properly the measurement of the limits of the visual field in its several dimensions; it includes also the detection and measurement of defects in the field of vision (scotomata), wherever they may be situated. The simplest, and for many purposes the best, method of testing the central portions of the field, up to a distance of about 45° from the point of fixation, is by means of a blackboard or a large sheet either of dark or of white paper, upon which a central point of fixation is marked by a small cross, +. The patient is placed at a measured distance from the board (usually one foot), and is directed to look with one eye (the other being covered) at the central cross. A bit of chalk or crayon, fixed to the end of a short wand of the same color as the board or paper, is then moved from the periphery toward the centre of the field, until it reaches a point at which it is seen by the patient. The observation is repeated for other ocular meridians in succession, until the boundaries of the field have been determined at a number of points sufficient to admit of drawing a continuous outline through them.[14]

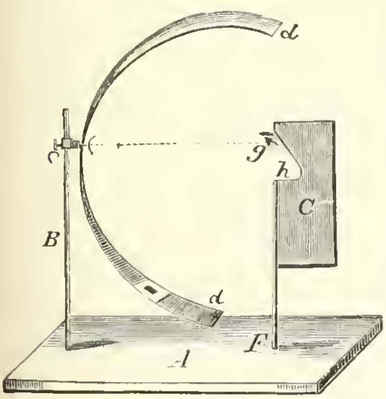

FIG. 3692.

For mapping the periphery of the field, when of nearly normal extent, a plane surface is insufficient, and

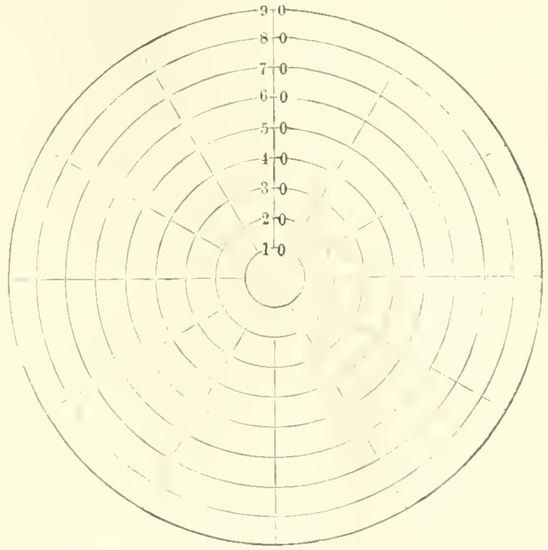

FIG. 3693.

for all distances greater than 45° from the point of fixation the distortion of the peripheral portions of the chart becomes excessive. For the projection of the entire field, with all its parts in due proportion, we require a hemispherical background instead of a plane surface; to this end we make use of the *perimeter*,[15] which is merely one-half of a broad blackened hoop, upon the inside of which the angular distance of any point of the fundus, lying in the meridian corresponding to the direction of the hoop, may be noted (Fig. 3692). By turning the hoop about a central pivot as an axis, it is brought into the necessary position for the observation of the extent of the field in different meridians; each point, as determined, is transferred to a blank chart printed, in concentric circles (Fig. 3693).

For the direct mapping of the visual field in its entire extent the perimeter of Scherk[16] has been devised; it consists of a hollow hemisphere, of one foot radius, blackened on the inside. The eye to be examined is placed at the centre of the sphere, and the limits of the field are marked with chalk in the same manner as when the blackboard is used. For greater convenience the hemisphere is made in separable halves, and the mapping is done for one-half of the field at a time.

Most of the perimeters, as found in the shops, have an arrangement of cords and pulleys, by means of which the test object is moved along the arc; this is a complication of at least doubtful advantage. A further complication consists in a self-registering apparatus, analogous to that employed in the "*conformateur*" used by hatters to prick a small diagrammatic outline of the shape of the head. For practical utility the arrangement in use at the Utrecht clinic is to be commended; it consists of a blackboard, about three feet square, to the centre of which is pivoted a removable half-hoop of one foot radius; the blackboard serves for the direct mapping of limitations of the field within the limits of 45° from the point of fixation, and the arc is used for peripheral measurements. The divisions of the arc between 0 and 45° are projected upon the board in circles whose radii are equal to the tangents of the respective angles.[17] The

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half-hoop of the perimeter is usually made of brass, and is rather heavy; one-half of a hoop of a cheese-box, stiffened at the back by a piece of thin board sawed to the proper curve, answers every purpose in practice; the points are determined by moving a bit of chalk or a small square of white cardboard along the blackened arc.


FIG. 3694.

Instead of the small square of cardboard a small electric lamp, the intensity of which may be regulated at will by means of a rheostat or by varying the internal resistance of the battery, may be used in determining the limits of the visual field in cases of cataract or other obscuration of the media; a candle may be used for the same purpose.

For testing the limits of the field for color perception, small pieces of colored cardboard, usually 1 cm. square, are used instead of the bit of chalk or square of white card. A small convex mirror of very short radius of curvature, such as the bulb of a thermometer, may also be used to reflect white or colored light from a lamp placed a little above and behind the patient's head.

The perception of form in the peripheral regions of the retina is tested by means of two small black squares on a white ground, with an interspace equal to one of the squares (Fig. 3694). These squares, of sizes corresponding to the thickness of the limbs of Snellen's test letters (Nos. XX. to C.), are moved along the arc of the perimeter toward the centre of the field, until the white interval is seen between the two black squares.

Dioptometry—from διά, through—has to do with the eye considered as an optical instrument, with especial reference to the detection and measurement of the different anomalies of refraction and accommodation. The detection, measurement, and correction of the several anomalies of refraction and accommodation are treated in this HANDBOOK under the titles, *Accommodation and Refraction*, *Astigmatism*, *Hypermetropia*, *Myopia*, and *Presbyopia*.

Dioptometry is either objective or subjective, according as the investigation turns upon observations made by the examiner or by the person examined. The objective methods are of the wider applicability, inasmuch as they may be employed in cases in which the patient is incapable either of making accurate observations or of accurately reporting his observations; subjective determinations have, on the other hand, the special advantage that they are the actual measurements of the function performed by the eye under examination. Objective examination affords, in many cases, the readiest means of discovering and of approximately measuring a refractive anomaly, and is often of service as a guide to the examiner in the conduct of such tests as require the active co-operation of the patient.

In objective examinations the chief dependence is upon the ophthalmoscope (see *Ophthalmoscope*, also *Shadow-Test*). A second method, based upon the observation of the images formed by reflection at the anterior surface of the cornea, and therefore suited to the detection of deviations from normal curvature of the first and most important of the refracting surfaces of the eye, demands notice in so far as it may be employed in clinical investigations.

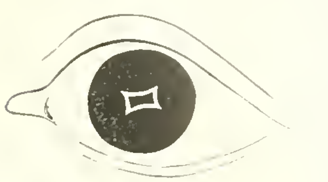
FIG. 3695.

The image of a luminous point or small flame, as it is seen mirrored by a cornea of irregular curvature, undergoes conspicuous changes of form according as the reflection is from one or another part of the corneal surface. This is especially noticeable in irregularity of contour resulting from the cicatrization of a corneal wound or ulcer, or from distention of the corneal tissue as a result of softening from disease. It is also very characteristic in keratoconus (conical cornea), in which affection the principal image remains nearly in one position, at the rounded vertex of the cone, whatever the direction from which the light is thrown upon it. When the light falls upon the cone from the side, two images are often seen, the one small and nearly central, corresponding to the vertex of the cone, the other lateral and distorted, formed by reflection on the side of the cone nearest the light. In regular astigmatism, in which asymmetry of the cornea is ordinarily the most important factor, the image of the point of light appears drawn out in a direction corresponding to one of the two principal meridians; when two lights are used, their images will be seen to be appreciably nearer together when they lie in the plane of the corneal meridian of greatest refraction than when they lie in the plane of the meridian of least refraction. Inasmuch as the distance which separates the two images is determined by the corneal curvature in the meridian in which they lie, it is possible, by measuring this distance, to obtain the necessary data for calculating the radius of curvature. The ophthalmometer of Helmholtz,[18] adapted by Donders and Middelburg[19] to the investigation of the curvature of the cornea in its different meridians, is an instrument by the aid of which such measurements may be made with almost the accuracy of an astronomical observation.

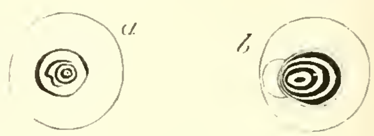

FIG. 3696.

If a rectangular white card is held at a distance of a few inches in front of an eye, the image, as seen reflected on the cornea, will appear more or less distorted whenever the corneal curvature is either irregular or asymmetrical. The most striking distortions are observed in conical cornea and in astigmatism; in the former condition the four straight sides of the card appear incurved in the direction of the vertex of the cone (Fig. 3695); in the latter condition a square card is reflected as a parallelogram, and a circular card as an oval.

This experiment is further developed in the keratoscopic disc of Placido,[20] a circular card or metal disc, about 23 cm. in diameter, with concentric rings painted in black and white upon the side turned toward the eye to be examined. The observer, looking through a central hole in the disc, sees an image formed by reflection on a large central area of the cornea; the effect of any asymmetry or distortion of the reflecting surface is revealed by a characteristic asymmetry or distortion of the image (Fig. 3696).

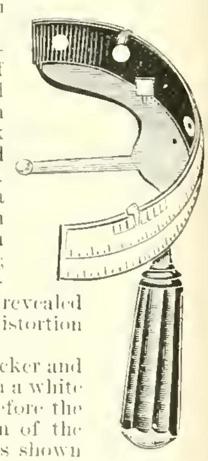
FIG. 3697.

In the "astigmometer" of De Wecker and Masselon[21] a square black card with a white border 1.5 cm. in width is held before the eye to be examined, and the form of the image of the white border noted, as shown in Fig. 3695.

The ophthalmometer of Javal and Schiötz[22] is a simplification of the Donders-Middelburg modification of the ophthalmometer of Helmholtz; instead of lights, special test objects (*mires*) of enamelled metal are used, and the images are viewed through a small telescope which contains a doubly refracting prism, by means of which the images are doubled and brought into such relation to each other that their mutual distance can be ascertained at a glance. The several parts of the instrument are so proportioned that the refraction for any meridian may be read off in dioptries without the trouble of making calculations (see *Ophthalmometer*).

In the ophthalmophakometer of Tscherning (1900), small adjustable electric lamps are carried on an arc like

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that of the Javal-Schiötz ophthalmometer. By means of this instrument Tscherning has succeeded in measuring the curvatures of the posterior surface of the cornea and of the two surfaces of the crystalline lens. The ophthalmophakometer, like the ophthalmometer of Helmholtz, is adapted rather to accurate research work in the physiological laboratory than to clinical use.

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FIG. 3698.

The *arc keratoscopique* of De Wecker and Masselon (Fig. 3697)[23] is a simplification of the ophthalmometer of Javal and Schiötz; a number of small white discs, arranged at equal distances upon a blackened arc like the arc of a perimeter, give reflections in which the interspaces are nearly equal when the curvature of the cornea is regular, but unequal when the curvature changes from the centre toward the periphery (Figs. 3698 and 3699). The instrument is especially adapted to the detection of conical cornea.

In subjective dioptometry we distinguish methods which turn upon the recognition of the forms of test objects, such as the test letters of Snellen, and methods in which the accurate recognition of form is not required.

In any case in which the acuteness of vision is normal, the detection and measurement of simple ametropia (H or M) may be made by means of trial glasses used in connection with the test letters of Snellen. Having placed the patient at a measured distance of 5 metres from the card of test letters, we note the smallest line of letters which he is able to read correctly with the unaided eye. If by this test we find V. = $\frac{5}{5}$, the presence of myopia of any grade in excess of 0.02 dioptrie is excluded, and the eye is either practically emmetropic or hypermetropic with accommodative power in excess of its hypermetropia (A > H). To decide between these two possible conditions we place a weak convex glass before the eye and note whether there is any falling off in the acuteness of vision at the distance of the test card. If we still find V = $\frac{5}{5}$, the presence of some degree of hypermetropia is established, and we exchange the convex glass for another of greater power, until we have hit upon the strongest convex glass through which V remains at the normal standard $\frac{5}{5}$. The value of this convex glass in dioptries* is the measure of the manifest hypermetropia.

Whenever, by the use of the test letters, we find V < $\frac{5}{5}$ we suspect the presence of myopia, and proceed at once to try the effect of a weak concave glass. If V is improved by this glass we try stronger glasses in succession, until we have found the weakest concave glass through which V = $\frac{5}{5}$. The value of this concave glass in dioptries† is the measure of the myopia (M), or possibly of the myopia augmented by some degree of abnormal tension of the accommodation.

In order to measure the total hypermetropia (Ht), and sometimes, also, to obtain the true measure of a myopia, it is necessary to bring the eye under the full influence of one of the stronger mydriatics, and to repeat the examination with the test-letters. The problem is so far simplified by the suppression of the accommodation that it is now only a question of what glass, whether convex or concave, raises V to its maximum at the distance of the test card.

If no glass suffices to raise V to the normal standard of $\frac{5}{5}$, and especially if the patient is in doubt as to which of several glasses of somewhat different power gives the best visual result, we may suspect the presence of astigmatism. The special methods used for the detection and measurement of astigmatism have been described under that title (see *Astigmatism*).

A large collection of trial lenses is an indispensable part of the armamentarium of the ophthalmic practitioner, and it is convenient to include in it the full range of numbers as found in commerce, or for which grinding tools are kept by the working opticians. With such a series of spherical lenses (in pairs), ranging (through zero) from + 20 to − 20 dioptries, and a full series of cylindrical lenses (in pairs), ranging from + 10 to − 10 dioptries, it is possible to correct almost any case of simple hypermetropia, myopia, or astigmatism by means of a single glass for each eye, and, similarly, to correct any case of compound or of mixed astigmatism by means of a combination of two glasses for each eye. The lenses of the trial case should be accurately centred, and set in brass cells turned with a thin projecting flange (like the wheels of a railway carriage) so that any two may be provisionally mounted, with the two flanges in contact, in a trial frame made with a single groove.[24] In the higher numbers of each series the lenses should be of the plano-convex and plano-concave form, and they should be so set in their cells as to bring their plane surfaces very nearly in contact when any two lenses are used in combination, thus making it possible to build up any desired double convex, double concave, or periscopic lens, or by combining a plano-spherical with a plano-cylindrical lens, to build up any required spherico-cylindrical lens with the same combination of surfaces as in the lens to be prescribed.*

The trial frames should be of the lightest practicable weight and of the simplest possible construction. For most purposes a single groove, made wide enough to receive the thin flanges of two lenses, is sufficient. A dozen or two of such frames, of different widths and height of bridge, costs no more than one or two of the complicated and less convenient trial frames shown in almost endless variety in the catalogues of the manufacturing opticians.

By enlarging the series of test letters through the addition of a few numbers, so as to extend its range to say 0.1 metre, the position of the near-point (p) may be approximately determined by direct observation. Oftener, however, we determine the position of p after having provisionally corrected the eye for distant vision by means of glasses; for practical purposes it is generally sufficient to measure the distance (P_2) of the binocular near-point (p_2) from the anterior nodal point of the eye (see *Accommodation and Refraction*).

It is possible to use the card of test letters for the direct determination of the grade of myopia, by noting the greatest distance at which the letters corresponding to that distance are distinctly recognized. In the lower grades of myopia good measurements may sometimes be made in this manner, but in the higher grades the convergence of the visual axes is apt to be attended with some exercise of the accommodation, so that the measurements are often somewhat in excess of the actual myopia.

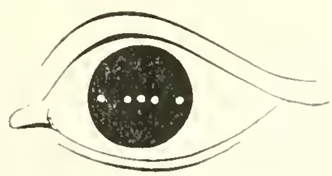

FIG. 3699.

* Less 0.2 dioptrie, as a correction for the distance of the test object.
† Plus 0.2 dioptrie, as a correction for the distance of the test object.

* The following specification of a series of trial lenses has been found satisfactory in practice:

Spherical lenses, in pairs: + 2.0 D, through 0, to − 2.0 D, with a common interval of 0.125 D (thirty-three pairs); + and − 2.25 D to + and − 7.0 D, with a common interval of 0.25 D (forty pairs); + and − 7.5 D to + and − 12 D, with a common interval of 0.5 D (twenty pairs); + and − 13.0 D to + and − 20.0 D, with a common interval of 1.0 D (sixteen pairs); + and − 22.0 D (two pairs); + and − 24 D (two pairs):—total, 113 pairs of spherical lenses.

Cylindrical lenses, in pairs: + and − 0.125 D to + and − 2.0 D, with a common interval of 0.125 D (thirty-two pairs); + and − 2.25 D to + and − 7.0 D, with a common interval of 0.25 D (forty pairs): + and − 7.5 D to + and − 10.0 D, with a common interval of 0.5 D (twelve pairs); + and − 11 D to + and − 14 D, with a common interval of 1.0 D (eight pairs):—total, 92 pairs of cylindrical lenses.

The entire collection of 205 pairs of lenses, together with a series of prisms, in pairs ranging from 1° to 12° angle, is contained in a box measuring 47 × 42 × 6.5 cm.; for convenience in keeping the case free from dust, the lenses are arranged in a bottomless tray which may be lifted out of the box.

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Optometry.

Optometers for the measurement of the refraction, and also of the range of accommodation, at some short distance, say, of one foot, have been made in a great variety of forms; they are, however, of much less value than might be expected, whether as regards saving of time in

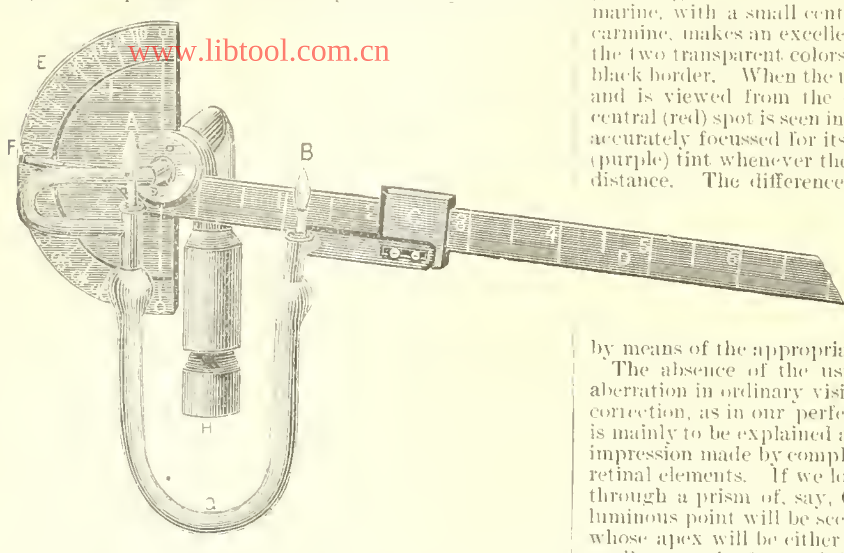

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FIG. 3700.

observation or accuracy of results. The binocular optometer of Javal (see Vol. I., p. 594), especially devised for the measurement of astigmatism, probably still remains the best instrument of its class.

A point of light, such as the flame of a small taper or gas jet, viewed from a distance of 5 metres or more, is seen by an emmetropic eye as a bright point, with some indication of bright rays, as in the familiar picture of a star (see Vol. I., 596). The same distant bright point is seen by a myopic eye, or by a hypermetropic eye in a state of accommodative relaxation, as a bright spot (circle of confusion) of a greater or less diameter, dependent on the grade of ametropia and the size of the pupil. When the pupil is fully dilated by a mydriatic, the size of the circle of confusion is approximately proportionate to the degree of ametropia, so that a pretty exact measurement may be made by simply noting the distance at which two tapers must be placed, one from the other, in order that the two circles of confusion may touch each other. Thomson[25] has devised as apparatus (Fig. 3700) in which two small gas jets are so arranged as to admit both of varying the distance between the two lights and of altering their direction to correspond to different ocular meridians; the degree of ametropia is read off from a scale which forms a part of the instrument.

By making the effective area of the pupil very small, as in looking through a pinhole pricked in a blackened card, the circles of confusion may be so reduced in size as to admit of tolerably distinct vision even in high grades of ametropia. If two pinholes are pricked in the card, at a distance of, say, 4 mm. from each other, a pretty distinct image will be formed by the rays passing through each of the pinholes, but the two bundles of rays will fall upon different parts of the retina whenever the eye is adjusted for any distance other than that of the object (Fig. 3701). This experiment, first described by Scheiner,[26] has been utilized in the optometers of Porterfield[27] and Young,[28] and has been further developed in a method for the clinical investigation of ametropia by Thomson.[29]

When a colored test object, in a field of a contrasting color, is viewed by an eye adjusted for some distance other than that of the object, the circles of confusion, representing parts of the object and of the field adjacent to the line of demarcation of the two colors, overlap in the retinal image and form the combination color proper to the mixture. The experiment succeeds best when the test object and the contrasting field are in transparent colors and viewed by transmitted light. A sheet of ground glass coated with varnish colored blue by ultramarine, with a small central area similarly painted with carmine, makes an excellent test object for this purpose; the two transparent colors should be separated by a thin black border. When the test object is hung in a window, and is viewed from the opposite side of the room, the central (red) spot is seen in its actual color when the eye is accurately focussed for its distance, but in a combination (purple) tint whenever the eye is focussed for some other distance. The difference between the carmine-red and the combination-purple is especially striking in astigmatism, when the test object is made up of radiating lines of carmine, on a blue field[30] and the eye is corrected for one of its principal meridians by means of the appropriate spherical glass.

The absence of the usual phenomena of chromatic aberration in ordinary vision is not due to an achromatic correction, as in our perfected dioptric instruments, but is mainly to be explained as an effect of the simultaneous impression made by complementary colors upon the same retinal elements. If we look at a distant point of light, through a prism of, say, 60° angle, the spectrum of the luminous point will be seen under the form of a triangle, whose apex will be either in the red or in the violet, according as "the focus of the eye is adapted to collect the red or the blue rays to a point";[31] in other words, according as the eye is slightly myopic or hypermetropic. In emmetropia the spectrum is seen under the form of a double triangle in which the narrowest part lies in the very strongly luminous yellow region. The impression made by a point of white light upon any single cone of the retina is, therefore, compounded of the spectral yellow and a composite yellow, made up of red and green. This mixed yellow, superimposed as it is, upon a field of diffused violet, is further modified to approach white.

The chromatic aberration of the eye reveals itself very plainly in looking at a point of light of which all but the blue and red rays have been extinguished by the passage of the beam through a sheet of cobalt-blue glass.[32] Looking through such a glass an emmetropic eye, focussed for the distance of the light, sees it of a nearly uniform purplish-blue tint, with an inconspicuous halo of a clearer blue; a myopic eye sees the same light red, with a blue halo; and a hypermetropic eye, uncorrected by accommodation, sees it blue, with a red halo. To measure the grade of the ametropia it is sufficient to find the spherical (concave or convex) glass through which the light appears of a purplish-blue bordered by a clearer blue.

An emmetrope, looking at distant red and green lights, such as are carried by vessels and used as railway signals, sees the two lights of about the same magnitude; a myope sees the green light as an aggregation of circles of confusion, and therefore larger than the image of the red light; a hypermetrope, with imperfect accommoda-

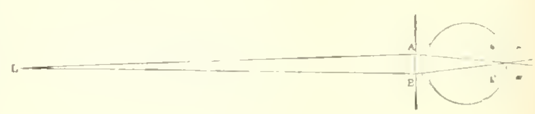

FIG. 3701.

tion, sees the red light larger than the green. When the vision is corrected for the distance of the lights they are seen in their normal relation of equality in size.[33] *

* The difference in the size and definition of the retinal image of a red and of a green light is quite sufficient to enable a hypermetropic or slightly myopic pilot, or railway employee, to utilize this difference as an aid to the discrimination of lantern signals, even though he be color-blind.

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Optometry.

Ophthalmostatometry—from ὀφθαλμός, eye, and στα-, root of ἵστημι, to stand—is the measurement of the position of the eyes. The most important measurements are those which have to do with the two eyes in respect of their mutual distance and the relative direction of the visual axes.

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The distance between the two eyes may be roughly measured by looking the patient in the face and letting him direct his gaze alternately upon the two eyes of the observer, who in turn reads off the position of the fixing eye with his fixed eye upon a graduated rule held in the hand or mounted like a spectacle frame. The right or left corneal margins, or the right or left margins of the pupils, may be taken as fixed points whose mutual distance is an approximate measure of the true interocular distance. An inaccuracy of this, as of other objective methods of measuring the interocular distance, arises from the fact that the visual axis does not exactly coincide with the geometrical axis of the eye, but, as a rule, cuts the cornea a little to the inner (nasal) side of its vertex. The angle which the visual axis makes with the axis of the cornea (angle *a* of Donders)[34] averages about five degrees in the emmetropic eye; it is somewhat greater in hypermetropic and less in myopic eyes, and in very high grades of myopia it may even be negative, so that the visual axis may cut the cornea at, or a little to the outer (temporal) side of, its vertex. Objective measurements of the interocular distance are, therefore, ordinarily a little too large, though sufficiently accurate for most practical purposes.

If we place a diaphragm, with a central perforation of about 1 mm. in diameter, in each of the two clips of a trial spectacle frame, and adjust the distance of each from the median line of the nose so that a distant vertical line shall be seen bisecting the small circular field as defined by the margins of the perforation, the distance between the centres of the two perforations will be the true measure of the distance of the two (parallel) visual axes from each other.[35]

To measure any deviation of the optic axes from parallelism, when the patient fixes his gaze upon a distant object, a lighted candle may be held about a foot in front of the deviated eye and moved in different directions until its image, as seen reflected on the cornea, occupies a position central to the pupil when viewed from a station just behind the light. The angle at which the light must be held to one side of a line drawn from the observed eye to the (distant) point fixed by the other eye is the measure of the angular displacement of the deviated eye; it may be conveniently measured upon the arc of a perimeter, the eye whose deviation is to be measured being at the centre of curvature of the arc (Landolt).

Ophthalmotropometry—from ὀφθαλμός, eye, and τροπή, turning—is the measurement of the movements of the eyeballs. Most important, from a clinical standpoint, is the estimation of the interrelation of the recti interni and recti externi muscles.

In insufficiency of the recti interni, not amounting to strabismus divergens, the phenomenon of double vision (see *Diplopia*) does not ordinarily manifest itself so long as it is possible to maintain the fusion of the two retinal images through the forced exercise of the convergence; if, however, we displace one of the retinal images upward or downward, by means of a weak prism, any insufficiency of the interni immediately reveals itself by a crossing of the images, which then assume an oblique direction, one to the other, instead of the vertical direction proper to the action of the prism. The measure of the insufficiency is the prism, with edge turned horizontally outward, which is required to convert the oblique into a vertical diplopia. This test, which may be applied both at a long range and at shorter distances, reveals the state of the convergence as related to the degree of accommodation which is brought into play at the particular distance.

The "glass-rod" test of Maddox (see Vol. III., p. 492), especially in its later form as developed by its inventor, is even more convenient in use, and is of wider applicability than the vertical prism. By rotating the disc of fluted glass in front of one of the eyes, the resultant bright streak may be given any desired direction, from the vertical to the horizontal, thereby revealing a deviation of the visual axes from parallelism in any direction. The measure of the deviation is the prism, or sum of two prisms before the two eyes, which brings the streak through the flame.

Insufficiency of the recti externi, or preponderance of the recti interni, is tested, *mutatis mutandis*, in the same manner as insufficiency of the interni.

Binocular vision, conditioned on the simultaneous perception and comparison of the two retinal images of the

FIG. 3702.

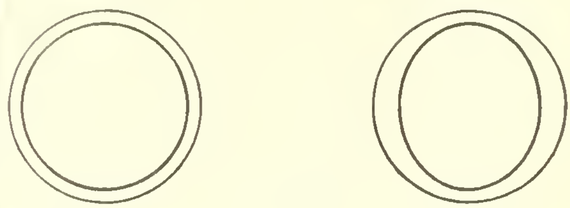

FIG. 3703.

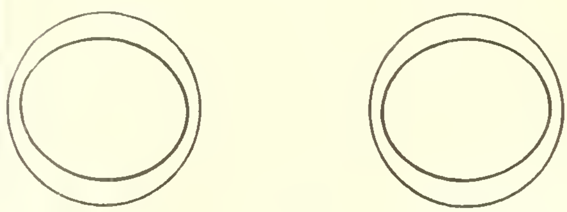

FIG. 3704.

FIG. 3705.

object upon which the two eyes are directed, is most easily tested by means of the stereoscope. Rejecting all representations of objects in which solid forms are suggested by perspective, as is almost always the case with photographs of objects in nature, we make use of diagrams of the simplest possible construction; a few examples of these are shown in Figs. 3702 to 3705.[36]

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Viewed in the stereoscope Fig. 3702 is seen as two discs, the one vertically above the other, but lying in two different planes at different distances from the observer; the more distant of the two discs appearing also to be the larger. Inverting the slide in the stereoscope, the relative distances and sizes of the discs appear reversed. Fig. 3703 shows a circle and an ellipse, which may be considered as two different perspective views of another, larger ellipse; when the two images are combined in the stereoscope a horizontally elongated ellipse is seen rotated about its vertical diameter as an axis; inverting the slide, the ellipse is seen rotated in the opposite direction. In Fig. 3704 the ellipse is seen to tip backward or forward, according as the slide is placed in the stereoscope in the position shown in the plate, or inverted. Fig. 3705 shows a combination of a ring with a white centre and a black disc of the same diameter; the effect is that of a mirror or of a shining surface polished with plumbago. *John Green.*

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ORANGE, SWEET AND BITTER.—(See also *Citrus.*)

I. *Citrus Aurantium* L., the sweet orange, is a familiar plant in all warm countries. It is a small, rather slow-growing tree, with hard wood, an upright, much-branched trunk, bearing a well-rounded, rather close head. Leaves numerous, thick, evergreen, smooth, and shining, oval; the blade articulated to the distinctly winged petiole. Flowers axillary, perfect, regular, large, fragrant, white; calyx short; petals five, long, fleshy, spreading; stamens numerous; ovary free, eight- or more celled, several ovules in each cell. The leaves and petals are fragrant, and show by transmitted light pellucid spots indicating the large oil reservoirs in their parenchyme.

II. *C. vulgaris* Risso, the source of the bitter or Seville orange, is a smaller tree, with a closer head, larger, more fragrant flowers, and a rougher, darker, sour, and bitter fruit. This plant is also rather more spiny than the other, and propagates more truly from seed.

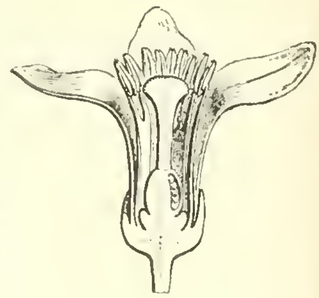

FIG. 3706. — Sweet Orange Flower. (Baillon.)

The official products and preparations are as follows:

Sweet Orange Peel. Aurantii Dulcis Cortex. "The rind of the fresh fruit of *Citrus Aurantium* L." The preparations of this are the five-per-cent. syrup, used wholly as a vehicle and for flavoring, and the twenty-per-cent. tincture, chiefly used like the last, but a stimulant in doses of 2–8 c.c. (fl. ʒ ss.–ij.).

Bitter Orange Peel. Aurantii Amari Cortex. "The rind of the fruit of Citrus vulgaris Risso."

Preparations, the fluid extract, dose 2–4 c.c. (fl. ʒ ss.–i.) and the twenty-per-cent. tincture, dose 2–8 c.c. (fl. ʒ ss.–ij.). It will be observed that this peel may be used dry, while that of the sweet orange must be used in the recent state. The bitter principle of this peel makes it an important aromatic bitter, as well as a flavoring agent.

Oil of Orange Peel. Oleum Aurantii Corticis. "A volatile oil obtained by expression from the fresh peel of either the sweet or the bitter orange." This is purely a diffusive stimulant, but is almost wholly used for flavoring. Its preparations are the five-per-cent. spirit and the twenty-per-cent. compound spirit, made with five per cent. of oil of lemon and two per cent. of oil of anise. This latter enters into the aromatic elixir.

Oil of Orange Flowers. Oil of Neroli. Oleum Aurantii Florum. A volatile oil distilled from the fresh flowers of the bitter orange. (The flowers themselves are no longer official.) This is used purely as a perfuming and flavoring agent. The following are the preparations: *Stronger Orange Flower Water* (*Aqua Aurantii Florum Fortior*) is obtained as a by-product in the distillation, being the water so used, saturated with the oil. From this is made the *Orange Flower Water* (*Aqua Aurantii Florum*) by mixing it with an equal volume of distilled water. From this, in turn, is made the syrup, by adding to 850 grams of sugar enough of the water to make 1,000 c.c.

Oil of Petit Grains, not official, is distilled from the unripe fruits of the bitter orange, and is very similar to oil of orange flowers, but much less agreeable.

The use of orange fruit is like that of other laxative fruits, with the special effect of citric acid. It is to be borne in mind that, while a moderate use of oranges is wholesome, the excessive use can bring on very stubborn and severe dyspepsia, especially in tropical countries. *Henry H. Rusby.*

ORBIT, DISEASES AND INJURIES OF THE.—These affections have great interest and importance, not only with reference to the preservation of sight, but also on account of the close topical and vascular connection of the contents of this cavity with other parts, particularly the brain, and the difficult and serious problems in diagnosis and prognosis which they frequently offer. They are, comparatively, not very common. The one most frequently met with is

ORBITAL CELLULITIS.—This is not generally difficult to recognize. It is usually an acute disease, and often of a violent inflammatory character. Pain, which is a prominent symptom, is in proportion to the degree of swelling and consequent pressure, and, when this is ex-

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cessive, it is very intense. It is referred to the ball and orbit and to the parts of the face to which the ramifications of the ophthalmic branch of the fifth nerve are distributed, and is always increased by the slightest backward pressure of the globe. The conjunctiva is congested and soon becomes chemosed, and the lids are swollen and oedematous and have an erysipelatous appearance.

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The most striking symptom is the exophthalmus, which is decided, even in slight cases and in the early stages. The diplopia resulting from displacement of the eyeball is sometimes among the first symptoms, and may even occur before the exophthalmus attracts attention. In severe cases, particularly if an abscess is formed, the protrusion of the ball may be so great that the lids can no longer cover the cornea. The movements of the eye are, of course, restricted and painful, or it may be completely fixed in its unnatural position.

More or less constitutional disturbance is to be expected, and the formation of pus is usually announced by well-marked rigors. Suppuration is the rule, but a few cases end in resolution, a result said to be much more frequent in children than in adults. This form of the disease is sometimes called "oedematous cellulitis." When an abscess is evacuated spontaneously, the pus escapes through the skin of the lids, near the superior or inferior orbital margin, or sometimes behind the lids, through the palpebro-ocular fold of the conjunctiva. In the latter case the disease is sometimes mistaken for purulent conjunctivitis. In rare cases orbital cellulitis assumes a chronic form, and ends by the escape of pus only after the lapse of months or years. There may be little or no pain, and no decided symptom except the exophthalmus. There is likely to be periostitis or caries in such cases.

Etiology.—Idiopathic cellulitis is so rare that Pagenstecher is disposed to deny its occurrence, and to maintain that cases described as such have been due to the extension of inflammation from a focus which had escaped the attention of the observer (*Arch. of Oph.*, vol. xiii.). Primary cellulitis in healthy adults must be considered, to say the least, a very unusual affection, but its occasional occurrence in delicate children is generally admitted. Perhaps the most frequent causes are direct injuries of the orbital tissue and extension of local inflammation from neighboring parts. Operations upon the appendages of the eye, or even upon the ball itself, are sometimes followed by this complication. Bull (*Jour. Med. Sci.*, July, 1878) reports a case following excision of a prolapsed iris, and one after iridectomy for glaucoma. The most frequent cause of orbital abscess is empyema of the accessory cavities of the nose with caries of their walls. Phlegmonous erysipelas of the face has extended to the orbital tissue in a number of cases. Finally, orbital abscess may be the result of a metastatic process in puerperal fever, phlebitis, typhus, carbuncle, etc. While thrombosis of the orbital vein necessarily occurs in orbital phlegmon, and may extend to the cavernous sinus, orbital cellulitis may have its origin in suppurative phlebitis of the ophthalmic vein. It is well known that suppuration may be communicated to the ophthalmic vein and cavernous sinus from abscesses of the lids or lips, operations about the face, the extraction of teeth, and especially from facial erysipelas. In a fatal case of suppurative phlebitis of the ophthalmic vein and cavernous sinus, following malignant abscess of the tonsil, Professor Panas (*Arch. d'Ophthal.*, t. v.) thinks that the disease was communicated through numerous anastomoses which have been shown to exist between these vessels and the spheno-palatine vein. Cases of orbital cellulitis following diphtheria are reported by Knapp and Heyl (Nettleship, "St. Thomas' Hospital Reports," vol. xi.). Knapp (*Arch. of Oph.*, xiii.) has shown that orbital cellulitis is present in all cases in which blindness results from facial erysipelas.

Diagnosis.—The conditions with which orbital cellulitis is most likely to be confounded are periostitis of the orbital walls and new growths in the cavity. In periostitis the progress of the disease is usually less rapid, and the pain, though perhaps less severe, is an earlier symptom and may even be the first. Except in cases in which only the deeper parts of the orbit are affected, a tender spot can frequently be detected by passing the finger as far back as possible and pressing against the wall. While in cellulitis the eye is usually protruded directly forward, and its motions are limited equally in all directions, it is likely to be given a special direction by the more localized swelling of periostitis. These two lesions may, however, sometimes appear together, the inflammation extending from the periosteum to the orbital cushion. The acute course of cellulitis will usually distinguish it from orbital growths. The eye is rarely protruded directly forward by a tumor, and the latter may often be felt with the finger. The diagnosis is, however, sometimes extremely difficult, and may prove a stumbling-block to the most skilful and careful observer. This is well illustrated by a case which occurred some years ago in the experience of no less an authority than Professor Jaeger. He was sent by the Emperor to Milan to examine Marshal Radetzky, who had been suffering for three months with a high degree of exophthalmus and its accompanying symptoms. He reported that the patient, who declined any operative interference, was affected with scirrhus of the soft parts of the orbit, which would probably soon end his life. Not long afterward, under homoeopathic treatment, there was a copious discharge of pus, and the eye returned to its normal position (*Annales d'Oculist.*, xxiii., p. 14).

Prognosis.—Though a large proportion of cases of orbital cellulitis recover without serious injury to the eye, the disease is a dangerous one and places not only sight but sometimes life in peril. The most frequent causes of loss of sight are injury to the optic nerve from pressure and stretching, and interference with the circulation in the central vessels of the retina. The tense chemosis may cause the cornea to slough, or panophthalmitis may result from interference with the circulation of the choroid or from direct extension of the inflammation to that membrane. The movements of the ball are sometimes permanently impeded by cicatricial contractions or atrophy of the external muscles, or their paralysis from injury to the nerves. Life is threatened by direct extension of inflammation to the meninges, through the sphenoidal fissure or optic foramen, by flow of pus into the intracranial cavity, or by thrombosis of the ophthalmic vein. According to Berlin (Graefe-Saemisch, vol. vi.), fatal pyæmia may result without extension of thrombosis beyond the orbit, or the thrombosis may extend to the brain sinuses. He thinks that the latter condition may be diagnosticated positively if exophthalmus occurs suddenly in the other eye. Exophthalmus frequently results from venous obstruction only, with little or no inflammation of the orbital tissue, and is a constant and important symptom of phlebitis of the cavernous sinus.

Treatment will necessarily vary with the violence of the local inflammation and the general condition of the patient. In traumatic cases, and others occurring in persons in fair health, leeches may be applied to the temple in the early stages of the affection before suppuration has commenced. Even this kind of depletion, however, is to be condemned in the large proportion of cases in which the inflammation of the orbital tissue is a complication of some exhausting disease. Hot stupes will promote resolution while there is hope of that termination; but warm fomentations or poultices should be applied when it is desirable to encourage suppuration. Extract of belladonna applied to the temples and brow is useful in relieving pain, but most cases will require the liberal exhibition of anodynes. When suppuration is evident, there is no question about the propriety and urgency of free incision, and when it is doubtful it is often prudent to make an exploratory puncture. When great swelling inflicts intense pain and threatens the integrity of the eyeball and optic nerve, deep and free incisions should be made without waiting for indications of suppuration, and with a view to relieving the tension of the parts. A narrow, straight bistoury or a long Graefe cataract knife

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is entered near the upper or lower margin of the orbit, and its point kept near the roof or floor, while it is passed toward the apex of the orbit. It is well to keep the wound open by a tent of carbolized or borated lint. Curetting of the inner wall of the orbit and drainage through the nose may be necessary when the accessory sinuses are involved (see Transactions of the American Ophthalmological Society, 1900).

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TENONITIS.—The capsule of Tenon is a fibrous envelope of the ball, derived from the dural sheath of the optic nerve, and lined by a serous membrane which, according to some authorities, is continuous with the arachnoid. The eyeball moves in this envelope like the head of a bone in its articular capsule. The recti muscles pass through this capsule at the equator of the ball, where it is intimately connected with their sheaths, and in the neighborhood of the corneal margin it is merged in the conjunctiva and subconjunctival tissue. While it forms a barrier to the extension, within the eye, of inflammatory processes when they commence in the orbital tissue, its direct connection, by means of the anterior ciliary vessels with the intra-ocular circulation makes this danger greater when the capsule itself is inflamed. On the other hand, it probably rarely entirely escapes participation in very acute and intense intra-ocular inflammation, and is the cause of the protrusion of the ball in panophthalmitis. In enucleation in such cases the extensive and firm adhesions of the capsule and the muscles and connective tissue about the ball often considerably complicate the operation. Tenonitis is said to occur occasionally after facial erysipelas or as a rheumatic affection, but is usually the result of extension of inflammation from the ball, or of direct injury. It has sometimes followed operations, especially those upon the external muscles. I have met with two cases: one after simple division of a muscle for strabismus, the patient recovering in the course of a few days, without injury to the eye; and one after the advancement of the internal rectus. In the latter case the disease ended in disorganization of the ball.

The *symptoms* are conjunctival and subconjunctival congestion, sometimes with chemosis, moderate exophthalmus, restriction of the movements of the ball, and pain, greatly increased by pressing the eye backward. The lids are less affected than in cellulitis, and if pus forms it escapes on the surface of the ball.

Treatment will, of course, depend upon the cause and the intensity of the inflammation. Rheumatic cases require hot stupes, cotton compresses, anodyne applications, and the appropriate internal medication. In the early stages of traumatic tenonitis leeching at the temple, the local application of ice, and calomel internally may be needed.

PERIOSTITIS of the orbital walls is sometimes difficult to distinguish from cellulitis, and indeed the two conditions may exist together, or phlegmonous inflammation of the orbital connective tissue may originate in periostitis. The usual seat of periostitis of the orbit is near the margin, where it can be detected by pressure with the finger. The exophthalmus is not directly forward as in uncomplicated cellulitis, and the movements of the ball are limited more in the direction of the seat of the disease than in other directions. When the disease is at the apex, paralysis of some of the muscles of the ball is likely to ensue from involvement of the nerves at their entrance into the orbit. Periostitis usually, though not invariably, ends in suppuration. Sometimes there are more or less permanent localized thickening of the periosteum and consolidation of the neighboring tissue, which closely simulate a tumor. I have met with several such cases. In one there was a distinctly localized hard swelling in the upper inner wall of the orbit, extending as far back as the finger could reach. An exploratory incision was made, and when the finger was introduced into the wound it was found that the swelling was much less clearly defined than it had appeared to be—in fact, that it was merely a localized engorgement of the periosteum and neighboring orbital tissue. The part was freely scarified and the wound was kept open with a tent. The case soon ended in complete recovery without suppuration. In another case there was such a decided resemblance to a tumor in the region of the lachrymal gland that extirpation had been advised by two experienced surgeons. As the patient was known to have been under treatment some months previously with an aggravated attack of syphilitic pharyngitis, periostitis was diagnosticated, and a rapid cure followed the administration of heroic doses of iodide of potassium.

Prognosis.—A large proportion of cases end favorably. The bone may become involved in the disease. In a few cases death has resulted from direct extension of inflammation from the periosteum to the meninges of the brain, or from the escape of pus into the intracranial cavity. The danger is, of course, much greater when the deeper parts of the orbit are affected. In the chronic form the progress of the disease is very slow, sometimes extending over months or even years.

The *cause* may be traumatic or rheumatic, or the disease may be due to an extension of inflammation from one of the neighboring cavities, but it is most frequently syphilitic. The local *treatment* is the same as in cellulitis, and when suppuration is suspected or when excessive swelling endangers the eye or brain, early and free incision should not be neglected. Iodides and tonics are generally needed.

CARIES AND NECROSIS of the orbital walls are usually the result of periostitis when not due to disease of the accessory sinuses. The seat of the disease is, fortunately, most frequently near the margin of the orbit, where the danger of injury to the eye or of extension to the brain is much less than when the deeper parts of the orbital cavity are involved. The adherent cicatrix of the skin, however, which invariably forms, is likely to cause serious deformity of the lids by its excessive contraction. This cannot be prevented, but must be remedied by operation, as best it may, after the affection of the bone has run its course. Abscesses should be promptly evacuated and a free opening maintained. When they discharge spontaneously the resulting sinuses will frequently need to be enlarged. The cavity should be frequently syringed with antiseptic solutions. The danger of reckless probing should be borne in mind, and no forcible attempts to remove sequestra should be made. Acute cases, which are often mistaken for erysipelas of the lids and face, may need local treatment. Iodide of potassium is always in order, and should be given in large doses if syphilis is suspected. Many patients require a long course of treatment by quinine and iron and cod-liver oil, and careful attention to diet and hygiene.

HEMORRHAGE IN THE ORBIT is extremely rare from other than traumatic causes. It has occasionally occurred in scorbutic subjects, in sudden suppression of the menses, and from violent coughing or muscular straining. Permanent hæmatomata have been formed by repeated hemorrhages.

When hemorrhage occurs in the orbit after serious injuries of the head, it is an almost certain symptom of fracture of the walls of the cavity; though intracranial hemorrhage may find its way into the orbit without fracture. In a few cases of injuries bleeding has resulted from rupture of vessels within the orbit. The symptoms are exophthalmus and ecchymosis of the lids and conjunctiva. The ophthalmoscopic appearances are those resulting from sudden pressure.

Treatment.—Iced-water or pounded ice should be applied while there is probability of further hemorrhage, and afterward absorption may be hastened by a compressive bandage.

EMPHYSEMA of the orbit is still more rare than hemorrhage. The symptoms are exophthalmus and the characteristic crepitation on pressure upon the puffy lids. The *causes* are rupture of the lachrymal sac, or communication between the orbit and the frontal sinuses, ethmoidal cells, or nasal cavity. This communication with neighboring air spaces is generally traumatic, but may be the result of ulceration. Rampoldi reports

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a case in which the emphysema developed, without injury, from chronic coryza. Exophthalmus, with diplopia, appeared whenever the patient sneezed or coughed, until he learned to prevent it by supporting the eye with his hand. The story is told of a convict who produced exophthalmus by introducing a pin at the root of a molar tooth and forcing in air from the mouth; and malingerers are said to have produced the same result by making a puncture beneath the eyeball and blowing in air through a tube. French jockeys have been accused of resorting to the latter expedient to give a youthful appearance to old horses with sunken eyeballs. No *treatment* is likely to be of much use. The patient should be cautioned against blowing his nose and encouraged to wait for the rent to close.

EXOPHTHALMIC GOITRE, often called Graves' disease or Basedow's disease, is a complicated affection in which, in its typical form, protrusion of the eyeball is associated with enlargement of the thyroid gland, functional disturbance of the heart, and marked nervous and nutritive derangement. Though cases presenting this association of symptoms had previously been reported by Parry and others, the first systematic description of the disease now known as exophthalmic goitre was given by Graves in 1835, and his name is associated with it by English, American, and some French authors; while the Germans claim that Basedow was the first to describe it accurately (Casper's *Wochenschrift*) in 1840, and they always speak of it as Basedow's disease.

The exophthalmus is not usually so excessive as that met with in cases of abscess or tumor of the orbit, but in a few instances it has been so great as to prevent the lids from closing over the cornea. The effect of the protrusion of the ball is, in a large proportion of cases, heightened and the deformity much increased by an associated affection of the lids, a symptom to which attention was first called by von Graefe. The upper lid does not follow the movements of the ball as its axis is directed upward or downward, but remains fixed and more or less retracted, exposing the sclerotic and giving a staring and startled expression to the patient. This is due to contraction of the small, flat muscular fibres, extending from the lid back into the orbit, which were discovered by Müller and are known by his name. They are of the unstriated kind and are under the control of the sympathetic nerve. Sometimes, also, reflex contraction of the orbicularis from irritation of the eye is diminished, and winking is absent or incomplete. These lid symptoms are not constant, but are sometimes found when the disease is but slightly developed, and may be valuable indications in doubtful cases. The ball can be forced back nearly or quite to its normal position by pressure with the fingers, but it projects immediately when the pressure is removed. Vascular bruit has been detected with the stethoscope by Snellen. Diplopia from displacement of the visual axes may occur, even as an early symptom, and, in some advanced cases, continued stretching produces paresis of the external muscles of the ball. There has been much discussion about the condition of the pupil: some cases have been reported in which it was dilated, and a few in which it was contracted, but, without doubt, it is usually unaltered. Vision is not generally impaired. The ophthalmoscope has occasionally shown retinal hemorrhages, and Becker (*Klin. Monatsblatt für Augenheilk.*, 1880) has observed pulsation of the retinal arteries in some cases, but, as a rule, there is little or no change in the fundus beyond a dilatation of the retinal veins, and even this is not constant. Both eyes are almost invariably affected. Cases have been reported in which one only was involved, but this is so rare that Eulenberg thinks that some suspicion must remain in respect to the diagnosis. Slight keratitis, with conjunctivitis, is common in severe cases, but blindness from ulceration of the cornea is a rare occurrence. Some authorities attribute this ulceration to simple exposure of the cornea from excessive exophthalmus, while others believe it to be an instance of so-called neuroparalytic keratitis, due to a disturbance of nutrition resulting from the obscure neurosis that lies at the bottom of all the manifold symptoms of this disease. The latter is the view taken by von Graefe and others, who consider the corneal affection a result of paralysis of the "trophic" fibres of the ophthalmic branch of the fifth nerve; the corneal sensibility being lost or retained according as all the fibres of the nerve, or the trophic only, are involved. Some authors, among them Charcot, are disposed to think that the corneal inflammation is produced by irritation of the nerve (see "Neuroparalytic Keratitis," Harlan, *Am. Jour. of the Med. Sci.*, April, 1874).

In nine cases out of ten the subjects of the disease are females, usually adults under thirty years of age, but a few instances in children under ten have been recorded. Male patients are generally older and their attacks are likely to be more severe. Most cases of corneal ulceration have occurred in males.

The exophthalmus usually disappears entirely after death, and no constant lesion is discovered by post-mortem examination of the orbit. Fatty degeneration of the muscles, from disuse and stretching, has been noted; and hypertrophy of the orbital fat has been found in some cases, but it may be considered an accidental result of the vascular engorgement which seems to be the cause of the protrusion of the eyeball.

The *pathology, symptomatology, and treatment* of exophthalmic goitre will be discussed in a separate article in THE APPENDIX.

PULSATING EXOPHTHALMUS, a comprehensive term based on convenience rather than on scientific accuracy, is now quite generally used to include a large class of cases which are dependent upon different pathological conditions, and which in the present state of our knowledge it is always difficult and generally impossible to distinguish positively during life.

Symptoms.—There is protrusion of the eyeball, and pulsation is evident to the touch and sight. Above the eye, and beneath the upper and inner margin of the orbit, is a rather firm, elastic tumor, also pulsating. The patient complains of a puffing or whirring noise in the head, and an aneurismal bruit is heard, on auscultation, over the eye and temple, and sometimes over the whole side of the head. In some cases this sound has been audible at a distance of several feet from the patient. There are usually distention and pulsation of the supra-orbital vein, and sometimes of the infra-orbital also. When the carotid is compressed in the neck the pulse and bruit cease, the tumor becomes soft, and the eye can be pushed back into the orbit. The hollow between the ball and the orbital arch is obliterated. The conjunctiva is congested, and in many cases a tumor is formed by intense chemosis of its lower fold, which projects beyond the lid. There may be no decided ophthalmoscopic changes, but the retinal vessels are usually congested, and the disc is sometimes found swollen as a result of pressure upon the optic nerve in the orbit. Pain may be slight or severe.

Vision is not generally much affected in recent cases, but the eye has often been destroyed by long-continued and excessive pressure. The symptoms usually appear suddenly, after direct injury to the orbit or a severe blow upon the head in traumatic cases; or during violent effort, as in childbirth, in cases of spontaneous origin. They have not been noticed, however, in a number of traumatic cases until some weeks or months after the injury.

In several spontaneous cases the patients have been roused from sleep by a loud sound like the report of a pistol.

Progress and Termination.—The deformity and inconvenience are so great, and the danger to the eye and to life is so decided, that few cases have been allowed to pursue a natural course, uninterrupted by more or less active treatment. As a rule, the character of the affection is chronic, and some cases have undergone little or no change in the course of years. In others the eye has been destroyed by sloughing of the cornea and general ophthalmia. The causes of death include erysipelas, complications of brain and heart, and hemorrhage. Of

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the last class, in the cases of Hussey and Critchett ("Ophthalmic Hospital Reports," vol. ii., p. 127; *Med. Times and Gaz.*, December, 1854), the patients died of hemorrhage directly from the orbit, and in one of Nélaton's cases (*Lancet*, 1873), profuse epistaxis, resulting from fracture of the body of the sphenoid bone and rupture of the carotid, was the cause of death. In 1876 (Trans. Internat. Med. Cong.) I reported a case of spontaneous

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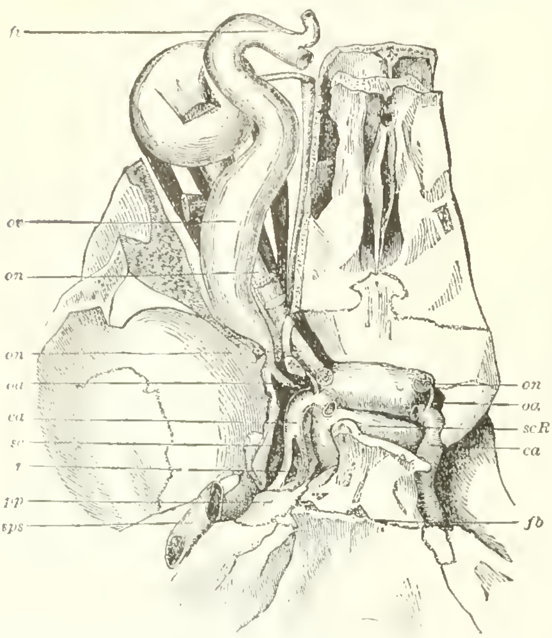

FIG. 3707.—*sc*, The dilated cavernous sinus, opened from above. Within this, the internal carotid (*ca*), which is cut open above to show the perforation in the under and outer side of its wall (*r*); *fb*, the fracture in the sphenoid bone; *pp*, detached spicula from the point of the petrous bone; *scR*, sinus circularis Ridlevi; *sps*, a part of the dilated superior petrosal sinus; *ov*, dilated ophthalmic vein; *fr*, vena frontalis; *oa*, ophthalmic artery; *on*, optic nerve. (After Delens.)

cure, and gave abstracts of six other cases recorded in literature up to that time, and I find three others which have been reported since:

1. Bitsch (*Klin. Monatsbl. f. Augenhk.*, xvii., 1879): Exophthalmus, murmur, pulsation. Probable spontaneous rupture of carotid in cavernous sinus. Cure by extra- and intra-ocular inflammation.

2. Gauran (*Gazette des Hôpitaux*, October, 1883): Aneurism of both orbits, caused by a fall upon the head, cured spontaneously.

3. Glascott (*Brit. Med. Jour.*, November 25th, 1882): "Arterio-venous aneurism of orbit," lasting two years. Spontaneous cure in the course of phlegmonous inflammation of the face and head.

This makes a total of ten cases, to which might be added several others in which the effect of remedial measures was doubtful.

Pathology.—The typical symptoms of "pulsating exophthalmus" are protrusion of the eyeball, pulsation, and aneurismal bruit, and all cases presenting these symptoms were formerly classed as "orbital aneurism." Following the view maintained by Travers, in his report of the first case in 1809 (Med.-Chirurg. Trans., vol. ii.), for thirty years writers generally held that these cases of so called aneurism of the orbit were all of the anastomotic variety. Then Busk's paper (*ibid.*, vol. xxii.) threw a doubt on this, and most authors thought that they were of the ordinary spontaneous or traumatic kinds, affecting the ophthalmic artery, until Nunneley, in 1864, maintained that in the great majority of such cases of protrusion of the eyeball there is no disease whatever in the orbit, but that the symptoms depend on obstruction to the return of blood through the ophthalmic vein. Though there is no positive proof that such a thing as an aneurism of the orbit has ever existed, it is, of course, not an impossible condition.

A review of the now very extensive literature of the subject makes it seem probable that pulsating exophthalmus may be produced by true arterio-venous or anastomotic aneurism of the orbit; by aneurism of the carotid artery, or of the ophthalmic at its origin; by aneurismal varix between the carotid and the cavernous sinus; by thrombosis of the ophthalmic vein or cavernous sinus; by dilatation of the sinus; or by obstruction of the return of venous blood by growths at the bottom of the orbit or behind it. The protrusion of the ball is the result of venous engorgement; while the pulsation and bruit are communicated from the carotid, or are produced by the rush of blood into dilated vessels confined in a bony cavity and with obstructed outlets, or are symptoms of an aneurismal varix of the orbit due to a communication between the carotid artery and the cavernous sinus. From a study of the comparatively few post-mortem records, and the histories of a large number of cases in which the patients have survived, I am convinced that marked pulsation and bruit have most frequently been produced by aneurismal varix of the orbital veins. In three traumatic cases direct communication between the carotid artery and the cavernous sinus was found after death; and in three spontaneous cases post-mortem examination showed that there had been rupture of diseased carotid arteries in the cavernous sinus. In a number of cases the diagnosis of arterio-venous communication in the cavernous sinus has been made, with more or less confidence, during life.

In a traumatic case, reported by Knapp, this diagnosis was subsequently confirmed as positively as it could have been by a post-mortem examination. Ligature of the carotid gave partial relief, but, nearly two years afterward, there was a recurrence of the orbital disease, with great increase of the pulsating tumor, enormous protrusion of the eye, and sloughing of the cornea. After extirpation of the eyeball, the orbit was found to be filled with an irregular pulsating mass, which was removed entire, and was found to consist chiefly of an aneurismal varix (*Arch. Ophthal.*, vol. xii.). The accompanying illustration (Fig. 3707) shows the condition found, post mortem in one of Nélaton's cases (Sattler, Graefe and Saemisch "Handbuch," vol. vi., p. 848). There was a fracture of the sphenoid bone and of the petrous portion of the temporal, and a small hole in the carotid communicating with the cavernous sinus. The sinus and the ophthalmic vein were dilated and tortuous.

It must be confessed that serious objections can be urged against the use of the terms "pulsating exophthalmus" and "vascular protrusion," and perhaps it may be well to discard them when accurate and definite diagnosis is possible. It is quite true that, as Mr. Curling said in opposing the introduction of these terms, "to class affections of very different character under one common head, taken from a prominent symptom, is not calculated to advance surgical pathology and practice"; but it is equally true that such advance is not promoted by feigning a positive knowledge when we have it not, and giving a definite name to indefinite conditions. Confession of ignorance is an essential preliminary to the acquisition of accurate information, and the lesions producing the prominent symptoms of protrusion of the ball and pulsation may be conveniently and profitably classified with reference to these symptoms, until the accumulation and study of post-mortem records throw more light upon the subject.

In 1875 (Trans. Am. Ophthal. Soc.) I published abstracts of fifteen cases, including the imperfectly reported one of Guthrie, in which post mortem examinations had been made. As in two of these cases (Lenoir's and Hamilton's) the symptoms had been produced by vascular malignant growths of the orbit, this number should be reduced to thirteen. In the papers since published, of

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Rivington (Med.-Chirurg. Trans., vol. lviii., p. 282) and Sattler (Graefe-Saemisch. vol. vi.), are quoted the following two cases that escaped my search:

1. Hirschfeld (*Gazette des Hôpitaux*, 1859, p. 51; *Lancet*, 1873): Traumatic; post mortem, a blood-clot found in the cavernous sinus, and this clot covered a small circular hole in the carotid, which looked as if it had been punched out and was occupied by a string of decolorized clot about two inches long passing into the mass of coagulum.

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2. Oettinger (Sattler, *ibid.*): Spontaneous; post mortem, no change in the arteries, but traces of inflammatory processes in the retrobulbar tissues, and obliteration of the ophthalmic vein.

I can find only the three following reports of post-mortem examinations recorded since 1875:

1. Blissig, 1876 (Sattler, *ibid.*): Traumatic; post mortem, "decided dilatation of the internal carotid in the cavernous sinus." As the common carotid was tied eight weeks after the injury, and the patient lived five weeks after the operation, Sattler seems to think that the cause of the dilatation may have been a wound in the artery that had closed.

2. Schlaefke, 1879 (*Arch. für Ophthal.*): Traumatic; post mortem, dilatation of the cavernous sinus and aneurismal enlargement of the cavernous portion of the carotid artery; all the orbital veins enormously distended and the frontal and supra-orbital dilated.

3. Coggin, 1883 (*Arch. of Oph.*): Spontaneous; post mortem, marked aneurismal dilatation of the cavernous portion of the carotid artery, ophthalmic vein not much enlarged. In this case the pulsation and bruit seem to have been communicated from the carotid aneurism.

This makes a total of eighteen post-mortem records, an analysis of which gives the following result:

True aneurism of *both* ophthalmic arteries in the orbits (doubtful), 1; post-orbital aneurism of ophthalmic artery, 1; aneurism of carotid in cavernous sinus, 1; dilatation of carotid in cavernous sinus, 4; wound of carotid in cavernous sinus, 3; thrombosis of cavernous sinus and ophthalmic vein, 5; dilatation of cavernous sinus and ophthalmic vein, 2; pressure on cavernous sinus and ophthalmic vein by new growth, 1.

The case considered doubtful is that recorded by Guthrie ("Operative Surgery of the Eye," p. 158, 1823). The following is his report: "I have seen one case of true aneurism of the orbit which terminated fatally. The symptoms were similar to those above mentioned (cases of Travers and Dalrymple), but no tumor could be perceived; the hissing noise in the head could be distinctly heard. On the death of the patient an aneurism of the ophthalmic artery was discovered on each side, about the size of a large nut. The vena ophthalmica cerebralis was greatly enlarged and obstructed where it passes through the foramen lacerum, in consequence of a great increase in size which the four recti muscles had attained, accompanied by an almost cartilaginous hardness, which had been as much concerned in the protrusion of the eye as the enlargement of the vessels." The description is so meagre and loose, and the post-mortem appearances reported are so very peculiar, that this case is not generally regarded as affording positive proof of the existence of true orbital aneurism.

An aneurism of the ophthalmic, the size of a hazelnut, just at the entrance of the artery into the orbit, was accidentally discovered in a cadaver by Carron du Villards (Sattler, *ibid.*, p. 846). There was no history of the case, and it is not even known that it was one of pulsating exophthalmus.

Finally, in one of Nunneley's spontaneous cases (Med.-Chir. Trans., vol. xlviii., p. 28) a circumscribed aneurism of the ophthalmic artery, as large as a hazelnut at its origin from the carotid, was discovered. The post-mortem was made nearly five years after a successful ligation of the carotid. The arteries of the orbit are described as unusually small. These three cases comprise all the post-mortem evidence of any connection of the ophthalmic artery with the symptoms of pulsating exophthalmus.

While the above was passing through the press, I met at last with a report of what seems to have been a veritable case of "orbital aneurism," carefully examined and treated during life and verified by autopsy—the only one, so far as I know, on record. The report was read at the last meeting of the British Medical Association by Dr. Alexander Dempsey, of Belfast, and may be found in the *British Medical Journal* of September 18th, 1886. The symptoms, which first appeared a few hours after childbirth during violent vomiting, differed little from those observed in the reported cases of carotid aneurism which have occurred under somewhat similar conditions. The common carotid was tied, and death resulted from secondary hemorrhage from the wound in the neck and from bleeding from the aneurism through the cornea. There was an aneurism of the internal carotid artery, at the point of origin of the ophthalmic, which had no communication with the cavernous sinus. Its diameter at its widest part was from one-half to three-fourths of an inch. The orbital aneurism is described as follows: "The ophthalmic artery, from its origin, was also very considerably dilated, I should say to fully four times the size of the opposite one, and on tracing it into the orbit we found an immense sacculated aneurism developed on its superior aspect. The sac would contain easily a mandarin orange. In its centre there was a post-mortem clot, but around its circumference there was a firm, laminated fibrous ante-mortem clot which was a complete cast of the sac, except at its anterior part, where it was open and communicated with the eyeball by a large opening at the upper, back, and outer part of the globe. The contents of the globe had escaped, when hemorrhage had taken place, through the cornea. The superior petrosal sinus of the opposite side was distended, but the other sinuses of the brain appeared normal. The arteries of the circle of Willis were dilated, especially the anterior communicating. The veins of the orbit were all very much enlarged, especially those at the inner angle of the eye."

While it would seem that any obstruction to the return of blood by the ophthalmic vein may produce the symptoms of pulsating exophthalmus, even complete obstruction by thrombosis of the sinus does not, by any means, always do so. In a case reported by Lloyd (*Oph. Rev.*, vol. iii., No. 37) there was aneurism of both the basilar artery and the internal carotid, and the cavernous sinuses of both sides were blocked with firm fibrinous red thrombi; yet there had been but slight exophthalmus, which lasted only a few days, and never any pulse or bruit. Lloyd attributes the recession of the globe to the establishment of collateral circulation; and Sattler says that when an intracranial aneurism is formed gradually it may completely compress the ophthalmic vein and cavernous sinus without producing either pulse or exophthalmus.

Though *aneurism by anastomosis* was formerly the favorite diagnosis in cases of so-called "orbital aneurism," it has never been verified by post-mortem observation, and more recently its occurrence has been doubted. The following congenital case (Harlan, Trans. Am. Ophthal. Soc., 1875, and Internat. Med. Congress, 1876) seems scarcely to admit of any other probable view than that of aneurism by anastomosis, or cirsoid aneurism. The patient was a healthy man, twenty-five years of age. The left eye had always been prominent and the left side of the head larger than the right. From his earliest recollection there had been a rushing sound in his eye and head. The left eye was enormously protruded and forced downward and outward. No useful vision. Whole left side of face hypertrophied. Above the eyeball, and lying more to the nasal side, there was a distinct tumor of almost cartilaginous density. Pulsation was strong enough to communicate an evident motion to the head of the auscultator; and a loud aneurismal bruit was not only an annoyance to the patient, but could be heard by others some distance from his head. There was a doughy

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swelling of the soft parts, extending about an inch above the orbit, in which strong pulsation could be felt. Pressure upon the left carotid stopped all pulsation, and the tumor became soft and could be pressed back into the

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FIG. 3508. Congenital Aneurism by Anastomosis of Orbit.

orbit. The supra orbital and frontal arteries were much distended and pulsated strongly, and this aneurismal condition extended down the angular branch of the facial on the right side. A vascular tumor, formed by engorgement and hypertrophy of the inferior conjunctival fold, almost concealed the cornea, and had several times bled quite freely; this was removed by constriction with silk ligatures. Some months later, the patient presented himself with violent acute inflammation of the contents of the orbit. The tumor was increased to twice its former size, the exophthalmus was enormous, the eye could no longer be covered by the lids, and the cornea sloughed. In a few weeks the tumor had completely consolidated and was rapidly diminishing in size. In this case the congenital origin, the hypertrophy of the whole side of the face, the involvement of the external vessels, and the evident extension of the disease beyond the orbit to the subcutaneous tissue of the brow point to aneurism by anastomosis, or cirsoid aneurism. The only other possible supposition is a rupture of an aneurism of the carotid in the cavernous sinus and consequent aneurismal varix of the orbit, but the history of the case makes this more than improbable.

Vascular malignant growths of the orbit may produce the symptoms of pulsating exophthalmus, and in at least two such cases the carotid artery has been tied for the cure of orbital aneurism. The bruit in these cases may be very decided, but is not likely to be so loud; the tumor shows more tendency to extend toward the temporal side of the orbit, and is less reducible after compression of the common carotid than in cases of pulsating exophthalmus dependent upon the causes that we have been considering. Of course, multiple tumors and other indications of malignant disease should be carefully looked for.

Treatment.—The long continuance of some cases without material change, and the recovery of a few without interference, or with only hygienic care and medical treatment, should discourage resort to serious surgical procedure when there is no immediate danger or decided suffering or deformity, though these conditions may, perhaps, be considered exceptional. Milder remedies should, at least, be given a trial first.

In a very decided traumatic case reported by Dr. Holmes, of Chicago (*Am. Jour. Med. Sci.*, July, 1864), complete cure followed the exhibition of veratrum viride and extract of ergot for two months; and Dr. Freeman, of Canada (*ibid.*, 1866), reports the cure of a spontaneous case, in a few weeks, by application of cold, direct pressure on the swelling, and the use of digitalis. In a few cases, digital compression of the carotid artery has effected a cure.

Compression of the common carotid has been frequently tried. In my own traumatic case (Trans. Am. Oph. Soc., 1875) the patient himself kept up intermittent compression for several hours daily. At the end of six months there was decided improvement, in two years all prominence of the eye had disappeared, and some months later he was entirely cured. Of course, this case is open to the suspicion of spontaneous cure, but the patient always experienced great immediate relief from the compression, and was confident that it was the cause of the final cure. It is almost impossible to apply instrumental compression effectually, and it has never been successful. According to Sattler, of twenty-nine cases treated by compression, continued or intermittent, permanent cure can be claimed in only four, though more or less improvement followed in five others.

Galvano-puncture has been tried in two cases unsuccessfully (Petréquin, *Gazette Médicale*, 1846, and Bourguet, *ibid.*, 1855). In Petréquin's case the patient died.

Acupressure, with hot needles, has failed in one case.

Injection of ergotin has been tried once without success.

Injection of coagulating fluids has effected a cure in three cases (Bourguet, *loc. cit.*; De Sormeaux, quoted by Rivington, Med.-Chir. Trans., vol. lviii.; and Brainerd, *Lancet*, 1853). Bourguet and De Sormeaux used tincture of the chloride of iron, and Brainerd used the lactate.

Ligature of the common carotid has proved by far the most efficient means of treatment, and a number of brilliant successes have been reported. It must be remembered, however, that it is not without its chances of failure and its dangers of a fatal issue. Sixty three ligations of the common carotid, performed on 61 patients, in the treatment of pulsating exophthalmus, have been compiled by Sattler. In 17 cases (26.98 per cent.) the operation had little or no permanent effect; in 8 (12.70 per cent.) it resulted fatally; and in 38 (60.30 per cent.) the result was favorable.

Extirpation of the orbital tumor is a bold procedure and has a brief but favorable record. In his report of a successful case of this operation Knapp (*Arch. of Oph.*, vol. xii., No. 2) makes the following reference to three others: "Among the different methods recommended and practised, I chose the one, extirpation, which I find mentioned in Sattler's compilation of one hundred and six cases only three times, namely: (1) Morton's case (Sattler, No. 70), excision of the whole contents of the orbit, excessive hemorrhage arrested by glowing iron and compression, recovery; (2) Frothingham's case (Sattler, No. 80), ligation of common carotid, retardation of increase for three years, then rapid growth, extirpation with very considerable hemorrhage; (3) Hanson's case (Sattler, No. 106), ligation of common carotid, return of symptoms as early as the second day, three weeks later extirpation of the tumor with preservation of the globe, profuse hemorrhage arrested by perchloride of iron."

VASCULAR PROTRUSION, WITHOUT PULSATION.—As has already been stated, in thrombus of the cavernous sinus, though more or less exophthalmus is almost invariable, pulsation and bruit may be absent; and this is, perhaps, the rule. *Cavernous tumors* of the orbit have been met with in a few cases. A typical one is described by von Graefe (*Arch. für Ophthal.*, t. vii.), in which the

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whole mass was removed with the eyeball. Wecker ("Maladies des Yeux") extirpated a somewhat similar tumor without removing the ball. In each of these cases the tumor consisted of spongy tissue encysted in a dense capsule. There has never been pulsation in any well-established case of cavernous angioma of the orbit. The only remedy is extirpation. The exophthalmus in goitre may be considered of the nature of vascular protrusion without pulsation.

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Simple Angioma (Telangiectasis) sometimes extends into the orbit from the skin of the lids, forming a soft, slightly compressible tumor. The best treatment is extirpation or electrolysis. Simeon Snell has lately reported several successful cases of the latter, and considers it especially applicable when the disease extends deeply into the orbit (*Lancet*, July, 1886). Frequent repetition of the operation is usually necessary.

Encephalocele.—Though encephalocele, or meningocele, of the orbit is extremely rare, it is important to bear in mind the possibility of its occurrence. This is well illustrated by a case described by Guersant ("Maladies des Enfants," p. 246). The patient was examined by a number of the fellows of the Surgical Society of Paris, who all agreed in considering the case one of vascular tumor, and in advising treatment by setons. The patient died with cerebral symptoms, and a post-mortem examination showed that the tumor consisted of brain substance, covered by membranes, which had passed through the fronto-ethmoidal suture. It may be extremely difficult to distinguish such a tumor from a vascular swelling, particularly as, if of considerable size, it would be likely to pulsate; and, if situated behind the ball, it would cause exophthalmus. Its congenital character should excite strong suspicion; it would be increased in size by forced expiration and much diminished by pressure. If the contained fluid, obtained by acupuncture, is found to be not coagulable, it is probably cerebro-spinal. Other congenital defects would be likely to occur in connection with it. In a case in which Oettingen (*Klin. Monatsblatt*, February, 1874) diagnosticated a spheno-orbital meningocele associated with some angiomatous tumor, there was also a small occipital meningocele, which bulged out when the orbital tumor was pressed upon; and tapping the latter with the finger communicated an impulse to the former. Even here, however, the author could not feel quite sure of his diagnosis, and suggested the possibility of a vascular tumor communicating with the intracranial cavity by means of absorption of the orbital wall.

Tumors of the Orbit.—The remaining tumors of the orbit may be classed as cystic and solid. The most prominent *symptom*, and one that, in greater or less degree, is necessarily constant when the tumor is situated behind the ball, is exophthalmus, which will vary in extent and direction with the size, position, and character of the tumor. If the latter is situated outside the muscular pyramid, it will cause the ball to protrude in a direction opposite to its own position; if within the pyramid, it will press the eye more directly forward, and will participate more in its movements. Diplopia is a frequent and sometimes an early symptom. The motion of the ball is not necessarily affected by a small tumor, but is limited by a large one; and, if this is outside of the muscles, the limitation will be chiefly in the direction of its site. Complete immobility of the eye suggests malignant growths, as their well-known tendency is to involve and include the neighboring structures. Paralysis of the orbital muscles often causes squint, ptosis, etc., and compression or stretching of the optic nerve may produce blindness in an otherwise sound eye; or, the nerve may be involved in a morbid growth. Injury to the ciliary nerves may be shown by dilatation of the pupil, or may result in sloughing of the cornea from neuroparalytic keratitis. Finally, the eye may be destroyed by ophthalmitis resulting from interference with its nervous and vascular supply. Pain is a very variable symptom, being sometimes severe and sometimes absent. It is in some cases referred to the bottom of the orbit, in some it appears as frontal or ciliary neuralgia, and in others as general headache. The ophthalmoscopic appearances are sometimes negative, but often show some signs of pressure upon the optic nerve, such as venous congestion and arterial contraction, retinal hemorrhage, "choked disc," or optic atrophy.

Diagnosis between tumors of the orbit and periostitis or phlegmon, vascular protrusion and disease of the neighboring cavities often presents serious difficulties. The mode of onset of the disease, whether sudden or slow, and whether accompanied or not by acute inflammatory symptoms, is an important consideration, but will not always be a safe guide in case of chronic periostitis or chronic abscess (p. 399). Vascular protrusion may generally be distinguished by the fact that the ball can be pressed back, by the effect of compression of the common carotid, by the dilatation of vessels beyond the margin of the orbit, and by the existence, in some cases, of pulsation and bruit. It must be remembered that pulsation and bruit have led to mistakes in cases of highly vascular malignant growths. Careful inquiry should be made as to predisposition to syphilis or malignant disease. Valuable information is obtained by careful exploration with the finger pressed well back behind the ball. Osseous growths and solid tumors attached to the walls of the orbit, if not too deep in the cavity, can usually be distinguished in this way with a considerable degree of certainty, though periostitis will sometimes simulate the latter closely. An effort should be made to decide, by palpation, whether the tumor is hard, elastic, or fluctuating, whether fixed or movable, and whether situated outside of or within the muscular pyramid. Enlargements of the lachrymal gland, on account of their position, can generally be recognized with comparative ease. It may sometimes be necessary to determine the character of the contents of a supposed cyst by puncture. The nasal cavities and the vault of the pharynx should be explored with the mirror.

Cystic Tumors.—The most common true retention cysts found in this locality are the *sebaceous*. They probably arise from the skin, though their connection with this point of origin may not always be traceable.

Fig. 3709.—Congenital Cyst of the Lower Eyelid with Microphthalmos.

Cysts of the lachrymal gland ("dacryops") are rare. They are due to retention of the tears from obstruction of the ducts. The swelling enlarges with increased secretion of tears and its character is not usually difficult to recognize.

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DROPSY OF TENON'S CAPSULE has been described as a form of exudation cyst, but its pathology is somewhat doubtful, and its occurrence is, to say the least, extremely rare. *Serous cysts* have been attributed to dis-

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FIG. 3710.—Orbital Sarcoma.

ease of the bursa in the trochlea of the superior oblique muscle, or of those sometimes found on the levator and superior rectus; and Wecker considers it probable that most serous orbital cysts arise in this way. This view is probable, but lacks proof in pathological anatomy. Congenital *dermoid cysts* are found more frequently in the orbit than elsewhere. It is generally stated that their usual seat is near the external angular process of the frontal bone, but of 51 cases collected by Berlin 27 were on the nasal side, 12 on the temporal, 8 below, and 4 above. Their walls are of a cutaneous structure, and contain sebaceous matter and sometimes hair. Teeth have also been found in them. Wecker (*loc. cit.*) says that serous cysts may form voluminous tumors, which enlarge the orbit by excessive pressure, and extend through foramina into the cranial cavity. He, however, gives but one instance, quoted from Delpech. The cyst was prolonged into the cranial cavity through the optic foramen, which was sufficiently enlarged to admit the index finger. Inflammation of the sac, induced by incision and exploration, extended to the brain and resulted in death. It was found that a diverticulum of the cyst, three inches long, had encroached upon the under surface of the cerebral lobe, and had contracted firm adhesions with the meninges. This case, which is also quoted by Mackenzie as one of hygroma, Berlin thinks must have been a meningocele. If serous tumors of very large size have ever existed in the orbit, it is not likely that they originated in diseased bursæ, which are never known to produce such tumors elsewhere, but it is more probable that they were *cysts of new formation*, similar to the so-called hydrocele of the neck, whose pathology is not well known. A rare form of cyst is usually described as "congenital orbital cyst with anophthalmos or microphthalmos." In a few cases there has been entire absence of the eye, but generally there has been a rudimentary ball. In the latter case the tumor appears beneath the lower lid and is described as "lower lid cyst." The lower lid is bulged forward by an incompressible but tensely fluctuating cyst, the bluish color of which is evident through the thin and distended skin. Fig. 3709 shows a typical example. Behind the cyst was a rudimentary ball, hardly larger than a pea (Harlan, Trans. Am. Oph. Society, 1893 and 1902). The pathology of these cysts is obscure, but it is generally believed that they are formed of embryonic elements intended for the development of an eye. *Hæmatoma* of the orbit has already been referred to in discussing hemorrhage. *Echinococci* and *cysticerci* have been found in the orbit. Though some of the text-books refer to them as if not very infrequent, they are, in fact, extremely rare. Berlin says that, with an experience of forty thousand eye patients, he has not met with a single case of either, but that thirty-nine more or less reliably reported cases of the former are to be found in literature, while he has been able to find reports of only three rather doubtful cases of cysticerci in the orbit, though they are comparatively frequent in the eyeball and its appendages. Furnaget has collected eight cases. (*Archives of Ophthalmology*, xvi., p. 6.)

SOLID TUMORS.—As almost every form of tissue is represented in the orbital cavity, almost all kinds of tumors are possible there. In addition to the vascular and cystic tumors referred to above, the following forms of more solid growths have been described by authors: Lipoma, fibroma, enchondroma, carcinoma, osteoma, neuroma, and sarcoma. A discussion of the histology and pathology of these various diseases is, of course, beyond the scope of the present article. Epithelioma may extend into the orbit from the skin of the lids. Enchondroma and carcinoma are very rare, and fibroma and neuroma not much less so. Lipoma is frequently referred to in a general way, but only a few cases have been recorded. Osteoma is, comparatively speaking, not very uncommon. The larger proportion of solid tumors met with in the orbit belong to some of the numerous forms of sarcoma. Berlin (*loc. cit.*) says: "When we perceive in any part of the orbit a solid tumor with a nodulated surface, which does not fluctuate or pulsate, is not compressible or stone-hard, is not in probable connection with the brain, and does not arise from the lids, the ball, the lachrymal gland, the optic nerve, or the neighboring cavities, we may decide on the diagnosis that we have to do with a sarcoma of the orbit."

Some of the most extensive growths that attack the orbital tissue originate in the eyeball. By far the most common intra-ocular tumors are retinal glioma and choroidal sarcoma, and these, when they have once passed the fibrous envelope of the ball, extend rapidly in the orbit. The former generally ends fatally by direct extension to the brain, or by metastasis to that or some other organ. Orbital sarcomata sometimes grow to an enormous size and make terrible ravages upon neighboring parts. Fig. 3710 is from the photograph of a patient nine years of age at the Wills Eye Hospital. (Harlan, Trans. Am. Oph. Society, 1894.)

Enlargements of the lachrymal gland may be due to acute or chronic inflammation. In the case of the former there are redness and swelling of the upper lid, congestion of the conjunctiva, and considerable pain. It frequently ends in suppuration, which is sometimes followed by fistula. In the chronic form the inflammation is usually indolent, and the swelling may be mistaken for a neoplasm.

Simple hypertrophy of the lachrymal gland is rare. It is said to result from repeated attacks of inflammation, and to occur sometimes spontaneously or even congenitally. Exact observations in regard to it are wanting.

Various forms of degeneration of the gland have been met with, the most frequent of which, according to some authorities, is the adenoid. There are a few well-established cases of sarcoma and carcinoma. I exhibited a sarcomatous lachrymal gland as large as a hen's egg, at the meeting of the American Ophthalmological Society, in 1882, and Dr. Knapp referred to one nearly as large, which he had recently removed. There were no adhesions in either case and the tumors were easily enucleated. The prognosis as to the probability of a return of the disease is favorable.

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The position of such tumors makes their diagnosis comparatively easy. The ball is usually forced downward, forward, and inward; but in the case referred to above its direction was decidedly outward. This exceptional symptom, which is probably unique, may be accounted for by the unusual size of the tumor and its development toward the inner side of the orbit (Fig. 3711). The ball resumed its normal position in a few weeks after the operation.

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Tumors of the optic nerve have been reported in thirty odd cases, and have consisted of glioma, myxoma, sarcoma, endothelioma, and carcinoma. (Knapp, Trans. Internat. Med. Congress, 1876, Berlin, Graefe-Saemisch.) Graefe reported several cases and gave the following symptoms as diagnostic: Progressive protrusion of the eyeball, parallel to the axis of the orbit, or a little outward; preservation of the mobility of the eye; preservation of a layer of connective tissue between the eye and the tumor, and the integrity of the centre of rotation; soft consistence of the tumor; absence of pain; absence of subjective luminous sensations, and rapid abolition of vision. In some cases more recently reported there was more loss of mobility of the ball than von Graefe seems to have met with, and in several there was severe pain in the eye and orbit, and the tumors have not always been of soft consistence. Valuable assistance in diagnosis can be obtained by palpation—pressing the finger deep into the orbit behind the ball.

Osteomata may grow immediately from the diploë of the bone, or originate in inflammatory exudations from the periosteum. In the former case they are likely to extend at the same time into the orbit and into one of the neighboring cavities. They vary in size from a mere nodule to a mass filling the whole orbit, and may be of cancellous structure or of ivory-like density. The latter is much the more common form. They have, in a few cases, occurred in both orbits at the same time. The etiology of orbital osteoma is very obscure. Syphilis, which might naturally be thought a frequent cause, is an extremely rare and even doubtful one. Bony tumors of the orbit are of slow growth, and are injurious only by their mechanical effects, which, however, are sometimes serious enough. A few cases are reported in which a cure resulted from necrosis and spontaneous separation. (Lediard, Trans. Oph. Soc. United Kingdom, iii., p. 23.)

In the *removal of orbital tumors* antiseptic precautions should be carefully carried out. If there is useful vision, or even a sound eye, the eyeball should be preserved whenever possible, unless its retention renders impracticable the thorough removal of tissues involved in malignant disease. It will usually be possible to retain the ball when the growth is outside the intramuscular space, and sometimes even when it is within it. This has been done, with satisfactory results, in the case of tumors of the optic nerve, by Knapp and by Grüning. (*Arch. of Ophthal.*, iv., p. 323, and v., p. 508.) To avoid the deformity of the resulting cicatrix, it is usually better, when practicable, to operate through the conjunctiva, and this will, of course, be necessary in the case of tumors within the muscular space. To gain room, the external canthus may be freely incised, the upper lid may be dissected back, or the external wall of the orbit may be temporarily resected, and replaced after the removal of the tumor, by the method devised by Krönlein. (Knapp in Norris and Oliver's "System of Diseases of the Eye," viii., p. 918.) In removing tumors situated well forward or attached to the orbital walls, or of large size, it may be necessary to make the incision through the skin of the lid. The handle of the knife will often be found of more use than its edge in freeing the growth from its attachments, and much of the operation can most conveniently be performed with a strong pair of blunt-pointed scissors, curved on the flat. Extensive malignant disease sometimes necessitates the removal of all the contents of the orbit, and the application of the chloride of zinc paste to its bared walls. Though such cases are extremely discouraging, in a few that were apparently desperate the operation has succeeded at least in securing some years of comfort to the patient. According to Bull, surgical interference in malignant orbital tumors is almost invariably followed by recurrence, the growth of the secondary tumor is more rapid, and repeated operations shorten the life of the patient. (Trans. Am. Oph. Society, 1896.) It may be necessary to resort to the actual cautery to check hemorrhage, though this can usually be accomplished by hot water and compression. When extension of the disease to neighboring cavities renders its complete removal impracticable, the operation should never be undertaken. Exostoses may be removed with comparative safety when situated on the floor or on the inner wall of the orbit, but the attempt is rarely justifiable when the deeper parts of the roof are involved. Of sixteen cases collected by Berlin, in which exostoses of the orbital roof were operated on, in six the patients died of meningitis. Knapp reports several cases in which osteomata of the roof, situated peripherally, were successfully removed. (Trans. Fifth Internat. Oph. Congress.) It has occasionally been found possible to cut these bony tumors with the pliers or to wrench them from their bases with the forceps, but usually the chisel and mallet will be found more efficient. The use of the dental engine has been suggested and may be applicable to some cases. The attachment of the base to the orbital wall is less firm than the structure of the tumor, and in operating this should be made the point of attack. The difficulties of the operation are greatly increased when the growth originates in the diploë and extends on both sides of the bone. Knapp (*Arch. of Oph.*, ix., p. 464) describes a method of shelling out such tumors within their periosteal envelope, by cutting, with the chisel, the orbital wall encasing them and removing them entire. He thinks the operation may be performed with success even though the exostosis project into the cranial cavity.

Injuries of the Orbit derive their greatest interest and importance from the fact that only a thin plate of bone separates this cavity from the brain. Punctured wounds of the roof of the orbit may very easily penetrate the intracranial cavity. Such injuries were formerly sometimes inflicted by the sword, while in more modern times the umbrella-stick has figured most prominently as the offending instrument. These, of course, are very fatal wounds. Out of fifty-two cases of perforation collected by Berlin (Graefe-Saemisch, vol. vi.) the patients survived in only eleven, and of these five suffered from subsequent effects. Great caution should be used

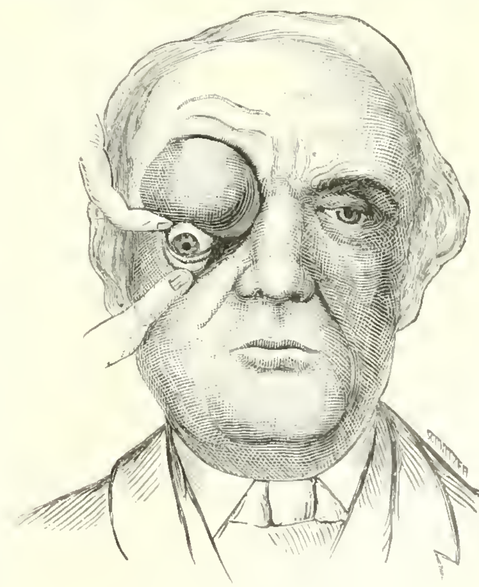

FIG. 3711.—Sarcoma of the Lachrymal Gland.

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in the treatment and prognosis of such cases, as the surgeon is liable to be misled by the innocent appearance of the external wound and the absence of immediate symptoms of an alarming character. Mackenzie relates several cases in which the patients walked considerable distances after receiving the injury and then fell dead.

The result of a *gunshot wound* of the orbit will depend upon the direction that the ball takes. In a large proportion of cases the brain is injured and death ensues; but a ball passing obliquely through the temporal region may destroy one eye only, and cases are reported in which sight was entirely destroyed, without other injury, by balls crashing through both orbits behind the eyes. I met with one such case, during the civil war, in which very little deformity resulted, and the external appearance of the eyes was not affected.

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Fractures of the base of the cranium frequently extend into the walls of the orbit, generally the roof. In the post-mortem examination of eighty-six cases of fracture of the base, von Hölden found fracture of the orbit in seventy-nine. (Berlin, *loc. cit.*) Blindness may result immediately from rupture of the optic nerve, or from hemorrhage in its sheath, or it may be subsequently induced by neuritis. Intracranial hemorrhage and hemorrhage and emphysema of the orbit, as results of fracture of the orbital walls, have already been referred to.

It is important to remember that *foreign bodies*, even of considerable size, may easily escape detection in the orbit. A number of striking instances of this have been recorded. Mr. Carter has reported a case in which a piece of iron hat peg, nearly three inches and a half long, remained concealed in the orbit for several weeks, without the knowledge of the patient. It was removed, and the eye remained uninjured. Hennen found a flattened musket ball which had lodged in the orbit, without injury to the eye. Shot from fowling-pieces and chips of iron driven with force by the hammer or lathe sometimes pass through the ball and lodge in the orbit. Shot may become encysted and cause no irritation, and even larger and rough substances may give little indication of their presence. A man presented himself at the Wills Hospital, in Philadelphia, with a wound near the corneosclerotic junction, but he was very positive that the foreign body that inflicted it had rebounded. The eye was but slightly inflamed, and the patient continued to improve and would have been discharged if a little sympathetic irritation of the other eye had not been noticed. In enucleating the ball great difficulty was experienced in cutting the optic nerve, and a splinter of iron, one inch long, was found lying by its side.

x-Ray examination may be made useful in detecting the presence of a foreign body and even in determining its location.

Cases were formerly reported in which impaired vision was attributed to injury of the supra-orbital or infraorbital nerve by blows upon the edge of the orbit, but it is probable that the ophthalmoscope would have revealed some intra-ocular lesion produced by concussion, or that a fracture involving the apex of the orbit may have injured the optic nerve. Contusion of these nerves is not now recognized as a cause of amblyopia.

Dislocation of the eyeball may be caused by a foreign body thrust into the orbit behind it. It has frequently been produced by the "gouging" thumbs of brutal fighters. The ball lies, upon the malar bone and the orbicularis muscle contracts behind it, retaining it beyond the lids. The optic nerve is, of course, violently stretched, but is not usually permanently injured if the dislocation is soon reduced.

In the *treatment* of injuries of the orbit it is important to bear in mind the dangerous character of its anatomical relations, and the serious mischief that may easily be inflicted by probing. It is better to treat many trivial cases with unnecessary caution than to underestimate the danger of one that may have a serious or even fatal termination. Complete rest, cold applications, and sometimes leeching will be required in the early stages, and if pus forms subsequently it should be allowed prompt and free escape. If incisions are necessary for the removal of foreign bodies, they should be made through the conjunctiva rather than through the lids, to avoid the danger of ectropium or other deformity that might follow the contraction of cicatrices. In reducing dislocation of the eyeball, the upper lid should be stretched and drawn forward, while the ball is gently pressed back. It may be necessary to divide the external commissure. A compress bandage will be required to retain the eye in position for a few days.

Diseases of the Neighboring Sinuses may seriously affect the orbit by pressure upon its walls or by extension into its cavity.

The *frontal sinus* is sometimes greatly distended by the accumulation of retained muco-purulent secretion in chronic inflammation of its lining membrane. The upper and inner wall of the orbit is bulged by pressure, and the eyeball is forced downward and outward. These accumulations are sometimes very extensive, and involve the ethmoid sinus or the frontal sinus of the other side by destruction of the intervening walls. Dr. Bull (Trans. Am. Oph. Soc., 1885) reports a case of chronic abscess involving both frontal sinuses and the ethmoid sinus of one side, the result of an injury received fourteen years before. The disease may also result from direct extension of inflammation from the mucous membrane of the nose. The pus may finally escape into the nose, into the orbit, or externally, but the opening that gives it exit is not likely to be free enough to lead to a cure. The most common locality for spontaneous discharge is at the inner canthus, above the tendo oculi, and a permanent fistula is likely to result. When the bone over the swelling is very much thinned by distention and absorption it yields to pressure by the finger with a kind of crackling sensation, which has been well compared to that produced by pressure upon the lid of a tin box, and which will distinguish the case from one of solid growth. The sinus should be freely opened with a strong knife, or, if necessary, with a drill, near the inner canthus or beneath the superciliary arch, and a silver tube inserted, through which the cavity can be washed out frequently with disinfectant and stimulating solutions. It may be necessary to open the cells through the inner wall of the orbit, remove all carious bone, and establish drainage through the nose.

Similar distention of the *maxillary antrum* by fluid accumulation forces the floor of the orbit upward. It may result from any cause that produces chronic inflammation of the lining membrane of the cavity, but the most frequent cause is a diseased tooth. Pus may escape into the nostril, through the alveolus at the canine fossa, or into the orbit. When it enters the orbit it causes an infiltration and swelling of the lower eyelid, and finally a fistula. When there is a diseased tooth, the best plan of treatment is to extract it and puncture the antrum through its socket; or, if the abscess points in the alveolar process, an opening may be made behind the upper lip. In either case a tube should be inserted and injections used.

A few cases of retention tumor of the *ethmoid cells* have been met with. Dr. Knapp (Trans. Fifth Internat. Oph. Cong.) reports one in which the wall felt so dense that he took it for an exostosis and proceeded to remove it, when the chisel pierced a bony shell, and a quantity of muco-purulent discharge escaped. And a similar experience occurred in my own practice (Trans. Am. Oph. Soc., 1900).

Cysts, polypi, or solid tumors of any of these cavities, or of the nares, may press upon the walls of the orbit or destroy them and extend into its cavity. A discussion of all of these diseases would lead into too wide a field for the limits of this article, and the reader must be referred to works on general surgery and to the elaborate chapter on this subject in Mackenzie's treatise on "Diseases of the Eye." Intracranial growths sometimes involve the roof of the orbit, and in chronic hydrocephalus its cavity is narrowed by pressure, and the eyeball is pushed forward.

George C. Harlan.

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OREXIN.—(Phenyl-di-hydro-quinazoline hydrochlorate.) This is the trade name applied to a complex derivative of quinoline. It forms in bright, colorless, lanceolate crystals, without odor, containing two molecules of water, which effloresce on exposure. It has a bitter, pungent, and almost caustic taste. It is freely soluble in hot water. It is almost free from toxic effects, as two grains per pound weight were required to cause death in a rabbit.

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Orexin was introduced by Professor Penzoldt, of Erlangen (*Therap. Monat.*, February, 1890), as a stomachic, as it was found to exert a tonic influence over the digestive organs, and a stimulant action on the appetite. It possesses neither antipyretic nor antiseptic properties. Penzoldt used it in a great number of cases of anorexia in healthy individuals, as well as in others suffering from various diseases accompanied by loss of appetite. Its use is contraindicated when there are gastralgia, acute catarrh, ulcers, or any condition in which there is hypersensibility of the mucous lining of the stomach, on account of its local irritant action. The class of cases in which it proved most serviceable were those in which the stomach was not diseased, but in which the loss of appetite was due to some general condition, such as anæmia, phthisis, or debility. It was said to be of special value in commencing pulmonary tuberculosis, its employment being followed by a considerable increase in body weight. The dose is from three to seven grains, once or twice a day. Within the last few years the *tannate* of this agent has been brought forward as being superior to the hydrochlorate. It is a yellowish-white, odorless, and almost tasteless powder, soluble in water.

Although favorable reports of its use appear from time to time, it has failed to gain the confidence of the profession and is rarely employed. *Beaumont Small.*

ORGANOTHERAPY.—(Synonyms: Histotherapy—from ἱστός, tissue; cytotherapy—from κύτος, cell).

History.—The oldest medical manuscript in existence, the "Papyrus Ebers," mentions the use of animal extracts in medicine. Among the writers of antiquity Homer, Democritus (450 B.C.), Aretæus, Dioscorides, Galen (600 A.D.), among writers of the Middle Ages, Guido de Chauliac (1300 A.D.), John Hunter, Burton (in his "Anatomy of Melancholy") all speak of the treatment of disease with various animal products. It is interesting to note some of the bizarre preparations that were recommended, *e.g.* (Dr. William Salomon, "New London Dispensatory," 1677), human heart, *cor hominis*, in powder for epilepsy, human skull and human brain, *tinctura cranii*, *essentia cranii hominis*, *spiritus cerebri humani*, for a variety of disorders, chiefly "debility."

Brown-Séquard, in 1869, advanced the hypothesis of the "internal secretion" of the glands and tissues; he held that all the cells of the body manufacture specific soluble products which, entering the blood, exercise "an important if not necessary" influence on other cells. Insufficiency of this function in certain organs, he argued, produces certain definite disorders that can best be remedied by supplying the deficient secretion. The extravagant and sensational claims advanced by over-enthusiastic disciples of this "method" have done much to discredit organotherapy. Of recent years, however, many clinical and experimental data have accumulated to show that certain organs actually do manufacture internal secretions, and that these products profoundly influence metabolism. The postulates of Brown-Séquard were in part, therefore, correct and his method was not altogether irrational.

It is manifestly a precarious and an unscientific procedure to introduce substances of unknown properties into a sick organism without first determining their effect on the healthy body. Before organotherapy could be raised above the level of crude empiricism and could attain the dignity of a rational system of treatment, the power of organ extracts to influence physiological processes had to be studied. This problem was approached in two ways, viz.: on the one hand, different animal preparations were administered to normal animals or human subjects and the effects determined; on the other hand, different organs (chiefly ductless glands) were removed and the perversions of function that followed established. The knowledge, moreover, obtained from operative ablation of organs was in many instances supplemented by clinical observations on human subjects in whom spontaneous degeneration or atrophy of these organs had occurred. In this way a fund of knowledge was acquired that based organotherapy on a rational foundation, and furnished concise indications for the administration of definite organ preparations in definite diseased states. Organotherapy was finally rendered still more exact by the discovery and isolation of "active principles" that possessed all the specific properties of the organs from which they were derived; these, it was shown, could be advantageously administered in the place of the crude extracts, of indefinite and uncertain composition, that were formerly employed.

I. The Ductless Glands.

1. Thyroid Gland.—The *administration of thyroid gland* in large doses accelerates proteid and fat metabolism, causes increased elimination of nitrogen, phosphorus, and chlorine, and leads to an increased absorption of oxygen. Clinically, polyuria, polyphagia, polydypsia, sweating, tachycardia, palpitation, tremor, emaciation, fever, and occasionally glycosuria are observed. This syndrome is called *thyroidism*, and has so many cardinal features in common with exophthalmic goitre (Basedow's, Graves' disease) that this affection is held by many to be due to excessive activity of the thyroid gland, *scil.*, *hyperthyroidism*.

Removal of the thyroid gland is followed in a few days or often after a longer time (as late as nine months) by anæmia and oligæmia (*cachexia thyreopriva*, if the normal gland is removed, *cachexia strumipriva* or *operative myxœdema* if the diseased gland is removed); there is often an initial rise of temperature usually followed by a descent to subnormal; the growth of the bones is retarded in young animals, and various trophic disturbances develop; the rate of respiration increases; a variety of nervous phenomena are observed that may be either irritative or depressive in character, viz.: at first fibrillary twitchings of the muscles followed later by tetany and contractures, or again paresis and diminished sensibility. Other symptoms are palpitation, tachycardia, vomiting, loss of mental vigor, irritability followed by languor and lassitude, apathy, and finally idiocy.

A similar syndrome is presented in myxœdema and cretinism (synonyms: infantile or fœtal myxœdema, myxœdematous idiotism); myxœdema is undoubtedly due to arrest or insufficiency of thyroid function, *scil.*, *athyroidism*. We witness the same arrest of development of bones and external soft parts, the impairment of psychic and of nearly all somatic functions. The infantile type is maintained throughout, the physiognomy is typical, there are characteristic disturbances of the organs of sense and of the intellect, the skin is bloated, the sweat glands are depressed, the heat regulation is disturbed. There are general muscular quiescence, apathy, and idiotism. Exact metabolic studies have so far not been made. In one case the oxygen absorption was found subnormal and the nitrogen excretion reduced. It is probable that metabolism becomes retarded after ablation or atrophy of the thyroid gland.

The function of the thyroid is either nutritive or antitoxic, *i.e.*, it either supplies something to the blood that is necessary to normal life or it removes something that is harmful. The most plausible theory advanced to explain hyperthyroidism and athyroidism is the following. The blood normally contains certain bodies that can inhibit metabolism; the origin of these bodies is obscure; the thyroid secretion possesses the power of neutralizing these substances and rendering them inert. Normally metabolism is regulated in this way. Hyperthyroidism causes complete neutralization of these inhibitory sub-

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stances followed by acceleration of metabolism; athyroidism, on the other hand, by permitting the accumulation of excessive quantities of the inhibitory bodies, favors retardation of metabolism.

The active principle of the thyroid gland is thyroidin (iodothyrin), a proteid body containing over nine per cent. of iodine. Removal of the iodine renders this substance inert. Iodothyrin administered to healthy animals produces the same effects as fresh thyroid gland or thyroid extracts. When administered immediately after ablation of the thyroid it is capable of arresting the convulsions that frequently follow this operation. The action of iodothyrin is cumulative, but only of short duration. In order to do good it must be administered continuously. When iodothyrin is given to dethyroidized animals all the iodine appears in the urine in a short time and is wasted. In animals with a thyroid the bulk of the iodine is retained. The thyroid, therefore, seems to be concerned in arresting and preserving the valuable iodine that is ingested with the food and that is intended to play some physiological rôle.

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It appears, from experimental investigation, that the iodine body of the thyroid is an indispensable regulator of oxidation, and is also needed to preserve the normal function of the brain and nervous system and possibly of other organs. The "colloid substance" of the thyroid that was long believed to be the active ingredient of the gland has been shown to contain an organic iodine compound, probably iodothyrin.

Various *preparations of thyroid gland* are in use in medicine. Bircher in 1889 implanted a piece of thyroid gland under the skin. Later different extracts were prepared with glycerin alone, or with glycerin and carbolic acid or thymol. These extracts were administered hypodermically. The French favor fluid extracts made with carbolized physiological salt solution sterilized under pressure with carbonic acid gas and pressed through clay candle filters; this extract, too, is used for hypodermic injections. Vermehren precipitates the glycerin extract of thyroid with alcohol, gathers the sediment, desiccates it, and administers it in pill form (Vermehren's thyreoidinum). Many clinicians give the fresh gland raw by mouth; some boil the gland to make it more palatable, and claim equally good results as from the raw organ.

Still others give clysmata of thyroid gland. The most popular preparations nowadays are compressed thyroid tablets made from the desiccated gland. These are less disagreeable to the patient, and if prepared by a reliable house enable the physician accurately to determine the dose. True, very little is known of the amount of active principle which they contain, but the same objection applies to all the other preparations. As it is essential to individualize in thyroid medication, it is at all events of advantage to know that the qualitative and quantitative composition of the tablets is approximately uniform. For the many methods in use for preparing dry thyroid extracts and tablets we refer to text-books of pharmacology.

The *dose* to be administered naturally depends on the preparation employed. Many subjects manifest an idiosyncrasy for thyroid products, so that it is always well to begin with very small doses and carefully to watch for symptoms of thyroidism (see above). Dried thyroid powders frequently contain ptomains and peptonized proteids that are toxic; they may consequently give rise to additional untoward symptoms. The best guide is the pulse. Quickening of the heart beat and palpitation should lead us to stop the administration of the drug until the heart action becomes normal. Gastric disturbances or rapid loss of flesh should also put us on our guard. Occasionally a change of preparation or a different mode of administration will enable the patient to tolerate the drug, but it is usually best either to stop its exhibition, or at least materially to diminish the dose.

The fresh gland furnishes about twenty seven per cent. of dry powder, so that each unit of powder corresponds to about four times its equivalent in fresh gland. Manufacturers of thyroid tablets always indicate the amount of thyroid powder contained in each tablet. Beginning with a fraction of a tablet a day the dose may be gradually increased to seven or eight tablets in the twenty-four hours. Of the raw gland one-eighth to two may be given in the course of a day. The common dose of the desiccated powder is from one to five grains three times a day.

Therapeutics.—Thyroid preparations are employed most successfully in all those diseases which are due to insufficiency of thyroid function, viz., infantile myxœdema (*cretinism*), operative myxœdema (*cachexia strumipriva*), and adult (*sporadic*) *myxœdema*. Thyroid treatment in these states is a true substitution therapy.

In all forms of myxœdema thyroid medication as a rule produces amelioration of all the symptoms; in a minority of the cases only the main symptoms are relieved, while the minor and probably secondary manifestations persist. In adult myxœdema, for example, the swelling may recede while the anæmia persists. In cretinism the results are particularly brilliant. The skin becomes soft and moist, the bloating disappears, the physiognomy changes, healthy growth of the bony structures and of the soft tissues is stimulated, normal development of the teeth sets in, and the mental condition improves.

The younger the subject the better apparently the result, although all ages seem to react favorably. A case is on record, for instance, of a woman of seventy-two years who had been a sufferer from myxœdema for twenty-six years, and who was completely cured in three months. Some authors maintain that the older the disease the more rapidly does it yield to thyroid therapy. The sex of the patient is without influence. Each individual seems to react differently.

In a very small proportion of cases thyroid treatment is without result, and one or two cases are on record in which the disease was aggravated. The unsuccessful cases constitute not quite two per cent. of all the cases reported in the literature. As it is not excluded that in some of these instances the thyroid preparation employed was worthless, this is a remarkably good showing, and one that warrants the use of thyroid, with the precautions outlined above, in all cases of myxœdematous disease.

Thyroid preparations have also been employed in a large number of other diseases; the indications for the exhibition of thyroid being based either on our knowledge of its physiological effect or, in many instances, on pure speculation. In some diseased states the results obtained have been sufficiently favorable to warrant recording.

As trophic disturbances of the skin are common in sporadic and operative myxœdema, thyroid preparations have been used in the treatment of many *skin diseases*. The best results have been obtained in psoriasis. The sphere of usefulness in this disease is, however, limited, and thyroid should be employed as a last resort, only after all other standard remedies and measures have failed. In lupus, cutaneous tuberculosis, leprosy, keloid, alopecia, eczema vulgaris, acne rosacea, ichthyosis, thyroid has also been tried with varying effect. The results are often negative and uncertain throughout. Scleroderma does not yield to thyroid therapy. It is probable that thyroid gland acts favorably in some cutaneous affections by stimulating the circulation of the skin. Improved vascular supply leads to improved nutrition, increased activity of the cutaneous glands, and increased vitality of the epidermal layer, all tendencies that must act beneficially in correcting the trophic perversions that form the basis of many skin lesions. Thyroid preparations, either in the form of the dry powder or as an ointment, have also been applied locally to *serpiginous ulcers, suppurating buboes*, syphilitic and soft *chancres*. Good results are claimed for this method.

Loss of weight is a common result of thyroid medication. This observation has led to the employment of thyroid gland for the reduction of *obesity*. A loss of fat undoubtedly can be brought about in the majority of

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Organotherapy.

cases. Patients with anæmic obesity are more suitable for thyroid therapy than patients with plethoric obesity. In the latter the results are as a rule indifferent; in the former oxidation is increased, as shown by the increased amount of oxygen that is absorbed and the greater amount of carbon dioxide that is eliminated. Together with the fat some proteid is, however, always lost in these cases, so that from this point of view alone thyroid medication is to be condemned in the treatment of obesity. As obesity, moreover, is frequently complicated by various cardiac disorders, gout, diabetes, and kidney lesions (all conditions in which thyroid preparations may do harm), this therapy is dangerous also on these grounds. It must further be remembered that as soon as the administration of thyroid gland is discontinued the fat returns; consequently the drug must be taken continuously. This leads to the indiscriminate use of thyroid preparations by the laity, a procedure that is manifestly dangerous. Finally, the exhibition of thyroid is totally unnecessary in obesity, for correct dietetic treatment produces results that are equally favorable, more constant, more permanent, and not at all dangerous. In carefully selected cases which are rigorously supervised by the physician small doses of thyroid, together with rational dietary regulations, produce satisfactory results and may be permitted.

In *insanity* the results of thyroid therapy are not constant; some cases are strikingly benefited, others are not affected at all. It is probable that in many sufferers from melancholia, recurrent mania, delusional insanity, and the insanities of adolescence, the climacterium, and the puerperium there is at the same time some derangement of thyroid function, and that these cases precisely, and possibly these cases alone, derive benefit from the use of thyroid preparations. The insanities of myxœdema, needless to say, often improve under thyroid medication. The largest statistics on the subject show that of 1,032 such cases 16.8 per cent. recovered, 24 per cent. were improved, and 59.2 per cent. remained unimproved. The results, therefore, in this particular form of mental derangement are fairly good.

Because infantile myxœdema and *rachitis* are both characterized by disturbances of the bony development thyroid medication has been employed in the latter disease. The relation between the two diseases is, however, purely superficial and their pathogenesis radically different, so that we need not be surprised to learn that thyroid therapy has led to absolutely negative results in rickets.

There is a superficial resemblance between *acromegaly* and myxœdema, and in some cases of acromegaly the thyroid has been found degenerated or atrophied. Some experiments are also on record that seem to show that the pituitary body hypertrophies after removal of the thyroid. These observations have led to the employment of thyroid in acromegaly. The results of this treatment are not satisfactory. A few isolated cases are on record, however, in which thyroid medication seemed to do good after all other measures, including the exhibition of pituitary extract, had failed. The method deserves further trial.

Simple goitre often yields to thyroid treatment. Some statisticians report improvement in two-thirds of the cases. Young persons, it is claimed, are more benefited than older subjects. It is necessary to continue the administration of the remedy for a long time, as otherwise the goitre is liable to return. The swelling rarely if ever disappears completely. The treatment must be considered symptomatic and in no case curative. The treatment is useless in goitre that has undergone secondary degeneration (colloid, cystic). The simple parenchymatous form is the most suitable for treatment with thyroid gland. Of 60 cases of the latter kind 14 were cured, 29 improved, and 19 not benefited. One author reports improvement in all of a series of 79 cases, another one improvement in 92 per cent. of a large series of cases.

The treatment of *Basedow's Disease* (exophthalmic goitre) with thyroid preparations seems altogether paradoxical, for, as we have seen, the cardinal symptoms of this disease are actually produced by the administration of thyroid. To expect a cure would be to avow faith in the homœopathic "law" of similars. Nevertheless the remedy has been extensively employed in this disease either empirically or from ignorance of the physiologic action of the thyroid extract, and finally on the basis of various hypotheses that are not worth recording. The consensus of opinions, as was to be expected, is that thyroid has a tendency to do harm in this disease. In many instances no effect was noticed when small doses were given. A few cases of improvement are also reported, chiefly by American and French authors, but the case reports (which have been carefully studied by the author) do not show that the amelioration of symptoms could in any way be attributed to the action of the thyroid preparations given. In exophthalmic goitre, therefore, the use of thyroid should be discouraged as useless.

A more rational method of treating Basedow's disease has recently been tried, apparently with good results. It consists in injecting the serum of dogs whose thyroid has been removed. This method is at least based on sound physiologic reasoning. It warrants further trial, for of the nine cases treated all improved.

Thyroid preparations have at one time or another been tried in nearly every known disease. Benefits have been claimed in tetany, the various disorders of lactation (galactagogue action), certain middle-ear disorders, muscular and osseous dystrophies, hemorrhages in uterine diseases, cancer of the breast, and syphilis. Very little value, however, attaches to isolated case reports, for in the majority of them grave sources of error are not excluded, and no conservative judgment in regard to the therapeutic value of the thyroid preparations administered can be rendered.

2. The Suprarenal Glands.—Injection of suprarenal extract produces a very marked rise of blood pressure. This is primarily due to vaso-constrictor action, for suprarenal extract exercises its chief effect on the peripheral circulatory apparatus. This is made manifest after section of the medulla or the cord (even complete removal of the cord), section of the vagi, of peripheral nerves, or paralysis of the nervous end apparatus with atropine, for all these operations do not hinder the rise in blood pressure after injection of suprarenal extract. Direct application, moreover, to mucous surfaces causes rapid contraction of the blood-vessels of the part. It is not established whether suprarenal extract acts directly on the muscle cells of the arterial muscularis or on the ganglion apparatus of the vessel walls. Suprarenal extract also acts directly on the heart, causing retardation and strengthening of the heart beat, and in this way, too, a rise in blood pressure. It seems that the extract directly stimulates the heart muscle and at the same time irritates the vagus centre. The former action strengthens the heart beat, the latter retards it. If the medulla is destroyed or the vagus severed, the heart beat is greatly accelerated after the exhibition of suprarenal extract, more so than after simple section of the vagi. Applied to the excised heart of a frog suprarenal extract also causes quicker and more forcible contractions. The *direct* effect of the extract on the heart muscle is accelerating, in other words, excitory, as in the case of the arterial muscularis.

Other effects that follow the injection of suprarenal extract are: (1) The excretion of dextrose (suprarenal glycosuria); (2) local pigmentation around the point of injection; (3) destruction of red blood corpuscles and deposit of hæmosiderin in the spleen and lymph glands; (4) excretion of pigments related to bile pigments.

Removal of the suprarenal glands, a very difficult operation, is invariably followed by the death of the animal. If one gland alone is removed or if accessory adrenals are left behind, compensatory hypertrophy of the remaining organ occurs and the animal may survive for months or even years.

The statements made by different authors in regard to the effect of removal of the adrenals on general nutrition are contradictory. The same applies to the effect on the

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temperature; some report a rise, some no change, some subnormal temperatures. The effect on the nervous system is marked. All authors agree that degenerative changes in the brain, cord, and sympathetic plexuses follow removal of the adrenals. The statements in regard to the clinical nervous phenomena observed are not uniform. There is always great muscular asthenia. The digestion is always impaired, with vomiting, hæmatemesis and diarrhœa. The blood pressure always falls. No uniform changes in the pulse rate or the respiration have been noted. Occasionally, when the animals survived for a period of several months, abnormal pigmentation of mucous and cutaneous surfaces has been noted. The most marked changes occur in the chemical composition of the blood. (The statements in regard to changes in the hæmoglobin content and the number of red blood corpuscles are absolutely contradictory.) The blood of an animal whose adrenals have been removed becomes very poisonous and acts like curare on healthy animals. It accelerates the death of other animals whose adrenals have been removed, whereas the injection of normal blood into such animals improves their condition. It appears that after removal of the adrenals certain substances accumulate in the blood that paralyze the motor endings of the nerves and may be the muscles themselves. We are justified in assuming, therefore, that one of the functions of the suprarenals is to disintoxicate the blood. There is much experimental evidence to show that the toxic principle which the adrenals normally arrest or neutralize is a fatigue product of muscle and nerve activity.

Our knowledge of the *function* of the suprarenal glands is supplemented by clinical studies in Addison's disease. Here we find in the majority of cases spontaneous degeneration of the adrenals (usually tuberculous) and a symptom complex which corresponds in many features with some of the symptoms that follow *removal* of the adrenals, viz., asthenia, cardiac weakness. In other features Addison's disease resembles the syndrome following *injection* of adrenal extract (pigmentation, glycosuria).

This observation makes it probable that the function of the suprarenals is twofold, viz., that on the one hand they supply a substance that stimulates the sympathetic ganglia and striped and unstriped muscle fibre; on the other hand, that they arrest or disintoxicate certain poisonous principles which are the product of nervous and muscular activity. The latter fatigue products, we must imagine, when present in excess produce asthenia, blood impoverishment, and occasionally pigmentation and glycosuria. Only on this duplex basis can we explain how insufficiency of suprarenal function or absence of the glands can produce the whole syndrome of Addison's disease.

The "*active principle*" of the suprarenal glands has recently been isolated; it is called adrenalin. Older impure preparations are sphygmogenin (a syrupous liquid), suprarenin, and epinephrin (both albuminoid bodies). Other substances (lecithin, jecorin, pyrocatechin, neurin, etc.) that have been isolated from adrenal extracts, do not possess the specific properties of the fresh glands. With the discovery of adrenalin and its manufacture on a large scale all the other preparations have been superseded with the exception possibly of the desiccated and powdered gland itself.

Dose and Administration.—In one case of Addison's disease a piece of fresh gland was implanted under the skin of the patient. No effects were observed and death occurred in three days. The dry powdered extract is given by mouth in capsules or in compressed tablets, in doses varying from twenty to forty grains a day. The gastric juice does not destroy the action of suprarenal preparations. It must be remembered, however, that the drug when given by mouth exercises no effect on the blood pressure.

For hypodermic use, for administration by mouth, and for local application adrenalin is the most convenient, the most accurate, and the safest preparation at our disposal. It is usually dispensed in the form of the hydrochlorate (adrenalin chloride) as a white crystalline powder. It is a most powerful remedy. One part to ten thousand blanches the conjunctiva in from thirty to sixty seconds; 0.000008 of a grain, injected intravenously, causes a rise of blood pressure that is equal to the effect of 0.005 gm. of the dry powdered extract; 0.0000014 gm. per kilogram of body weight exercises a distinct physiological effect. It is the most powerful hæmostatic and astringent known, and the strongest stimulant of the heart. The preparation is non-irritating and non-cumulative. It is generally employed in the strength of 1 to 1,000 for hypodermic and local as well as for internal use. Hypodermically a few drops (two to ten) usually suffice to bring about the desired immediate effect (see below). By the mouth, from five to ten drops should be given every fifteen to thirty minutes for two or three times, and then every three hours, as needed.

Therapeutics.—In *Addison's disease* suprarenal preparations have been extensively employed. The results are not altogether unfavorable. In many instances improvement seemed to be maintained as long as the drug was exhibited. In one case the patient improved for two years under adrenal treatment. As soon as the remedy is stopped in these cases relapses are liable to occur; they are often sudden and severe, and may even terminate fatally. In the majority of cases the remedy is altogether without effect. In a few cases the patient's condition seemed to grow worse. No case of a complete cure is on record.

A number of statistics on the treatment of Addison's disease with suprarenal preparations have been published, but they are essentially without value because the stage of the disease, the time during which the cases were under observation, the quality of the suprarenal preparation are not included in the tabulation. In many instances the diagnosis is not even positive. One series, the most accurate one, includes 48 cases. Of these 6 were greatly improved, 22 slightly improved, 16 were not affected, and 2 grew worse. The results obtained so far are withal sufficiently encouraging to stimulate further trial.

Suprarenal preparations are the most rapid *cardiac tonic* which we possess. In sudden heart failure due to shock or hemorrhage, narcotics, anæsthetics, etc., hypodermic injections of adrenalin are very effective. The action of adrenalin is very transitory, however, so that in chronic heart lesions it cannot take the place of nitroglycerin, digitalis, or strychnine, but should merely be employed as an adjuvant to these remedies.

As rapid and powerful *vaso-constrictors* suprarenal preparations have a large sphere of usefulness. They can be given by mouth for the arrest of *internal hemorrhages* of all kinds (hæmoptysis, hæmophilia, etc.), and can be applied locally as *hæmostatics* to all bleeding surfaces. In the treatment of epistaxis adrenalin is particularly useful. In *inflammation of the conjunctiva* depletion of the engorged vessels with relief of pain and redness is rapidly brought about by the instillation of a few drops of adrenalin solution into the eye. In *glaucoma*, *episcleritis*, *vascular keratitis*, and *kerato-conjunctivitis* suprarenal gland is a valuable adjuvant to other treatment. In *operations on the nose* or other mucous surfaces the application of a spray of adrenal extract or of adrenalin will produce rapid ischæmia of the parts and consequently render surgical interference practically bloodless. Whenever it is desired to apply cocaine to intensely inflamed surfaces suprarenal extract may be first applied with profit, as it relieves the congestion of the tissues and in this way renders the action of cocaine more powerful. For the details of the employment of suprarenal preparations in ophthalmology, in intratympanic surgery, and in nose and throat work we refer to special articles on these subjects.

Suprarenal gland has been used in the treatment of *diabetes* (this use being based on the view that certain forms of disturbed carbohydrate metabolism are due to "lack of vaso-motor tension"), but the results of this treatment have been quite unsatisfactory. In view of the fact that fluctuations always occur in the condition of diabetic subjects, the reports in regard to temporary amelioration.

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following the use of suprarenal extract, must be judged with caution. The discovery of suprarenal glycosuria has also led to the employment of adrenalin in diabetes, but the results obtained are altogether negative so far. In a few cases the dextrose excretion was even increased for a short time.

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In *asthma* with vaso-motor ataxia occurring in neurotic subjects the drug apparently has a certain application, and beneficial results from its administration are reported.

In the *asthenia* of certain nervous diseases, both functional and organic, the drug may do good as a muscle tonic. It is said to cause the feeling of profound fatigue so frequently complained of by neurasthenics to disappear. It also acts on the uterine muscles, and has been successfully employed to stimulate uterine contractions and to arrest uterine bleeding.

Other conditions in which suprarenal preparations are reported to have exercised favorable effects are acute maniacal excitement with low blood pressure, cyclic albuminuria, and the pain of cancer of the breast and the œsophagus.

3. Thymus Gland.—*Removal of the thymus* in animals in which it persists during life is not followed by any characteristic perversions of function. In man the gland spontaneously decreases in size from the second year, and is almost totally obliterated in adult life. The organ is therefore not essential to life, nor apparently of physiological importance in adult man. Of its function we know nothing.

Injection of thymus extract produces a fall of blood pressure, acceleration of the pulse rate, restlessness, dyspnœa, and in large doses collapse and death.

No *active principle* has been isolated. The gland contains iodine in smaller quantity than the thyroid. Dogs who are fed on thymus excrete a peculiar purin body, and the theory has consequently been advanced that the thymus is concerned in the metabolism of nuclein and the genesis from nuclein of uric acid and its chemical congeners.

The *dose* of thymus is much larger than the safe dose of thyroid. From ten grains to several ounces of the fresh gland have been given per day. Of the dry extract the common dose is from twenty-five to sixty grains a day. No thymus preparation is used hypodermically.

Therapeutics.—Thymus is particularly useful in *simple goitre*. In this disease it acts very much like thyroid, only not so energetically. The statistics in regard to the efficacy of thymus treatment of simple goitre vary greatly. In many of the successful cases reported other treatment was given at the same time; and some of the cases were not kept under observation for a sufficiently long time to justify final conclusions in regard to a cure. The consensus of opinions is, however, very favorable. A critical review of the whole literature of the subject seems to show that about one-half the cases of simple goitre are much benefited by thymus. In several instances thymus brought improvement after thyroid had failed.

In *exophthalmic goitre* the reports are very much at variance. A few authors report aggravation of all the symptoms; others report altogether negative and indifferent results; a few report improvement. One author studied twenty cases of Basedow's disease treated with thymus, and contrasted with them twenty cases treated by various other means. The balance in regard to the retardation of the pulse rate, the decrease of the thyroid swelling and of the exophthalmus inclined toward treatment without thymus. The statistics as a whole are better than for thyroid treatment, but not as good as for other standard methods of treating exophthalmic goitre.

4. Pituitary Gland.—*Removal of the pituitary body* constitutes an operative inroad of such magnitude that only very few statements in regard to the effects of ablation of this organ are recorded in the literature. All the symptoms described, moreover, are ambiguous, and may be ascribed to shock or to injury of neighboring vital parts. From this source, then, we gain no reliable information. Spontaneous degeneration consisting in hypertrophy of the connective-tissue portions, cystic degeneration, sclerosis, atrophy, and tumor formation on the other hand is almost invariably followed by the syndrome of acromegaly. One case of hypertrophy of the pituitary body is on record in which acromegaly was absent, and a few cases of acromegaly are reported in which the gland was not found diseased. The connection between disease of the organ and acromegaly is nevertheless sufficiently apparent to warrant the employment of pituitary preparations in the treatment of this disease. In two cases of adiposis dolorosa the pituitary is also reported enlarged.

Injection of the infundibular portion of the organ produces a rise of blood pressure. Injection of the hypophyseal portion does not produce such a rise, but merely retardation of the pulse beat that persists to a certain extent, even after division of the vagi. A substance has also been isolated from the gland that causes contraction of arterioles and augmentation of the heart beat.

The *function* of the gland is not understood. Some authorities claim that it regulates the intracranial blood pressure, and is also concerned in the regulation of general metabolism. It is finally believed to exercise some effect on the growth and development of the bony structures and the cutaneous tissues of the body.

No *active principle* has been isolated.

The gland is usually administered in the form of a trituration or desiccated as a powder ("hypophysin"). The *dose* varies from one and a half to ten grains a day.

Therapeutics.—Pituitary gland is used exclusively in *acromegaly*. It seems to exercise no effect on the course of the disease, but does seem to be efficient in relieving some of the most distressing symptoms, as, for example, the headache, the neuralgic pains in the limbs, the general lethargy, and the loss of memory. In a series of thirteen cases seven showed relief of symptoms, five showed no improvement, and one case grew worse. Some authors claim to have seen marked benefits accrue from the combined use of pituitary gland and thyroid, particularly in regard to the relief of headache; but it is difficult to determine how much of this good effect must be attributed to the thyroid (see above) and how much to the pituitary gland. It is best in the present state of our knowledge to give sufferers from acromegaly the benefit of the combined use of thyroid and pituitary, in connection, of course, with other established measures for the relief of symptoms.

II. The Blood-Forming Organs.

The rôle which the spleen, the lymph glands, and the bone marrow play in blood formation has suggested their employment in various diseases of the blood. Extracts made from the three organs are used rather indiscriminately, either singly or in combination. Very few clinicians in administering these preparations apparently have clear conceptions in regard to the physiologic function in blood formation which these different organs perform. A summary of our present knowledge in regard to the hæmatopoietic function of the spleen, the lymph glands, and the bone marrow reads as follows:*

The *spleen* plays only an insignificant part in blood formation. It is not at all concerned in the formation of red blood corpuscles (in man!) nor in the formation of granular mononuclear and polynuclear leucocytes, nor of eosinophile leucocytes. It appears to manufacture a small proportion of the lymphocytes. Its chief rôle is to arrest the fragments of red and white corpuscles that are carried to it in the blood of the splenic artery (spodogenic tumor of the spleen in infections).

The *lymph glands* manufacture only lymphocytes and have no other function in hæmatopoiesis. The lymph glands are closely related to the spleen; both contain lymphoid tissue.

The *bone marrow* forms the granular mononuclear and polynuclear leucocytes, and in all probability the red

* The views held by different authors are greatly at variance in some respects. I have in the main followed Ehrlich, who is *facile princeps* in this field.

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blood cells. It is not related to the spleen and lymph glands and consists largely of myeloid tissue.

There are then two types of leucocyte-forming tissue—the lymphoid (spleen, lymph glands) and the myeloid (bone marrow). Metaplastic transformation of lymphoid to myeloid tissue may, however, occur. In myelogenous leukæmia, for example, large quantities of myeloid tissue are found in the lymph glands and the spleen. Under these conditions, therefore, the spleen may be said to play an important part in blood formation.

1. THE SPLEEN.—*Extirpation of the spleen* is invariably followed by vicarious hypertrophy of numerous lymph glands, and in many instances by enlargement of the thyroid. A colossal lymphocytosis develops very soon, but no increase is witnessed in the number of mononuclear and polynuclear granular leucocytes. If the animal survives for a year or longer, marked eosinophile leucocytosis develops.

The injection of splenic extracts produces a fall of blood pressure followed by a continuous rise and often by elevation of temperature. Splenic juice is irritating and may produce abscesses when injected hypodermically, and inflammation of the upper digestive tract when given by the mouth. "Erythrol" is a salt-water extract of spleen that is given in the dose of one or two teaspoonfuls a day, and is said to be non-irritating and not disagreeable to the taste.

Therapeutics.—On physiological grounds splenic extract should be administered only to increase the lymphocytes. The spleen, however, contains much nuclein, and it is well known that this substance produces a marked general leucocytosis. From this point of view spleen may be used to produce general leucocytosis, but it seems much more simple and expedient to employ pure nuclein for this purpose.

It is very difficult to render conservative judgment in regard to the efficacy of splenic extracts in diseases of the blood. Innumerable reports have been published, but very few of them are free from ambiguity.

The most careful and exact observers report very little benefit. In the majority of cases other preparations were used together with the organ extract, so that no positive conclusions in regard to the latter can be reached. How splenic extract should produce an increase of red blood corpuscles, as some writers claim, or how, *e.g.*, red bone marrow should cause a marked lymphocytosis, as others relate, it is difficult to understand on the basis of the physiological considerations we have outlined above.

In *leukæmia*, in which disease we have a relative decrease of lymphocytes, and also often a decrease of polynuclear neutrophiles, splenic extract might be expected to act beneficially. Physiologically, the supplying of spleen would raise the number of lymphocytes; chemically, the presence of nuclein would raise the number of granular leucocytes. What effect, however, splenic extract would have on the development of the myelocytes that are so colossally increased in this disease, what effect finally on the primary process, it is hard to foresee. Some good results have been claimed from this therapy, notably in regard to the increase of polynuclears (nuclein?) and the improvement in the subjective sensations of the patient. It does not appear from the case reports that the course of the disease is appreciably modified.

In *other blood diseases* no valid reports of good results are on record. In *typhoid fever* and in *tuberculosis* splenic extract has been given, apparently with some benefit. We are inclined to attribute this to the nuclein leucocytosis.

As the spleen is occasionally found enlarged in operative and sporadic *myxœdema*, splenic extract has been employed in this condition. It seems to improve the general condition of the patient and to ameliorate the distressing mental symptoms. Combined with thyroid it seems also to enhance the efficacy of the latter. In this disease spleen has been given in the form of the dry desiccated organ (four hundred to six hundred grains a week) and as fresh gland (twenty grains per dose three times daily in capsules).

A few cases of *exophthalmic goitre* and of *paludism* (*cachexie paludienne*) are on record in which great benefits were claimed from splenic medication.

2. LYMPH GLANDS.—*Total extirpation of all the lymph glands* is manifestly impossible. In many clinical cases, however, the lymph glands are found extensively degenerated or involved in tumor formation. In all such cases the number of lymphocytes is greatly reduced.

What has been said in regard to the physiological function of the spleen applies with equal force to lymph glands; they, too, may possibly increase the lymphocytes, and they, too, contain much nuclein and consequently can produce leucocytosis. Theoretically, therefore, lymph gland extract is indicated wherever splenic extract is indicated in blood diseases. As a matter of fact, lymph-gland preparations have not been extensively used. All the case reports describe the administration of lymph-gland extract in combination either with spleen or with bone marrow.

3. BONE MARROW.—*Removal of all the bone marrow* is of course impossible. Comparative counts of corpuscles in the afferent and efferent blood-vessels of the marrow have yielded essentially negative results. In clinical cases in which the bone marrow was largely displaced by other tissues (malignant tumor formation), the number of polynuclear leucocytes was found greatly decreased. In the bone marrow are found preliminary forms of red blood corpuscles, and after great loss of blood the yellow marrow of certain bones is converted into red marrow, showing that a process of regeneration is stimulated here. It seems, therefore, that bone marrow should be employed to stimulate the formation of red blood corpuscles and of leucocytes other than lymphocytes. In addition it contains iron in organic combination, and many clinicians recommend its use on these grounds. They argue that the iron in the form found in bone marrow is more readily assimilable than iron in other combinations or metallic iron.

These claims are probably exaggerated, and are not based on experimental or clinical evidence of value. In fact, the majority of clinicians obtain equally good and equally bad results with the standard inorganic preparations of iron.

Bone marrow is either given raw in doses of several ounces a day or in the form of glycerin extracts. As the marrow of young animals is more active in blood formation than the marrow of adult animals, it seems advantageous to employ the former alone. The anterior extremities of the ribs are crushed so as to expose the cancellous tissue. The fragments of bone are then extracted with glycerin for a number of days, the extract is filtered off and given in teaspoonful doses from three to six times a day.

What good effects have been claimed from bone marrow can hardly be attributed to any ingredient that might be utilized to build up corpuscles, or, as we have seen, to the iron which it contains. We must hypothetically assume the presence of some body in bone marrow that is capable of stimulating blood formation.

In *leucocythæmia* (leukæmia) the employment of bone marrow is altogether irrational, because in this disease we have already hypertrophy and overactivity of the bone marrow.

In *progressive pernicious anæmia* some good results are claimed. No case is on record, however, in which bone marrow was given alone. The best that can be said, therefore, is that as an adjuvant to other remedies it may be tried. It certainly cannot replace arsenic.

In *chlorosis* and in secondary *anæmias* the results have been more favorable than in the primary anæmias. Here again it may be used in combination with iron, but cannot replace the latter.

In *pseudoleukæmia* (Hodgkin's disease) the best results have been recorded. The exhibition of bone marrow is a more rational procedure in this disease than in all the other diseases of the blood, for here the spleen and the lymph glands are extensively diseased and the bone marrow, we must suppose, vicariously assumes the greater portion of

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the hæmatopoietic function. Anything that can stimulate the bone marrow to increased blood formation is indicated. It is not impossible that bone marrow does this (see above). The best results are reported from the combined use of bone marrow, thyroid, and arsenic.

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III. The Generative Organs.

The use of orchitic and of ovarian extracts is of historical interest. Brown-Séquard, when an old man, performed his first experiments with "*suc testiculaire*" on himself, and claimed to experience "a return of vital energy and rejuvenescence with renewed and efficient peristalsis and control over the bladder and sphincter." His conclusion was that the testicles secrete into the blood a substance that profoundly influences nervous and possibly muscular metabolism and increases mental vigor. There can be no doubt that the ridiculous claims of charlatanistic advocates of this particular application of the "Brown-Séquard method" have done much to bring organotherapy into disrepute. Nevertheless, the use of testicular and ovarian extracts, if we carefully weigh all the clinical evidence, cannot be absolutely condemned as useless. Favorable symptomatic results at least, that are not due to suggestion, are obtained without question in certain conditions.

1. The Testicles.—*Removal of the testicles* in children exercises a very marked effect on growth and development. The voice remains treble, the subjects usually grow obese, show lack of mental vigor, and manifest psychic perversions of various kinds (eunuchs). The *injection of testicular extract* into normal subjects produces indifferent results.

Several so-called active principles have been manufactured from testicles. The best known is spermin. There are two different kinds of spermin. The one can be converted into its polymer piperazin (dispermin), the other cannot. Poehl discovered the latter, and claims the most startling effects from its exhibition. His statements are borne out by many Russian and some French authors, but the reports are not convincing. The majority of conservative French and German authorities failed to witness any physiological effects from Poehl's spermin and report negative results from its administration in all the morbid conditions for which it is recommended. Brown-Séquard states that spermin is not the active principle of testicular extract. Charcot's crystals which are found in testicle juice are phosphate of spermin.

Testicular extract is best made from the testicles of young animals by maceration of the glands, extraction with normal physiological salt solution, to which may be added a little carbolic acid, thymol, or glycerin. The extract is sterilized according to d'Arsonval, under pressure with CO_2 and filtered through a clay candle filter. No uniform data in regard to the concentration of this extract nor the exact dosage are given by the different authors who have written on the subject. The best results are claimed from hypodermic injection, and Brown-Séquard states that testicular extract is inactive when given by mouth.

The most interesting results are claimed in the treatment of *locomotor ataxia*. The destructive sclerotic lesions of the spinal cord that form the anatomic basis of tabes cannot of course in any way be influenced by the injection of testicular fluid. A cure is, therefore, *a priori* out of the question. It appears, however, that many of the symptomatic manifestations of the disease can be ameliorated by orchitic medication, so that the remedy may be tried. The statistics published are altogether contradictory. Brown-Séquard and d'Arsonval have published the most comprehensive tabulation of results. Three hundred and forty-two cases were treated. All improved, and some, they claim, were "cured" (!). Other French authors report eighty-five and ninety per cent. of successful cases. German clinicians, on the other hand, claim essentially negative results throughout.

In neurasthenia, hysteria, hypochondriasis, melancholia, and kindred *psychoses* transitory improvement is reported by many writers, but the element of suggestion can hardly be excluded in cases of this character.

In general *debility* from wasting disease and in *senility* a certain tonic effect is conceded by nearly all authorities. It appears, therefore, that the chief therapeutic sphere, and probably the only sphere of testicular extract is to act as a tonic to the cerebrospinal centres. This power, it seems, is also inherent in many other organs, though possibly not to such a marked degree as in the testicles. Whether the latter produce a specific internal secretion that is distributed to other organs, or whether all organs secrete such a tonic principle, cannot be determined.

For the arrest of *surface hemorrhage* minced testicle, locally applied, has been found to be of value.

2. The Ovaries.—*Removal of the ovaries* before the age of puberty prevents the appearance of the characteristic phenomena of puberty. The pelvis does not enlarge, menstruation fails to appear, the mammæ and the genital organs atrophy, and occasionally certain male attributes develop. In adults, aside from the cessation of menstruation (a few cases are recorded in which periodic uterine bleeding persisted even after removal of the ovaries) and atrophy of the genital organs, a variety of distressing nervous phenomena and in many patients obesity are apt to develop. In cows removal of the ovaries causes the milk to become richer in fat.

The *administration of ovarian extract* to healthy animals has been known to cause death from hemorrhage into the spinal cord. Males are claimed to be more susceptible to this influence than females.

No *active principle* has been isolated.

Ovary is administered as dry powdered gland in *doses* of from one to five grains. The powder is conveniently dispensed in compressed tablets. Glycerin extracts have also been recommended for hypodermic use.

Therapeutics.—Ovarian extract is a useful remedy for all the symptoms following double *oöphorectomy*. The nervous and vaso-motor disturbances (insomnia, headache, psychoses, flatulence, lumbar pains, etc.), of the climacterium and of certain uterine disorders also often yield to ovarian medication. The drug is not, however, reliable in all cases, and it is impossible to predict in any given case whether or not ovary will do good.

Senile debility in old women seems to be counteracted by the use of ovary. Of sixty-four old women treated in one of the Paris hospitals all, we are told, were greatly benefited and rejuvenated.

In *hysteria* good results are also related. In a young child hysterical contractures disappeared after a few doses; "*mais que n'obtient-on pas dans l'hystérie!*"

In *chlorosis* ovary is of greater benefit than spleen, lymph glands, or bone marrow. It is believed by leading authorities that the ovaries secrete a substance that stimulates blood formation, and that in chlorosis this function is insufficient. On these grounds they supply ovary and claim very favorable results.

Ovarian extract has finally been given with success as an *aphrodisiac*.

IV. The Nervous System.

Brain cortex, cord, and nerve tissue have been employed either singly or in combination in many nervous or mental disorders. The most common preparation used is a sterile glycerin extract that is injected hypodermically.

All nervous tissues contain cholin and neurin, two bodies that are highly toxic. They are probably catabolic products of brain and nerve activity, for in nervous diseases in which nerve metabolism is increased the cerebrospinal fluid contains abnormally large quantities of cholin. It is probably due to the action of the latter substance that the injection of nervous extracts often produces a rise of temperature, leucocytosis, increased absorption of oxygen, and increased excretion of nitrogen. In addition to this toxic action nervous tissue, and particularly brain cortex, seems to exercise a distinct tonic effect, *i.e.*, in healthy subjects a feeling of exaltation and of in-

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creased energy. There is no record of any influence having been exerted on the pulse and respiration.

Therapeutics.—The best results, it is claimed, are obtained in *neurasthenia*, but suggestion cannot be excluded. In *epilepsy* and in a case of *bulbar palsy* one authority reports www.libtool.com.cn *mental diseases* the psychopathic disorders seem to remain unaffected, whereas the physical condition of the patients improved greatly under this treatment. Of eleven cases of *tabes* treated with nervous extracts seven are reported benefited.

As against many favorable reports we find an equal or even greater number of absolutely negative results. Nerve-tissue extracts probably possess tonic properties for the nervous system and merit employment in this sense. Many other remedies that we possess are, however equally efficacious, so that nerve extracts are by no means an indispensable adjuvant to our therapeutic armamentarium. Charlatans in and out of the profession have utilized these preparations extensively to impose on a credulous laity, so that their employment has fallen into considerable disrepute among conservative physicians.

V. The Secreting Glands.

Aside from their external secretion some of the glands of the body seem to furnish an "internal secretion" that plays an important part in intracellular digestion. In the case of the pancreas and the kidneys this may be practically considered established; in the case of the liver the intestinal glands, the mammæ, and the salivary glands it is highly probable.

1. The Pancreas.—Complete extirpation of the pancreas is invariably followed by the complete syndrome of diabetes mellitus. If a small portion of the gland is left behind, or if a piece of the extirpated pancreas is subsequently grafted under the skin, diabetes does not develop. Ligation of the pancreatic duct does not cause diabetes. There are numerous theories in regard to the rôle of the pancreas in carbohydrate metabolism; they cannot all be discussed in this place. The preponderance of experimental evidence points to the secretion by the pancreas of a glycolytic, *i.e.*, dextrose-destroying ferment. If this secretion becomes insufficient or is arrested, the blood sugar is not destroyed, consequently it accumulates. This leads to hyperglycæmia and glycosuria. Diabetes may also be due to other causes. Degeneration of the pancreas in man may and may not produce diabetes. From very recent investigations it appears that in nearly all cases of diabetes certain cell groups in the pancreas (the "islands of Langerhans") are found degenerated. These cells are not connected with the efferent ducts of the gland, but pour their secretion into the lymph spaces. It is probable that they furnish the specific internal secretion. Ligation of the pancreatic duct causes atrophy of the cells furnishing the external secretion, whereas the islands of Langerhans remain intact for a long time. The writer is at present engaged in studying the effects of pancreas prepared in this way, *i.e.*, of "isolated" islands of Langerhans in carbohydrate metabolism, both *in vitro* and *in vivo*. It is expected that these researches will throw light on the nature of the internal pancreatic secretion, and will advance the organotherapy of diabetes. For the present this method of treatment, although so clearly indicated on theoretical grounds, has furnished essentially negative results. This may be due to the fact that all pancreatic extracts contain digestive ferments and certain nucleoproteids that are toxic and produce local necrosis when injected hypodermically; thromboses, pyrexia, tachycardia, increased diuresis, and increased N excretion when administered intravenously. The administration by mouth is negative in diabetes. It is probable that the trypsin contained in pancreas extracts destroys the "internal secretion" as it destroys the fat splitting enzyme that we *know* to be present. An extract of pancreas containing no digestive ferments, prepared as suggested above, may act more favorably.

The administration of pancreas by mouth is practised for the relief of *steatorrhœa* and other *intestinal disorders* that are due to perversion or absence of the external secretion of the gland. This treatment is not, however, organotherapy proper, and will therefore be discussed under other headings.

2. The Kidneys.—Complete anuria may persist for many days without causing the development of uræmic symptoms (*e.g.*, hysterical anuria). If a double nephrectomy is performed in a dog and kidney extract is injected intravenously, the life of the animal will be prolonged beyond that of a nephrectomized control animal that is not treated with renal extract. The onset of uræmic symptoms can be delayed in this way. From these observations the conclusion has been drawn that the kidneys furnish an internal secretion that is disintoxicating for certain urinary bodies, and that prevents the occurrence of uræmia. It has also been shown that the toxicity of the blood of uræmic animals is greatly reduced by its passage through healthy kidneys. Uræmia is not, therefore, considered to be due to the retention of urinary bodies alone, but also to insufficiency of the internal disintoxicating secretion of the kidneys. In harmony with this theory kidney extract has been employed in the treatment of a considerable number of uræmic cases, apparently with good results. Kidney therapy is too modern, and case reports are too scanty to warrant extended analysis. The subject, however, seems capable of fruitful development.

3. The Liver.—Liver extract contains many substances with active physiologic and toxic properties, and no less than ten well characterized ferments besides. It is difficult therefore to understand how those who employ liver extract for the sake of an hypothetical internal secretion of the hepatic cells can exclude the action of all these bodies. It has been claimed that the virtues of cod-liver oil are due to the presence in this product of an internal secretion. A few good results are reported from the use of hepatic extract (prepared according to d'Arsonval's method) in *diabetes*. The preparation is said to stimulate the liver cells to increased activity in the sense that it enables them to store more glycogen. A great reduction in the sugar excretion has been reported by reliable clinicians. Some authors have also used liver extract symptomatically for "*hepatic insufficiency*" following alcoholic cirrhosis, and report improvement of many of the subjective symptoms.

4. Mammary Gland.—Mammary gland extracts are believed to exercise an influence on the female generative organs. Desiccated sheep's mamma has been given by mouth in twenty-grain doses for *uterine hemorrhages*. It is said to cause contraction of the uterine muscles and to arrest bleeding. Good results are also claimed from this therapy in the leucorrhœa and irregular bleeding of subinvolution, and in benign tumors of the uterus it is said to relieve many of the reflex symptoms, to control the leucorrhœa and bleeding, and to improve the general health of the patient.

5. Intestine.—There is some experimental evidence to show that the intestinal wall neutralizes many of the toxic products that are generated in the bowel lumen. Insufficiency of this function would lead to autochtonous intestinal intoxication. It has also been shown that the injection of sterile fæces does not produce death so rapidly in animals which have been treated with intestinal extract as in animals which have not. The disintoxicating action of the cells of the intestinal wall is believed to be carried out with the aid of a soluble internal secretion which they produce. It does not seem improbable that the violent systemic disturbances of intestinal strangulation, volvulus, and invagination are in part due to insufficiency of this function and the resulting self-intoxication. The same applies to certain anæmias, psychoses, etc., which may be attributed to auto-intoxication from the bowel.

Extract of intestine has, in fact, been employed with some success in *chlorosis*, and in several cases of stercoræmic poisoning following *strangulation* of intestinal hernias. We are told that in a few of the latter cases the general condition of the patients improved so much un-

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der this treatment that operative interference was rendered more safe. This field of organotherapy also merits further cultivation.

6. PAROTID GLAND.—The parotid gland and the ovaries appear to stand in some sympathetic relation to one another. Parotid extract has been used with success by eminent clinicians in Germany and Scotland for the relief of certain symptoms due to ovarian disorders, notably the pain and reflex manifestations of ovaritis in cases in which the glands were enlarged and prolapsed.

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VI. MISCELLANEOUS TISSUES.

Nearly every tissue of the body has at some time been made to yield an extract. No exhaustive experimental or clinical data relating to their employment are, however, recorded excepting in the case of muscle tissue, lung tissue, and heart. We will therefore discuss these three alone.

1. MUSCLE TISSUE.—Muscle extracts contain abundant quantities of potassium salts and consequently are toxic when given hypodermically. In addition, muscle juice has a distinct thermogenic action and can produce salivation. Reliable investigators claim that small quantities of muscle extract prepared in the cold and sterilized under CO_2 pressure act as distinct muscle tonics.

Muscle extract has been employed apparently with some success in all primary myopathies in which there was no injury to the anterior horns or the peripheral nerves. A leading French neurologist recommends its use in all "*dystrophies musculaires progressives*" with lesions of the fibrillæ of the muscle and connective tissue.

2. LUNG TISSUE.—Pulmonary extract has been successfully employed in the treatment of pulmonary arthropathies. It is believed that destructive lesions of the lungs, in addition to interfering with the respiratory interchange of gases, inhibit the formation of an internal secretion of the pulmonary cells, and that the lack of this secretion in the blood leads to the development of the osteo-arthritic lesions of lung disease. Very good results are reported from pulmonary therapy in a case of Marié's disease (*ostéo-arthropathie hypertrophiante pneumonique*). The arthritic process was arrested, the dynamometric pressure rose from 9 kgm. to 19.5 kym., and the general health of the patient was markedly improved after the twenty-ninth injection. In pleuro-pulmonary suppuration with osteo-arthritis pulmonary extract is also said to act beneficially, and recently "pulmozyme," a pulmonary preparation, has been advised for the treatment of lesions of the lungs themselves. Case reports are scanty and results not uniform, so that judgment cannot as yet be rendered on this therapy.

3. HEART.—Heart extract was extensively used a few years ago in the treatment of a large variety of disorders. The effects claimed from the injection of this preparation were, among others, an increase in the pulse rate, a rise of arterial pressure, increased diuresis, and a general tonic effect. The extract used by the chief advocate of cardiotherapy unfortunately contained appreciable quantities of alcohol, so that we need not be surprised to learn that it exercised the above effects. The literature on cardiotherapy is large and many cures are reported. A careful analysis of the case reports, however, reveals the method to be utterly devoid of value and the claims of its advocates to be unfounded. Cardiotherapy is mentioned only to be condemned. *Alfred C. Croftan.*

ORPHOL. See *Naphtol-bismuth.*

ORRIS ROOT.—(*Rhizoma Iridis*, Ph. G.; *Iris de Florence*, Codex Med.) The peeled rhizomes of three or more species of *Iris* are cultivated for this object in the south of Europe, especially in the vicinity of Florence. They, and a few other species also, are familiar garden flowers both there and in this country. The three following are recognized as the sources of "Orris": *I. florentina* L., with very sweet-scented, white, or pale slaty-blue flowers; *I. Germanica* L., with dark, violet flowers; and *I. pallida* Lam., with flowers light blue, very large, and fragrant. They all resemble each other in respect to the more important particulars. The former is a native of the southern and eastern Black Sea regions, the others of Europe; all have been cultivated for a long time.

The rhizomes are gathered in the latter part of summer, trimmed and peeled, and then dried in the sun, and afterward separated into grades, according to size, symmetry, and appearance. The pieces are more or less long and flattened, with rounded surfaces and ends, often curved or twisted in drying, of a nearly white color, a hard but brittle texture, and a yellowish fracture. Pieces with the branches attached are called "hands"; the detached branches, "fingers." The scars where the roots have been cut away may be seen on the lower surface. Taste bitterish, aromatic, and sharp. Odor, for which it is valued, mild and pleasant, recalling that of violets. Orris which has been kept for one or two years is more fragrant than that just dried. This product has been for centuries used as a perfume, and less generally as a medicine, and is mentioned by most of the classical writers upon medicine. It yields, upon distillation, about 0.1 per cent. of a so-called volatile oil, "*orris camphor*," a buttery-looking substance. This consists chiefly of *myristic acid*, with a trace of *irone*, a liquid with a violet-like odor. *Iridin* is a glucoside, occurring in acicular crystals, in very small amount. There is a specific amaroid, giving the bitter taste. Orris contains also a little resin and fixed oil, and a very little tannin. Starch is abundant.

ACTION AND USE.—Internally given, orris, like our Blue Flag (*Iris versicolor* L.), is a cathartic and occasional emetic, but it is almost never employed in this way. It is a common ingredient of tooth powders, as well as of sachet powders (violet), and is otherwise used as a perfume. The oil is also used in tooth washes. Large, fine pieces are now and then given to teething children to chew upon. *Henry H. Rusby.*

ORTHIN.—This is one of the numerous compounds introduced for its antipyretic properties. It is a combination of hydrazin and para-oxybenzoic acid; the base is an unstable body, but the hydrochlorate is a stable preparation, and is the salt supplied under the name of orthin. It is very soluble in water. The solution should always be freshly prepared and preserved from the light. It is recommended as an antipyretic in typhoid fever, pneumonia, rheumatism, and all febrile disorders. Kobert, who introduced it into therapeutics (*Deutsche med. Wochen.*, 1890), claimed that it was non-toxic and free from all ill effects. Its use, however, has been accompanied by sweating, prostration, and other symptoms of poisoning. The dose advised by Kobert is from five to eight grains. *Beaumont Small.*

ORTHOFORM—meta-amido-para-oxybenzoic methyl ester ($C_6H_3.OH.NH_2.COOCH_3$)—is a white powder without odor or taste, and permanent in the air. It is soluble in alcohol, ether, chloroform, and some of the oils, but very slightly soluble in glycerin or water. It is precipitated, but not rendered inert, by formaldehyde and mercuric bichloride (Luxenburger), produces a brown color with bismuth subnitrate, and decomposes silver nitrate and potassium permanganate. It is not affected by zinc oxide, iodoform, salicylic acid, carbolic acid, lysol, aluminum acetate, or iodine, and may be safely combined in prescription with most of the ordinary antiseptics and dusting powders. It is said to remove most of the odor of an equal amount of iodoform.

Acting on the sensory end-organs, orthoform produces a local anæsthesia, which, owing to the insolubility of the drug, is mild and long continued. This slow action, together with a distinctly antiseptic power, makes it a valuable dusting powder for raw surfaces. It is therefore applied to burns, fissures, painful ulcers, ulcerating hemorrhoids, etc. The anæsthetic effect from a ten-per-cent. powder or ointment lasts for from two to forty-eight hours (Kindler). As the drug has no penetrating power,

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it is of little use on unbroken skin or mucous membrane. Blondel used a few drops of a saturated solution in forty-per-cent. alcohol for fissured nipples. In zoster or herpes with ruptured vesicles much relief is obtained.

In throat and nose work its use is chiefly limited to ulcerative conditions, though Cheatham reports good results in rose fever. Garnaud's formula for laryngeal tuberculosis is: Menthol 3.0 (gr. xlv.), cocaine alkaloid 0.5 (gr. viij.), orthoform 2.7 (gr. xl.), expressed oil of almonds, 100 (℥ iij. ʒ ij.). It is also used as a spray in five-per-cent. solution in albolene. In painful cancer and ulcer of the stomach it has been administered in dose of 0.5 (gr. viiss.) several times a day with relief from the pain and without any systemic effect. Suspended in water it has been thrown into the bladder for painful cystitis. In dentistry, its slow anæsthesia fits it for allaying the ache of an exposed nerve.

Orthoform is used in five to twenty per cent. powder, ointment, collodion, or solution in oil. Injected hypodermically in alcoholic solution it acts like cocaine, but the latter drug is generally preferred.

Ruhemann, H. H. Wilson, Vogt, Decker, and others who have extensively employed the drug, report the occasional occurrence, from its use, of a peculiar vesicular dermatitis resembling that from poison ivy and very resistant to treatment. Brocq observed hyperæmia and pruritus. Miodowsky had a moist gangrene following the application of a five-per-cent. ointment, and Friedländer collected fifty cases of local or general poisoning and eczema.

W. A. Bastedo.

ORTHOFORM, POISONING BY. See *Synthetic Poisons, Organic.*

OSMIC ACID.—In medical parlance the title *osmic acid* is given to the body *osmic tetroxide*, OsO_4. True osmic acid (H_2OsO_4) is not known in the free state. Osmic tetroxide is a volatile crystalline substance, softening at a moderate heat like wax, and melting at a lower temperature than does that body. It dissolves slowly but completely in water, forming a colorless solution, which, however, on exposure to light, rapidly darkens, even to blackness, by decomposition of the tetroxide with formation of the tetrahydroxide, $Os(OH)_4$. Osmic tetroxide is a powerful oxidizer, and, to living tissues, is excessively irritant. Its odor is powerful and disagreeable, and its vapor intolerably pungent and poisonous, with a peculiar faculty for exciting irritation of the conjunctiva. In the event of the inhalation of fumes of osmic tetroxide, hydrogen sulphide ("sulphureted hydrogen") has been recommended as a chemical antidote, to be taken by inhalation; but since in this case the remedy is itself a powerful poison, the greatest care would be required in its employment.

Osmic tetroxide is of peculiar service to the histologist, by reason of a faculty it possesses of staining nerve tissue. As a medicine it has been used, by hypodermatic injection, for the relief of peripheral neuralgias. The results have been quite variable, but a certain amount of efficacy for the remedy seems to have been demonstrated. A one-per-cent. aqueous solution of the tetroxide is used, and the same should be made only in small quantities when wanted, and kept in the dark. Of such a solution, quantities from 0.20 to 1 gm. (from ♏iij. to ♏xv.) have been injected at a dose. The injections are made as near as possible to the painful spot. The operation is often severely painful, is occasionally followed by temporary swelling and thickening of the tissues at the site of the puncture, and, practised over an efferent nerve, has in one instance been followed also by paralysis. No constitutional effects have followed these injections.

Edward Curtis.

OSPEDALETTI, ITALY, a town of one thousand inhabitants, with nearly a mile of frontage toward the sea, is situated midway between Bordighera and San Remo. It is a quiet Riviera resort, lying under the spurs of the Ligurian Alps, well sheltered from the winds and with a southern exposure. "There is no doubt," says Dr. Wendt, in an article upon this resort in the previous edition of the HANDBOOK, "that little Ospedaletti is more effectually protected from winds than almost any other resort on this coast. Moreover, it gets the sun early and keeps it late. There is less blinding calcareous dust there than, for example, at Hyères, Cannes, or Nice."

"Ospedaletti spreads out for something like a mile along the head of a small crescentic bay. The eastern headland of this bay is formed by Cape Nero, and the western extremity, much farther from the village than the former, by Cape Sant Ampeglio. Thickly planted olive hills surround the place, relieved in the plain by orange and lemon trees, and the usual array of graceful palms. Successive girdles of mountains protect it from the icy north blasts, but less in a northeasterly than in a northwesterly direction. It is fully exposed only to the warm westerly marine breezes." "Immediately behind this village there rises a hill of gentle slope, and a number of mountain torrents of mild proportions trace their undulating course seaward." "The place is so hedged in as to constitute a veritable sun trap." "For undergoing a course of absolute quiet and repose," continues Wendt, "in a sunny, well protected situation, no more suitable place has yet come to my notice on the Riviera."

The hygienic conditions of Ospedaletti appear to be good; the town is spoken of by Linn as having a particularly clean and neat appearance. The drinking-water comes from the same mountain source as that which supplies San Remo, and is "soft, sparkling, and pure." The mean temperature of five winters is given by Linn ("The Health Resorts of Europe," by Thomas Linn, M.D., 1901) as follows: January, 49.82° F.; February, 51.62° F.; March, 53.42° F. The mean relative humidity is 62 per cent., and the number of rainy days, 32.

There are several hotels and pensions of moderate price, well kept, and very comfortable. There is also a fine casino. Medical service can be had there. A short distance from the village are some hot sulphur springs. "Gouty and rheumatic elderly people," says Wendt, "should do particularly well at Ospedaletti." Linn states that this place is rapidly coming into favor as a resort, and it seems to combine very many favorable conditions for a winter health station, viz., its fine natural situation, its pleasant surroundings, its excellent protection from cold winds, the large amount of sunshine, its near proximity to San Remo and Bordighera, and the quiet and repose obtainable there. Moroever, it is said to be two degrees warmer than its neighbors, Bordighera and San Remo.

Edward O. Otis.

OSTEITIS, OSTEOMYELITIS, PERIOSTITIS.—I. OSTEITIS.—Inflammation of bone may be induced by simple traumatism—as a fracture or stripping away the periosteum, by thrombosis or embolism of a nutrient artery, by extension from a periostitis, by extension from arthritis, by exposure to cold or to the action of certain poisons—as phosphorus and mercury, by syphilis, by pressure—as the rarefying osteitis of aneurism, by the eruptive fevers, and especially by typhoid fever. While these fevers may possibly act as primary causes, it is quite certain that they predispose to the development of an osteitis. Lastly, certain germs play an important part in the causation of an osteitis. They are either introduced through compound injuries, or else they are carried to the bones by way of the circulation. The emphasis which should be laid upon this last factor in the causation of osteitis cannot be exaggerated.

It is of little clinical value to classify the inflammations of bone, from an anatomical standpoint, into osteitis, osteomyelitis, and periostitis, since primary periostitis, with the exception of the traumatic and the syphilitic varieties, is very rarely observed; and, on the other hand, every case of myelitis leads, sooner or later, either rapidly or slowly, to involvement of the periosteum in the inflammatory process.

Regarding the firm bony substance itself, when compared with the marrow and the periosteum, it may be

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truly said not to take any active part in inflammation; and therefore osteitis, in a narrower sense of the word, as compared with myelitis and periostitis, is unimportant. The firm bone, however, is passively affected, as we shall subsequently notice; and clinically the death of the bone, or of a part of it, may prove to be an affair of the greatest gravity. So much is this true that it has been customary to study acute osteitis under the title of one of its most frequent results—necrosis—and a certain form of chronic osteitis under the heading of caries.

II. PERIOSTITIS.—Periostitis, like osteomyelitis, may originate from traumatism, either simple or compound, and in character may be simple (that is, aseptic) or septic (from the presence of micro-organisms). The syphilitic variety of the disease should probably be classed under this latter heading, although we cannot to-day speak with certainty as to its germ origin. The periosteum is first affected during the secondary stage of syphilis, that is, the stage of invasion following the incubation of the syphilitic virus in the system. Those bones which are subcutaneous seem especially liable to periostitis—for example, the tibia, sternum, and ulna; but the others are not exempt. In severe cases there sometimes appears to be a simultaneous involvement of most of the bony sheaths of the body, with consequent almost unbearable osteocopic pains. These pains are distinctly worse at night, and seem to be increased by warmth; but I am inclined to think that sufferers from osteitis and periostitis of other than syphilitic origin also complain most at night.

The syphilitic periosteum is quite tender, and I have many times noticed pitting on pressure. In this disease it is rare for the periosteum to become separated from the bone by exudations; and consequently necrosis, from failure of the superficial blood supply, is very infrequent in this form of periostitis.

In the later or "tertiary" stages of syphilis, nodes, usually flat, and of sharply defined extent, sometimes make their appearance. They are caused by infiltration of the periosteum with small round cells, and, like all gummata, tend to soften and break down. Their course, and the probability of bone involvement, seem influenced for the worse if the medical attendant, finding fluctuation, use the knife instead of rapidly pushing the iodides or other appropriate medicines.

In acute periostitis, when accompanied by free exudation of fibrin, serum, and pus, the cortical lamellæ of the Haversian systems may be separated from their vascular supply; and unless the surgeon promptly realizes the state of affairs, and makes free incisions down through the dense, unyielding periosteum to the bone, a necrosis of more or less superficial character may, and often does, result.

The clinical picture of acute periostitis is best studied, as it will be later, together with osteomyelitis; for these two diseases are commonly associated together.

A rather rare concomitant of an acute osteomyelitis, usually of a mild type, is a periostitis with exudation of a simple serous character between the periosteal sheath and the bone. Because of the abundance of albumin in this fluid, Ollier here adopted the title of "osteitis albuminosa."

Chronic, non-infective periostitis may be either fibrous or ossifying in character. In the former there is much increase in the amount of connective tissue, and the thickened membrane adheres unusually closely to the bone. In the latter we have as a result an ossific deposit, which may go on increasing for months or even years, ultimately producing exostoses or osteophytes. The new bone of inflammatory origin is not deposited in a regular system of lamellæ, probably owing to faulty nutrition; and it is sometimes absorbed, and disappears, the abnormal activity of the osteoblasts ceasing. This variety—ossifying periostitis—may be associated with either rarefying or condensing osteitis.

With regard to tuberculous periostitis I may state that it is especially apt to appear in the subjects of the so-called scrofulous diathesis, and in the poorly nourished, and to be accompanied by tuberculous osteitis. The discussion of its symptoms, course, and treatment need not be dissociated from that of the latter disease.

III. OSTEOMYELITIS.—The terms osteitis and osteomyelitis will here be considered as one. Where the vascular changes greatly predominate, where pus, fibrin, and serum are abundantly produced, where the brunt of the inflammation is felt by the marrow and contents of the Haversian spaces, the latter term may be applied with especial propriety. And, on the other hand, those cases in which changes in the firm bony structure itself form the prominent feature, may properly be designated as cases of osteitis. However, the two go hand-in-hand. Changes in the relative density of the bony structure can occur only through cellular activity in the marrow spaces and vascular canals. These changes are of two kinds: osteoporosis, or rarefying osteitis, and osteosclerosis, or condensing osteitis. In the former the character of the bone changes from compact to cancellous, and if the process continue the bone may even entirely disappear, its place being taken by a mass of granulation tissue. This variety of osteitis is very common. It is one of the essential phenomena in tuberculous osteitis; it is the process by which the rough, ossified callus following fractures is rounded off; and when a bone is subjected to pressure—as by a growing aneurism—it is a rarefying osteitis by which it is eroded.

In osteosclerosis, on the other hand, the bone grows more compact, and may even—as may be observed in some exostoses—become as dense as ivory.

It often happens that both osteoporosis and osteosclerosis are going on at one and the same time in different parts of the same bone: an osteoporosis within, for example, and an ossifying, even condensing, periostitis externally; and as a result the bone may become widely expanded, although it is a mere shell filled with granulations or with inflammatory deposits.

Or, again, following an osteoporosis, the opposite process may be inaugurated, and the cavities caused by the former morbid process may become filled with new bony deposit, perhaps of even abnormal density. We do not yet know why inflammation of bone terminates sometimes in one and sometimes in the other of these conditions. It is supposable that in condensing osteitis the osteoblasts have an undue activity. In rarefying osteitis the absorption of bone is thought by some pathologists to be caused by the presence of certain large, multinucleated cells—the myeloplaxes of Robin; cells which are also by reason of the power which they are supposed to possess called osteoclasts. In subacute osteomyelitis ragged holes, opening from the marrow spaces and Haversian canals, are formed in the solid bone. These cavities are known as the caverns or lacunæ of Howship. They contain many of the so-called osteoclasts, which, if not the cause, are certainly the witnesses of the osteoporosis.

Other pathologists repudiate the idea that these large cells possess any such power, and attribute the absorption to the influence of the new granulation tissue which is present in these cases, and which lies in contact with the bone. In agreement with Billroth they hold that just as a granulating synovial fringe erodes the articular cartilage against which it rests, "like ivy climbing over a ruin," so here in bone the granulations possess a similar disintegrating power.

In acute osteomyelitis the vascular changes are of the deepest import, since obstruction of the nutrient arteries means death of the bone *en masse*. Let us study the common cases of apparently spontaneous origin. Here the marrow tissue is at first of a deeper red, from intense congestion. Sometimes it is mottled with hemorrhagic spots. Later, a grayish hue appears, due to the presence of great numbers of pus cells; and occasionally little medullary abscesses develop. In bad cases not only does thrombosis of the nutrient vessels occur, but gangrene of the marrow and of the contents of the Haversian canals also takes place, with rapid liquefaction. The bone cells being no longer nourished die. The infection may spread rapidly, involving the whole length of the bone.

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or, in the milder cases, it may remain limited to a comparatively small area.

Usually the process begins in the bone, and extends thence along the course of the nutrient vessels to the periosteum, which then becomes involved. Some surgeons think that the infection spreads also through the canaliculi, from bone cell to bone cell, and from centre to surface.

Sometimes the reverse is the case, the periosteum being first attacked. Inflammatory products—pus, fibrin, and serum—rapidly strip the swollen and œdematous periosteum from the bone, inducing the most frequent form of necrosis, that of the superficial lamellæ.

The pressure caused by the exudations is very great; so much so that fat contained in the medullary tissues may be forced out, and can sometimes be seen in globules upon the surface of the pus (Roser).

The pus finally breaks through the periosteum at some point of softening and disintegration; it enters the intermuscular connective tissue, and may finally reach the surface. In that case the pus can sometimes be seen to pulsate from its contact with the richly vascular medullary substance.

When the osteomyelitis is near a joint, the articular lamella may become involved by extension, perforation through the cartilage may occur at some point, and the most dreadful arthritis ensue. In the very young, separation of the epiphysis from the shaft may, after a week or two, occur. The cartilaginous epiphysis, from its comparative lack of vascularity, is not so subject to attack as is the adjacent bone; yet even this may die.

Those parts of the bone which are cut off from their blood supply die in consequence; and this necrosed bone, upon its subsequent separation, is called a *sequestrum*. Next in frequency to the cortical sequestrum is the central sequestrum—that composed of the bone surrounding the main medullary canal. In extreme cases the whole thickness of the bone, or even the whole bone, may die. This separation of living from dead bone occurs, however, only at a much later period. On an average from three to five months is required for the complete separation in the case of a young adult. The length of this period of time also varies according to the extent of the involvement and the degree of vascularity. In the elderly, the same separation may need, perhaps, as long a period as one year for its accomplishment.

Along the line of demarcation between living and dead bone, granulations spring up; they start from the blood-vessels. The granulation tissue seems to possess the power to erode and absorb the dead bone with which it is in contact, until at last the sequestrum lies loose upon a bed of granulations springing from the sound bone. In the process of solution of the dead osseous substance, whereby separation is effected, certain salts—such as calcium phosphate—which are not soluble in an alkaline medium, are dissolved and disappear. Hence it is thought that the granulations evolve an acid. Formerly it was believed that lactic acid was the solvent. Tillmanns' later researches seem to show that it is the active, nascent carbonic acid contained in the blood which dissolves the dead bone tissue; and that, in the accomplishment of this, aid is derived from the activities of the osteoclasts.

Unfortunately, this process of absorption is extremely slow, so that we can hardly hope for the complete disappearance of even a moderate-sized sequestrum. Evidences that a certain amount of absorption has already taken place are found, however, upon almost all loose pieces of dead bone.

When a sequestrum lies near the surface of the body, nature is sometimes able to extrude it, and new bone, the *involucrum*, is formed from the granulation tissue, and pushes the sequestrum out. More commonly, however, it cannot escape. The greatest growth of involucrum springs from the periosteum, save in those cases in which the bone-forming layer of the periosteum has been destroyed by the suppurative process; and this new bone of periosteal origin, while it strengthens the shaft as a whole, prevents the escape of the sequestrum. The reason for the failure of a central sequestrum to be ejected is obvious.

For mechanical reasons, therefore, nature cannot, as a rule, complete a cure after separation of the sequestrum. Consequently, if the surgeon do not interfere, there will continue to be, for an indefinite length of time, a discharge of pus through more or less tortuous openings, called *cloacæ*. As regards the kind of interference which is needed, I will simply state briefly that the surgeon must chisel, saw or drill through the ensheathing involucrum (involving the transverse diameters as little as may be) and release the imprisoned dead bone. It is very unwise to delay interference after the cast-off bone is found to be loose in its cavity, since the patient is thereby subjected to serious danger from exhausting suppuration, from amyloid degeneration of the viscera, from involvement of the neighboring joints in the inflammation, and from hemorrhage, through mechanical erosion of some large nutrient vessel by the jagged sequestrum.

Causation.—Although we have discussed to some extent the pathology of acute suppurative osteomyelitis, we have not as yet dealt with its true cause. The question arises, Have we not here to deal with microbes? Numerous accurate investigations of the pus obtained either directly from the medullary canal or from the depth of the tissues immediately in contact with the bone, and subsequent pure cultivations, have settled this question definitely. "It is not due to a specific poison, however, as was believed to be the case for a long time, but it may be caused by any kind of micro-organism which excites acute inflammation and suppuration" (Tillmanns). Among these the variety most frequently found in cases of this nature is the staphylococcus pyogenes aureus; less often the staphylococcus albus and staphylococcus citreus; and rarely the pneumococcus, the bacillus communis coli, Eberth's bacillus, the typhoid bacillus, the bacillus pyogenes fœtidus and pyocyaneus, and the micrococcus pyogenes tenuis and tetragenus. Although I mention the pyogenic streptococci last, they are far from being the least in importance. They are found chiefly in the osteomyelitis of young children, and this type of the infection is very apt to prove promptly fatal from sepsis.

How are we to explain the entrance of germs into the bone without an apparent traumatism as a doorway? The only plausible assumption seems to be that they pass into the blood through slight abrasions of the mucous or other tegumentary surfaces of the body and eventually find lodgment in the bone. Clinical facts support the theory that, preceding osteomyelitis, patients will be found to have suffered from bronchitis, enteritis, etc. (Kocher).

The majority of cases of this disease, with the exception of suppurative myelitis in connection with compound fracture, occur during the time of the development of the skeleton—*i.e.*, during childhood and adolescence. One is inclined to think that the physiological growth of the bone predisposes to inflammatory processes. This theory finds support in the fact that in most cases of acute and chronic myelitis the disease is found to be near the epiphyseal cartilage, and therefore in the most newly formed bone. It furthermore seems to appear with greatest frequency in that end of a long bone which furnishes the greatest amount of growth, and in which the current of blood is least active. It is commonest in the upper end of the tibia and the lower end of the femur; and in the upper end of the humerus and the lower end of the radius and ulna. It will be remembered that the nutrient arteries of the long bones of the lower extremity run *away* from the knee; and in the upper extremity they run *toward* the elbow.

The selection of the youngest bone tissue as the favorite nidus of the microbes seems dependent upon the peculiar form of the developing blood-vessels. It will be found upon investigation that the sprouting blood-vessels of the growing long bone correspond to wide, hollow spaces close to the epiphyseal cartilage. It will be easily

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seen that the blood current grows less rapid in these lacunæ, where the capillaries enlarge, thus giving the cocci contained in the blood a better opportunity to adhere and remain. It is further stated (Hoyer, Rindfleisch) that the blood of the medullary canals flows unenclosed by any tunic in these spaces, and thereby the cocci are brought into direct contact with the bone.

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Schiller has demonstrated by a series of experiments that coloring matter introduced into the circulation is retarded in its course and deposited in the blood-vessels of the youngest bone tissue; thus showing, as Hueter says, that there is a tendency for the cocci contained in the blood to be left at this point as a sediment. This being so, we can readily understand how the infection of the young medullary substance occurs.

Clinical Picture.—Sometimes exposure to cold, a wrench or a blow, exhaustion from eruptive fevers, etc., may act as predisposing causes, determining either the time or the seat of the attack, or both. Or, again, no cause whatever may be discoverable. In any case of acute, suppurative osteomyelitis the actual and exciting cause is probably always bacterial.

The disease usually begins with one or more chills, followed by fever, which is often very high. In a child delirium is common, and the little sufferer may not be able to point out the seat of pain, which, however, rapidly becomes severe.

With the intensity and mode of infection, and the degree of vital resistance possessed by the patient, the symptoms vary. He may even die within a day or two, overwhelmed by the poison. To rather less severe cases, from a resemblance in the violence of their onset and symptoms, Chassaignac has given the title "typhus des membres." Later, and in more insidious cases, typhoid fever may be simulated. There may be some slight resemblance to a cellular erysipelas. In not a few instances, owing to the fact that the constitutional manifestations alone were taken into account, a dozen other diagnoses—some of them quite absurd—have been made.

Repeated rigors and pyæmic temperatures may point to the involvement of more than one bone, or to suppurating foci elsewhere, and pyæmia, septicæmia, ulcerative endocarditis, etc., may develop in the worst cases, especially in the absence of prompt surgical intervention.

Diagnosis.—The disease with which that under consideration is most often confounded is acute articular rheumatism, and this mistake is especially likely to occur when more than one long bone is attacked. The local symptoms, however, will soon clear up the diagnosis, unless, owing to delirium of the patient, or to the fact that he is too young for speech, attention is not called to the real seat of suffering. Rather near the articular end of the bone, as a rule, a distinct swelling is soon observed. This is caused first by the great congestion and œdema of the periosteum and adjacent tissues, and later by the separation of the periosteum from the bone by inflammatory products. While the tenderness over this swelling is very marked, it does not extend beyond the limits of the tumor. Furthermore, unlike what is observed in acute rheumatism, motion of the neighboring joint is not specially painful. The skin over the swelling is not reddened at this time; it may even be paler than normal. Later, when the pus is about to escape through some disintegrating point of its dense sheath, the skin becomes reddened, softened, and gives way.

Acute Epiphysitis.—Acute epiphysitis presents problems of the gravest importance. In addition to the risk of a suppurative joint trouble, by extension, the focus of infection—whether it begins in the shaft or in the epiphysis—is commonly close to the narrow line of cartilage which connects the two. The importance of this lies in the fact that if the cartilage become severely involved in the inflammation there may result a diastasis—*i.e.*, a separation of the epiphysis from the shaft, with dislocation, a condition which demands the utmost care and the most skilful splinting to prevent a final deformity from union in a bad position. Even when the involvement of the cartilage is somewhat less grave, if the normal cellular activity in the vicinity of this narrow line of cartilage be permanently impaired or destroyed, growth of the bone, so far as this end is concerned, will cease. And the seriousness of this circumstance is still further enhanced by the fact that the greater portion of the growth of the long bones takes place normally from that end which is most subject to attacks of acute osteitis. For example, in the case of the long bones of the extremities the ends which are nearest the knee, and farthest from the elbow, supply most of the growth, and are also more subject to acute osteitis than are the opposite ends. And—to mention a single instance only—von Bruns has collected evidence which shows that diastasis of the femur from all causes occurs in the proportion of twenty-eight cases of separation of the lower epiphysis to one of the upper. And according to Ollier, the development in length of the thigh bone is about two-thirds from the epiphyseal cartilage of the lower end and one-third from that of the upper end. When it occurs in a little child, a diastasis of the lower end of the femur, even though the separated parts are properly replaced and adequately splinted until bony union shall have taken place, may result in a shortening of as much as nine inches; whereas if the diastasis occurs at the upper end, the records show that only about half this amount of final deformity results. These are facts, therefore, which it behooves the physician in charge to know in order that he may, for his own protection, and especially in view of the possibility of a suit for malpractice, give timely warning to the parents.

Treatment.—As regards the treatment of acute epiphysitis, prompt surgical intervention and careful splinting to prevent diastasis are the only means worth mentioning. On the other hand, the proper management of the sequelæ will depend upon the precise character of the pathological conditions left by the acute disease. A problem very difficult to solve is that which is presented when the epiphyseal cartilage of only one of the two bones (of either the forearm or the leg) is involved by the disease. In such a case growth will be entirely arrested in one bone while it will continue to take place in the other. Under such conditions the ultimate result—if the parts are left to themselves—can scarcely fail to be a dwarfed and grotesquely twisted limb. Surgical intervention may be resorted to at a relatively early period, with the idea of preventing the evil to which attention has just been called, or surgical measures may be adopted for the correction of the deformity after it has been fully established.

In the former case the surgeon, having to do with a case of diastasis, should—after all suppuration has ceased—chisel through the thin plane of cartilage of the neighboring or sound bone of the same extremity. This stops the growth of that bone, and results in a straight though shortened limb. On the other hand, if interference is postponed until the deformity shall have reached its full measure of development, the surgeon will have to tax his ingenuity by the employment of various means (chiselling, aseptic fracturing, resection, etc.), to overcome in a measure the extreme deformity so commonly found at that time.

Something further needs to be said about the treatment of acute osteomyelitis in its incipient stages. In the first place, it must be borne in mind that the inflammation, in a case of this nature, has already produced, or is soon to produce, pus, and that this pus is confined beneath dense, unyielding tissues. The indication is therefore plain: the knife must be used, and that too with as little delay as possible. A free cut should be made through the periosteum, clear down to the bone; and with a dressing forceps entered closed and withdrawn opened, the wound should be enlarged for free drainage. Then it should be irrigated with some antiseptic solution—bichloride of mercury 1 to 2,000, for example—and, if the incision has been made through deep tissues, a drainage tube is to be inserted down to the bone. Otherwise the wound may be packed loosely with wet antiseptic absorbent gauze.

When, in 1854, Chassaignac and other French surgeons

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advocated a similar free incision, their advice was followed by disastrous results; generally by pyæmia and death. That was before the days of antisepsis. To-day, any surgeon who knows what surgical cleanliness means can make such an incision without threatening the life of his patient; and it is, in fact, his duty to employ the knife. Whether this incision alone will be of much value will depend upon whether the infective nidus was situated in the periosteum, or whether that membrane was only secondarily involved by extension of inflammation from the marrow. The latter supposition is in most cases the correct one, and may be considered almost a certainty if drops of free oil be observed between the periosteum and the bone—it evidently having been forced out by the tremendous pressure within the bone.

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It is well to wait a very few hours after cutting down to the bone, rather than to penetrate at once to the marrow; unless indeed the violence of the onset seems to the operator disproportionate to the amount of trouble thus far discovered, in which case delay would add to the peril. If, at the end of this period of delay, the local and general symptoms seem aggravated, or at least not diminished in intensity, showing that the trouble is within the bone, and not mainly periosteal, then the trephine should be used, or the burr or chisel, and the marrow should be exposed, curetted just as far as it appears to be diseased, irrigated, and freely drained. This should be done at several places if the disease seems to be extensive; and it should be followed by continuous irrigation with solutions of bichloride of mercury, or of acetate of aluminum, of appropriate strength—this irrigation to be kept up until the more severe symptoms shall have subsided.

Such treatment seems radical, but is really conservative of the patient's limb, and very possibly of his life.

The constitutional treatment consists simply of measures intended to support the patient's strength. It is, perhaps, of little avail to give antiseptics; still, the safer ones—as benzoate or salicylate of soda—may be employed. It may also be well to use free inunctions of the Credé liquid silver ointment. The writer's experience has not been favorable to the injection of antitoxin serums in such cases.

As regards those cases which are seen at a later stage and in which the disease is complicated by the presence of a certain extent of necrosis of the bone tissue, the practical questions which present themselves are these: How is the existence of such a bone necrosis to be ascertained? and, What steps are to be taken for the relief of the condition after we have discovered its existence? By the intelligent use of the flexible silver probe—or, in certain cases, of two probes—the surgeon should have no difficulty in ascertaining that a necrosis exists, and also occasionally in determining how great is its extent, and whether the necrosed portion is or is not loose. In other instances, however, he will be forced to resort to an explorative operation in order to determine to how great an extent the bone is necrosed, and whether the sequestrum has become sufficiently detached to warrant the adoption of radical surgical measures for the removal of the dead bone. Furthermore, in reaching the latter decision he will have to weigh very carefully the question how far the patient's health is being undermined by the constant discharge of pus which invariably accompanies the separation of the dead from the living bone.

The late Prof. Thomas M. Markoe, in his article on "Necrosis" in the first edition of the HANDBOOK, expressed himself as follows in regard to the steps which should be taken in the presence of a necrosed condition of the bone:

"Having now settled the question as to the propriety of operation, the time of its performance may be considered. As a general rule, it is better to remove the sequestrum just as soon as it can be ascertained to be loose. But if the patient be much reduced in health, if the season be unfavorable, and if the discharges and the sufferings from the local disease be not excessive or exhausting, then it is quite proper, and generally quite safe, to wait until, by careful attention to nutrition, by fresh air and exercise, perhaps by change of air and surroundings, we secure a better reparative condition of the system, in view of the often serious operation which is contemplated. If there be no considerations of this nature, the operation should be undertaken without unnecessary delay.

"The operation itself consists in releasing the sequestrum from its mechanical confinement within the tissues, and removing it. The operative procedure will vary, therefore, with the extent and solidity of the tissues enclosing the sequestrum, and with the accessibility of the sequestrum from the surface. In most cases of superficial necrosis, or exfoliation, it is only necessary to divide the soft parts covering the dead piece in order to remove it with great ease. This, however, is not always the case in exfoliation, for it sometimes happens that the dead plate extends on the sides of the bone far from the surface, and it occasionally occurs that a thin plate of superficial necrosis surrounds completely certain portions of the shaft of the bone, thus producing a condition of things which renders operation extremely tedious and severe, and, not infrequently, even then the entire removal of the deepest portions of the sequestrum is not accomplished.

"To take a typical case of necrosis of the shaft of the tibia, where the diagnosis is clear, the involucrum sufficient, and the sequestrum entirely separated, the steps of the operation may be described as follows: A free incision is made on the anterior surface of the limb, where the bone is most superficial, and this incision should extend as far as the supposed limits of the necrotic action, and may be crossed by another at about its middle, so as to give easy access to the surface of the involucrum. The flap then being dissected up clean from the exposed bony surface, we select the most favorable point for attacking the bone case enclosing the sequestrum. This is generally to be found at one of the larger cloacæ, which, being further enlarged by the chisel or gouge, soon gives us access to the cavity in which the dead bone lies. By means of this first exposure of the cavity we learn the size, the degree of freedom, and the extent of the sequestrum, and we take our measures accordingly. If the sequestrum prove to be very long, then the incision through the involucrum must be extended so as, if possible, to release it without breaking off any of the irregular and slender processes in which it terminates. About this the operator should be extremely careful, as, if any of these fragments are left in the bottom of the wound, they are apt to give trouble, and if we cannot reach and remove them with slender forceps they are frequently a long time in making their way to the surface, during which time, of course, the wound will not heal. In exposing one of these large sequestra, it should be borne in mind that restoration of the involucral bone which we are cutting away takes place to only a very limited extent, particularly in those who have passed the earlier periods of life. It must be remembered that nature has already, in forming the involucrum, accomplished a very elaborate and extensive restoration of bone, and if we destroy this new formation she will hesitate about repeating the process. In point of fact, we find that the cavity left after these operations does not, except in very young subjects, fill up with bone, but rather with a firm, fibrous, cicatricial tissue, which, while it fills up the gap left in the bone, contributes very little to its strength. We must be careful, therefore, not to weaken the bone by any unnecessary cutting in its transverse diameter, though in the longitudinal direction we may proceed with more freedom. The cutting is done most satisfactorily, I think, with a gouge, though if a cloaca is not in a favorable position for enlargement a small trephine answers a good purpose in making the first opening through the involucrum. The gouge and the rongeur, however, will be all that in most instances will be required. After the removal of the sequestrum a careful examination should be made with the finger and the probe, to make sure that no fragments remain, and that no cavities are left without sufficient openings to secure drainage."

By way of supplementing the remarks quoted above I

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will state that it is important, after laying bare the bone, to curette away the entire granulating surface, and to sterilize the living bone, thus laid bare, by peroxide of hydrogen or other effective means. Often such curetting lays bare the entrance to more than one chamber containing sequestra. There may even be a chain of such running along the marrow. And unless the operator makes sure by probe and curette that this is not the case, his work, in removing the first sequestrum exposed, may prove by no means a success; and a continuing discharge of pus will show that he has not removed the whole cause. Following these steps, it is possible by at least nine different ways to treat the bony cavity in an endeavor to hasten its healing. (1) The old-fashioned way of simply packing with gauze to compel healing from the bottom. (2) Neuber's plan of "deep canalization." (3) Schede's healing by the moist blood clot. (4) Thiersch's skin-grafting directly upon bone. (5) Lücke and Bier's "osteoplastic necrotomy." (6) Healing by aid of decalcified bone chips. (7) Autogenetic fresh bone chips (human). (8) Heterogenetic fresh bone chips (rabbit or calf or lamb, for example, have been used). (9) Heteroplastic fillings. These are still largely in the experimental stage; but we may mention sterilized plaster-of-Paris, bone charcoal, iodoform starch, dental gutta percha, and Richter's cement. Upon the skull the writer has successfully used a specially prepared celluloid plate, deprived of all excess of nitric acid, and substituting in its composition a little synthetical urea for the more irritating camphor, to give resiliency. The lack of space permits us to discuss briefly only two or three of these nine methods.

According to Neuber's plan, which has for its object a material shortening of the tedious healing by granulation, the integument and subjacent connective tissue, for a short distance on either side of the wound, should be stripped up in the form of flaps, and then these should be stretched in such a manner as to cover, either entirely or at least to a large extent, the excavation left in the bone by the removal of the sequestrum. They may be retained in place by nailing them to the bone. The deep trough-like depression in the skin which remains after healing takes place soon grows shallower through the development of connective tissue between the bone and the skin; and eventually this connective tissue is supplanted to a greater or less extent by newly formed bone.

A still more recent method is that for which Schede deserves the credit. It consists in allowing the wound, after removal of the sequestrum, to fill entirely with blood clot. This, under perfect asepsis, does not break down or putrefy, but undergoes rapid organization, blood-vessels springing into and permeating it from all sides. This idea, in properly selected cases, proves an excellent one. It is, of course, unsafe unless accompanied by absolute sterilization of the cavity and by protection from atmospheric germs.

Thiersch's method of skin-grafting directly upon the bone is frequently successful in hastening a cure. As with Neuber's plan, nature, in the course of time, deposits new bone beneath the skin, and to a large extent fills up the deep depression left by the removal of the sequestrum.

Still another recent plan which deserves to be mentioned here is that of Lücke and Bier. It is spoken of as "osteoplastic necrotomy." In the execution of this plan the long bone is sawn transversely with the wire saw, half-way through at two points, viz., just above and just below the seat of the necrosis. These transverse lines are connected, on one side, by a longitudinal one, and along this latter line the chisel is used, until the cavity of the bone is opened; then, by depressing the handle of the chisel, the rectangular flap of bone and superjacent parts is broken loose along a line opposite to that made by the chiselling, and is temporarily turned back like the lid of a box; and, finally, as a last step, the sequestrum is to be extracted. The cavity in which it lay must next be well curetted and irrigated, and then, after provision has been made at the most dependent point for free drainage, the lid-like flap mentioned above is to be restored to its natural position.

There are certain subacute and chronic cases of osteomyelitis, limited in extent and indicating a mild degree of bone infection, which deserve mention. They are accompanied by more or less pain and tenderness of the bone over a small area, and this may continue for months and years with slight or no constitutional symptoms. In some of these cases, called "Brodie's abscess," the pus may finally reach the surface, or may remain permanently surrounded by compact bone; an osteoporosis has occurred, sufficiently great to hollow out a pus cavity, usually lined with granulations; but commonly no necrosis—no death *en masse*—takes place. It may be that a few of these abscesses represent the site of softened and broken-down gummata of late syphilis.

The treatment is self-evident. By means of the trephine the cavity is to be reached and drained. Even supposing the diagnosis to be erroneous; supposing the case to be in reality that uncommon disease, a neuralgic osteitis—one in which a chronically congested vascular state in the bone seems to induce nerve dystrophia and consequent neuralgia,—experience proves that penetration of the bone gives the surest relief, and is a safe operation.

Rheumatic Osteitis does occur, but is very infrequent, and is apt to be secondary to rheumatic periostitis. The coexistence of rheumatism elsewhere in the fibrous framework aids the diagnosis. Heat, counter-irritation, and, as a last resource, opening the bone, give the greatest relief, and should be conjoined with the usual purely medicinal and hygienic means of treatment.

Syphilitic Osteitis presents itself chiefly as a result of gummatous involvement in the later stages of the disease. It is also, however, to be noted as one of the manifestations of inherited syphilis. The osteochondritis of infants, first described by Wegner, is a frequent manifestation, as is also dactylitis syphilitica. Regarding the former, Taylor states that it is often the only sign of this inheritance; and that at other times its presence decides the syphilitic nature of coexisting lesions. It involves chiefly the shafts and epiphyseal junctions of the long bones; and is usually found at birth or within the following month. The swellings are rather distinctly limited, as a rule, and the baby suffers when they are handled. In bad cases separation of the epiphyses, suppurative osteomyelitis, and necrosis may develop.

The dactylitis when present affects mainly the first phalanges. It differs from the tuberculous variety in this regard, as also in the fact that when luetic it is apt to be multiple, and to appear upon both hands.

"Parrot's nodes," involving the two halves of the frontal bone and the two parietal bones, are found in infancy, and are due to the same cause. These swellings, upon all sides of the anterior fontanel, are very characteristic, and are caused by both a periostitis and an osteitis of these bones.

In later childhood and in adolescence are found the bony irregularities, hypertrophies, and asymmetries which often are so characteristic of syphilis. In the face, the nasal bones are those which suffer most. As a result of necrosis of the bony support the nose undergoes shortening, the lower part retreating toward the upper part; or else the bridge is sunken. Of the remaining parts of the skeleton the tibia presents the most striking of these late bony inflammatory changes due to syphilis. It may be greatly thickened, its crest being no longer a mere ridge, but broadened and swelling forward, so that when seen from one side the tibia presents the characteristic shape of a sabre.

For a fuller study of the bony stigmata of this disease, including the pathology and clinical course of gumma of bone, the reader is referred to the article upon *Syphilis*.

Necrosis of the Jaws Dependent upon the Action of Phosphorus.—This is a condition which the surgeons of the present generation rarely have the opportunity of observing. I may therefore be permitted

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again to quote from Professor Markoe's article on "Necrosis" in the first edition of this work.

"These cases occur almost exclusively among the operatives in match factories, who are living in an atmosphere containing the fumes of phosphorus and phosphorous acid. The workmen most liable to be affected are those employed in the dipping-room, and in the packing-rooms. In the first there is a constant prevalence of the fumes of the volatilized phosphorus, and the air in the second is still further vitiated by phosphorous acid from the frequent burning of the matches while being counted and packed. It is believed that these phosphorous emanations, which are quite soluble in water, are dissolved in the saliva, and thus come in contact with the teeth and gums, upon which latter the poison seems to exert its primary influence. Why these particular parts are selected by the poison in preference to the rest of the buccal and to the Schneiderian membrane, which are equally, if not more, exposed to its action, is a pathological fact which we are not able to explain. That the poisonous action is a local, not a general, one seems further proved by the fact that constitutional cachexia does not often appear as a condition preceding the local outbreak; and still more strongly by the fact that if the teeth be sound, and the gums unbroken, the disease is rarely developed. On the other hand, it ought to be stated that there are sometimes evidences of slow systemic poisoning by phosphorus, terminating in necrosis; and also that it is rarely those who have been for only a short period subjected to the poison who develop necrosis, but rather those who have been some years in the occupation. Again, it has been recorded that the prolonged internal use of phosphorus may lead to typical necrosis of the jaw, as in a case recently reported by Mr. Hutchinson. It may, therefore, in the light of our present knowledge, be assumed that the action of the poison, at least in most cases, is purely a local one, though the system is probably predisposed to the local outbreak by a constitutional infection from the poison slowly introduced into the blood, either by inhalation of the vapor or by the ingestion of the drug as a medicine. It acts by inflaming first the gums and the linings of the tooth sockets, from these spreading to the alveolar processes of the bone, and finally, by extension by continuity, involving a large part, and not infrequently the whole, of the bone. This destruction of the entire bone is sometimes found in the lower jaw. In all the cases I have seen affecting the upper jaw, the ravages of the disease were mainly confined to the alveolar arch."

(For further information in regard to this subject consult the articles on *Occupation, Hygiene of*, and on *Phosphorus, Poisoning by*.)

Osteitis Deformans.—This essentially chronic condition is, though recognized and studied since 1876, still illy understood as to its etiology. It occurs most often in middle age, and involves perhaps more frequently the long bones, but also at times the skull, pelvis, and vertebræ. Hypertrophy may go hand-in-hand with softening, resulting in malformations which give the disease its name. Nevertheless, it does not advance to the extent of causing fractures. Some authors—Tillmanns for instance—differentiate two clinical varieties, the painful and the painless. The former is the more frequent, usually involving the bones of the lower limbs. The painless is believed to occur more often in the upper limbs, and in females rather than in males. Generally several bones are involved, thus indicating a systemic rather than a local cause. Treatment has thus far proved of little avail; and since we cannot definitely ascertain the real cause and direct our treatment to that, the only course which remains to us is to alleviate pain or other symptoms.

Tuberculous Osteitis.—Under this title we shall discuss that inflammation of bone which, until within a few years, writers have studied under the name of caries; paying more attention, as in necrosis, to the result of the process than to the causative agent.

This is a chronic malady, affecting mainly the red-marrowed, cancellous bones, such as the bodies of the vertebræ and the carpal and tarsal bones. It is essentially an osteoporosis, with tuberculous deposit as its cause and accompaniment, and it results in molecular death of the bone. Sometimes, by extension, the compact tissues are involved, but here the bone first changes its character, becoming cancellous through osteoporosis; and later even the remaining bone trabeculæ may disintegrate, and a suppurating cavity be left. The lime salts are dissolved, and the remaining membranous or gelatinous bone breaks down under the devitalizing influence of the tubercles.

It may be objected to the term *tuberculous* that caries is not always of this nature. It is undoubtedly true, however, that chronic, granulating, rarefying osteitis is commonly so, and at the present day the cases of caries in which careful investigation fails to find the bacillus tuberculosis are very few, and are becoming fewer.

The bone frequently expands in one or both of its diameters while becoming a mere shell filled with pus, bony detritus, and granulations. Apparently the growing mass of granulation tissue forces out the walls of bone when they become thin enough to permit it. A rather common example of this condition is found in "spina ventosa." Here the bone—a metacarpal, for instance—may gradually assume the shape of a spindle. Syphilitic dactylitis may produce the same distention; this latter inflammation, which is usually a result of inherited syphilis, most often involves one of the first phalanges.

The deposit of tuberculous material in bone may or may not present all the ordinary appearances of a focus of tuberculous disease. It may undergo caseation, or it may, as it usually does, soften and liquefy. Some suppuration is probably always present, but this varies greatly in degree. In the caries of children it is almost always a feature. Pott's disease, for example, is accompanied by the formation of so-called "cold abscesses" of varying size, and the pus starting from the disintegrating bone follows a downward course, governed by gravity and the path of least resistance, and may finally find an exit for itself upon the surface. Or, in cases with less discharge, the pus may become cheesy, its ensheathing connective-tissue covering may undergo a change into calcareous material, and the abscess may never descend far from the diseased vertebral bodies which gave it origin. Such an abscess may be discovered only at the autopsy.

In elderly individuals the formation of granulation tissue and a slow advance of the disease, with but slight discharge—a "caries sicca"—are generally to be expected.

Tuberculous osteitis may occur at any age, but it develops more commonly in early childhood than at any other time. Its onset is usually insidious. The patient may, after a time, complain of a little tenderness or aching after exertion. Later, some swelling of the bone may perhaps be noted. The skin is not involved at first; after several weeks—possibly months—it becomes distended, looks inflamed, breaks down at one or several points, and gives exit to pus. This pus varies in consistency, and is sometimes gritty to the feel, containing minute spicula of bone. A probe introduced may—if the sinus be moderately straight—touch bare bone, and may by moderate pressure be made to fix itself firmly in the cancellous tissue; this could not be done in the case of the compact sequestrum of necrosis. The lips of the sinuses and their walls soon become lined with flabby, inactive granulations, in which the bacilli are sometimes to be discovered. Meanwhile the patient may be subject to more or less fever, night sweats, and similar signs of vital depression.

By extension a caries may involve an adjacent joint, with resulting "white swelling" and all the manifestations of tuberculous osteo-arthritis. Or, conversely, a primary joint tuberculosis may lead to erosion of the articular lamella of the bone, and then to tuberculosis of the cancellous tissue.

Caries commonly, though not invariably, makes its ap-

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pearance in individuals of the so called scrofulous diathesis—*i.e.*, those who are especially subject to affections of the glands, skin, and mucous surfaces. Often a family history of tuberculosis may be obtained, or it may be learned that the parents died from some unnamed lung trouble. The patient is apt to be pale and anæmic in appearance, although this is not always the case. In adults the bone disease is sometimes a reappearance of inflammation which existed there for a time during childhood, and then remained for years quiescent.

At any stage in its progress the disease may come to an end, and reparative processes of varying degree begin. Caries does not necessarily go on to the complete destruction of all the cancellous bone involved. If the patient's general condition can be improved, so that the vitality of the bone is enabled to resist the encroachment of the tuberculous disease, suppuration may cease, fistulous sinuses close, and new bone form to some extent. This is the rule in Pott's disease. The bodies of one, two, or sometimes more vertebræ melt away, the comparatively sound bodies above and below come in contact, and if the patient continues to live, as he commonly does, the disease is brought to an end, and the vertebral bodies near the focus of the disease, but which have escaped, unite by firm bony union. In some bones—the calcaneum for example—there is very little tendency to bony repair. The space once occupied by bone becomes partly filled by simple connective tissue.

It is important to bear in mind that a mere local bone tuberculosis may at any time give rise to a general tuberculosis. Although such a catastrophe is quite exceptional, it does sometimes occur. Therefore, when it is possible to remove by surgical means the diseased bone, it should be done. It has even been suggested, of late, that in spinal caries an attempt be made to scoop away the diseased tissue and thus hasten recovery; if need be, resecting one or more ribs to allow thorough work. But whether this become a recognized practice or not, in all readily accessible regions the proper treatment consists in the free use of Volkmann's sharp spoon; the most thorough work under these circumstances being always the best. As with suppurating tuberculous lymph nodes, so here this treatment may save months of effort on the part of nature to remove the tuberculous deposit.

It goes without saying that surgical cleanliness must be strictly observed during and after the operation.

It is to be expected that, in many instances, one such scraping will not suffice entirely to put a stop to the disease. Perhaps the step may have to be repeated a number of times before all the affected tissue is reached and eliminated. During the dressing of bones or of sinuses which have been operated upon for caries, iodine should be our main reliance. In irrigation we may wisely employ a one- or a two-per-cent. solution of the compound tincture, which does not precipitate as does the simple tincture upon dilution with water. This strength will stain the tissues a yellowish hue.

The gauze used for packing and drainage should be first moistened, and then well rubbed with some one of the numerous powders which depend for their value chiefly upon the iodine which they contain—such as (in order of strength) iodoform, iodol, nosophen, aristol, and europhen. The author rather inclines to aristol, and considers it practically as effective as iodoform without the objectionable odor of the latter.

In obstinate cases of caries, after the vigorous use of the sharp curette or gouge, it is well to cauterize also, before beginning the iodine treatment. Perhaps the application first of pure carbolic acid and then of strong alcohol is as effective a measure as any that can be adopted. The severity of this procedure may be easily regulated by shortening or protracting the time during which the pure acid is allowed to remain in contact with the parts before the neutralizing action of the alcohol is brought to bear upon them.

The prognosis in children, after such thorough treatment, is fairly good. In adults it is distinctly more difficult to eradicate the disease completely. In the tarsal bones, for example, it is questionable whether in adults it is not wiser to excise entirely the affected bone or bones in order to prevent a relapse.

When despite thorough local treatment the disease extends and perhaps involves an entire extremity, amputation at some distance above may be our only remaining resource.

Regarding medicinal treatment, cod-liver oil, iron, and good nourishment are to be administered in the hope of improving the general condition. In the phlegmatic temperament cold bathing daily is of more value than the oil. These means, however, will not remove the bacilli from the bone marrow. They are merely useful adjuvants to the proper local treatment.

Robert H. M. Dawbarn.

OSTEO-ARTHROPATHY, HYPERTROPHIC PULMONARY. See *Acromegaly*, and *Hands and Fingers, etc.*

OSTEOCHONDROMA. See *Chondroma.*

OSTEOMA.—An osteoma is a tumor consisting of bone tissue.

Not every bony new formation is an osteoma. The bones occasionally found in the deltoid muscles of infantrymen, caused by the pressure of the rifles, and the "riders' bones" forming at the attachment of the adductor longus in cavalrymen are not true tumors, nor is the new formation of bone at the site of a fracture an osteoma, even though the callus formation be exuberant. A true osteoma may, however, arise from a callus. Furthermore, inflammatory new growths are not true tumors. Thus the newly formed bone around a sequestrum in osteomyelitis, and the osteophytes, periostoses, and hyperostoses resulting from ossifying periostitis are inflammatory new growths and not osteomata. It seems probable that the so-called "osteomata" of the choroid and vitreous should be looked upon as inflammatory new growths. The absence of sufficient, evident etiological factors and the purposeless character of the new growth are to be emphasized as two important criteria of osteomata.

Osteomata are most usually found in connection with bones. Either long bones or flat bones may be affected. In the long bones the tumors are especially apt to arise near the epiphyseal lines. As a rule the bony tumor is formed from a connective-tissue periosteum, after the manner of the cranial bones; less often the osteoma is formed by the transformation of cartilage, while osseous tumors in other tissues are less common, being found occasionally in the membranes of the brain and cord, in tendon, ligament, muscle, in the mammary, parotid, adrenal, thyroid, or prostate gland, in the tracheal mucosa, pleura, or lung, and rarely in the skin. Osteoma in the corpora cavernosa is rare.

In addition to simple osteomata, bony tissue is also found in the mixed tumors of the parotid and testicle, in osteosarcomata, osteochondromata, etc.

Osteomata may be single or multiple. "Cortical osteomata" or "exostoses" are bony tumors on the surface of bone; a "central osteoma" or "enostosis" is a bony tumor in the interior of bone. A "continuous osteoma" is directly continuous with bone; a "discontinuous osteoma" is separate from adjacent bone. "Dental osteomata" spring from the cement substance of the teeth. "Subungual exostosis" is employed to designate the osteoma occurring beneath the nail of the great toe.

There is much confusion in the use of the terms "exostosis," "enostosis," or "endostosis," "hyperostosis," "periostosis," and "osteophyte." Although it is customary to give the termination "oma" to all tumors, the use of "exostosis" and "endostosis" to designate certain osteomata is so common that it seems necessary to continue to employ these terms. The terms "osteophyte," "periostosis," and "hyperostosis," however, should be applied only to the inflammatory new formations of bone, such as occur in ossifying periostitis. Since certain true tumors are called "exostoses" and "enostoses,"

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it would be well if these terms were not applied to other bony growths, but, in addition to their more limited significance, the terms are generally applied to almost any irregularity on or in bone. In this article, "exostosis" signifies an osteoma situated on the surface of a bone; "enostosis," an osteoma situated in the interior of a bone.

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Osteomata have in the main the structure of normal bone, though they have not the regular architecture of the trabeculæ, nor the typical arrangement of the vascular and medullary canals and bone corpuscles.

Virchow classified osteomata according to their structure as osteoma eburneum, osteoma spongiosum, and osteoma medullosum.

"Osteoma eburneum," or "eburnate osteoma," or "ivory exostosis" is a tumor consisting altogether or for the most part of dense osseous tissue. In this form the tumor is made up of nearly parallel or concentric branching layers of compact bone, containing possibly a few small vessels, and covered by a connective-tissue periosteum. The number of bone corpuscles is usually not great.

"Osteoma spongiosum," or "spongy osteoma," consists of looser, cancellous bone. In the spaces between the trabeculæ there may be marrow.

"Osteoma medullosum," or "medullary osteoma," has an outer shell of compact bone covering cancellous bone and a central marrow cavity, the tumor having the structure of a long bone. At times the marrow cavity composes the greater part of the tumor. The marrow in the osteomata may be either normal red or white marrow, or a myxomatous change may occur, such as is seen in osteomalacia, etc.

The eburnate osteomata are more frequently found on the bones of the head than elsewhere; they are usually multiple, rarely attain a greater diameter than 1 or 2 cm.; and occur as small, flat, rounded outgrowths from the bones. The eburnate osteomata of the orbit and frontal bone, and the osteomata occurring near the epiphyses of the long bones may grow to the size of a man's fist or larger. These tumors have a very rough, irregular surface; they may be very firmly or loosely attached to the bone. The multiple osteomata of the dura and arachnoid are small and very rough and spiculated. The multiple osteomata of the skin are the smallest medullated osteomata. They occur as platelets the size of a grain of sand in the cutis or subcutaneous tissue. Skin osteomata are more common in old people.

It is at times impossible to tell where normal bone ends and osteoma begins; in other cases a slight attachment gets severed, the osteoma becomes necrotic, and is discharged as a foreign body. This has happened in the case of some of the tumors arising in the diploë of the frontal bone.

The tumor formed from cartilage, "osteoma cartilaginea," is covered by a more or less incomplete layer of cartilage. These tumors are found on the long bones, especially on the humerus, tibia, and femur. They may be progressive and form tumors as large as a man's head. In the early stages they are usually made up of compact bone; later they may be spongy. It is often impossible to distinguish between osteomata of cartilaginous origin and ossifying enchondromata.

The following are the chief etiological factors:

1. Misplacement of embryonal bone elements. Although formerly it was considered the most important factor in the etiology of tumors, the tendency of the present day is to attribute importance to this factor only in those rare cases of multiple osteomata which are present from birth.

2. Post-natal disturbances of development are supposed to be of much more importance. Under this heading rachitis is of special interest. It is supposed that, as a result of the irregular growth which takes place in rachitis, small bits of cartilage are nipped off and come to lie behind the growing line of the bone. These islands for some unknown reason develop into enchondromata or osteomata. Usually osteomata arising in this manner are multiple. According to Otto Müller, this post natal misplacement of cells is most apt to occur in cases of recurring rachitis. Müller traces the different possibilities which may result from misplacement of these cartilaginous elements. The focus may disappear, or persist unaltered, or it may persist as a tumor-like centre without sufficient vitality to cause it to grow; the focus may develop into a chondroma, or an osteoma; into a rapidly growing myxo-enchondroma, or into a malignant tumor (chondrosarcoma, etc.).

3. Trauma is a factor in the production of some osteomata.

4. Heredity has been observed to be of etiological importance quite often. Reinecke collected from the literature thirty-six cases of multiple osteomata which occurred in families. In one instance the condition was transmitted through five generations; in two instances to the fourth generation; in fifteen instances to the third generation; and in twelve instances to the second generation. It has been observed that the inheritance is more common among the male members of a family. Inheritance is of importance chiefly in connection with multiple osteomata.

5. An osteoma may arise secondarily. In the case of some of the osteomata of the membranes of the brain and cord it appears that a soft, fibrous tumor of the arachnoid may impinge upon the periosteal dura mater, and a new growth of bone from the dura may then replace the fibrous tumor.

6. The opinion which prevails at the present time is that the osteomata arising in gland, muscle, lung, tracheal mucosa, etc., are best accounted for on the hypothesis that they arise from a metaplasia of cells.

7. It must not be forgotten that heredity, trauma, disturbances of development, etc., are of themselves not sufficient to account for the presence of osteomata, and in every case there is some unknown influence at work, which gives the decisive impulse to tumor formation.

Diagnosis.—An osteoma is a painless, benign, slow-growing tumor, usually small, in most cases arising from bone, appearing, as a rule, during childhood or early youth, that is, during the developmental period of bone. The tumors are seldom seen in very young children, and are rare after the third decade. Tumors found in older people have their origin earlier in life. The growth of osteomata is slow and ceases after middle life. The exostoses at the epiphyses do not enlarge after the growth of the skeleton is complete. Osteomata occur more frequently in males than in females. The tumors are sometimes symmetrical, as in the nasal osteomata. The position, the consistence, and the features that have been mentioned will usually give the basis for a diagnosis. It is often difficult to distinguish between "dental osteoma," which arises from the cement substance and is found at the root of the tooth, and "odontoma," which arises from the dentin and may be found also on the shaft or crown of the tooth.

Prognosis.—All osteomata, even the progressive osteomata, are benign. This of course does not apply to the mixed tumors containing bone. No osteoma is dangerous except as a result of its pressure upon neighboring parts. The frontal or orbital osteomata may press upon the brain or eye; an osteoma of the pelvis may obstruct labor; an osteoma may press upon vessels or nerves, or the skin over the tumor may be injured and a chronic ulcer result.

Unless treatment is indicated to relieve pressure, the tumor should not be attacked.

Treatment is altogether operative. Owing to the firm attachment and dense structure of some osteomata, it is often difficult to remove them without injury to the adjacent soft parts. *Harry T. Marshall.*

OSTEOMALACIA.—(Synonyms: Mollities ossium; malacosteon; halisteresis ossium.)

Pathology.—Under this name is recognized a disease in which an unusual softening of fully formed, hard bone develops; this softening being followed by great deformity of those bones upon which strain is placed, either by the action of muscles or by the mere weight of the body. The softening is caused by an insufficient amount of in-

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organic salts. Whether this insufficiency of salts is due to absorption (decalcification) or to failure of calcification during the regeneration of the bone, has not been fully determined. Recent investigations seem to indicate that both processes go hand-in-hand. By the absorption of the calcareous matter in the bones the medullary substance encroaches upon the bone. Two forms of the disease have been distinguished—viz., osteomalacia cerea, or waxy osteomalacia, in which the whole shaft is softened and consequently bends like wax; and osteomalacia fragilis, or brittle osteomalacia, in which the inner portion of the bone is affected, and there remains a thin bony shell which is very liable to fracture.

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In the spongy parts the process starts in the medullary spaces, and in compact bone from the periphery of the Haversian canals: in the latter case the affected area constitutes a margin of bone in which the calcareous salts are absent, although it still retains its connections with the calcified portions. The limits between the decalcified and the normal bone may be quite regular, or they may present an irregular or even a zigzag outline. The affected margin of bone stains red in Van Gieson's mixture. At first, when the salts of lime begin to disappear, the basement substance still presents a finely fibrillated or a homogeneous appearance, with the original lamellation still preserved; but after a time the decalcified tissue may disintegrate and be absorbed, its place being occupied by new-formed marrow or granulation tissue. The canals either disappear or persist as small, oval vacuoles. The canaliculi along the softening margin become irregularly widened and enlarged, and appear like "latticework" spaces, star-shaped and feathery. Large and small smooth-walled cysts may be found in decalcified areas; they are filled with mucoid material, resulting from the enlargement of the Haversian canals and spaces, and they may extend into the marrow itself. Canals perforating the bone trabeculæ also appear in considerable numbers, but osteoclasts and Howship's lacunæ are not present any more numerously than in normal growing bone.

The marrow is variously changed. In some places it is yellowish and fatty, in others it contains reddish lymphoid tissue with giant cells, while in still other places there are gelatinous areas. It may also contain cysts. Constant and characteristic changes do not occur; in fact the marrow may even become quite fibrous. Some areas are very anæmic while others are distinctly hyperæmic. Pigment and hemorrhages are frequently found in the marrow, and there may be a great accumulation of small spheroidal cells.

The periosteum is thickened in many places and has a fibroid structure with few nuclei. When it is stripped off, the underlying bone is found to be rough, and often is perforated by openings from which marrow escapes.

Simultaneously, or subsequently, there takes place a more or less extensive formation of new osteoid tissue, which in many instances is excessive, and which for the time being may remain uncalcified. This new tissue is produced by the osteoblasts, and may be quite dense and contain only fine spaces; it may present a lamellated appearance, or more frequently an interwoven, fibrillated structure, with large corpuscles. This new tissue is formed most extensively at points of flexion and of fracture of the softened bone; the callus formation may be prolific, but it is not followed by perfect calcification. It also forms to an excessive degree at the points where the bone is exposed to mechanical strain, *i.e.*, where strong muscles, tendons, and ligaments are attached. This new-formed osteoid tissue is easily distinguished from decalcified old bone, as it contains larger, better formed cells.

Owing to the softness and pliability of the bones which are acted upon by the superimposed weight, by the resistance of ligaments, and by the traction of muscles, there is sure to be produced a series of deformities. These consist of curvatures of the spine, sternum, ribs, and long bones, of partial and complete fractures of various bones, and of contractions and alterations of shape of the pelvis. Fractures refuse to unite properly and false joints result; or if they do unite, angular deformities occur.

The chest is flattened laterally, its antero-posterior diameter increased, and the ribs and sternum are much distorted. Softening of the clavicle allows the weight of the limb to rest on the thorax, and a corresponding depression in the wall of the chest results. The bones of the arm are usually fairly free from marked deformity, owing to the absence of pressure. The lower ribs may come into contact with the crests of the ilia. The spine is variously altered. The normal curves may be accentuated, or new ones produced. In some cases there is a simple curve of the column backward, a condition of kyphosis; or this may be accompanied by a compensating curve inward in the upper part of the column, or the curves may be exclusively lateral. For this reason the stature of the patient is much decreased.

The abdomen bulges and is very prominent. The deformities in the pelvis are characteristic. The iliac bones may yield when pressed together, and spring back when released. The pelvis is usually very flat, the promontory being on the same plane as the pubis and pressed forward and downward. The sacrum is strongly curved longitudinally, the apex being turned forward. The acetabula are pressed inward and approximated, the ascending branch of the pubis being bent inward. The pillars forming the pubic arch are also pressed inward and approximated, so that the symphysis pubis protrudes forward in a beaked form. The tuberosities of the ilia are brought nearer to each other, and may even come in contact. The brim of the pelvis has the shape of the letter Y. In some cases, in consequence of these deformities, the cavity of the pelvis may be reduced so as scarcely to allow the passage of the natural evacuations through it.

The early deformity of the bones of the lower extremity consists in an exaggeration of the normal curves of the bones, but in the later stages there will be bends and twists which are due to the traction exerted by certain muscles. Fractures at the angles are frequent. Imperfectly healed masses of callus are found about these points of fracture, and these contribute greatly to the deformity of the bone. In the femur, as a rule, the greatest deformity is found in the angle of the bone just beneath the great trochanter. The pressure of the body above causes the bone to give way at this point, so that the trochanters may be higher than the head of the bone. It is characteristic of the puerperal form that the bony changes almost always begin in the pelvis, and from here advance upward upon the spinal column; while in the other form of the disease, which occurs in both men and women—after the puerperal period in the latter,—the disease usually begins in the lower extremities. In order of frequency the various bones are affected as follows: most frequent of all is the pelvis, next the sternum, then the upper extremities, and lastly the lower extremities. While the proportion of inorganic to organic matter in normal bone is about two to one, this is reversed in osteomalacic bone until the proportion is as one to two. The nervous system is found post mortem to be free from gross lesions, but histo-pathological examination has revealed in the cord organic changes which appear to begin in the cells of the anterior cornua. These are not inflammatory in character, and clinical evidence shows that they are capable of repair.

The weakened muscles show, post mortem, fatty degeneration, multiplication of nuclei, and other changes similar to those observed in progressive muscular atrophy. The chest and abdominal organs usually are not altered.

The urine presents no characteristic changes and is of little importance for diagnostic purposes. The presence of lactic acid in the urine cannot be regarded as proven. The same holds true of albumose. In some cases the excretion of lime salts has been very great, leading to the formation of gravel and small calculi. Albumin has been found in some cases.

The microscopical examination of the blood is of no

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importance in the matter of diagnosis. Under various conditions there may be a slight increase in the eosinophile cells in the blood, but variations in the number of these are not an uncommon occurrence in normal individuals.

The ovaries have been thought to have an influence on the disease. In some cases of osteomalacia they were found in a hyaline condition, in others in a fibrous or other pathological condition, but in many they were perfectly normal. Perhaps the ovarian internal secretion plays a part of some importance in the chemistry of the organism. Removal of the ovaries has seemed in a number of cases to have been followed by a surprisingly beneficial result.

Etiology.—The real cause of this remarkable affection is unknown. It is a singular fact that the disease is much more frequent in certain regions than in others. It is very common along the Rhine and in Westphalia, in Eastern Flanders, in Schütt Island in the Danube, and in Northern Italy. This suggests that there is some specific cause for the disease, endemic in certain localities. It is in addition found occasionally in almost every country in Europe, but in North America Dock was able to collect records of only ten cases. It is mainly a disease of adults, occurring between the thirtieth and the fortieth years, but it may exceptionally be found later or earlier in life. The disease attacks females almost exclusively during the child-bearing period. Isolated cases have been found in men, but are extremely rare. Among exciting causes, child-bearing is certainly the most important, for both the first signs of osteomalacia and also fresh exacerbations of the disease usually date from a pregnancy. It has, however, been found in women who have never had children, and it may begin after the menopause. The relations of osteomalacia to the sexual processes are so close that there is some justification for the supposition that osteomalacia is directly dependent for its development upon disturbances of metabolism in the ovaries.

Individuals in all classes of society may be affected, but the disease appears to be favored by damp and unsanitary surroundings. Various theories have been put forward to account for the disease, but none of them is satisfactory. Lactic acid has been found in the bones, and the solution of the lime salts in the bones has been attributed to this substance. It has, however, been conclusively shown that the acid may be in excess without producing the disease, and efforts to cause the malady in the lower animals by feeding them with lactic acid have signally failed. Micro-organisms again have been carefully searched for, but with no constant result, and there is no ground for believing that bacteria are instrumental in producing this condition. Fehling's theory is that there is a trophoneurosis, due to reflex irritation from the ovaries, and the remarkable results of castration in osteomalacia seem to confirm this theory; but while the facts cannot be doubted, there is a growing tendency to question the theory. In some cases in which recovery followed the operation of castration, no abnormality could be discovered in the uterus, ovaries, or vessels. The disease has also been attributed to affections of the nerve centres, but anatomical observations on the nerve centres are very scanty and inconclusive. Virchow asserted that the disease was of an inflammatory or hyperæmic nature, but study of the bones gives rise to strong doubts about the validity of this theory.

There are on record a number of cases in which, while the symptoms were somewhat similar to those of osteomalacia, multiple myeloid tumors were found in the bones. In osteomalacia the bones are softened, owing to the removal of the earthy salts by absorption. In multiple myeloma the osseous tissue undergoes atrophy without at the same time being changed in its chemical composition. The atrophy, in this case, is due to the development of a new growth in the marrow spaces and to its spread outward, causing absorption of the hard parts of the bone, and ultimately leading to fractures and deformities. There can be no doubt that cases of multiple myeloma have been confounded with osteomalacia, but they are distinct conditions, and not dependent in the slightest degree on each other. According to Bradshaw, the cases of multiple myeloma may be divided into those with and those without albumosuria. Of these latter there are seven cases in the literature. The first case of this albumosuria was reported by Bence Jones in 1847. Most of these cases were considered to be osteomalacia, and were supposed in some way to depend on the albumosuria; hence the origin of the theory that osteomalacia was due to an albumosuria. This view, it is needless to say, is incorrect, for it has been shown that they were not cases of true osteomalacia at all, but the albumosuria occurred in persons affected with multiple myeloid tumors of bone. The Bence Jones albumose has never yet been found in a case of pure osteomalacia. This condition, known as multiple myeloma, has been variously designated in the literature, some calling it sarcoma, others (*e.g.*, Marchand) calling it "general marrow hyperplasia with disappearance of the bone substance." Schönenberger reports a case of osteomalacia in which there were found, as complications, multiple giant-celled sarcomata and multiple fractures.

Hirschberg reports a similar case, as does also von Recklinghausen. The publication of all these cases seems to render improbable the theory of the neoplastic origin of osteomalacia.

Symptoms.—In the beginning the disease is obscure; it starts very gradually, in most cases, with an ill-defined, deep-seated pain, most often felt in the sacral region of the back, in the pelvis, and down the thighs, and at times even in the legs. Pressure seems to increase the pain. This pain is more or less constant and persistent, is increased by movements, and is usually diagnosed as rheumatic. An important feature of the pain is that it usually starts in the latter part of pregnancy, ceases after delivery, and recurs with subsequent pregnancies. While the pain continues, motion becomes gradually impaired, and there is more and more difficulty in walking, partly because of the pain and partly because of the muscular weakness. This weakness in the muscles of the thigh and pelvis may be present before any bony deformity is discoverable.

Attacks of painful spasm are often present, particularly in the adductors of the thigh. Owing to weakness of the ilio-psoas muscle as well as to deformity of the pelvis, the trunk is thrown from side to side to enable the foot to clear the ground in walking, and thus a peculiar waddling gait results. In other cases the steps are short, slow, uncertain, and almost hobbling, the lower limb and pelvis being jerked forward as if they were one piece. There is tremor of the muscles, the knee jerks are increased, and ankle clonus often is present. After a longer or shorter time walking becomes absolutely impossible, and the patient is permanently bedridden. Even then severe pain persists in most cases, often spontaneous in character and much increased by pressure of bed clothes, etc.

While these symptoms are going on, various distortions of the body occur, sufficient to cause a decided alteration in the appearance of the skeleton. Deformity of the spinal column is usually the first to be noticed. As a rule, there is kyphosis, less often some other deformity, and the head generally becomes more and more bent on the sternum, resulting in the patient growing decidedly shorter. This may help in diagnosis because the patient is apt to remark that she has to keep shortening her gown in front. If the patient becomes bedridden early in the disease then the extremities become less distorted and are less often fractured. The softened bones are usually painful when pressed upon, and they may bend under pressure. The bones of the face and skull are almost never involved. The thorax becomes barrel-shaped and pressed together laterally, so that the sternum has an almost horizontal position. The abdomen becomes very prominent. The teeth become carious or are lost. The pelvis is deformed as described above. In the muscles several observers have noticed trembling and

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fibrillary contractions, also paresis and sometimes complete paralysis. In a few reported cases the softness of the bones of the extremities was so extreme that one could bend the limbs at will, like wax, and give them the most extraordinary positions.

The internal organs perform their functions well for a long time, and the appetite remains good. Fever is observed only when the disease is undergoing some marked temporary exacerbation. With regard to changes in the urine, it is a fact that a great many statements have been made, but their significance is extremely doubtful. It is said, for example, that the amount of phosphoric acid excreted is diminished. With regard to the amount of lime, no definite statement can be made. Lactic acid has been repeatedly detected in the urine, as has also albumin. Concretions of lime have been found in the bladder and the kidneys. Microscopical examination of the blood gives no aid in diagnosis. Neusser has found myelocytes and an increase of eosinophile cells in the blood in some cases; but these results in general do not seem to have been confirmed by other observers. Women affected by the disease are said to be more fruitful than others. Eisenhart found the average number of children born in Germany to be 3.9, whereas it was 6.4 in the sufferers from this disease; abortion is also more frequent.

Prognosis.—The course of the disease is a chronic one, most cases lasting for years and undergoing remissions and exacerbations. Pregnancy has a very deleterious effect, always lighting up a fresh attack. The prognosis now is much better than it was twenty-five years ago. We know that the disease is curable in some cases, and we have gained considerable control over it by medical and surgical means. The most important part of the treatment depends upon the possibility of preventing conception. The more frequent termination of the disease, however, is in death, after a duration of time seldom less than two or three years, although in some cases this event may be postponed for five, ten, or even a greater number of years. Death results either from general debility, or, more often still, from the dyspnœa caused by the compression of the lungs, or by some such disease as lobular pneumonia. Death sometimes occurs in labor and is then due to the rupture of the uterus, or it follows one of the more or less dangerous operations for the extraction of the child.

Diagnosis.—This is somewhat difficult to make in the sporadic cases in the early stages. It is almost always called rheumatism, on account of the pains which are located in the pelvis and lower extremities, and which are made worse by bad weather. More careful examination and a rigid inquiry into the history will elicit points—such as sensitiveness of the pelvic bones to pressure, increased knee jerks, and muscular weakness, etc.—from which a diagnosis may be made. At the outset the symptoms may suggest incipient disease of the cord or of the vertebræ. Strümpell mentions the fact that he has repeatedly seen cases in which women, as a sequel to pregnancy or even apparently spontaneously, have developed paresis in the lower extremities, particularly in the psoas and iliacus muscles, associated with pain and exaggerated tendon reflex, and in which diagnosis at first was very difficult. At any rate, it is important to know that even before there are demonstrable changes in the bones there may be paralysis, probably due to an early involvement of the muscles in the morbid process. As soon as bone tenderness and deformity arise, the diagnosis is rendered easier.

From peripheral nervous diseases osteomalacia is distinguished by a careful examination of the bones. In the latter disease the tendon knee reflexes are increased, while in almost all peripheral nervous lesions the tendon reflex is diminished or entirely abolished.

Not very infrequently the complaint of the patient at the start is regarded as hysterical.

As the disease is almost entirely confined to adults we are seldom in danger of confounding it with rachitis. In addition, osteomalacia does not produce swellings of the epiphyses or changes in the bones of the skull. Examinations of the urine and blood do not help us in diagnosis.

There may be difficulty in differentiating the disease from malignant tumors of the bone—for example, from primary sarcomata and especially from diffuse carcinomatous infiltration of the bones, and there is little doubt that the older writers confounded these conditions with osteomalacia. According to Köhler, who carefully investigated cases of the latter type, they are to be distinguished from cases of osteomalacia, first, by the fact that the growths occur only in the bones of the trunk, and second, by the absence of muscular weakness and of any unnatural elasticity of the bones. In multiple myeloma the disease mostly occurs in men in the latter half of life, the bones of the thorax are those chiefly affected, the patient is able to leave his bed until near the end, deformities are not extreme, and fractures are common.

Treatment.—If the case be seen early in pregnancy, in view of the gravity of the labor and the bad influence of pregnancy upon the disease, abortion should be produced if the fœtus can easily be removed by the natural way.

The patient should then occupy a dry, sunny house, and should be put on a very substantial diet, of which milk should form a large part. The chief remedial agent is phosphorus, one-twentieth to one-fifteenth of a grain three times a day. Extract of red bone marrow, a tablespoonful three times a day, is also highly recommended. Others advise the administration of cod-liver oil, quinine, arsenic, etc. Above all things subsequent pregnancies must be avoided. Phosphorus seems to be the most efficient drug and produces at times strikingly good results.

If a woman becomes affected with osteomalacia during the nursing of a child, this must be at once stopped, as it is found to exert an injurious effect upon the disease.

If in spite of all treatment, diet, etc., the disease progresses, recourse should be had to surgical means—*i.e.*, the ovaries should be removed, or, what is probably better, a Porro operation—supravaginal amputation of the uterus—may be performed. Either of these operations fulfils two conditions, viz., it prevents further pregnancies and apparently often arrests the disease. Improvement sets in sometimes surprisingly early, the pains being relieved within forty-eight hours. Many from being bedridden recover so far as to walk and perform their ordinary duties. Of 44 cases collected by Baumann in which Porro's operation was performed, 18 died and 26 recovered. Of the latter, 3 died from other diseases, and 2 were lost sight of. Of the remaining 21 cases, 17 were cured or markedly improved. Finley collected the histories of 40 cases, and the after-histories of 16 of these were traced; 12 of these were cured and 4 improved.

If a case be seen late in pregnancy, the procedure to be adopted will then depend on the degree of the deformity. If this be slight, then premature labor may be induced. If, however, it be very great, Cæsarean section should be done. If the patient be found in labor, the procedure will likewise depend on the condition which is found on examination. If it is found that the child will be able to pass with some help, we may use forceps; or if it may pass after some reduction in size we may perforate, crush the head, and extract the child. Even this latter may not be possible, and we are then forced to perform Cæsarean section. In case this is done the ovaries should be removed, or hysterectomy performed, so as to prevent future pregnancies, and also in order favorably to influence the disease. What the relation between the ovaries and the disease may be is at present inexplicable. We know that there is a close connection between the various processes of nutrition and certain organs of the body. This has been shown in the case of the pancreas, the thyroid, and other glands, but what the influence is, or how much is exercised by the ovaries, is entirely conjectural.

Clarence Arthur McWilliams.

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OSTEOMYXOMA. See *Myxoma.*

OSTEOPOROSIS. See *Atrophy.*

OSTEOPSATHYROSIS.—This term is used in a general sense to designate the condition of excessive brittleness of the bones, and is practically synonymous with *fragilitas ossium.* It may occur as the result of senile or cachectic atrophy, prolonged activity, pressure atrophy, neuropathic atrophy in such diseases as paralytic dementia, locomotor ataxia and syringomyelia, and in syphilis, leprosy, osteomalacia, and rachitis. In rare cases the condition appears in an idiopathic form, apparently of congenital origin, and may be inherited. The etiology and pathology of this form are unknown. Senile osteopsathyrosis is the result of the old-age osteoporosis. The skeleton as a whole, or only certain portions, may be involved. The bones usually become fragile and are easily broken; but in other cases the bones lose their lime salts to such an extent that they may be easily bent or may be cut with a knife. A similar condition may occur in the cachexia of various chronic diseases. In syphilitic infection of long standing and associated with marked cachexia, there often occurs a marked osteopsathyrosis of the long bones and also the bones of the cranium. In the great majority of syphilitics there is an increased fragility of the skeleton. In leprosy there is found in a certain class of cases a very characteristic osteopsathyrosis (leprous osteomalacia) affecting chiefly the bones of the hands and toes. The phalanges, one after another, may be affected until all the fingers and toes are destroyed, or they may be irregularly involved. (See also *Bones, Osteomalacia, Leprosy, Syphilis, Atrophy,* etc.)

Aldred Scott Warthin.

OSTEOSARCOMA. See *Sarcoma.*

OTTAWA, CANADA.—Ottawa, the capital of the Dominion of Canada, is situated upon the river of that name, in the eastern part of the Province of Ontario, about one hundred and ten miles west of Montreal. It has a population of about fifty thousand, and is the centre of a large lumber traffic. The extensive government buildings are noteworthy for their architecture and material; and in the vicinity are various points of scenic interest—the Chaudière and Rideau Falls, and the Rideau Canal with its series of locks. A journey down the Ottawa River to Montreal (ten hours) is one of great interest, and affords constant views of imposing scenery. The climate is a cold one, comparable with that of northern New York and New England; the winters are long and there is much snow.

The accompanying chart will indicate the various climatic features.

Edward O. Otis.

OUABAIN.—This name has been applied to at least three distinct glucosides, by different chemists, under the impression that they were identical, all derived from African arrow poisons, or from the substances used in their manufacture. The name was derived from "Ouabaio," "Wabei," or "Wabajo," in relation to the Indians who used the arrow poison referred to. Fraser, in order to eliminate this indefiniteness, proposed for one of these substances, that generally employed, the name *Acocantherin* ($C_{30}H_{46}O_{12}H_{26}O$). It is derived from a species of *Acocanthera,* almost certainly *A. Schimperi* (A. DC.) B. et H. (*Carissa S.,* A. DC., fam. *Apocynaceæ*), though the present article of commerce is believed to be derived chiefly from a species of *Strophanthus* ("*S. glaber*"), of the same family. This glucoside occurs in colorless, transparent plates, if crystallized from water, or in fine tufted acicular crystals, if from alcohol. Nearly one per cent. dissolves in water and nearly two and a half per cent. in alcohol, but it is insoluble in ether and chloroform. The aqueous solution is tasteless. Sulphuric acid turns it red, afterward becoming green. Its primary effect is to slow and strengthen the heart. If the dose is very small, there is little effect upon blood pressure; if large, the latter is greatly increased, apparently through the vaso-motor effects. It powerfully stimulates unstriped muscle. In toxic doses it is an extremely active poison, 5-10 mgm. producing death in animals in a very short time. It is estimated that gr. $\frac{1}{65}$ introduced into the blood of man, would prove fatal. There is an early rise of blood pressure accompanied by increased cardiac action, which is followed by weakened contractions of the heart, rapid pulse, and paralysis of the vaso-motors. For further reference to the physiological action of ouabain see *Pharm. Jour.,* 1888, 162; London *Lancet,* xi., 1888, 392; *Ther. Gaz.,* November, 1891; *Br. Med. Jour.,* i., 1892, 27; *Virchow's Arch.,* Bd. cxxxiv., 1893; *Pharm. Jour. and Trans.,* July, 1895; *Berlin. klin. Woch.,* Mar. 31, 1902.

The local application of ouabain produces a condition of anæsthesia, and it has been found that a few drops of a 1 to 1,000 solution, instilled into the eye, cause an insensibility of the conjunctiva and cornea. This lasts for one or two hours, the pupil at the same time being powerfully contracted and the tension of the eye increased.

The medicinal uses of ouabain have not been developed, though they would undoubtedly be almost identical with those of strophanthin, with which ouabain was for some time believed to be identical. The dose of ouabain is

CLIMATE OF OTTAWA. LATITUDE, 45° 26′ N.; LONGITUDE, 75° 41′ W.—PERIOD OF OBSERVATION, FOURTEEN YEARS (BROKEN PERIODS).

	January.	March.	June.	August.	October.	Spring.	Summer.	Autumn.	Winter.	Year.
Temperature, Degrees Fahr.—										
Average or normal	10.6°	20.5°	64.9°	65.7°	45.0°	38.3°	66.4°	43.9°	12.7°	40.3°
Average range	18.3	16.5	19.8	18.9	18.5					
Mean of warmest	35.3	43.2	76.2	79.9	62.9					
Mean of coldest	17.0	26.7	56.4	61.0	44.4					
Highest or maximum	53.1	55.1	95.3	98.5	80.4					
Lowest or minimum	−33.0	−32.0	34.7	34.1	17.0					
Humidity—										
Average relative	88%	83%	72%	77%	82%	74%	75%	82%	88%	80%
Precipitation—										
Average in inches (rain or snow)	2.81	3.02	2.08	1.81	2.73	7.13	5.79	7.84	8.64	29.40
Wind										
Prevailing direction	NW. & NE.	NW.	W., E.	W., NW.	NW., E.	NW., E.	W., E.	W., NE.	NW.	NW. & NE.
Average hourly velocity in miles	8.1	7.5	4.9	3.8	5.1	6.6	4.2	5.4	7.6	6.0
Weather—										
Average number of clear days	7.5	7.5	10.7	12.3	6.5	27.0	31.0	18.7	17.9	94.6
Average number fair days	10.2	9.2	13.7	13.3	9.7	32.7	41.0	33.2	27.7	134.6
Average number of clear and fair days	17.7	16.7	24.4	25.6	16.2	59.7	72.0	51.9	45.6	229.2

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commonly given at from gr. $\frac{1}{2000}$ to gr. $\frac{1}{500}$. It is really probably much larger, though its little known character requires that it be used with great caution.

Ouabain has been employed as an antispasmodic in whooping-cough, by Dr. William Gemmell, of Glasgow (*British Medical Journal*, April 26th, 1890). He reports the treatment of forty-nine cases, of which twenty-five had been dismissed cured, four had died, and the remainder were under treatment. The fatal terminations were due to diphtheria, meningitis, and progressive emaciation. From his observations, he arrives at the following general conclusions: 1. Ouabain is of marked benefit during all stages of whooping-cough, and if carefully used produces gratifying results. In the first stage it cuts short the attack; in the second, it reduces the violence and frequency of the cough, and diminishes the number of whoops; and in the third, it hastens convalescence in a remarkable manner. 2. Ouabain is a drug which does not appear to be cumulative; its administration can be stopped suddenly without any ill effect beyond an exacerbation of the whooping-cough; it can be as suddenly resumed. 3. It should be given, at first at any rate, in a dose of gr. $\frac{1}{1000}$ every three hours (gr. $\frac{1}{125}$ daily). 4. For children under one year of age the dose should not exceed gr. $\frac{1}{2000}$ every three hours. 5. In children of from six to twelve years of age, if the cough be very violent and the whoops are numerous, gr. $\frac{1}{500}$ may be given in each dose, but the action of the drug must be carefully watched. 6. Ouabain may be given alone, dissolved in water, or in combination with potassium bromide, or with chloral hydrate. The simplest way is to dissolve one grain in distilled water, so that each minim of the solution shall be equal to gr. $\frac{1}{1000}$ ouabain, as: ℞ Sol. ouabain, ♏ xlviij.; syr. aurantii, ʒ iv.; aq. ad ℥ vi. M. Sig.: A teaspoonful every three hours. 7. Under the administration of ouabain, it is found that the temperature, pulse, and respiration are, in uncomplicated cases, slightly below normal. When the drug is pushed, the respirations become very slow indeed; in one patient, aged four, they were often as low as sixteen per minute. It is from this that danger is to be expected. During the administration the action of the skin is promoted, the amount of urine is increased, and the movements of the bowels become more regular. Ouabain has also been used with equally satisfactory results by Dr. J. Lindsay Porteous, of Yonkers, N. Y. (*New York Medical Journal*, vol. liv., 345). He gave it in three cases, one adult and two children, and in all marked improvement was immediately noticed. To a child of fifteen months gr. $\frac{1}{4000}$ was given every three hours; to a child of four years, gr. $\frac{1}{2000}$ every four hours, and to the adult, gr. $\frac{1}{500}$ every three hours. In all these cases the patient was entirely well at the end of a week.

Beaumont Small.

OURAY SPRINGS.—Ouray County, Colorado. Post-Office.—Ouray. Hotel and cottages.

Access.—Via Denver and Rio Grande Railroad (narrow gauge) from Denver, Colorado Springs, and Pueblo.

The town of Ouray is situated in a picturesque amphitheatre of the Rocky Mountains, 389 miles from the city of Denver. The altitude of the town site is 7,500 feet above the sea level, but the neighboring mountain peaks tower several thousand feet higher. Mount Sneffils, five miles west, reaches an elevation of 14,225 feet, while Uncompahgre Peak, ten miles east of the town, attains the superb altitude of 14,440 feet above tide water. The famous and beautiful Bear Creek Falls are two miles south of the town, and near them is the wonderful piece of toll-road, cut in walls of perpendicular quartzite. All about the neighborhood are rich mines of gold and silver. There are also many other natural features of interest, including caves, waterfalls, cañons, peaks, lakes, and gorges, reached by good roads or mountain trails. The climatic conditions about Ouray are quite unexceptionable, sunshine being the rule, with warm and pleasant days during the summer, followed by cool, refreshing nights. The highest summer temperature is about 90° F., and the lowest winter minimum 5° F.; but owing to the rarity and dryness of the atmosphere, these extremes represent much less variation than in most localities of the East. The number of springs in the town limits is estimated at more than one hundred, the temperature of their waters ranging from 130° to 140° F. No analysis has been made, but we are informed by the proprietor of a number of the springs that the waters contain lime, soda, manganese, and iron, and some of them sulphur. Two bath-houses have been fitted up, and are much resorted to in the treatment of rheumatic affections. It is said that the internal use of the waters has been found beneficial in cases of dyspepsia, indigestion, constipation, and blood and skin disorders. The town of Ouray has about twenty-five hundred permanent inhabitants, and is well supplied with pure and wholesome water from mountain springs by water works constructed on the gravity plan. The city possesses a complete system of sewerage, and is always in a clean and healthful condition. The climate is said to be very beneficial to persons suffering from bronchial and pulmonary troubles.

James K. Crook.

OVARIES, DISEASES OF.—The ovaries are two small ovoid or rounded bodies, one of which is attached to the posterior surface of the broad ligament just internal to and below the fimbriated extremity of each Fallopian tube. They are of a pinkish color and vary in size and shape, even in health, without being actually malformed. The average measurements are: Length, 30-50 mm.; breadth, 15-30 mm.; and thickness, about 12 mm. Ovaries greatly exceeding the above in size are rarely met with, but Altoukhov reported before the members of the Moscow Obstetrical and Gynæcological Society the case of a patient whose right ovary measured 35 × 13 × 7 mm., and the left one 80 × 14 × 6 mm., and at the same time mentioned a patient of Nega's in whom the left ovary was 54 and the right 108 mm. in length. In the latter case the uterus was infantile and the patient a pronounced nymphomaniac; but whether or not the enlarged ovary caused the nymphomania it is very hard to say. Probably excessive irritation of the vulva caused the hypertrophy of the ovary.

The function of the ovaries of producing and discharging ova has long been known, but of late they have been credited with producing an internal secretion which alleviates or prevents the troubles of the menopause.

Absence of Ovaries.—One or both ovaries may be congenitally absent. When both are wanting there is usually a lack of development of the mammæ and other sexual organs, and when only one is missing the corresponding side of the uterus is poorly developed. When a woman has absolute amenorrhœa, without any molimina, and sterility, you may suspect that she has no ovaries; but as long as one ovary and tube are present maternity and menstruation will likely go on undisturbed. The only way to make sure about the presence or absence of both sets of appendages is to open the abdomen and explore the pelvic cavity.

Transplantation of Ovaries.—On account of the serious results, matrimonially and otherwise, of the absence of both ovaries, either congenitally or as a result of operation, the procedure of transplanting ovaries is of considerable interest. J. Lankashevitsch interchanged ovaries between rabbits, dogs, etc. The operations were carried out with the strictest aseptic precautions. Each ovary was removed along with its mesentery, the cut edge of which was attached to the broad ligament of the new host near the spot from which the corresponding ovary had been taken, but sufficiently far from the cornu of the uterus to avoid compression. In a few instances, however, the ovary was fastened to either the mesentery or the peritoneum of the abdominal wall; the sutures used were fine silk and were placed very close together.

The only dog used was killed nine months after operation, and the transplanted ovary was found firmly adherent in its new situation, and to be but slightly diminished in size. Capillaries and muscular tissue ran from

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Ovaries.

the ovary to the subjacent tissue. Germinal epithelium was seen in places and a few normal follicles lay in the cortex side by side with others which had undergone atrophic change. Yellow areas of degenerated tissue were scattered here and there throughout the organ. In the case of animals which were killed two or three years after operation, the large ovaries remained, whereas the smaller ones had almost entirely disappeared: and in the latter case the genitals also had become atrophied if the animal's own ovaries had been removed. Conversely, it may be stated that the transplantation of large (*i.e.*, from large animals) ovaries exerts an inhibitory action upon the atrophy of the genitalia, and also upon the deposit of fat in the pelvis which usually accompanies the menopause.

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B. A. Katsch has also investigated this subject, and practically obtained similar results to the above.

The ages of the animals from which the ovaries are taken have an important bearing upon the result as regards rapidity of regeneration of the follicles, etc., this rapidity of regeneration being inversely proportional to their age. When the ovaries are first implanted their tissues tend to degenerate to some extent in the following order, viz., connective tissue, germinative tissue and its derivatives, and lastly, the medullary layers, the Graafian follicles undergoing a change similar to that which occurs at the menopause. Their death takes place centripetally, but they may become regenerated from the germinal epithelium. When this rejuvenescence of the ovaries, as one might call it, does not take place, the genitals atrophy.

In none of the animals operated upon did pregnancy follow, although ample opportunity for this to take place was given.

The conclusions to be drawn from the consideration of the above facts are: (*a*) Ovaries can be transplanted from one animal to another, (*b*) ovaries from the carnivora will take the place of those of herbivora and *vice versa*; and (*c*) the transplanted organs flourish and partially functionate. These reported results open up visions of the practicability of performing the same operations upon women, but the field of feasibility would necessarily be very limited by the difficulty of obtaining absolutely healthy ovaries to transplant, as well as for other reasons which it is unnecessary to mention.

R. T. Morris adds as further proof of the possibilities of this operation that the occurrence of pregnancy after oöphorectomy is due in many cases to the transplantation of portions of the ovary. As early as 1895 Morris began ovarian grafting in the human being, having had twelve cases up to 1901. He places the ovary in normal saline solution at a temperature of 100° F. In his early cases he made a slit in the fundus of the uterus and placed the ovary in it, but in his more recent ones the ovary was attached to the broad ligament as near the seat of attachment of the patient's own ovary as possible. The result thus gained is the avoidance of a premature menopause, thus showing that the ovarian graft has retained its vitality. In one case pregnancy resulted, but an early abortion occurred.

Accessory or Third Ovaries.—These have been described, but were probably merely pieces of an ordinary ovary, which had become separated from the rest of the organ by fissures. It is significant that during the thousands of cœliotomies which have been performed of late years, no competent observer has definitely reported a case in which more than two ovaries have been found in any one patient.

Displacements of the Ovary.—While the ovaries are developed in the abdomen they usually descend into the pelvis, but now and then one or both fail to do so and remain at the level of the pelvic brim. This malposition, however, gives rise to no symptoms, but will prevent the physician from feeling the organ during an ordinary bimanual examination. It may be diagnosed by not discovering the ovary in its usual place, or in thin subjects by feeling it at the pelvic brim during deep abdominal palpation.

Hernia.—A more important form of displacement, on account of the discomfort to which it may give rise, is hernia of the ovary. Here it descends along the round ligament and lies in the sac of an ordinary inguinal hernia, or it may lie in one of the labia majora, or even form part of a femoral or obturator hernia. In addition to the usual symptoms of a hernia, one gets an exacerbation of pain at the menstrual period and also an increase in size and tenderness at the same time. Pressure gives rise to a peculiar nauseating pain, which is almost pathognomonic of pressure on either an ovary or a testicle.

Treatment.—If in a position in which it is subjected to much irritation or pressure, the ovary may be protected by a cap or pad; but if these fail, it may be removed by an ordinary herniotomy operation.

Prolapses of the Ovary.—In health the ovary lies to one side of the uterus, at the level of or slightly below the fundus. In certain conditions, however, it falls considerably below that level, at which time the position may be considered to be pathological. It is due to a retroposition of the fundus dragging it out of place, or to adhesions due to an old pelvic peritonitis, acting in a similar manner. A general want of tone of the parts or prolonged ovarian congestion will also cause the ovary to become prolapsed. Other causes of this condition are sudden strains or any enlargement of the organ.

The *symptoms* are caused by the congestion consequent upon the displacement of the organ and by the disturbance of and pressure upon it by the distended bladder or rectum, and the various movements of the pelvic muscles. These all cause a dragging, aching pain in the pelvis, which is exaggerated at the onset of the menstrual congestion. More or less severe paroxysms of pain are caused by coitus and the passage of hard fæcal matter along the rectum.

When the organ is not embedded in adhesions, the *diagnosis* of a prolapsed ovary is comparatively easy. On making a vaginal examination a tender ovoid, mobile body is to be felt, either low down behind the uterus or in one or other lateral region of the pelvis.

The *treatment* consists in finding and removing the cause wherever possible. If the uterus is prolapsed or retroverted, restore it to its normal position, and keep it there by tampons or a pessary. If there is a general want of tonicity in the parts, try to improve the condition by hot douching, local counter-irritation per vaginam, and the insertion of a boroglyceride or glyceride of tannic-acid tampon, as well as by the local use of electricity, especially faradic. The bowels should be kept regular, and gentle exercise (walking) be encouraged. Some writers advocate pelvic massage for this condition, and claim to have obtained striking results from this line of treatment. It is questionable, however, if the doubtful good obtained is not entirely eclipsed by the ill effects which the necessarily prolonged handling of the genitals produces.

When the ovary is adherent, and the above treatment fails to relieve the pain, etc., an operation will be required. The indication will then be to separate the adhesions and possibly stitch the ovary in a more favorable position on the broad ligament. In order to prevent the formation of fresh adhesions the raw surfaces may be covered with Cargile's animal membrane or with a small portion of omentum, which may be cut off and carefully sutured over them. The abdominal route is the one recommended for this operation, as you are able to expose the parts thoroughly, and treat any small pockets of pus which are so apt to be present in old cases of pelvic peritonitis. You can also stitch the ovary in place better by the abdominal than by the vaginal route.

Atrophic Disturbances.—*Atrophy of the ovary* may be physiological (as when it follows the menopause) or pathological. Pathological atrophy is apt to accompany excessive obesity, while prolonged pressure by adhesions or tumor, interference with the vascular supply and removal of the uterus, are also causes of this condition. It is also said to follow alcoholism, acute exanthemata, rheumatism, etc., but the condition then is not one of true atrophy but of cirrhosis.

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In *cirrhosis of the ovary* there is an increase in the fibrous tissue of the organ at the expense of the glandular and muscular elements. In the early stages the ovary is of normal size, but is firmer than usual; while later it is small and very hard, its surface is glistening white and thrown into brain-like convolutions by contraction of the fibrous tissues.

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The *symptoms* are pain, sterility, and various reflex neuroses, the patient often complaining of gastric disturbance, visual defects, and headache. The pain is usually related to menstruation, or is of a peculiar dull sickening nature, coming on from ten days to two weeks before the onset of the flow. Local examination of the pelvis is not apt to reveal very much, as the ovaries are too small to be felt except in particularly favorable cases, when they are felt to be very hard, painful, and small.

In the way of *treatment*, not much can be done, although in the earlier stages electricity may possibly check the condition. When fully established, however, oöphorectomy is indicated.

The *etiology* of the condition is unknown.

HYPERTROPHY.—This is caused by anything which produces chronic congestion, or by any inflammatory process which stops short of the formation of pus. As examples of those causing congestion may be cited chronic constipation, prolapsus ovarii, too frequent coitus, etc. Pure hypertrophy, however, is where there is an increase of all of the constituent parts of the ovary, and is extremely rare, the above conditions being much more likely to be followed by cystic or fibrous enlargement than by true hypertrophy.

The *symptoms* of hypertrophy of the ovary *per se* are practically *nil*, but will be those of the condition giving rise to it; consequently no *treatment* is necessary.

INFLAMMATION OF THE OVARY.—In the ovary, as elsewhere, *congestion* is an early stage of inflammation. Just as in other regions, it has its own symptoms and may be checked without going further.

The causes of congestion are exposure to cold, especially during menstruation; chronic constipation, in which case the left ovary is the one chiefly affected, owing to its proximity to the rectum; excessive sexual excitement, prolapse of the ovary, inflammation of neighboring structures, bacterial toxins or germs (invasion by the latter rarely stops short of producing pus), and twisting of the pedicle of the ovary. Sometimes the removal of one ovary produces an hypertrophy of the other, which, as a rule, is transitory. It may, however, go on to chronic inflammation and cystic formation; but if promptly, properly, and patiently treated by rest, hot douches, and boroglyceride tampons, the congestion should subside in a few months' time. One can readily understand how disappointed a patient is when the removal of one ovary has simply resulted in the transference of her pain to the opposite side. She will often blame the operator for not having removed both ovaries, and want him to perform a second oöphorectomy; but if he is firm in his refusal to do so until a more or less prolonged course of local treatment has been tried, both he and his patient will time and again be rewarded by the return of the diseased ovary to health and usefulness.

Besides the above pathological forms of congestion a physiological variety occurs during menstruation, pregnancy, and sexual excitement, but this does not require consideration in this article.

Oöphoritis, or inflammation of the ovary, may be either acute or chronic, the former usually passing on to the chronic variety if untreated, and if the infection is not sufficiently acute to carry off the patient before the affection reaches the chronic stage.

Acute oöphoritis is practically always caused by the presence of germs. These may be carried to the organ by the blood or lymph vessels from some more or less remote source of infection, or else may attack it by a more direct route, as where there is an acute infectious inflammation of the Fallopian tube, or where the ovary is adherent to the rectum, appendix, or other portion of the bowel, and the germs reach it from thence.

The two most common forms of infection are gonorrhœa and puerperal septicæmia, both of which may cause a most severe disease. In addition to these, however, acute inflammation may be set up by injury, by poisons, such as arsenic and phosphorus, by the acute exanthemata, mumps, acute rheumatism, etc. The writer, some years ago, saw a woman who was suffering from an ordinary attack of typhoid fever; she was quite suddenly seized by a sharp pain in the region of the right ovary, the pulse became more rapid and the temperature rose. Appendicitis and perforation of the bowel having been excluded, the abdomen was opened and the right ovary was found to be enlarged and acutely inflamed. The removal of the organ was followed by relief of all pain, with ultimate recovery of the patient.

Symptoms.—The patient suffers from an acute agonizing pain in one or other ovarian region, the pain radiating up toward the umbilicus into the loin, down the leg, etc. More or less nausea is present. Defecation and micturition are frequently painful. Examination of the lower abdomen reveals great tenderness over the affected region, and the same will be found per vaginam, by which passage also one can feel the ovary to be somewhat enlarged if the parts are not too tender.

Treatment.—Absolute rest in bed is distinctly indicated, as is also the application of ice, or, if that fails, heat, over the lower abdomen. The parts may be too tender to allow of hot douches being used, but they usually give great relief. The water ought to be as hot as the patient can possibly stand it, and at least one gallon should be used. The force of the water may be regulated by the height of the douche pail above the patient's bed, and ought not to be too strong. Lavage of the rectum is often of service, especially when the left ovary is the one affected. Blistering the abdomen over the diseased area will often be of service.

The tincture of aconite, given in doses of one or two drops every hour, often benefits the condition by quieting the circulation, but there is no drug which has any specific action upon the malady. The bowels should be well emptied early in the attack and then kept at rest. The best way to influence them is by sulphate of magnesia in drachm doses every hour for five or six hours; the drug being dissolved in hot water. After this has taken effect keep the bowels closed by tinctura opii, or by a pill plumbi cum opio. As regards diet, it should be fluid, light, and non-stimulating, consisting principally of milk and its preparations.

Prognosis.—If the patient is seen in time and if the infection is not too virulent, the above treatment suffices to cure the vast majority of cases. But the disease may pass into the chronic variety, or else an abscess may be formed. This abscess if not interfered with may either resolve, remain quiescent, or rupture. If the organ has become adherent to either the bladder or the bowel, it may rupture into them and its contents be discharged externally. Otherwise it will rupture into the general peritoneal cavity, causing acute inflammation of its lining membrane and the death of the patient. After the escape of the contents through either the bladder or the rectum the sac may refill, and should then be removed by the surgeon; in fact, when an abscess of the ovary exists which will not yield to milder measures, the surgeon must interfere. It is better if he can wait until the virulence of the germs is lessened, as this greatly reduces the risk of the operation and occurs within a few weeks, probably not more than five or six.

Diagnosis.—This is sometimes a matter of great difficulty and importance. The conditions with which it is most likely to be confused are: (*a*) appendicitis (when the right ovary is attacked); (*b*) intussusception; and (*c*) pelvic tumor with a twisted pedicle.

In appendicitis the pulse and temperature are more liable to be interfered with, there is more vomiting, the tenderness is higher in the abdomen, and it is more than probable that a vaginal examination will give a negative result, whereas in acute oöphoritis the examining finger will probably feel the diseased ovary.

Intussusception rarely occurs in adults. It gives rise

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to a sausage-shaped tumor, and either to complete constipation or to bloody and mucoid stools.

A tumor with a twisted pedicle makes itself evident either to sight or touch, if not to both. An ovary enlarged by an abscess would give a more chronic history, *i.e.*, it would not give rise to the sudden acute pain which torsion of a pedicle causes.

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Chronic Oöphoritis is much more common than the acute form which it may follow. It frequently, however, comes on quite independently of the acute variety, and is much more insidious in its onset. Women are most liable to it during the period of greatest sexual activity, from which statement it may be correctly inferred that it is much more common among married than among single women. Excessive sexual excitement, especially without gratification of the desires, is one of the commonest causes of this condition. In addition to this, mumps, masturbation, operations upon the cervix (?), and prolonged congestion of the ovary are prolific causes.

Pathology.—When an ovary which is the seat of chronic inflammation is examined, it is found to be somewhat enlarged, and to contain more or less numerous small cysts. The organ is firm, and its peritoneal covering is tough and thickened. There is also an increase in the fibrous tissue.

Symptoms.—Chronic inflammation of the ovary produces pain in one or both sides of the pelvis, according as to whether or not one or both ovaries are affected. When the disease is unilateral, the left is the one usually the seat of the trouble on account of the proximity of the rectum. This pain may radiate down the thighs, across the abdomen, or up toward the umbilicus, and is aggravated by defecation, by any sudden movement, as on taking a jump or misstep, by jolting, coitus, etc. It also becomes more marked a week or ten days before the menstrual flow appears, being relieved by the local depletion which is thus caused, in proportion to the amount of blood lost. A sharp pain in either one or both breasts, and especially in the left, is often experienced. Pressure through the abdomen over the diseased organ causes pain, as does also coitus. On making a local vaginal, or, better, rectal examination of the pelvis, the ovary is felt to be enlarged, tender, and often more or less prolapsed.

The *diagnosis* is not difficult as a rule. The location, in the ovarian region, of a pain which becomes more severe several days before menstruation; the reflex mammary pain; painful defecation and the presence of an ovoid tender mass in the region usually occupied by the ovary, will point strongly to chronic inflammation of the ovary. Of course the inflamed organ may be plastered against the pelvic wall by adhesions, in which case you will have to be guided by symptoms alone.

Treatment.—This consists in finding and removing the cause wherever this is possible. Regulate the bowels and diet and limit the patient's exercise. This may require to be entirely prohibited in obstinate cases, the patient being confined to bed. Stop excesses of all kinds, whether bacchanalian, gastronomic, or sexual. The domestic duty most likely to aggravate or at all events keep up the trouble, is working the treadle of the sewing-machine, which should be strictly forbidden. Depletion of the pelvis may be effected by accelerating the action of the bowels by means of sulphate of magnesia or one of the many aperient waters, by hot douching, by hip baths, by medicated tampons, or by vaginal cones or bougies. For the douchings plain boiled water cannot be improved upon, but it must be used in quantities of not less than a gallon, and must be as hot as the patient can possibly bear it. The vagina, not being a very sensitive organ, can tolerate a much higher temperature than the skin of the perineum and vulva, but these parts may be protected by a towel wrung out of warm water. The tampons are better if they are made small, about the size of a large walnut, using two or more if necessary. They will thus fit more snugly and cause the patient less discomfort than if a single large one is used. While tampons saturated with boroglyceride or pure glycerin are useful, the employment of a ten-per-cent. solution of ichthyol in glycerin, or a combination of ichthyol, tincture of iodine, glycerite of hydrastis, and boroglyceride is to be preferred. Counter-irritation through the skin of the abdomen, or per vaginam, is a valuable adjunct to the above course of treatment. The first may be carried out by painting the skin of the abdomen with the tincture of iodine, or blisters may be employed. When these are used a small blister should be placed over the centre of the painful area. When this one heals a second is to be placed at its side, and so on until the first one has been completely surrounded; each one being allowed to heal before applying the next. The counter-irritation per vaginam is best effected by painting the lateral fornices with a mixture of equal parts of the liniment and tincture of iodine.

Little can be done in the way of internal medication for this condition. The bromides, especially a combination of those of ammonium and sodium, have been highly commended and may be of some use in quieting the circulation and pain. The chlorides of gold and sodium have also been employed with benefit. Temporary exacerbations of pain must be combated by the local application of heat and the administration, by the medical attendant himself, of morphine. Alcohol should be absolutely forbidden as it only aggravates the condition eventually, although it may relieve the pain for the time being.

The above line of treatment ought to be conscientiously persisted in for many months before abandoning it as useless—that is to say, when the woman can give up the time for it. When she cannot do this, and it is necessary to cure her quickly so that she may return to her ordinary sphere of usefulness in a comparatively short time, as also in those cases in which all non-operative means have failed, removal of the offending organ is the only resource left. This may be done per viam abdominalem or per vaginam, but this operation will be fully described in another article. (*Cf. Ovariotomy.*)

Hæmatoma of the Ovary.—During the course of acute fevers, as a result of injury or pressure upon or torsion of the broad ligament containing the ovarian vessels, one of the capillaries within the stroma of the ovary or wall of a Graafian follicle may rupture and give rise to a collection of blood, which is called an hæmatoma ovarii. It may also be caused by the impregnation and rupture of an ovum in the ovary, the possibility of the occurrence of which has been but recently demonstrated. Hæmatoma of the ovary is not at all uncommon, but is rarely of any clinical significance. On inspection the ovary is seen to have a larger or smaller bluish-red mass projecting from its surface, which mass is semifluctuating. Microscopic examination reveals a mass of blood clot lying within a more or less well-formed capsule.

Ovarian hæmatoma rarely gives rise to any symptoms or calls for any treatment. If symptoms are present they are usually those of chronic ovaritis and call for the same treatment, except that where operation is indicated nothing should be removed but the diseased portion of the ovary.

Ovarian Pregnancy.—In Clifford Allbutt's "System of Medicine," published as recently as in 1896, the writer on "Diseases of the Ovaries" says: "It is extraordinary that belief in the occurrence of ovarian pregnancy should have obtained currency," and that "until some specimen is forthcoming in which an early embryo in its membranes can be demonstrated in a sac inside the ovary, we need not trouble ourselves to discuss ovarian pregnancy." Only three years later Croft and van Tussenbroch each reported an undoubted case, and since then at least three other cases have come to light, viz., those of Anning and Littlewood in 1901, Mayo Robson in 1902, and Thompson in 1902. It is a curious fact that of the five cases no less than three occurred in Leeds, England.

Symptoms.—Ovarian pregnancy gives rise to very much the same symptoms as those of ordinary tubal gestation, except that, as a rule, rupture is not preceded by the dull aching pain in the side, to which the latter gives rise. The absence of this pain may be ascribed to earlier rup-

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ture and to there being no firm muscular fibrous tube wall to distend.

The patient passes her time by a week or ten days, or else her last period has been replaced by a dribbling of blood which has persisted. This is followed by a sudden sharp pain in one ovarian region, accompanied by faintness, with possibly actual loss of consciousness, by sighing respirations, pallor, a cold clammy sweat, and rapid thready pulse. Although the temperature is usually subnormal, some elevation of it is quite compatible with the condition, as was recently seen in a case which the writer had under his care in the Montreal General Hospital.

On examining the patient the surgeon will find some tenderness over the affected organ, slight dulness in the flanks, and the seat of the effused blood will be warmer than the rest of the abdomen. Attention was first drawn to this sign by Grandin, and while it cannot be always distinguished, the writer has seen it in at least one case since the publication of Grandin's paper. Vaginal examination will reveal an oozing of blood from the vagina, a softened velvety cervix, normal uterus, and a rather vague mass in one fornix.

The *etiology* is still *sub judice*. As shown by the fact of only five undoubted cases having been reported, pregnancy occurring in the ovary is extremely rare; but it is quite possible that many of the cases of hæmatoma of the ovary which have been reported have really been cases of ovarian pregnancy, it being probable that villi and other signs of gestation would have been observed if they had been carefully searched for. On the other hand, it is almost certain that many of the older cases of reported ovarian gestation have really been nothing more than hæmatomata, as proved by microscopic examination. In order to be certain that the gestation is ovarian, it must be shown that the original attachment is inside the ovisac, and that the ovum derives its nourishment from thence. This can be done with certainty only in the very earliest weeks of pregnancy, as the ovarian tissue is liable to become so displaced in cases of tubo-ovarian pregnancy as to appear to have been the original seat of implantation of the ovum. In a true ovarian gestation the ovum immediately upon impregnation attaches itself to the wall of the ovisac; villi are thrust into this wall, and by this means the ovum is nourished. In the majority of cases the ovum continues to grow until between the fifth and sixth week, at which time it ruptures into the peritoneal cavity. This is followed by severe intraperitoneal hemorrhage, although, judging from the small numbers and size of the vessels, one would not expect such a result. In at least two of the fully reported cases the abdomen was found to be filled with blood at the time of operation.

Treatment.—This will vary according as to whether or not hemorrhage has ceased and the patient can be kept under observation and constant readiness for operation, and also whether or not the clot is undergoing absorption. If seen some time after rupture has taken place and if the patient can be kept under close observation, temporizing measures may be adopted. In such a case one of the most important points to be remembered is that all cardiac stimulants are absolutely contraindicated, as their exhibition is very liable so to increase the force of the heart's action that the clots, which are plugging the mouths of the ruptured vessels, will be forced out and a fresh hemorrhage take place. The very best way to improve the patient's condition is to use decinormal saline solution, either per rectum, or subcutaneously, or intravenously, according to the acuteness of the symptoms. It is only in the most urgent cases that the latter method is required, as the solution is very quickly absorbed from either the bowel or the submammary region. Absolute quiet and rest in bed are strongly indicated, and the circulation and pain may be calmed by the subcutaneous injection of morphine. Ice should be applied to the abdomen over the point of rupture, and hot vaginal douches may be begun some days after cessation of the bleeding. The diet should be nutritious but non-stimulating. Where under this treatment the clot does not become absorbed within a reasonable time, it may be cleared out by means of an incision through the posterior vaginal wall.

When the patient is seen soon after rupture, or when she cannot be kept under observation, the quicker the abdomen is entered, the bleeding controlled, and the gestation removed, the better it will be for the patient, shock or no shock. This condition of shock is to a very great extent due to loss of blood, and will not be lessened by allowing this to proceed. While some few of these patients will recover without operation, a much larger percentage of recoveries will take place if the knife is used early, energetically, and judiciously.

Tuberculosis of the Ovary.—Tuberculosis of the ovary is extremely rare, the ovary being only the third in order of frequency of the female genitals to be affected. In fact so rare is the disease that the older writers did not deem it worthy of consideration in their works. The rarity and almost impossibility of occurrence of primary ovarian tuberculosis can be readily understood when one realizes that in order to have such a condition the bacilli would require to enter the body from the exterior and then traverse a more or less complicated system of blood-vessels or lymphatics before entering the ovary. No case of primary tuberculosis of the ovary in the human subject has yet been reported. Although Acconi experimentally produced it in animals, Spaeth, Blebs, Oppenheimer, Sippel, and others have recorded cases in which the ovary was the only genital organ to show the disease in patients who were otherwise tuberculous. In the majority of cases it was the superficial part of the organ which was the seat of the disease, the presence of which in the deeper layers was frequently unsuspected until the ovary was examined under the microscope.

The form of tuberculosis present is the miliary form, and it may affect either the superficial or the deep layers. When the latter part is affected, the disease is apt to proceed until an abscess is formed, and this may rupture into the peritoneal cavity. The germs may reach the ovary either through the blood or the lymph current by direct continuity, as in the case of tuberculosis of the peritoneum or tubes, or by bacilli working their way through a weak spot in the bowel wall and falling upon and infecting the ovary.

No age is exempt from this disease, but those under fifty are the most liable to be attacked. Out of 17 cases reported by Griffith 5 were under fourteen, 8 were between fourteen and twenty-five, 3 between twenty-five and forty-five, and 1 was fifty-five years of age.

The *clinical history* is very vague and there is no symptom or series of symptoms which can be considered to be at all pathognomonic of this condition. There may be absolutely no symptoms or else those described as occurring in chronic oöphoritis may be present. Where such is the case and you have a semifluctuating, rounded, non-sensitive mass occupying the region of the ovary, together with an evening rise of temperature, in a young woman who is otherwise fairly healthy, and who has not been exposed to the two common causes of pelvic abscess, viz., gonorrhœa and sepsis, you may suspect the presence of a tuberculous abscess of the ovary. Anything short of abscess formation cannot be definitely diagnosed previous to operation, as both physical signs and symptoms are too indefinite. Menstruation may or may not be affected, but when it is interfered with amenorrhœa is the form usually taken, and is more the result of the general than it is of the local condition.

Once diagnosed the only *treatment* to be adopted is removal, but this can be advocated only in the absence of extensive disease of other organs.

Tumors of the Ovary.—The ovary itself may be divided into the oöphoron which contains the ova, and the paraoöphoron or part nearest the ovary. Although this latter is anatomically quite distinct, it might be considered clinically to be part of the ovary. Of these three parts, the oöphoron is the most active as far as the formation of tumors is concerned. From it are derived 1.

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Fibromata; 2. Myomata; 3. Sarcomata; 4. Carcinomata; 5. Cysts; 6. Adenomata; 7. Dermoids.

The paraoöphoron gives rise to papillomatous cysts, and from the parovarium are developed unilocular, thin-walled cysts. Of the above tumors cystomata form about ninety-five per cent., the multilocular cysts being the commonest.

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1. *Fibromata.*—These are the rarest of all ovarian tumors, muscular tissue being found along with fibrous in most benign solid ovarian tumors. When pure, these tumors consist of many bands of white fibrous tissue which interlace and include in spaces round cells, and here and there among the fibres a few small spindle cells are seen. No blood-vessels or nerves are found in the substance of the growth. Fairbairn divides them into three groups: (1) Where the whole ovarian stroma is replaced; (2) where part of the stroma only is affected; and (3) where a pedunculated fibroid springs from the surface of the ovary.

Fibroids of the ovary are more likely to develop in women who have passed the menopause than are fibroids of the uterus, and they occur twice as often in married as in single women.

Herbert Spencer found the tumor to originate in the fibrous capsule of the Graafian follicle in three cases. Peter Horrocks asserted that when carcinomatous and sarcomatous tumors are bisected the cut surface remains flat, whereas in fibroids it becomes concave, owing to the elasticity of the fibres. But this diagnostic sign is untrustworthy. The disease is usually unilateral, but Cleeman recently reported before the Philadelphia Obstetrical Society a case in which a pure fibroma of each ovary was found in a patient. Ascites was also present.

Symptoms are often absent until the tumor has been present for a long time. The patient may, however, complain of dysuria, dragging pain in the pelvis, dysmenorrhœa, and enlargement of one side of the lower abdomen. Ascites is frequently present, but it does not form a constant sign. Local examination reveals an extremely hard, firm tumor of ovoid shape, situated to one side of the uterus; it is non-sensitive and usually mobile.

The only *treatment* is removal, and this ought to be effected as soon as the tumor is discovered, on account of the difficulty of diagnosis between it and sarcoma.

The *prognosis* is unfavorable if the fibroids are not removed, as, unlike uterine fibroids, they are liable to take on active growth at any period of the patient's life.

2. *Myomata.*—Tumors of the ovary composed wholly of muscular tissue are almost as rare as pure fibromata. They usually develop from near where the ovarian ligament joins the ovary, as this ligament contains an abundance of muscular tissue. In 1896 Gessner found a small fibroid tumor on the ovarian ligament, situated at an equal distance from both the ovary and the uterus, and he inferred from this "that a myoma of the ovarian ligament might invade a healthy ovary and convert it into a myoma of the ovary." Baldy, in "American Gynæcology," reports a case which occurred in a married woman, thirty-six years of age. Operation revealed multiple uterine fibroids, and that the right ovary was replaced by a fibroid mass of the shape and size of a lemon. This mass was attached to the posterior layer of the broad ligament and had the Fallopian tube running over its upper surface. The fimbriated extremity of the tube ended on the external surface of the capsule of the tumor. This latter itself was composed of smooth muscular fibres and a little connective tissue. A band composed of connective tissue and large blood spaces separated it from the true ovarian tissue which was apparently normal.

3. *Sarcomata.*—The ovary is not infrequently affected by tumors of a sarcomatous nature. Apart from regular sarcomata, masses of tissue indistinguishable from sarcoma sometimes occur in dermoids, the removal of which in these cases may be followed by malignant disease of the pelvis. When the ovaries are affected by these growths the disease is frequently bilateral, here differing from what takes place in other parts of the body where the affection is usually unilateral.

The ovary may be invaded by either the round- or the spindle-celled variety. The former is usually found when both sides are affected and in young patients. At the Würzburg Frauenklinik, out of 295 cases of ovarian tumors 20 were sarcomatous; the ages of the patients ranged from twelve to sixty-three, 7 being over fifty years old. Out of 4 which occurred in females under twenty, 3 were of the round-celled variety. Seven died after operation, 3 within the first four days and 4 before six months had elapsed.

Cohn states that their occurrence in relation to ovarian cystomata is as 1 to 100, and that they form ten per cent. of all malignant tumors of the ovary. In 400 cases of ovarian tumors of all kinds, including endothelioma, he found 5.38 per cent. to be sarcomata.

The tumors may grow either rapidly or slowly, and often attain a weight of from twenty to thirty pounds. Their consistence varies, some being hard (the spindle-celled variety), and others (the round-celled) soft and brain-like. They are surrounded by an outer wall, which sometimes is very soft and friable. The pedicle is usually short, and it is but seldom that adhesions to neighboring organs are formed, but ascites is usually present.

On section the surface may be yellowish-white or pinkish-gray, this depending upon the number of blood-vessels present as well as on the structure. Small cysts are often seen, and are due either to hemorrhage into the tissue with subsequent softening or else to fatty degeneration of the tumor cells.

Of the two varieties, the small round-celled is the most malignant; the greater the amount of fibrous tissue present, the less danger is there of any secondary trouble. This secondary infection attacks structures in the following order: viz., peritoneum, omentum, stomach, pleura, lungs, uterus, liver, diaphragm, and kidneys. The tumor may undergo degeneration, the commonest being fatty and myxomatous.

The *symptoms* are few at first, but ascites may develop early, and this forms one means of differentiating sarcomata from fibromata or myomata of the ovary. Pain and disturbance of menstruation are also more frequent than in benign solid ovarian tumors. Physical examination yields similar results in both fibroma and sarcoma ovarii. Metastases are indicated by ascites, œdema, enlarged abdomen, and rapid decline in the patient's health.

The only *treatment* is prompt and thorough removal of the affected organ, and it is also wise to remove the ovary of the opposite side, as it may be affected without showing it macroscopically.

Post-operative *prognosis* as regards recurrence is not good, but is better than when the ovary is the seat of cancer. When both ovaries are diseased or when the round-celled variety is found, the prognosis is decidedly more grave than when one side only is affected or when the growth is composed of spindle cells.

Endotheliomata.—These are malignant tumors which begin by a proliferation of the endothelial lining of the blood or lymph vessels of the ovary. They may be said to occupy a place midway between carcinoma and sarcoma, differing from them in structure but possessing similar clinical features. Billroth regarded them as being as malignant as carcinomata.

Endotheliomata were thus named on account of their origin, by Marchand, who first described them in 1879. They are usually solid, but may contain spaces. The surface is smooth, but may present tuberosities, composed of tissue which is of a brain-like or spongy consistence. They occur mostly at middle age, although Leopold has seen one in a girl of eight, and Olshausen one in a girl aged seventeen. In size they vary from that of a closed fist to that of a fœtal head. Usually they are unilateral and rounded, but may be bilateral and lobulated. The pedicle is short and the tumor prone to form adhesions.

On section, the cut surface may be either gray, or yellow, or white, the tissue being soft and friable and easily torn by the fingers.

Pick differentiates endotheliomata into three types, of

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which the first is of a rosary like form, consisting of chains of cells in rows lying in narrow clefts of fibrous tissue. The borders of the rows are parallel and frequently anastomose. In the second form the structure resembles glands and it is difficult to distinguish it microscopically from adeno-carcinoma, the spaces being encroached upon by several layers of polymorphous cells. In the third variety the cells are grouped as in alveolar sarcoma. All three forms may occur in the same tumor.

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Endotheliomata may occur in connection with other tumors, Pfannenstiel reporting a case in which an endothelioma and epithelial cyst-adenoma were present in the same patient. These tumors may degenerate, the usual form of degeneration being either hyaline or myxomatous, but colloid and fatty have been seen to take place.

Carcinoma.—Cancer of the ovary may be either primary or secondary. The latter usually accompanies malignant disease of the uterus, but it may complicate an affection of the stomach or mammary glands. It may originate in either the Graafian follicle or the germinal epithelium. It is convenient to divide cancer of the ovary into medullary carcinoma and adeno-carcinoma.

I. Medullary Carcinomata. These are solid tumors which are usually oval or rounded, but are also often nodular. They vary in size, but are rarely larger than the head of a full-term fœtus. There is usually a pedicle which is short and thick, but at times they are intraligamentous. Both ovaries are but seldom affected.

Medullary cancers have a dense, well-defined, fibrous capsule, and on section the cut surface is seen to be more or less homogeneous, of a yellowish or grayish-white color. At times extravasations of blood into the substance of the tumor produce a mottled appearance. Degenerations, especially caseous or fatty, are common, resulting in the formation of cyst-like cavities with irregular walls and turbid or yellowish contents.

Histologically the growth consists of carcinomatous cells infiltrating a fibrous stroma, which may predominate and form alveoli filled with cancer cells, but usually the cellular elements predominate.

II. Adeno-carcinomata. Adeno-carcinomata are tumors which closely resemble ordinary serous cysts of the ovary. They are oval or rounded, and rarely exceed an adult head in size. They usually have a short pedicle, but may develop between the layers of the broad ligament and often form adhesions to neighboring structures. Although they may appear to be unilocular, they are usually multilocular. The disease is generally bilateral.

In about half of the cases examined, Pfannenstiel has seen papillæ on the surface. The cyst wall is composed of connective tissue which is quite friable. This wall may be thickened in spots, owing to the development of carcinomatous nodules. Papillary and cauliflower growths may spring from the internal surface of the cyst wall and may nearly fill the cavity. The cyst contents may be clear, turbid from cellular elements, or blood-stained from hemorrhages into the cyst.

Cystic carcinoma of the ovary is usually papillary, the papillæ usually resembling ordinary papillomata, but on section the microscope reveals the presence of cancer cells, and the carcinomatous structure may at times even be observed by the naked eye. Any individual tumor may contain masses which vary greatly in structure from one another. One form consists of a diffuse infiltration of a medullary character. More often the masses are composed of papillæ and glandular structures with their lumen still apparent. An atypical proliferation of epithelial cells is everywhere seen and the papillary growths are covered with several layers of cells asymmetrically arranged. A similar arrangement of the epithelium is seen in the glandular forms of the disease, this giving rise to their alveolar appearance. Lime salts become deposited in the tumors, especially those of a papillary nature, and give rise to psammomata.

It is almost impossible to tell when an adenomatous tumor of the ovary is benign and when malignant, as the gradation from an ordinary cyst-adenoma to primary carcinoma is so gradual. Ziegler holds that no clear line of demarcation between the two can be drawn, and Pfannenstiel estimates that one-half of ovarian papillomata are carcinomatous. He, however, is rather an extremist, claiming that tumors which become carcinomatous should be classified as primary carcinomata, whereas most writers would consider these to be merely cases of carcinomatous degeneration of benign growths. Metastases frequently occur, affecting, in the following order, the peritoneum, omentum, liver, stomach, intestine, the ovary of the opposite side, and, but rarely, the pleura.

Differential Diagnosis of Solid Ovarian Tumors.—During the following brief consideration of this subject, it must be remembered that it will often be quite impossible to differentiate between a solid ovarian tumor and a solid subserous tumor of the uterus with a long pedicle, as, even where this is felt on palpation, the pedicle may be mistaken for the Fallopian tube, unless it be thicker than is commonly seen in the case of a long pedicle. A kidney may be prolapsed into the pelvis and give rise to some difficulty in the diagnosis, but it can usually be replaced.

First, these solid ovarian growths have to be distinguished from tumors of other organs; and secondly, from one another. The tumor is one of the ovary because (1st) it is situated in one side of the pelvis or lower abdomen; (2d) it is unconnected with any other abdominal organ, as ascertained by palpation and percussion; and (3d) uterine movements are not influenced by those of the tumor.

A *fibroid* is the hardest, slowest-growing, and least liable to produce other than pressure symptoms of any tumor of the ovary. It is more liable to appear after the menopause than a fibroid of the uterus.

Sarcomata are firm, and may be quite hard, but they grow rapidly, occur at an early age, and produce ascites, emaciation, secondary deposits, etc. They usually also have longer pedicles than the next variety.

The *malignant solid ovarian tumors* are more apt to be nodular than the above and produce the other signs of malignancy (ascites, emaciation, etc.) more quickly.

OVARIAN CYSTS.—Cystomata of the ovaries may arise from infolding and downward prolongations of the germinal epithelium, or else by enlargement of follicles which have failed to rupture, this failure frequently being due to inflammatory thickening of the outer coat of the ovary. Herman says that this latter "is such a simple and natural way of explaining the development of ovarian tumors that one would think that any other must only apply to exceptional cases," and there is much wisdom in this statement. Why these follicles develop into large cysts in some cases and not in others is not really known, although various theories have been advanced. They may occur at all ages and in every condition, but are more often seen in women who have borne few children than in those who have large families.

Hydrops folliculi is a condition in which one or more follicles become distended by fluid to the size perhaps of a cherry, retaining their globular form. One variety of this affection has been called Rokitansky's tumor, which consists of many distended follicles which have become pedunculated in some cases or compressed laterally in others. They contain a thin serous fluid and sometimes ova. This variety of tumor is both bilateral and rare.

Neoplastic Cysts.—Most ovarian cysts are of the proliferating variety, which Waldeyer divided into the proliferating glandular and the proliferating papillary cysts; but this is merely a clinical division. A more scientific classification is that of Pfannenstiel. He found that the contents of the two varieties differed from each other. In one there is a clear, thin, serous fluid, while in the other class the fluid is dark and turbid and contains a substance called pseudo-mucin. Using this fact as a basis, he named the two groups pseudo-mucinous and serous.

The *pseudo-mucinous* are the most numerous of all ovarian cysts. They are usually unilateral and the size may vary from that of a hen's egg to a tumor weighing two hundred and forty pounds; but one rarely now sees an

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ovarian cyst weighing over thirty or forty pounds, as they are usually removed as soon as discovered. No age beyond puberty is exempt from these growths, but they are more liable to attack women between the ages of thirty and forty-five, especially if they are sterile or unmarried. The shape is usually www.libtool.com.cn may be either even or lobulated, the latter being most often seen in the case of the smaller tumors due to the presence of daughter cysts. The color is usually bluish or purplish-white and glistening, with here and there blood-vessels running over the surface. At times bands of unstriped muscle are also seen upon the surface, on which portions of ovarian tissue may become flattened out.

When opened up, the tumor may consist of one large sac with its contents, but if the interior is carefully examined bands of tissue, the remains of the walls of previously existing loculi, will usually be seen. More frequently many smaller cysts with their walls agglutinated together are discovered making up the large tumor. The contents of these numerous loculi may vary from a thin serous fluid to that of a jelly-like consistency. The inner surface of the cyst wall is usually smooth, especially if the tumor is of large size, this pressure causing atrophy of the epithelium; but in the small cysts, small papillæ and other excrescences are often seen. This lining is composed of a single layer of cylindrical mucous-like cells, which stain very readily with eosin and hæmatoxylin. These cells are implanted upon a layer of connective tissue and at times ovarian or unstriped muscular tissues. Outside this again is a layer composed of germinal epithelium.

The *serous cysts* are much less common than the above, nor are they so large, rarely exceeding the size of a pregnant uterus at term and usually being much smaller. Externally they resemble the pseudo-mucinous, but have a greater tendency to adhere to the surrounding organs by means of bands. They are usually multilocular, but contain fewer divisions than do the pseudo-mucinous cysts. They contain a clear, thin, yellowish or greenish fluid, in which albumin is present to a large extent. This fluid is produced partly from the blood-vessels and partly by secretion by the glands in the lining membrane. The composition of the cyst wall is the same as that of the pseudo-mucinous; the cells of the epithelium are columnar and ciliated.

Symptoms of Ovarian Cysts.—The patient may merely have a vague sense of fulness of the abdomen or of weight in the pelvis, or else she may experience no sensations whatever until she accidentally discovers a lump in the lower abdomen. There may be no interference with menstruation, so that when it ceases suddenly one should always be on guard lest pregnancy has occurred. At times the flow is increased, in which case an endometritis may be found to exist.

The physical signs will vary according to the size of the tumor. Where this is small and confined to the pelvis, a bimanual examination will reveal an ovoid, tense cystic swelling to one side of the uterus. Rarely it may occupy the middle line, as occurred in a case of the writer's, the tumor lying in front of the uterus, where it was held by an adhesion on one side and the Fallopian tube on the other. A tumor of this size would cause a downward bulging of the vaginal fornix and could be easily felt by the finger in the vagina, as would also be the case when the contents of a large tumor were very fluid or the cyst was unilocular. When, however, the tumor has risen out of the pelvis it rests upon the brim, and the only sign of its presence to be made out by the examining finger is the depression of the uterus. On inspecting the abdomen, an enlargement is to be seen of the lower part and usually to one side, this enlargement being either regular or uneven. Upon palpation the mass will usually be felt to be tense, but fluctuating, though when the contents are gelatinous the sensation may be similar to that caused by a soft myoma. When the tumor is unilocular, or one loculus is especially large with very fluid contents, a thrill may be obtained by flicking the mass with the finger on one side, while the other hand is placed on the opposite side. This may be intensified by requiring an assistant to exert pressure on the mass by means of the outer edge of his hand placed mesially on the abdomen. Percussion will show that the intestines are pushed into the upper part of the abdomen and to the sides, and turning the patient on one side produces no change in the areas of dulness, an ovarian cyst differing in these two points from free abdominal ascites in which the percussion note is clear in whatever part of the abdomen happens to be uppermost at the time.

Diagnosis of small ovarian tumors (*i.e.*, while they lie wholly in the pelvis) is not as a rule difficult. The peculiar tense, semifluctuating sensation imparted to the examining finger by an ovarian cyst is felt in practically no other conditions than hydro- and hæmato-salpinx and encysted peritonitis. In the two former conditions the mass is elongated or sausage-shaped instead of ovoid as in the case of a cyst. Encysted peritonitis is fixed and has not the clearly defined margin of the ovarian tumor. When the cyst is adherent the diagnosis is more difficult, but space forbids further consideration of the subject. Of course, a parovarian cyst may be mistaken for an ovarian growth, but the treatment is the same and a definite diagnosis can be made only by opening the abdomen.

When the tumor has risen out of the pelvis it may be mistaken for ascites, a distended bladder, a tumor of the uterus (fibroma, myoma, or fibro-cyst), cyst of the mesentery, ovarian dermoid, renal cysts, hydronephrosis, phantom tumors, cyst of the parovarium, and pregnancy with hydramnios.

In *ascites*, unless encysted, the flanks bulge and the enlargement does not stand up prominently, as in the case of an ovarian cyst. Percussion will give a clear note over the highest point in the abdomen. That is to say, with the patient on her back a tympanitic note will be heard in the region of the umbilicus, while the note in the flanks will be dull; whereas if she is turned on her side, the flank which is uppermost will yield a clear note. Exceptions to this rule, however, occur now and then, as was well illustrated in a case which came under the writer's observation some years ago. An immigrant woman was brought into hospital and found to have a swelling of the abdomen which progressed rapidly. The fluid impact wave was readily obtained and percussion gave a dull note all over the abdomen, except just below the sternum. Posture made no change in this note. The uterus and vaginal fornices were depressed. The heart, liver, and kidneys were healthy, and a diagnosis of a rapidly growing parovarian cyst was made. On opening the abdomen for its removal a large quantity of fluid was removed from the general peritoneal cavity and the pelvic organs were found to be healthy. Shortness of the mesentery preventing the intestines from floating to the surface and the excessive quantity of fluid present accounted for the absence of the clear percussion note from its usual situation.

A *distended bladder* occupies the median line of the lower abdomen and appears as a tense pyramidal mass above the pubes. There is generally dribbling of urine, and careful catheterization of the bladder will clear up the diagnosis. For this little operation a male metallic instrument is the best, as something may be pressed against the bladder diagonally, thus cutting off the part into which the ureter of one side opens. A rubber catheter will coil up in the free part of the bladder, and this also will be the only part of the organ which can be emptied by the ordinary short glass catheter, while the long metallic instrument can be cautiously guided past the obstruction into the dilated portion.

Myomata and *fibromata* of the uterus are hard, and palpation fails to elicit any fluctuation. They move with the uterus, the cavity of which is enlarged. If they are interstitial or submucous, menstruation is increased.

A *fibro-cyst* of the uterus gives fluctuation, but moves with and is evidently attached to the uterus. It is a very rare form of neoplasm, and if it is punctured and if the fluid is allowed to stand spontaneous coagulation quickly supervenes.

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Cysts of the mesentery have a clear percussion note all around them, if they are not large enough to fill the whole abdomen, in which case a history of the growth having proceeded from above downward and not vice versa, as is the case of ovarian affections, can usually be obtained.

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A *dermoid of the ovary* is of slow growth and may occur in a very young girl.

Renal cystic tumors and hydronephrosis give a history of progressive enlargement from above downward and can usually be separated from the pelvic organs. In the case of a hydronephrosis ureteral catheterization will usually clear up the diagnosis.

Phantom tumors disappear when the patient is anæsthetized.

Pregnancy with hydramnios may be diagnosed by observing the rhythmical uterine contractions, by auscultation, and by the softening of the cervix and the changes in the breast coexistent with pregnancy. There will also be the history of amenorrhœa, and when all else fails time will clear up the diagnosis.

A *cyst of the parovarium* grows quickly, is never nodular, and, owing to its being unilocular and containing very limpid fluid, gives the wave impact very distinctly.

Complications of Ovarian Cysts.—Any organ or structure in the body may become diseased contemporaneously with tumor formation in the ovary, but the most common complications are albuminuria, ascites, adhesions, pregnancy, rupture of the tumor, and torsion of the pedicle.

The coexistence of *pregnancy* and ovarian cyst is grave and requires care before, during, and after labor. If the cyst is large an abortion is very apt to result. The tumor is very liable to rotate, causing torsion of its pedicle after labor, owing to the change in the intra-abdominal pressure. Infection and consequent suppuration of the cyst are also apt to occur. When pregnancy goes to full term the fœtal and maternal mortality is high. In 271 cases of ovarian tumor complicating labor, there was a maternal mortality of 25 per cent. and a fœtal of 75 per cent., while Zitter and Litzmann place the maternal death rate at 30 and 43 per cent. respectively.

Torsion of the pedicle is a not infrequent complication of ovarian cysts; dermoids, probably on account of the difference in consistence and weight of various sections of the growth, being the variety most often affected. Its onset may be either acute or gradual, the former being naturally the more grave.

The *symptoms* of a twisted pedicle are a sudden, acute pain, followed by rapid enlargement of the tumor. The abdomen becomes tender and the patient may show evidences of most profound shock, the respirations becoming rapid, the pulse small, thready, and rapid, with later on a rise of temperature.

When the onset is more gradual there may be few or no special symptoms. There may be an increase of the previous pain and some enlargement of the tumor. The rapid increase in size of the tumor is due to congestion, which may be so great as to cause hemorrhgae into the tumor substance or even into the peritoneal cavity.

The only *treatment* is to operate without delay.

Ascites may accompany an ovarian tumor, especially if it be malignant. Its chief importance lies in the probability of there being disease of the heart, kidneys, or liver, and in its rendering the diagnosis difficult.

Albuminuria should be looked for and cured if possible before any operative interference is carried out. It *may* be caused by pressure of the tumor on the ureters, in which case it will disappear after removal of the growth and no casts will be found in the urine.

Adhesion of the tumor to neighboring organs forms a serious complication when an operation is called for. These adhesions may be so intimate as to offer sufficient nourishment to the tumor even after it has been freed from its usual attachment, as sometimes occurs in torsion of the pedicle. They also complicate the diagnosis, as, for instance, when the tumor becomes adherent to and moves with the uterus.

Rupture of the cyst may occur and may be followed by permanent disappearance of the growth, or this may refill. When the contents are either irritating, as in the case of a dermoid, or malignant, a general peritonitis or secondary infection of the peritoneal cavity will follow. In some cases a blood vessel will be torn through and a more or less severe hemorrhage into the peritoneal cavity may take place.

Prognosis.—If left alone ovarian cysts are apt to increase in size until they prove fatal through interference with the alimentary, cardiac, digestive, and respiratory systems.

Treatment.—Removal of the cyst by either the abdominal or the vaginal route is the only treatment indicated. Formerly frequent tapping of the tumor and withdrawal of the contents were practised, but ovariotomy is now so safe a measure as to have no rival in the treatment of this condition. Tapping is not only useless, but is distinctly dangerous, as it sets up adhesions and may allow leakage into the peritoneal cavity, is liable to cause sepsis, and puncture of bowel or blood-vessels may occur, and the fluid tends to accumulate more rapidly afterward. Even when the tumor has ruptured spontaneously operation may be indicated by peritonitis or by hemorrhage. In a case of the writer's, rupture took place half an hour before the time appointed for operation, and on opening the abdomen the cavity was found to contain a large quantity of fluid blood which had escaped from a vessel that had been torn across.

Ovarian Dermoids.—In women dermoid tumors have never been found growing from any other organ in the abdominal cavity than the ovaries. They are comparatively rare, only between three and four per cent. of all ovarian tumors being of this nature. They may occur at any age, but are more liable to occur before puberty than any other form of ovarian tumor. Usually only one ovary is affected, but now and then the disease attacks both.

Until recently it was maintained that they were due to inclusion, in the developing ovary, of cells from the other layers, but Wilms has lately suggested the probability of their being caused by some eccentric development of ova, and he supports this theory by the facts of their being found occasionally in the fœtus, and of the tumor containing traces sometimes of nearly every organ in the body, which is not the case with dermoids situated elsewhere.

Ovarian dermoids are not large tumors, rarely being seen larger than a man's head. They contain a cheesy material, in which may be found almost any organ of the body, sometimes in a very rudimentary state. One of the commonest structures found is hair, which may measure five feet in length but which is usually short. In addition to these substances, teeth are often found embedded in the cyst wall, where also rudimentary mammæ may be seen. A heart with a mitral valve and chordæ tendineæ has once been described as having been found in a dermoid of the ovary. The more fluid contents are extremely irritating to the peritoneum, and if they escape into the peritoneal cavity they are almost sure to set up a most intense inflammation of its lining.

An ovarian dermoid gives rise to the symptoms of an ordinary ovarian cyst, from which it may be diagnosed by its slow growth and the peculiar want of elasticity which it imparts to the examining hand. An ovarian tumor seen in a girl before puberty is much more likely to be a dermoid than one of any other variety.

The proper *treatment* is to remove the tumor.

Papillomatous Tumors of the Ovary.—This variety of ovarian cyst is of sufficient importance to warrant some special consideration, and is divided into two groups, according as to whether the papillomata occur inside the cyst or on the outside of its wall.

1. *Papillomatous cystoma of the ovary* may be shortly described as a cystic tumor of the ovary containing masses of papillæ; from the tendency to form secondary growths, it may be looked upon as malignant.

Olshausen, in 1877, noted the difference between sim-

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ple cysts and those containing papillary projections. Inspection of the tumor with the naked eye reveals numerous papillæ on the inner surface of the cyst wall. These may be few in number or else so numerous as completely to fill the cavity of the cyst and even at times cause its rupture. The papillæ are pedunculated and vary from a simple www.libtool.com.cn complicated branching structure. Not only does this shape vary, but the color may range from almost white to a pinkish hue, this depending on the supply of blood going to the papillæ and also on their consistence. They are usually soft, but may contain sand-like bodies which cause the growths to feel gritty. After perforation of the cyst wall the peritoneum and other organs may become infected.

These cysts usually contain a clear, thin, watery fluid of a yellow color and alkaline reaction. It has a specific gravity of from 1.005 to 1.040, and does not coagulate on standing. It responds to the tests for albumin. On examining the fluid with the microscope, it may be seen to contain epithelial elements, compound granular bodies, and sometimes cholesterin and hæmatoidin crystals. Instead of the fluid being clear, however, it may be dark and turbid or even grumous the character varying at times even in different parts of the same tumor.

Microscopical Appearances.—In a pedunculated cyst the wall has an outer layer which is thin and dense. It is composed of laminated tissue, a few cells, and occasionally non-striped muscular tissue may be seen. The next layer is thicker and more cellular. Both contain blood-vessels. Internal to this second is a third layer, composed of epithelium which sometimes rests upon a thin homogeneous basement membrane. The epithelial cells may be cuboidal, cylindrical, or, in fact, almost any shape. Cilia may or may not be present, and even in the same tumor some cells may bear cilia while their neighbors do not, their absence or presence being purely accidental and having no bearing upon the case (J. W. Williams). These cells may be in one layer or in several, and in small cysts they are not usually so high as where they simply cover papillæ, the low merging gradually into the high. In the smaller cysts also, part of the outer wall may be replaced by true ovarian tissue. The stroma of the cyst wall, which may be dense and well formed, or else somewhat myxomatous, continues up through the pedicle into the papillæ, and is usually well supplied with blood-vessels, which are thus enabled to pour out a portion of their serum and so contribute their quota toward the fluid contents of the cyst.

The sand-like bodies, above referred to, are called psammomata, and consist of particles of carbonate and phosphate of calcium arranged in concentric rings.

Papillomata may extend from their primary site by three methods. They may do so by direct extension to contiguous structures, by the attachment of small broken-off fragments of the growth to the peritoneum, and lastly by true metastatic formation.

In the early stage no diagnosis of the exact nature of the pathological process is possible. This is clear only when the ascites can be made out, when the psammomata can be felt per vaginam, or when papillomatous masses burst into the bladder or rectum. Freund considers that the simultaneous appearance of ascites and hydrothorax favors the diagnosis of papilloma ovarii.

These cysts are apt to burrow between the layers of the broad ligament, both toward its base and laterally toward the uterus. They occur most frequently between the ages of twenty-five and fifty.

2. *Superficial papillomata of the ovary* are more rare than intracystic growths, and like them are nearly always bilateral. They are formed of branched, usually pedunculated masses, springing from the surface of the ovary. Their histological structure resembles that of the intracystic form of the disease, the epithelium being continuous with the germinal epithelium, as is also the case in some intracystic growths, although the etiology of the latter is uncertain.

The *treatment* of papillomatous disease of the ovary is prompt and thorough removal of the diseased structures, and this is usually followed by permanent relief.

F. A. L. Lockhart.

OVARIOTOMY.—Ovariotomy (from the Latin ovarium, ovary, and Greek *τομή*, cutting) is to be classed among the unsatisfactory terms which unfortunately are too common in medical nomenclature. Leaving out of consideration its hybrid formation, the word by no means expresses the removal of the ovary. In this sense oöphorectomy (*ὠόφορον*, ovary, *ἐκτομή*, excision) is far more appropriate; and if the Fallopian tube be also removed, *salpingo-oöphorectomy* should be employed.

Under the heading "ovariotomy" most text-books consider the operation for tumor formations alone of the ovary, ignoring the inflammatory and other conditions for which identically the same procedure is more frequently undertaken. In accordance with custom, however, the first class of cases will be dealt with here.

History.—The history of this procedure is of considerable interest. The kings of ancient Lydia are said to have had it performed upon women either for the purpose of preserving their youthful characteristics, or in order that they might be employed in the place of eunuchs. The actual nature of the operation, however, is somewhat doubtful, as in some instances in all probability only the clitoris was removed, although from the scanty details procurable it may be inferred that at least some genuine ovariotomies were performed. During the seventeenth century a Hungarian sow-gelder is said to have removed the ovaries from his daughter as a punishment for her frequent lapses from virtue. In the eighteenth century, although suggested much earlier by continental surgeons, the possibility of the operation was seriously discussed, more particularly by John Hunter in England and John Bell of Edinburgh, although, owing to the high mortality of all intra-abdominal operations, these men lacked the courage of their convictions and were unwilling themselves to undertake a hitherto untried procedure. Their teachings, however, bore fruit, and the first prearranged and successful ovariotomy was accomplished in 1809 by Ephraim McDowell, of Kentucky, who had been one of Bell's students in Edinburgh. It must of course be conceded that the ovaries had been removed by operation previous to this time, but in the majority of such cases, if not in all, the real nature of the procedure had not been recognized until later. Moreover, in several other instances ovarian cysts had been tapped through an abdominal incision, and portions of the sac walls had been resected. Nevertheless, it is important to recognize the fact that all such operations had lacked the careful pre-arrangement or the successful issue of McDowell's case.

In the United States the operation was repeated by the originator twice before 1817. Nathan Smith, of Connecticut, unaware of McDowell's cases, performed it in 1821; Rogers, of New York, in 1829; Billinger in 1835; and in 1843 Dunlap, of Ohio, and the Atlee brothers, of Pennsylvania, obtained favorable results. From this time on, the operation gained in favor in America, and the excellent work of W. L. Atlee and of Peaslee did much to popularize it.

In Great Britain Lizars, of Edinburgh, performed the operation four times in 1825, but no other attempts were made in Scotland until 1845. In 1833 Jeaffreson, of Framlingham, obtained the first successful result in England, although Granville had had two failures in 1826 and 1827. Interest in the procedure was revived in 1842 by Clay, of Manchester, who soon became noted for his work. Spencer Wells from 1858 to 1871 performed the operation 410 times, and his total number of ovariotomies reached nearly 2,000. His successors, Keith and Tait, also obtained splendid results. The first successful operation in Europe was performed by the German surgeon Chrysmar in 1820, a similar case in the previous year having terminated fatally. In Germany, until 1850, only 23 ovariotomies with 7 successes had been done, and until

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1870 there had been only 180 with a mortality of 105, or over 58 per cent.

It was not until 1844 that Woyerkowsky scored the first success in France, but here as in Germany the profession were so opposed to the operation that it made but little headway, and was not recognized until long after it had been established in America and England.

Following the introduction of the principles of antisepsis and asepsis the mortality was reduced to a remarkable degree until, instead of being regarded, as it was by many leading surgeons of fifty years ago, as almost the equivalent of murder, the procedure is now looked upon in uncomplicated cases and in the hands of a skilful operator, employing a rigid aseptic technique, as one of the simplest of abdominal operations. The gradual development of ovariotomy is very fully presented by Peaslee ("Ovarian Tumors," 1872).

Indications.—Internal medication and local treatment are futile in cases of ovarian tumor, and the days of simply tapping cysts are now past. So soon as the diagnosis is made, operative measures should be instituted. Some operators prefer the vaginal route, wherever possible, and in suitable cases this answers the purpose admirably. The relative merits of the two methods cannot be discussed here, but to-day, as a rule, the abdominal incision is chosen; since by its employment the tumors can be rendered plainly visible and accessible to close examination, and the question of complete or partial removal of one or both ovaries is consequently more easily decided.

It is true that in many instances an ovarian tumor may exist throughout a patient's lifetime, without detriment to her health, or without producing any symptoms whatever, so that its discovery is often more or less accidental. But despite this well-recognized fact we must always take into consideration the comparative frequency of malignancy in these tumors, and the liability to the occurrence of secondary implantations and metastases, even at a period when the main growth is causing no unpleasant manifestations. Moreover, the possibility of certain accidents, as torsion of the pedicle, or rupture of a cyst with perhaps a resulting hemorrhage or peritonitis, is worthy of consideration. Infection of the cyst contents from an adherent bowel may also occur and greatly increase the danger. Adhesions are likely to form, rendering operation at a later date more difficult, and secondary changes in other organs may begin insidiously and make considerable and rapid progress.

Age as a rule seems to make but little difference. Generally speaking, elderly women bear the operation very well. In children we must always bear in mind the relative frequency of sarcomatous tumors.

The coexistence of pregnancy does not modify to any extent the indications for operation, inasmuch as statistics show that fatalities to the mother and fœtus are much more likely to occur when the ovarian tumor is allowed to remain undisturbed than when it is removed even during the pregnancy. In the case of a malignant tumor the dangers incident to expectant treatment are even greater than in the non-pregnant state, since the physiological congestion tends to promote rapid growth. The liability to torsion of the pedicle is naturally increased as the enlarging uterus crowds the tumor, often rotating it, in its attempts to occupy the narrowing space to the best advantage. Thus in one series of one hundred and nine cases of ovarian tumor with pregnancy torsion occurred ten times. Large tumors in the presence of the additional bulk of the uterus may lead to pressure symptoms, sufficiently severe to endanger the life of the mother, and growths of relatively small size have been known to cause the death of the fœtus. Smaller tumors, especially if solid, may become impacted in the pelvis below the growing uterus, the accident either leading to abortion or giving rise to an impassable obstacle to delivery at term, thus necessitating a Cæsarean section or other radical measures. The pregnant uterus may also be crowded backward under the promontory of the sacrum, so that its development is hindered, and abortion is very likely to occur. Adhesions of the ovarian tumor to the uterus may prevent the symmetrical enlargement of the latter, leading to abortion or sometimes to a malposition of the fœtus. The adhesions may be torn apart by the traction exerted by the uterus, sometimes in conjunction with a sudden trauma. In such cases alarming or even fatal hemorrhage has been known to take place. Rupture of an ovarian cyst is also liable to occur from pressure or trauma, in the latter case because there is less room for the movement of the tumor, so that even a slight blow might suffice to cause such an accident.

The question of the advisability of operation during pregnancy is very apt to present itself, since a tumor that has existed unknown to the patient may attract her attention as soon as it is displaced upward, into the abdomen, by the growing uterus. The physician may also discover it during an examination in a case of apparently normal pregnancy.

If the tumor be discovered only in the later months, especially if it be small and cause no trouble, and if after it has been carefully watched for some time it shows no signs of enlarging, operation may be deferred until after delivery has taken place. All the various factors, however, in the individual case must receive careful consideration. If a cyst causes disturbances only during the last four weeks of pregnancy, or after the onset of labor, tapping may become necessary, and the short respite thus obtained may tide the patient over until a more favorable time for a radical operation. There is also the possibility that the cyst may not refill. In the earlier months, inasmuch as pregnancy is less liable to be interrupted by operation, interference is clearly indicated. The operation should be done as rapidly as is consistent with proper precautions, and during all the various manipulations the pregnant uterus should be protected from trauma, and the pedicle carefully ligated. In view of the stretching that may be exercised by the enlarging uterus, the tissues should not be too tightly bunched; it is far preferable to employ several ligatures, each including a small portion of the pedicle. The case should be treated afterward as if abortion were imminent, and opiates should be administered if necessary.

The only absolute contraindication to the operation may be the enfeebled physical condition of the patient. Thus in torsion of a pedicle with resulting collapse it will sometimes be very difficult to decide whether a postponement is not justifiable in the hope that the patient can be tided over the acute attack, and not submitted to operation until some days later when her condition is improved. Many unfavorable symptoms apparently contraindicating operation may be due entirely to the tumor, and disappear after its removal. Among the most important of these are ascites, circulatory and even respiratory changes induced by pressure, albuminuria, and in some cases glycosuria. In several instances sugar, which had been present in the urine of patients suffering from ovarian cysts, disappeared entirely after removal of the tumor.

Even in apparently hopeless cases unexpected results are sometimes obtained, and records are found of cases of widespread papillary adenocystomata and endotheliomata with peritoneal metastases, in which these latter caused no further trouble after the main tumor had been removed. Moreover, in densely adherent cases which at first seem to defy even an expert operator, by patience and careful work the tumor may probably be freed and then removed. At times in almost moribund patients radical measures may be indicated, and unless the condition be due to cachexia brought about by a malignant tumor, after prompt and active stimulation and infusion or intravenous transfusion of decinormal salt solution, operation will sometimes save. More particularly is this true in cases of torsion or rupture of a cyst or when the symptoms are due to pressure.

In brief, then, the indications for treatment in cases of ovarian tumors may be summed up as follows: Operate as soon as you are satisfied of the presence of such a tu-

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mor, unless there is good reason for believing that the physical resistance of the patient may be materially improved by waiting a few days.

Technique.—Too much stress cannot be laid upon a rigid technique. In view of our present knowledge it is absolutely criminal knowingly to transgress its well-recognized principles. The whole subject is dealt with in detail elsewhere. Suffice it to say here that we must bear in mind that asepsis not only regards our actions in the operating-room and our surroundings there, but also includes the careful preparation of the patient as concerns the field of operation, the evacuation of the bowels and all other details the proper conduct of which will put her in the best condition possible for the operation. In the room itself everything should be as clean as possible, and all materials coming in contact with the field of operation should be sterile. Especially does this apply to the hands which, although they cannot be rendered absolutely aseptic, can at least be made innocuous by means of diligent scrubbing, by the employment of antiseptic solutions, and by the additional precaution of using rubber gloves. Instruments should be boiled in soda solution, all dressings, towels, etc., should be sterilized with steam, preferably in the autoclave. Sea sponges, owing to the difficulty of satisfactorily disinfecting them, had better be discarded. Frequent rinsing of the hands in a basin of sterile water during the course of the operation is to be recommended, for by so doing we are less liable to transfer infection from one part of the field of operation to another, as for instance if the hand has become contaminated by the contents of a cyst during evacuation.

Instruments.—For an ovariotomy the instruments used in an ordinary abdominal section are required, and in addition several others devised more especially for this operation. The choice of instruments is largely an individual matter, and in simple cases one can manage with but very few. Nevertheless it is always best to be prepared for every contingency and the routine sterilization of a few extra instruments, even if they are only occasionally required, will sometimes save no little vexation. The following list of instruments will suffice:

Scalpels	2
Dissecting forceps, toothed	2
Dissecting forceps, toothed, long	1
Artery forceps, small	12
Artery forceps, long	6
Retractors	2
Transfixion needles	1
Needleholder	1
Needles (assorted sizes)	6
Scissors, straight	1
Scissors, curved on the flat	1
Museux forceps	2
Sponge holders	4
Ligatures and sutures, trocar with rubber tubing.	
Cyst forceps	2
Catheter.	
Syringes, dressings, drainage gauze, cautery, portable electric light and other accessories of an operating-room.	

The above instruments are all well known and need not be described here; the pattern is immaterial so long as each is satisfactory to the individual surgeon. The long dressing forceps will be found useful in repairing injuries deep down in the pelvis. The needles, ligatures, and suture material will vary with the predilections of the operator. The writer prefers full-curved sharp needles of three sizes for suturing everything, except the bowel, for which full-curved round needles are used. I generally employ Chinese silk twist for the pedicles and close the abdomen in layers, using a continuous catgut suture for the peritoneum, mattress sutures of silver wire for the fascia, and a subcuticular catgut suture for the skin. The Museux forceps proves of value when traction has to be made on a solid tumor, and the cyst forceps serves a similar purpose if the growth is cystic. The trocar and rubber tubing should be of rather large calibre, since the cyst fluid is often thick and tenacious and is liable to clog a narrow lumen. Sponges are preferably made of gauze, and must be carefully counted before and after the operation, to guard against the possibility of leaving one in the abdominal cavity. The cautery is used in searing the pedicle, to lessen the chance of the formation of adhesions; moreover, its employment will often control oozing from denuded surfaces where it may be impossible to pass sutures.

Anæsthetic.—The relative merits of ether and chloroform as an anæsthetic, and the cases most suitable for each, cannot be discussed here. The main point is that the patient remain deeply narcotized throughout the operation, and that there be a condition of complete muscular relaxation. It is very disturbing to have the patient vomiting or straining during an abdominal operation, and the anæsthetizer should have served a thorough apprenticeship in giving anæsthetics for minor procedures before being entrusted with this duty in abdominal sections. The administration of nitrous oxide gas with oxygen until the patient is completely unconscious and then continuing with ether is a very satisfactory plan. With the former the muscular relaxation is not so complete as with ether or chloroform, and as yet we have not sufficient data to warrant its use alone for ovariotomy, although in certain cases anæsthesia has been prolonged for several hours. Local anæsthesia with cocaine has also been used for abdominal sections, but is applicable only to exceptional cases, and general anæsthesia is almost always preferable.

Incision.—Everything being ready for the surgeon, so that he may proceed with the operation, the patient should be put in the Trendelenburg position, which facilitates the exposure of the pelvic organs. The abdominal incision should be in the median line and should be short at first; if it be necessary to enlarge it later, this can be very easily done, while in many cases of large ovarian cysts it may be possible to remove the sac, after evacuation of the contents, through a very small opening. Before the incision is made the bladder should be catheterized, and it is a good rule to pass a sound in all cases of pelvic tumor in order to determine whether the viscus has been carried upward. Not infrequently the bladder has been opened in making the abdominal incision through neglect of this simple precaution. The skin and subcutaneous fat are divided and the bleeding, which is usually slight, is controlled by hæmostatic forceps. The fascia is then divided in the median line. In doing this very frequently the sheath of one rectus will be opened, but this is a matter of no great moment. The adipose and areolar tissue having been separated down to the peritoneum, the latter is carefully picked up between two pairs of dissecting forceps and a small nick made in it. Through this the air enters, allowing the intestines to fall away, after which the opening can be enlarged as much as necessary. When the parietal peritoneum is adherent to the tumor, the intestines, or the omentum, great care must be exercised in opening it in order not to injure the structures lying beneath. It is important to see that the peritoneum is actually opened before attempting to separate the adhesions, as a mistake may lead to a widespread separation of the peritoneum from its attachment to the abdominal wall. Occasionally it will be found possible to get in above the adherent area through an opening made a little higher up. During the progress of the operation the incision may be enlarged as much as is found necessary, it being borne in mind that when we meet with a cyst, a small opening may suffice, while even solid tumors with a little judicious manipulation may often be delivered through a relatively small incision. The operator must not, however, handicap his efforts by trying to work through too small an aperture. Two fingers are now introduced, or if need be the whole hand, and the nature of the tumor, its location, the presence or absence of adhesions and their extent, are then determined. If it be a cystic growth the question of evacuating the fluid will have to be considered.

Emptying a Cyst.—If the cyst be small enough to allow readily of removal through the incision, puncture is not necessary. If, however, it be large and free from ad-

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hesions, it had better be emptied. On the other hand, if it be adherent it may be easier first to separate the adhesions, as the contour and relations of the tumor are then more easily recognized than when it is collapsed. Usually it is best to empty it at once, otherwise it is liable to rupture during manipulation. In the case of a large cyst there will also be more room for working, and the site of the adhesions can be more readily exposed if it is first emptied. It is important to avoid contaminating the abdominal cavity with the cyst fluid, inasmuch as we can never be sure that the contents are innocuous. Thus in the case of a papillary adenocarcinoma, the escape of the cyst contents into the abdomen would be very likely to cause secondary implantations. Or, again, the contents may be the greasy product of a dermoid cyst which may possibly be infectious in character, and at any rate will be extremely difficult to remove if once they become distributed in the abdominal cavity. To guard against such accidents gauze sponges are carefully packed around the presenting tumor to wall off the peritoneal cavity and to protect the edges of the incision. The patient is turned slightly on one side so that the escaping fluid may be more readily prevented from soiling the field of operation, and a cyst trocar with rubber tubing attached is then plunged into the tumor. If the tumor wall be too resistant, a small nick with a scalpel may greatly facilitate matters. In making the puncture the large vessels, which can be plainly seen coursing over the cyst wall, should always be avoided. As the sac wall collapses it is gradually drawn out with the hand or with a pair of cyst forceps, and the remaining part squeezed; or pressure is made upon the abdominal walls in such a manner as to get rid of as much of the fluid as possible. A lateral position of the patient is also of advantage in this connection. Any compartments in a multilocular cyst are usually broken down with ease. As soon as the sac has been emptied as far as is possible, the trocar is removed and the opening closed by grasping the edges in a pair of hæmostatic forceps, or by tying a ligature securely around it. The surrounding part of the wall should be carefully cleansed and the whole enveloped in a piece of gauze which has been saturated with sterile hot salt solution.

Adhesions.—Ovarian tumors that are not adherent or that have not grown downward between the layers of the broad ligament can usually be removed without much difficulty. The tendency of the growth at first is to drop down into the cul-de-sac, or later, if there be much enlargement, to ascend out of the pelvis into the upper abdominal cavity, where there is more space for it. Either of these displacements tends to produce an elongation of the broad ligament, to the posterior fold of which the ovary is attached, and also of the infundibulo-pelvic and ovarian ligaments, at the outer and inner poles of the ovary respectively. In this way a pedicle is formed which allows the tumor to be delivered through the abdominal incision, and which can be ligated and then severed.

True ovarian tumors rarely extend between the folds of the broad ligament, such growths being usually of parovarian origin. If there be no inflammatory action tumors of the latter class, as a rule, can be shelled out from between the folds by splitting the peritoneal covering and stripping back the two layers of the ligament. After the growth has been removed the two edges may be sutured with catgut. Hemorrhage is rarely severe, but any excessive bleeding can be controlled by clamping or ligating the ovarian vessels in the infundibulo-pelvic ligament, and the communicating branches from the uterine vessels at the cornu of the uterus. On the other hand, if chronic inflammatory changes exist, the removal of the uterus together with the tumor may be necessary. In these cases it is well to begin with a supravaginal hysterectomy on the side opposite the growth. The uterine vessels on the affected side are ligated and divided and the tumor is attacked from below. Removal, even in this manner, may at times appear too risky, in which case an incomplete operation must be done. Fortunately, however, in such instances drainage per vaginam is usually a feasible procedure.

Adhesions to the surrounding viscera form the most frequent complication of ovarian tumors. These vary from a few spider-web-like strands to masses of dense, organized connective tissue, requiring division with the scalpel or scissors. The method of dealing with these adhesions varies. If they are of recent origin they may be separated with the fingers, or pushed apart with a gauze sponge. If they are more resistant, the handle or blade of the scalpel may be required to divide them. Whenever possible, the separation should be done under the eye of the operator. By dragging the collapsed cyst well out of the incision with a pair of cyst forceps, or with the fingers covered with a gauze sponge to prevent slipping, or by making traction on a solid growth with a Museux forceps, the adherent structures can usually be drawn up also and separated in plain view. On the other hand, when the adherent viscera are fixed, it is sometimes impossible to expose the site of the adhesions satisfactorily, even with the aid of retractors and by packing aside the intestines with gauze. This complication is likely to occur when a large solid tumor is adherent posteriorly. In such cases it is necessary to deal with the adhesions by the aid of the sense of touch, and the knowledge of the anatomical relations. The site from which the tumor has been separated should be examined at the earliest possible moment to ascertain if there has been any damage done, in order that instant repair may be instituted. Adhesions to the parietal wall, which have been mentioned already, occur only in connection with tumors of considerable size.

Omental adhesions are rarely troublesome since, if need be, this tissue can always be sacrificed. It can usually be peeled off from the surface of the growth, but when more resistant it can be ligated and cut away. Even small omental vessels, if left unligated, are apt to continue to bleed; hence the omentum should be examined carefully for any hemorrhage before closing the abdomen.

Bowel adhesions represent the most serious complications, and great care must be exercised in dealing with them. In cases of inflammation of recent origin no trouble is apt to be found, as the adherent bowel may be gently peeled back with the finger or a sponge. If the adhesions be older and firmer, an occasional touch with the scalpel may be required, and if no line of cleavage be apparent, part of the tumor tissue may be left adhering to the bowel. In carrying out this manipulation a cyst, which has not been previously emptied, is liable to rupture at the weakened spot, and the operator must be prepared for this accident. If the intestinal wall be injured it must be immediately repaired, a round-pointed needle being employed for this purpose, and care being taken that no undue narrowing of the lumen of the bowel be produced. Free oozing from the outer surface of the bowel may continue for a short time, but unless the muscularis itself or the mesentery be injured it will soon stop. If the bleeding persists, however, measures must be taken to control it. When the injury has been severe and there is doubt as to the success of the repair, the question of drainage comes up. This will be discussed later.

The bladder is seldom apt to be injured, as it is less likely to be drawn up out of the pelvis than is the case in uterine tumors. The necessity of obtaining a positive assurance on this point has already been mentioned. The same rules, as to the separation of adhesions and repair of injuries, apply to this as to other important organs.

The ureters are rarely involved unless the growth be intraligamentary. If they be liable to injury, their relations must be established either by following their course down from the pelvic brim over the pelvic floor, or by means of catheterization through the bladder.

Adhesions in the cul-de-sac, and posterior to the broad ligament, are often very troublesome. They are separated most easily by getting the fingers below the tumor and working upward. By following the posterior surface of the uterus downward from the fundus and then

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separating the adherent surfaces laterally, this can often be quite readily accomplished. Hemorrhage may be profuse and may require the placing of clamps or ligatures on the ovarian vessels and at the cornu. If progress be not satisfactory at any one place another point of attack should be selected.

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Ligating the Pedicle.—As soon as all adhesions have been divided, the operation has been much simplified. If the pedicle be long enough the mass is now delivered through the abdominal incision; otherwise the ligatures are passed through the pedicle within the abdomen. If there be oozing from the raw surfaces of the viscera or pelvic walls, sponges wrung out of hot salt solution may be packed against them while the tumor is being removed. Silk is generally considered to be the most suitable ligature material. If properly boiled it is sterile, does not slip or swell like catgut, and very rarely causes any trouble. The broad ligament is transfixed in the thin area below the vessels, and a double ligature is carried through. Without being interlocked, one is tied externally over the infundibulo-pelvic ligament, while the other comes close to the uterine cornu. When the pedicle is large and thick more ligatures may be required and the tissues tied in three or four divisions. The ligatures having been secured, the pedicle is severed at least 1 cm. outside them, as the stump is apt to retract through the grasp of the ligatures, an accident which has often been followed by serious or even fatal hemorrhage. The stump may be seared with the Paquelin cautery to lessen the liability of adhesions forming to it, or the peritoneal edges may be approximated with catgut. Silk ligatures for the pedicle have proven so satisfactory that the use of the angiotribe or electric cauterization does not seem necessary.

Incomplete Ovariotomy.—After opening the abdomen and carefully examining the conditions present we may find it utterly impossible or inadvisable to remove the tumors completely. The difficulty may be due either to the character and the extent of the disease or to the dense adhesions binding the growth to important viscera. Papillary malignant disease may be so far advanced that the removal even of the main mass is evidently impossible, or an attempt to do this may be attended by profuse hemorrhage, even after the preliminary ligation of the main vessels, so that it only remains to pack tightly with gauze and not proceed further. In these malignant cases the marked cachexia, which is often present, may contraindicate a radical operation. Even if removal of the main tumor be accomplished, it is impossible to deal with the metastases upon the peritoneum, which, although occasionally disappearing, as a rule cause death. Where there have been inflammatory complications, and especially when chronic suppuration has occurred, the adhesions may be so firm that the time wasted in separating them and the attendant hemorrhage may injure the patient far more than the adoption of one of the alternatives at our disposal. Attempts to release a growth densely adherent to intestines, bladder, ureters, or vessels is liable to cause damage that may be irreparable or that may necessitate a prolongation of the operation which may prove fatal in the case of a patient whose vital energies are already exhausted.

When complete ovariotomy is impossible, various expedients come under consideration. In the case of a cyst we can resect as much of the walls as possible, and suture them to those of the abdominal incision. The interior of the cyst is then packed with gauze which acts as a drain and tends to destroy the epithelial lining of the walls and thus favors the formation of granulation tissue. In course of time this process leads to a union of the surfaces which thus effects a cure. A similar procedure may be carried out from the vagina. If the cyst walls cannot be brought up to the abdominal incision or down to the vaginal vault, the fluid should be evacuated, and an attempt made to destroy the lining epithelium by the application of carbolic acid, searing with the cautery, or even curetting lightly. A gauze drain is then inserted, the end being brought out through the abdominal incision or into the vagina. The principal indication in these incomplete operations is to see that all hemorrhage is controlled, and for this purpose gauze packing is often required. In the case of solid tumors that have to be left or can only partially be removed, if there be no oozing, the abdomen can usually be closed.

Not infrequently the question of conservatism arises, especially in the case of young women. In malignant conditions, it is best to remove both ovaries as the disease is often bilateral, although but one ovary may present gross pathological appearances. In retention cysts, follicular hypertrophy, corpus luteum cysts, as well as in some dermoid tumors, it is often possible to save a portion of the affected ovary. If the other one be normal, there is no absolute necessity for this; but in bilateral disease a small portion of ovarian tissue should be saved if possible, for the reason that even if pregnancy does not occur, a young woman may avoid a stormy menopause, not to mention the mental suffering that may be engendered by the knowledge of her condition. The Fallopian tube, if not seriously diseased, should also be saved. At times by resecting the diseased portion, enough of the healthy tube may be left to permit of a future conception.

Drainage.—In this respect the progress in surgical technique has been somewhat revolutionary. Whereas formerly drainage was regarded as indispensable in almost all cœliotomies, at the present day it is employed very much less, and very seldom in cases of ovarian tumor. By drainage we leave an avenue for infection which may cause the contamination of a sterile abdomen, and moreover drains partially or wholly fail to accomplish our object. That this is often the case is proved by the rush of fluid that not infrequently follows the removal of the drain. Besides the fact that such devices may be more dangerous than useful, their removal causes shock and pain to the patient, and their employment sometimes not only produces an elevation of temperature, nausea, and other unpleasant symptoms, but also tends to retard convalescence. Moreover, if a drain be employed, it is impossible to make use of the "peritoneal bath," by which is meant the leaving of 500 c.c. of sterile salt solution in the abdominal cavity before closing the incision.

Nevertheless, drainage is occasionally required in certain cases complicated by the presence of pus, which cannot be entirely removed, in persistent and dangerous oozing to meet which we are obliged to keep up compression for a certain length of time, after severe injuries to the bowel and in incomplete ovariotomy.

Fortunately, pus is encountered only in rare cases of ovarian tumor, and when present, as a rule, it is of slight virulence. Drainage may be considered necessary if it has been impossible to protect the general peritonal cavity from contamination by packing gauze around the pus focus before evacuating it. If, however, the pus as it escapes be caught on sponges, and if the pelvis or the site of the abscess be flushed out with salt solution and then sponged dry, by omitting drainage we have the additional safeguard of filling the abdomen with decinormal salt solution, to dilute any contaminated material that may remain, and to assist in its absorption. If the pus be considered virulent, as for instance when cover slips examined at the time of operation show streptococci, or when there is a communication with the bowel, drainage is usually indicated. A diffuse general peritonitis will often require similar measures. In the writer's experience the presence of gonococci in the pus has not proven an indication for employing the drain.

Persistent oozing from raw surfaces left after separating adhesions rarely requires drainage, but when it cannot be controlled by ligating the individual bleeding points, or by approximating the edges of torn areas, by the employment of mattress sutures and by tightly packing in sponges wrung out of very hot water, by touching the bleeding area with the actual cautery or by using some astringent iron solution, then a gauze drain applied to the bleeding area may give excellent results.

Injuries to the bowel wall sustained during the sepa-

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ration of dense adhesions should be repaired as soon as recognized. In these cases the tissues are apt to be so infiltrated and friable that sutures will not hold unless so much tissue is included as dangerously to narrow the lumen of the bowel. In such cases, when subsequent rupture of the coats of the intestine is to be feared, a drain should be inserted. In injuries to the sigmoid flexure and to the lower rectum, which are frequently implicated, vaginal drainage is most suitable.

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When incomplete ovariotomy has been performed, drainage may be required to permit the escape of the fluids or the breaking-down tissues. The gauze thus applied facilitates the obliteration of the cavities of the cysts, which cannot be removed. For the same reason, if suppuration has occurred, and the abscess wall cannot be removed completely, a drain may be required.

In instituting drainage we have the choice of two routes, the abdominal and the vaginal. The latter is usually to be preferred, since it provides an exit at the most dependent point of the pelvis. The abdominal sinus which is left after removing the gauze, even with the greatest care and the best technique, is very liable to become infected, and as a result a track is left which must close slowly from the bottom. The drain inserted through the abdominal incision requires to be removed much earlier than one used through the vagina. The mental effect upon the patient is not unimportant, and the old saying, "Out of sight, out of mind" is not without weight here.

As regards the form of drain used, experience goes to show that glass tubes should be discarded. Gauze either in the form of strips or a "Mikulicz drain" answers very well. If strips be used, they may be tied end to end, forming one long continuous wick; but if left separate, the end of each should reach the external opening and the first to be removed should be identified in some way, as by tying a piece of silk around the end or by knotting the gauze itself.

Toilet of the Peritoneum.—Having removed the tumor, the surgeon's next duty is to inspect the field of operation very carefully, to see that everything is in order. After first satisfying himself that no hemorrhage is in progress, he should examine the pedicle, and then inspect the broad ligaments, the pelvic walls, and any other situation where he has had occasion to separate adhesions. If there be any oozing, measures to control it must at once be instituted. The bowel must also be examined, more especially the rectum and the sigmoid flexure, as these are the parts most likely to be injured. The omentum is drawn out of the incision and laid upon a gauze sponge, when any bleeding points will be indicated by the staining of the material, and can readily be secured. Any holes in the omentum should be sutured and any ragged ends should be ligated and removed. Owing to the occasional implication of the vermiform appendix in pelvic disease, it should be examined as a matter of routine and, if necessary, removed. All bleeding having ceased, the abdomen is to be thoroughly flushed out with decinormal salt solution, and then sponged dry. This can be done by holding the uterus forward and the intestine back, while an assistant pours the sterile salt solution down into the cul-de-sac. Occasionally the employment of a funnel and rubber tube will prove more convenient. All clots or fluid having been removed by this procedure, the sponges and instruments should be counted to prevent the possibility of any being left in the abdomen. If drainage be indicated, the gauze is now inserted; otherwise the abdomen is filled with decinormal salt solution and the incision closed by the method in favor with the operator.

Dressing.—The incision having been closed, the surrounding skin is sponged with a bichloride solution (1 to 1,000) and afterward with alcohol. A small amount of sterile iodoform or boric-acid powder may be dusted along the line of the suture. Several layers of fine gauze are then placed over the wound, and above this a liberal amount of absorbent cotton. To retain the dressing in place wide strips of adhesive plaster are used, reaching well around on the sides of the abdomen, and extending from the pubes for some distance above the umbilicus. Over this is placed a scultetus bandage reaching from just below the trochanters up to the costal angle, and held down snugly in place by means of two strips passing around the inside of the thighs. The scultetus bandage may be changed daily, or as frequently as it is soiled. Unless the skin show considerable irritation from the adhesive plaster, the latter may be left undisturbed for ten days. By this time the skin incision will be well united and the subcuticular catgut suture absorbed. If, however, there be a rise of temperature, and pain along the incision be complained of, the whole dressing should be removed, in order to ascertain if there be suppuration in the wound.

With an abdominal dressing firmly applied in the above manner, there is less danger of the sutures tearing out during the vomiting. Distention also seems to be lessened by it, and there is no danger in turning the patient on her side, as soon as the nausea has diminished. The change of posture is one of the most welcome privileges allowed to a patient after a cœliotomy. Care must be taken that the dressing does not become drawn away from the pubes, as the lower end of the incision is not far above this point and exposure of it may lead to suppuration and the breaking down of the wound. After the first ten days a small strip of gauze held in place by two strips of adhesive plaster is a sufficient protection.

After-Treatment.—The after-treatment is that usually carried out after any abdominal section, and the details will vary with different operators. It is a very good plan to have a definite scheme of procedure written down, to be given to the nurse in charge of the patient. This may be suited to a moderately severe case, but can be modified as desired. Even if the operation has been a simple one and the shock slight, the patient will not suffer from the extra precautions taken.

Before the patient leaves the operating-room the stomach may be washed out, and it is a good plan to administer a stimulating enema composed of an ounce of brandy, five grains of ammonium carbonate, and one-twentieth of a grain of strychnine sulphate in a pint of decinormal salt solution. This is rapidly absorbed, and while greatly diminishing the thirst, also promotes diuresis, diluting the urine which otherwise is apt to irritate the bladder from its concentration. On reaching her room the patient is put into a warm bed, and hot-water bottles are placed around her to counteract any shock. These must be carefully protected so as not to burn her. The foot of the bed is elevated fourteen inches to facilitate the absorption of the salt solution which has been left in the abdomen. With the head low, as in this position, the nausea probably will be less. An attendant must remain at the bedside until the patient is perfectly conscious, as she is very apt to try to get out of bed when coming out from the anæsthetic. Shock must be combated by the use of stimulants, and of these strychnine is the most satisfactory; one-thirtieth of a grain may be given hypodermically as soon as the patient reaches her room. If the pulse remain over 120 to the minute, this had better be repeated every hour for four or five times; otherwise every two hours for three or four doses is sufficient, and after this every four to six hours, according to the character and rate of the pulse. It is probable that the work now being done on the determination of the blood pressure will ultimately give us more definite data for the employment of stimulating drugs under these circumstances. For the nausea nothing much can be done; drugs as a rule are useless, and sips of hot or cold water only aggravate it. A hot turpentine stupe or a small hot-water bag applied to the epigastrium above the level of the dressing, often affords some relief. Gastric lavage at the time of operation acts as a preventive, and may also be employed after the first twenty-four hours in persistent cases. As soon as consciousness returns the first complaint will be probably of thirst, but beyond moistening the lips and wiping out the mouth with a moist piece of gauze nothing much can

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be done for some hours. When, however, the nausea has subsided, water in small quantities may be given every few minutes. Hot water is preferable to cold, and the quantity may gradually be increased if no ill effects are seen. As has been said before, the administration of the enema and leaving 500 c.c. of salt solution in the abdomen will lessen the thirst very considerably. For the pain, if severe, a small dose of morphine or codeine may be given hypodermically. It is much better to avoid opiates whenever possible, and their routine use is to be condemned. Besides augmenting the nausea, in many patients they are apt to retard the opening of the bowels. Rubbing with chloroform liniment will often relieve the severe backache, and a change of position is always grateful. With the abdominal dressing described above there is no risk in moving the patient from one side to the other.

It is advisable to have the patient urinate naturally, and unless there is some contraindication, such as trauma to the bladder wall during the operation, from eight to ten hours may be allowed to pass without an evacuation of urine. After this time, if her efforts to void naturally have failed, she should be catheterized with the usual aseptic precautions. This should not be repeated unless it is absolutely necessary. If she have much distress referable to the bladder, it may be emptied earlier.

Most of the discomfort incident to abdominal operations is due to the tympanites, which is usually worse in those cases in which the structures have been adherent, and in which there has been much handling of the bowels. It is also frequently due to neglect in properly emptying them before the operation. This complication can be relieved very often by passing the long rectal tube and applying heat to the epigastrium. Tincture of capsicum in three-minim doses may be administered after the cessation of the nausea. In neurotic women a good deal of discomfort is usually the rule.

The patient generally feels much easier as soon as the bowels have been well moved. Eighteen or twenty hours after the operation two grains of calomel may be given. Eight or ten hours later a turpentine enema will often produce a satisfactory evacuation; if ineffectual it may be repeated in four hours, or a glycerin enema may be given instead. If there be still no results small doses of magnesium sulphate may be given.

The temperature, pulse rate, and number of respirations should be taken every three hours at first, and later every four or six hours, according to the progress made by the patient. A careful chart should be kept so that her condition from time to time may be readily ascertained.

In the matter of diet nothing but water had better be given by mouth until the bowels have been moved, but nutrient enemata consisting of peptonized milk, with the whites of two eggs and twenty grains of table salt, may be administered every three hours. As soon as the bowels have moved satisfactorily milk with lime water or carbonated water, albumin water or broth may be retained if given in small quantities at first. After the first three or four days, if satisfactory progress is being made, the patient may take soft food, and after about two weeks an ordinary light diet may be ordered.

Where there is no suspicion that suppuration is occurring in the abdominal wound, the dressing need not be disturbed for ten days; but if through-and-through sutures have been used for the abdominal incision, as in cases in which speed in closing the wound has been necessary, or if unabsorbable sutures have been employed for the skin alone, an earlier examination is advisable, and if any redness be found around the suture the offender had better be removed. All of them can be taken out as a rule on the seventh day. If the incision be firmly united, a small pad of gauze over it will be sufficient; transverse strips of plaster may be used to hold this in place, and at the same time prevent any stretching of the newly formed scar tissue. The scultetus bandage is worn until the patient is out of bed, after which a special elastic abdominal supporter should be provided. If no complications occur, the patient may sit up in bed on the sixteenth or eighteenth day after the operation, and get out of bed on the nineteenth or twenty-first day. Undoubtedly in many cases a shorter time than this is sufficient, but it is far better to be on the safe side.

Mortality.—The mortality depends upon a number of factors, such as the skill and experience of the operator, his facilities for carrying out an aseptic technique, and also the care of the patient after the operation. Granted that these have been all that could be desired and that the cases are uncomplicated, the percentage of deaths from the operation should be almost nothing. It is very difficult to determine the real mortality since statistics are notoriously misleading.

The results are steadily improving. A few references to the mortality in the early days of the operation have already been made, and half a century ago it was over fifty per cent. Owing to an aseptic technique, and to our knowledge gained by experience, the average mortality in cases subjected to operation for ovarian tumors at the present day is below ten per cent. Individual operators will have far better results than this. Lawson Tait a number of years ago reported a series of 139 ovariotomies without a death, and the results to-day are better than at that time. Even in cœliotomies for all sorts of pelvic diseases, including pelvic abscess, ectopic gestation, etc., records of series of over 100 consecutive cases without a death have been reported. The author has recently had two such series, one of 108, the other of 114 consecutive successful operations in a hospital practice, in which all conditions, including pus cases in a large proportion, were encountered.

The average skilful operator, taking cases as they come, and having every facility for good work, should have a mortality of not over three to four per cent. in ovariotomy.

Hunter Robb.

OVARY (ANATOMICAL). See *Sexual Organs, Female.*

OVULATION. See *Menstruation.*

OVUM.—(Greek ᾠόν, Latin *ovum*, an egg.)

The *ovum*, or egg proper, is a cell capable under certain conditions of giving rise by subsequent cell divisions to a complete multicellular organism. This definition applies to the female germ cells of plants as well as to those of animals. Frequently the terms ovum and egg are used loosely, however, not only to include the envelopes surrounding the egg proper, but even to designate the embryo and its fœtal membranes.

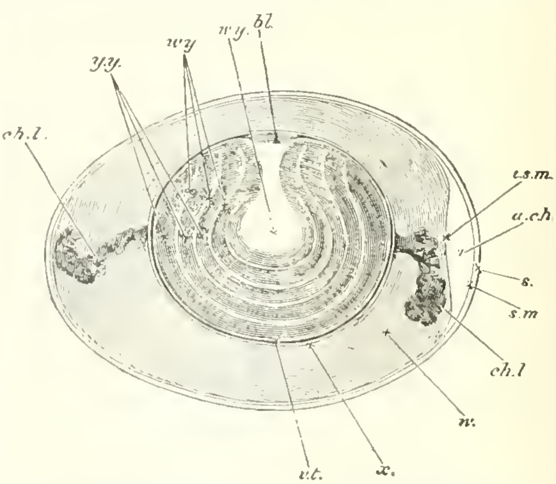

FIG. 3712.—Diagrammatic Section of an Unincubated Hen's Egg. *bl.*, Blastoderm; *w.y.*, white yolk; *y.y.*, yellow yolk; *v.t.*, vitelline membrane; *w.* albumen; *ch.l.*, chalaza; *a.ch.*, air chamber; *i.s.m.*, inner shell membrane; *s.m.*, outer shell membrane; *s*, shell. (From Balfour, modified from Allen Thomson.)

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Historical.—Although a hen's egg has been probably one of the most familiar of objects since long before man

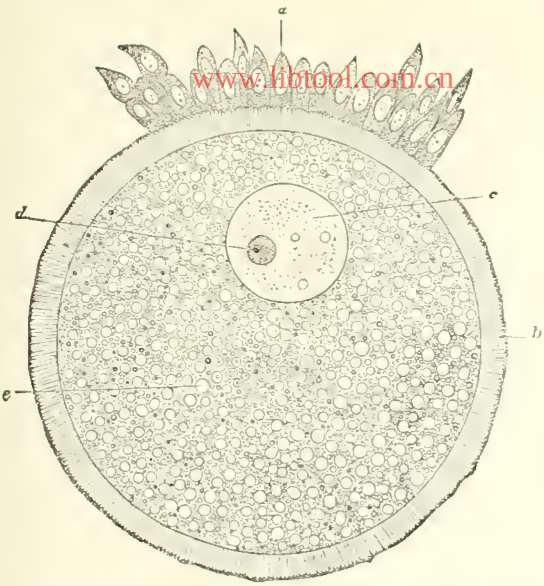

FIG. 3713.—Rabbit's Ovum, from a Graafian Follicle measuring 2 mm. *a*, Discus proligerus; *b*, zona radiata; *c*, nucleus; *d*, nucleolus; *e*, yolk-granule in the cytoplasm. Highly magnified. (From Waldeyer.)

ever thought of domesticating wild animals, it remained for the anatomists of the nineteenth century to discover its true nature; and although investigators of this subject were never before so active as during the last decade, and have carried on their work with a refinement of technique not dreamed of in earlier years, there is still a great deal to be learned.

Modern embryological observations may be said to have begun with William Harvey, who published his results in 1651. The best microscope that he could obtain was a simple lens, and with this he was able to make out the general outline of a chick embryo during the second day of incubation. His view of the ovum was that it consisted of a fluid matrix in which the embryo appeared by a process of spontaneous generation. The female sexual product was supposed at that time to be a fluid secreted by the "testes muliebres," the term "ovarium" not having been invented by Stenson until some years later.

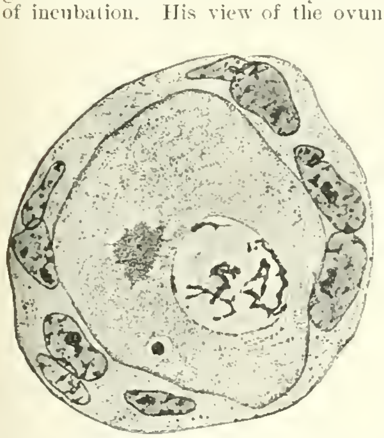

FIG. 3714.—Graafian Follicle and Ovum from the Ovary of a Rabbit Four Weeks Old. On the left of the egg nucleus is the attraction sphere containing two centrosomes and below is a small yolk nucleus. Highly magnified. (After Winiwarter.)

Regnier de Graaf published in 1677 a description of the follicles, which have since borne his name. He found that they contained a fluid which was capable of being coagulated by heat into a firm, white substance. He discovered also that in the Fallopian tubes of a rabbit killed seventy-two hours after coitus there were to be found a number of eggs which were vesicles and contained a fluid that could be coagulated by heat, like the white of egg, and, moreover, these corresponded in number to the empty follicles found in the ovaries of the same subject. He concluded, therefore, that the Graafian follicles were ova. But the chain of evidence was not complete because all trace of the eggs was lost between the time of coitus and the end of the third day, and, more-

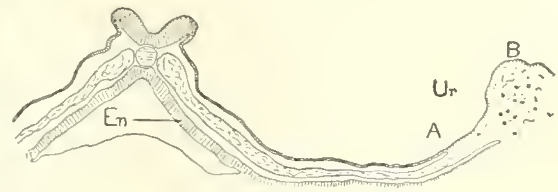

FIG. 3715.—Cross Section of an Embryo Dogfish 2.75 mm. Long. *A*–*B*, Blastodermic rim containing all the germ cells; *En*, endoderm. × 38. (After Woods.)

over, the blastoderms in the Fallopian tubes were not so large as the empty follicles. During the same year, 1677, Leeuwenhoek announced the discovery of spermatozoa, and there followed a long dispute as to whether the spermatozoon is the true germ and the egg a matrix

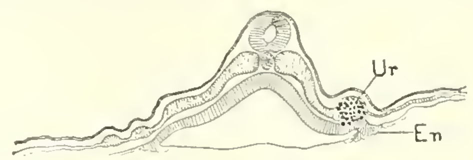

FIG. 3716.—Cross Section of an Embryo Dogfish, 3.5 mm. Long. *En*, Endoderm; *Ur*, germ cells. × 38. (After Woods.)

for its nutrition, or whether the germ dwells originally in the egg itself (see article *Evolution*).

It was not until 1827 that Carl Ernst von Baer was able to show that the Graafian follicle is not the ovum; but that the ovum is a minute body embedded in the follicular epithelium. And it was not until 1838 that Schwann was able to declare the egg to be a cell with the same fundamental structure as the other cells of the body.

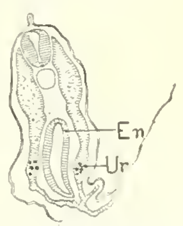

FIG. 3717.—Cross Section of an Embryo Dogfish, 5 mm. long. *En*, Endoderm; *Ur*, germ cells. × 38. (After Woods.)

Morphology.—The ovum is usually a more or less spherical body, but may be flattened or elongated, as is the case with most insect eggs.

The protoplasmic contents of the egg consist of a nucleus and a mass of cytoplasm, as in all cells, and, in addition, the cytoplasm usually contains a greater or less amount of yolk, or *deutoplasm*.

The cytoplasm of the eggs of echinoderms and other invertebrates has been shown to have a distinctly vesicular, or foam-like, structure, and it is probable that all eggs will show a similar structure. It is within the vesicles of the foam that the deutoplasm is deposited, sometimes in the form of clear oil globules, as in some worms and fishes, more often as more or less opaque yolk granules. In the hen's egg there are two principal kinds of yolk granules, the yellow and the white. The white granules are gathered together in the form of a small flask-shaped body, extending from the centre of the ovum to the upper pole, and the yellow yolk forms concentric layers surrounding this and alternating with thinner layers of white yolk (Fig. 3712). These may be seen in a carefully made section of a hard-boiled egg. Where the white yolk approaches the surface there is in the unfertilized egg a portion of the cytoplasm comparatively free from yolk and containing the nucleus.

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The size of the egg, the position of the nucleus, and the subsequent course of development, especially in the early stages, depend to a large extent upon the presence or absence of a burden of food yolk within the cytoplasm of the ovum. For example, the eggs of reptiles and birds are heavily charged with yolk and are very large, while all mammals, except the Monotremes, have eggs almost free from yolk, and they are very minute, measuring about 0.2 mm. in diameter.

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Eggs are classified according to the absence, presence, and position of the yolk, into three groups: (1) *Alecithal* eggs, having very little or no yolk; (2) *telolecithal* eggs, in which there is a large accumulation of yolk at one pole; and (3) *centrolecithal* eggs, in which the accumulation of yolk is at the centre and is surrounded on all sides by a purely protoplasmic layer. Eggs of this type are especially characteristic of the arthropods. In telolecithal eggs the pole that is the richer in yolk is called the *vegetative* pole. The nucleus lies nearer the opposite, or *animal* pole, and the purely protoplasmic portion surrounding the nucleus may be confined to a very small area, the *germinal disc*, near the surface, as in the hen's egg.

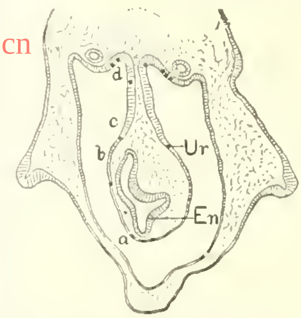

FIG. 3718.—Section of the Ventral Portion of an Embryo Dogfish, 15 mm. Long. *En*, Endoderm; *Ur*, germ cells. × 38. (After Woods.)

The nucleus is usually a spherical body surrounded by a delicate nuclear membrane, and is still frequently called by the old name, *germinal vesicle*, although it presents all the ordinary features of a cell nucleus (Fig. 3714), including linin network, chromatin granules, and nucleolus, the latter is called in the older books the *germinal spot* (see article *Cell*). The condition usually described is but one stage of a pretty definite series of changes which the chromatin and nucleolus undergo during the course of development of the ovum, and which will be referred to later.

In many eggs there may be seen near the nucleus an "attraction sphere" of finely granular protoplasm surrounding a very minute, darkly staining spot, the *centrosome*. The eggs of many animals of various groups contain also another body, often somewhat resembling a nucleus and hence called the *yolk nucleus* (Fig. 3714).

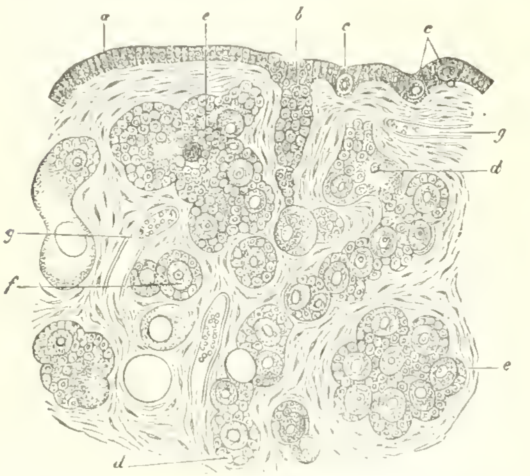

FIG. 3719.—Part of a Sagittal Section of an Ovary of a New-born Child. *a*, Ovarian epithelium; *b*, commencement of one of Pflüger's cords; *c*, *c*, "primitive ova" in the epithelium; *d*, *d*, and *e*, *e*, germinal involutions with developing ova and young follicles; *f*, young follicle; *g*, *g*, blood-vessels. Magnified. (From Waldeyer.)

It is also called, after the author who first described one of these bodies, the corpuscle of Balbiani. It is probable that the bodies classed together under this name are far from all having the same morphological or the same physiological significance.

The Envelopes.—The most primitive type of egg to be met with anywhere in the animal kingdom is that characteristic of the sponges and hydroids. In these groups we meet with eggs that are not only wholly naked, but also show the power, at least within the maternal body, of active amœboid movement. Naked eggs are found in representatives of other groups of cœlenterates; and the eggs of some echinoderms, at least, are without envelopes when discharged from the oviduct, although an envelope is formed immediately after the entrance of the spermatozoon.

In all the higher groups of animals the egg is provided with one or more coverings. These are divided into three principal classes. First we have the primary envelope or *vitelline membrane*, which is essentially a cell wall formed by the cytoplasm of the egg. This is found in representatives of all groups of the animal kingdom. It is generally thin and structureless, but it may consist of several layers or be pierced by radial pores forming a *zona radiata* (*b*, Fig. 3713). Sometimes the vitelline membrane is incomplete at the point where the egg is attached to the wall of the ovary, leaving an opening, the *micropyle*, which serves as a passageway for nutrient material during the ovarian life of the egg and later for the entrance of the spermatozoon.

The secondary envelope is found only in eggs that are surrounded in the ovary by a follicular epithelium, which gives rise to this envelope; and it is especially characteristic of the eggs of insects and mollusks. In these forms it is called a *chorion*, a term used also to designate a very different fœtal membrane of mammalia.

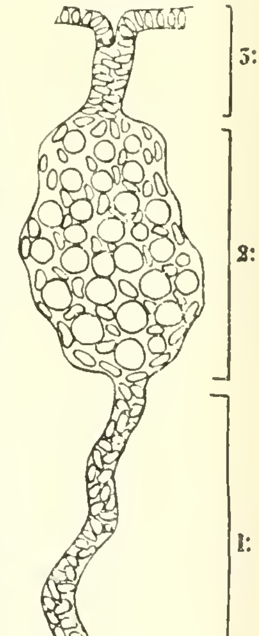

FIG. 3720.—Diagram of the Derivatives of the Germinal Epithelium in Mammalia. 1, Medullary cord; 2, germinal involution containing ova and follicle cells; 3, invaginated epithelium (Pflüger's cord) and covering epithelium. (After Winiwarter.)

After leaving the ovary the egg may receive one or more *tertiary* envelopes, which are secreted by the walls of the oviduct or by glands connected with it. These envelopes may be protective or nutritive in function or both. For example, in the hen's egg (Fig. 3712), the ovum, commonly known as the "yolk," covered by a thin vitelline membrane, lies embedded in a mass of albumen that serves as food for the embryo chick. But at opposite poles of the ovum there are attached much denser strands of albumen, the *chalazæ*, that undoubtedly serve also as a sort of packing to prevent the ovum from coming into too close contact with the ends of the shell. Outside of the albumen are two shell membranes and then the hard calcareous shell. The egg when it emerges from the ovary is provided with only a vitelline membrane. The albumen, shell membranes, and shell are tertiary envelopes and are secreted in succession by the wall of the oviduct as the egg passes outward.

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The outer coverings of the eggs of the different groups of animals show much diversity of form and structure, and many of them present wonderful adaptive modifications. But to treat of this fascinating branch of the subject would carry one far beyond the possible limits of the present article.

Early Development.—In the sponges, some cœlenterates, and some of the lower worms the development of eggs is apparently not localized, but may occur in various parts of the body. In the higher forms, on the contrary, the germ cells always undergo their development in certain well-defined regions or organs known in the female as the *ovaries;* and in all animals possessing a distinct body cavity, or cœlom, the cells of the ovary are originally continuous with the peritoneal epithelium. In vertebrates the portion of peritoneum containing the primitive germ cells, the *germinal epithelium,* is in the dorsal part of the body cavity, usually on the inner side of the Wolffian body near the mesentery. In the development of the ovary the germinal epithelium thickens, and the connective tissue beneath it also grows outward into the body cavity, so that the two together form an elevation upon the Wolffian body known as the *genital ridge.* From this the definitive ovary is formed.

We have called attention elsewhere to the very early appearance of distinctly germ cells in the worm Ascaris (see article *Heredity*). It has been shown recently that in vertebrates the germ cells may appear at a considerably earlier stage than had been thought possible.

FIG. 3721.—Part of a Section of the Ovary of a Rabbit Half a Day after Birth. *a*, Covering epithelium; *b*, protobrochal nuclei of oögonia and follicle cells; *c*, deutobrochal nuclei; *d*, leptotænian nuclei; *e*, synapsis stage; *m*, oögonia in mitosis; *k*, nuclei undergoing degeneration; *c.m.*, medullary cord; *c.m.p.*, medullary connective tissue. × 450. (After Winiwarter.)

Minot in 1894 and Rabl in 1896 had shown that what appeared to be germ cells, or primitive ova, may be seen in early stages of the embryo lying in positions far distant from the genital ridge. More recently (in 1902) Woods has published the results of his studies upon the embryos of the common marine dogfish, *Squalus acanthias,* in which he has been able to trace the history of the germ cells back to a mass of seemingly indifferent cells forming the rim of the blastoderm (see article *Area Embryonalis*). At first these cells are all alike, but in an embryo of 2.75 mm. length they have become differentiated into somatic cells and so-called primitive ova, that is, primitive germ cells which may become finally either ova or spermatozoa (Fig. 3715). The germ cells retain their primitive embryonic character, while the somatic cells begin to change into forms characteristic of epithelium, mesenchyma, and the like. At a little later stage when the embryo is beginning to fold off from the blastoderm, the germ cells are found in a compact mass in the mesoderm near where it joins the endoderm (*Cf.* Figs. 3716 and 3717).

From this point the germ cells begin to migrate, apparently by their own amœboid movements, toward the region of the future genital ridge. When the embryo is between 6 and 8 mm. long the unsegmented mesoderm divides into two sheets with the body cavity between. After this the germ cells are practically all found in the inner sheet, or splanchnopleure, which forms the mesodermal portion of the wall of the gut and the mesentery. In an embryo of 15 mm. (Fig. 3718) germ cells are still to be found in the splanchnic peritoneum, but by the time the embryo has reached a length of 19 mm. these cells have very nearly all congregated in the genital region. While at present this is the only case on record of such a migration in a vertebrate, it is probable that more extended research will reveal many similar cases among this group.

Development of the Ovary.—As has been indicated, the ovary is formed by the enlargement and further differentiation of the genital ridge. In it we may distinguish two principal parts—the cortical layer and the medullary portion. The cortex is derived from the primitive germinal epithelium, and from it are formed the peritoneal, or epithelial, covering of the ovary, the Graafian follicles, and the definitive ova. The medullary portion is derived from the underlying mesenchyme cells, which form the connective-tissue stroma and the blood-vessels of the ovary, and within it are embedded the nerve fibres that supply these vessels. In the mammalia the medullary portion contains also during the early stages a large number of strands of cells of a more or less epithelial character, forming what are called the *medullary cords,* and these have given rise to a considerable amount of discussion. For it has been seen that in the embryo these medullary cords may sometimes be found in contact with the glomerulæ of the Wolffian body, and it has been supposed that they were formed by outgrowths from the renal tissue into the ovary. Moreover, there are indications that ova may be developed in the medullary cords, and, if this were generally true and the cords have the origin supposed, the ova of mammals would have an entirely different origin from those of other ver-

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tebrates—from the renal epithelium instead of from the lining of the body cavity. This difficulty seems to have been cleared up very satisfactorily by the recent work of

FIG. 3722.—Nuclei from the Ovary of a Human Fœtus of about Seven Months. *B*, Two oögonia with protobrochal nuclei; *C*, nucleus of an oöcyte of the first order in the deutobrochal stage; *n*, nucleolus. × 1700. (After Winiwarter.)

von Winiwarter (1900). In his study of embryo rabbits he finds that the medullary cords are not formed as outgrowths of the glomerulæ, but are the first ingrowths of the germinal epithelium. They penetrate first the stroma of the ovary and then push through the hilum into the Wolffian body, where they may come into contact secondarily with the glomerulæ.

In the ovary of an embryo rabbit taken from the uterus twenty-three days after coitus, von Winiwarter distinguishes two principal parts in the primitive cortex. The outer one is the germinal envelope, which is continuous over the whole surface of the ovary and may be subdivided into a superficial distinctly epithelial layer and a deeper germinal layer. The inner part of the cortex is made up of the germinal involutions (*boyaux germinatifs*), which are simply thickenings of the germinal layer separated from one another by strands of the connective-tissue stroma of the medullary portion of the ovary. In their deepest parts the involutions are not yet sharply

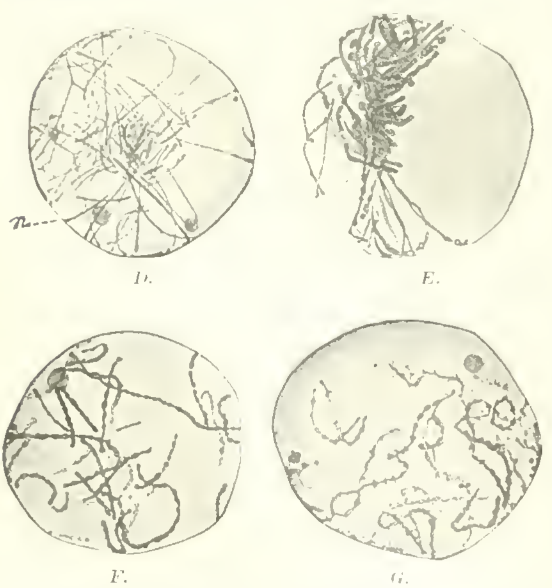

FIG. 3723.—Nuclei from the Ovary of a Human Fœtus of about Seven Months. Consecutive stages in the development of the oöcyte: *D*, leptotænian; *E*, synapsis; *F*, pachytænian; *G*, diplotænian; *n*, nucleolus. × 1700. (After Winiwarter.)

separated from the medullary cords, with which they were originally continuous. In the subsequent stages, by the combined ingrowth of the germinal layer and outgrowth of the connective tissue, the involutions become more separated from one another and from the outer epithelium, until in a new born child or a rabbit five weeks after birth the involutions are connected with the epithelium only by narrow cords of cells, the so-called egg tubes of Pflüger (Fig. 3719) (*Pflugerschen Schläuche*). Von Winiwarter's conception of the relations of these structures of the ovarian cortex is shown diagrammatically in Fig. 3720.

Development of the Definitive Ova.—The development of the ova in the later embryonic and early post-natal stages of mammalia (rabbit and man) has been described with great detail by von Winiwarter, and we will follow his account, except so far as it may be necessary to supplement it by reference to other forms in order to complete our general description of the later stages.

During its development the ovary is covered by a layer of epithelial cells with nuclei elongated at right angles to the surface. These nuclei (*a*, Fig. 3721) have a finely reticular structure with a few irregularly placed masses of chromatin. In an embryo rabbit of twenty-three days practically the whole cortex is composed of similar cells. Those beneath the epithelium differ only in having nuclei a little more rounded and more coarsely reticular (*b*, Fig. 3721 and *B*, Fig. 3722). This is the *protobrochal* (πρῶτος, first, and βρόχος, mesh) stage in the development of the nuclei and the cells are *oögonia.*

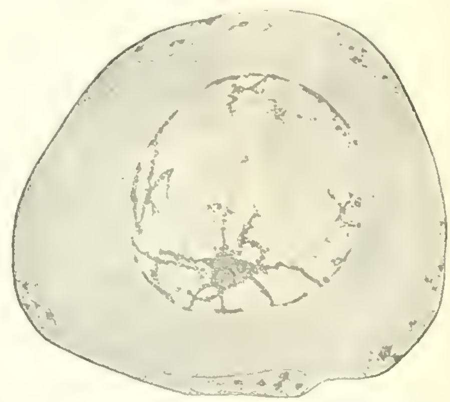

FIG. 3724.—Oöcyte of the First Order at the Beginning of the Second Period, from a Young Rabbit. The follicle cells are few and much flattened. × 1700. (After Winiwarter.)

That they are in process of rapid multiplication is shown by the presence of numerous mitotic figures among them (*m*, Fig. 3721). A large number of the protobrochal nuclei remain unchanged and the cells finally form the Graafian follicles (Fig. 3714). Others which are at first apparently exactly like them belong to the true oögonia, which finally cease dividing and begin to enlarge. They then become the *oöcytes of the first order.*

The ovarian history of the oöcytes may be divided into two stages: first, before the formation of the Graafian follicles; and, second, after that event. During the first stage the nucleus of the oöcyte undergoes a curious series of transformations.

The nuclei gradually enlarge and become globular in shape. At the same time the chromatin becomes more coarsely reticular, forming the *deutobrochal* stage (δεύτερος, second), and one or two nucleoli appear within the nucleus (*c*, Fig. 3721 and *C*, Fig. 3722). In the next stage (*d*, Fig. 3721 and *D*, Fig. 3723), the chromatin ceases to have a reticular appearance and is in the form of slender threads distributed evenly throughout the nucleus in more or less parallel pairs. From this the nucleus passes gradually into the synapsis stage (συνάπτω, to reunite, to condense), in which the chromatin threads are withdrawn from the greater part of the nucleus and are condensed into a tangled mass, generally near one side of the nucleus (*e*, Fig. 3721 and *E*, Fig.

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3723). When the tangle is unravelled, the chromatin emerges as a thick, beaded cord without any appearance of doubling (*F*, Fig. 3723). Whether this is really a single filament or is composed of several, is difficult to determine. In the next stage, however, the chromatin is distinctly divided into segments which are double, often forming rings or figure eights (*G*, Fig. 3723). Finally, when the oöcyte becomes surrounded by the follicle cells, the nucleus resumes a coarsely reticular structure (Fig. 3724). It will be noticed that during these stages the nucleus has increased very much in size (compare Figs. 3722 and 3724).

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In the embryo rabbit of twenty-three days there are already a considerable number of oöcytes in the deutobrochal stage lying in the deep parts of the genital involutions. In the newly born rabbit the oöcytes are much more numerous, and those in the deepest parts of the ovarian cortex have reached the synapsis stage (*e*, Fig. 3721). The earlier stages (*c*, *d*, Fig. 3721) may be seen lying nearer to the periphery. The Graafian follicles begin to be formed in a rabbit when about ten days old; but they are already present in a human fœtus of seven months.

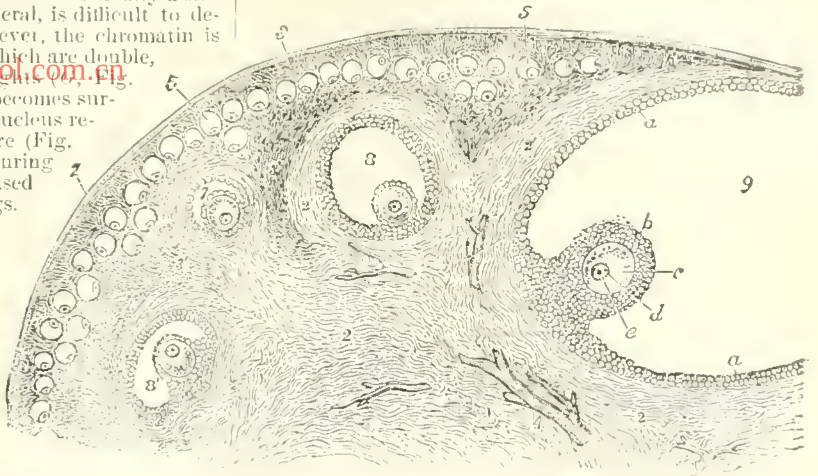

FIG. 3726.—Portion of the Section of the Cat's Ovary, represented in the preceding figure, more highly magnified. 1, Epithelium and outer covering of the ovary; 2, 2', fibrous stroma; 3, 3', less fibrous, more superficial stroma; 4, blood-vessels; 5, small Graafian follicles near the surface; 6, one or two more deeply placed; 7, one further developed, enclosed by a prolongation of the fibrous stroma; 8, a follicle further advanced; 8', another, which is irregularly compressed; 9, part of the largest follicle; *a*, tunica granulosa; *b*, discus proligerus; *c*, ovum; *d*, germinal vesicle; *e*, germinal spot. (From Schrön, in Quain's Anatomy.)

The egg follicle has a different structure in each group of vertebrates. In mammalia it is at first a single layer of flattened cells (Fig. 3724). But these cells soon increase in number until they form several layers surrounding the oöcyte. Then a fissure appears filled with fluid which incompletely separates the follicular cells into an outer and an inner sphere. The outer one is the so-called *tunica granulosa*, and the inner one, which surrounds the egg, is the *discus proligerus* and is continuous with the granulosa on one side, usually the side toward the centre of the ovary (Fig. 3726). This is now a typical Graafian follicle. In the mean time the connective-tissue stroma has so invaded the germinal involutions as to isolate the follicles and form a connective-tissue capsule, the *theca folliculi*, around each one.

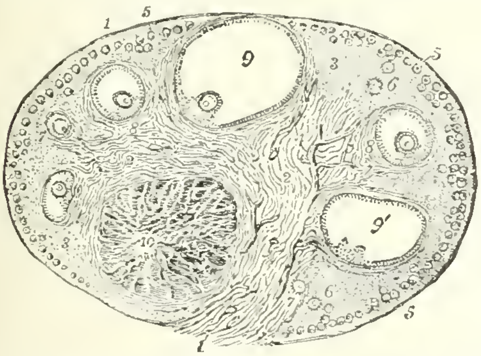

FIG. 3725.—Section of the Ovary of a Cat. 1, Outer covering and free border of the ovary; 1', attached border, or hilum; 2, the central ovarian stroma, presenting a fibrous and vascular structure; 3, peripheral stroma; 4, blood-vessels; 5, small Graafian follicles lying near the surface; 6, 7, 8, more advanced follicles, which are embedded more deeply in the stroma; 9, an almost mature follicle, containing the ovum in its deepest part; 9', a follicle from which the ovum has accidently escaped; 10, corpus luteum. × 6. (After Quain, from Schrön.)

At the time of the first appearance of the follicle cells the outline of the oöcyte appears to be clearly defined, probably by a thin cell wall. When the discus proligerus is established the oöcyte is seen to be surrounded by a clear membrane, apparently containing extremely fine radial canals through which there is supposed to be protoplasmic connection between the oöcyte and the surrounding follicular cells. This membrane is the *zona radiata*, or *membrana pellucida*. Whether it is a true vitelline membrane formed by the oöcyte or a secondary envelope formed by the follicular cells is still a matter of dispute.

After the follicle is developed the egg not only continues to increase in size, but also begins to acquire yolk material or deutoplasm. This is small in amount in man and other mammals, but in most other vertebrates a comparatively large amount of yolk is formed.

The final discharge of the egg from the ovary in mammals is brought about by the bursting of the Graafian follicle. This allows the egg with the surrounding fluid to escape into the body cavity whence it enters the Fallopian tube. For the details of this process see article *Menstruation*.

Before the egg can be fertilized, however, it must pass through two cell divisions of a peculiar character, which constitute the process of *maturation*. During the period of growth the egg is an "oöcyte of the first order." At about the time the egg is discharged it undergoes a very unequal cell division, forming the *first polar body* and the "oöcyte of the second order." The latter soon undergoes another division into the *second polar body*, and the definitive, or *ripe ovum*. The details of the process of maturation will be considered in connection with a similar process in spermatogenesis under the title *Reduction Division*.

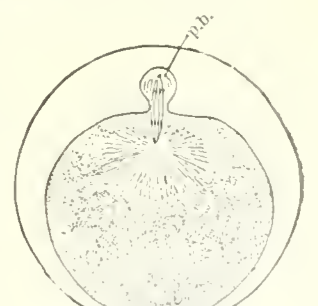

FIG. 3727. Egg of a Leech (Nephelis), three-quarters of an hour after being laid. Formation of the first polar body. Magnified. (After Hertwig.)

Robert Payne Bigelow.

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OWENS LAKE.—Inyo County, California. This second dead sea in California is located at the southern end of Owens Valley in Inyo County. It is eighteen miles long and ten miles wide. Its surface embraces one hundred square miles. The waters are remarkably rich in saline and alkaline ingredients. The following analysis was made by Professor Phillips, of London, in 1883: One United States gallon contains: Sodium chloride, gr. 2,450.81; sodium carbonate, gr. 797.01; sodium sulphate, gr. 2,427.69; potassium sulphate, gr. 29.77; potassium silicate, gr. 116.23; organic matter, gr. 14.11. Total, 5,835.62 grains.

We are informed by Dr. I. J. Woodin, of Independence, Cal., that numerous fresh-water springs are found along the shores of the lake, some of which are cold and others boiling hot. At the southwest end of the lake there is a valuable white sulphur spring which has not so far been improved. At a short distance from this spring is a mountain formed in great part of sulphur, of which Dr. Woodin sends us a handsome specimen, composed probably almost entirely of the pure element. The aspect of the country is mountainous, the elevation of the lake being three thousand feet above the Pacific. The region offers many attractions as a health resort, and it will no doubt soon be developed.

James K. Crook.

OWOSSO SPRING.—Shiawassee County, Michigan.
Post-Office.—Owosso.

Access.—Owosso is a station on the Detroit and Milwaukee Railroad, seventy-nine miles northwest from Detroit.

The following analysis was made by a chemist whose name has been lost: One United States gallon contains: Calcium bicarbonate, gr. 25.67; magnesium bicarbonate, gr. 19.09; iron bicarbonate, gr. 15.92; sodium chloride and potassium chloride, gr. 2.10; alumina and silica, gr. 0.62. Total, 63.40 grains.

This water, as shown by the analysis, is very heavily impregnated with iron. As the name of the analyst is not known, the analysis is not reliable.

James K. Crook.

OXALIC ACID.—Oxalic acid, having no medicinal virtues, is not official in the United States Pharmacopœia. Its importance depends entirely upon its toxicological relations. *E. C.*

OXALIC ACID, POISONING BY.—The salt obtained by evaporation of the juice of *Oxalis acetosella*, and now known as *binoxalate of potash*, *salt of sorrel*, or *salt of lemon*, was known at least as early as the middle of the seventeenth century, as Duclos makes mention of it in the "Memoirs of the Academy for 1668." A century later (in 1773) oxalic acid was obtained from this salt by Savary. Subsequently Scheele showed the oxalic acid obtained from sorrel to be identical with the *acid of sugar* obtained by Bergman, in 1776, by the action of nitric acid upon sugar.

The first case of poisoning by oxalic acid, of which we find record, occurred in England in 1814 (*Lond. Med. Repository*, i., 382). In this case the acid was taken in mistake for Epsom salt, a mistake which has subsequently become the most frequent cause of oxalic acid poisoning.

Attempts at homicide by oxalic acid are of rare occurrence, owing to the difficulty of disguising the taste. Christison mentions one as having occurred in England in 1827, and others have been subsequently reported from the same country, the acid having been mixed with gin, coffee, sugar, tea, or buttermilk.

Notwithstanding the very extensive use of oxalic acid and the oxalates in the arts of dyeing, calico-printing, etc., they are as yet innocent of industrial poisoning.

As many articles of vegetable diet—beet, spinach, rhubarb, sorrel, etc.—contain oxalates, their use in excessive quantity has been supposed by some to be attended with some danger of poisoning. As, however, the amount of hydropotassic oxalate present is only 0.75 per cent. (= 3 grains per ounce) in fresh sorrel (Mitscherlich), and much less in the other vegetables, their use in any reasonable quantity may be regarded as unattended with danger.

A more probable cause of poisoning is to be found in the adulteration of citric acid with oxalic acid, and the use of the adulterated product in the manufacture of medicinal effervescent drinks or of cheap "lemonade."

Poisoning by oxalic acid and the oxalates is of very rare occurrence in France, while in England, Germany, and the United States several cases occur annually. The reason for the greater frequency of oxalic poisoning in the last-named countries is to be found in the very extensive use in them of oxalic acid and salt of lemon for household purposes, to clean metallic vessels and to remove ink and fruit stains from fabrics, as well as in the popular habit of "taking a dose of salts" at certain times of the year. Oxalic acid and magnesium sulfate resemble each other very closely in appearance, and hence the former is frequently taken by mistake for the latter.

Symptoms.—Oxalic acid is both a corrosive and a true poison, one or the other action predominating according to the size of the dose and the degree of concentration of the solution. If it be taken in the solid form or in concentrated solution, as is usually the case, the symptoms of corrosion are the first to appear and may be the only ones observed. But if the poison be taken in dilute solution the symptoms of corrosion may be entirely absent.

In a typical case of oxalic-acid poisoning, the dose being in the neighborhood of 15 gm. (℥ ss.), taken in concentrated solution, the patient experiences the first effects of the poison either immediately, during the act of swallowing, or within a few moments. In exceptional cases the first appearance of symptoms has been delayed ten or twenty minutes, although larger doses were taken.

The strongly acid taste is observed and is followed by a sense of heat in the mouth, throat, and stomach. This rapidly increases in intensity until it becomes an intense, burning pain. In some cases the pain is accompanied by a sense of constriction of the throat and of impending suffocation. The act of swallowing is performed with difficulty, and later the voice becomes fainter and husky, and sometimes completely extinguished. Within ten or fifteen minutes violent and persistent vomiting begins in almost every case. The vomited matters are most frequently of a "coffee-ground" character, and separate on standing into two layers: the upper a clear, yellowish, and strongly acid liquid; the lower a thick, red-brown sediment of altered blood. Occasionally true hæmatemesis is observed. In cases in which the poison has been taken in small quantity and in dilute solution, the vomited matters may be free from blood. In some cases persistent vomiting and pain, and later persistent purging of a bloody material are the only symptoms, and they may continue, with or without intermission, for five, six, or seven days. Death finally occurs from exhaustion in from five to ten days.

When very large doses have been taken (30–60 gm. = ℥ i.–ij.), the patient, after vomiting, may go into a state of collapse and die within five minutes.

The lips, mouth, and fauces are, shortly after the poison has been taken in solution, reddened, swollen, and painful. Later they become paler, and finally, sometimes within an hour, of a dirty, ashen-white hue, either throughout or in patches. The tonsils and uvula are much swollen. There is severe thirst.

Soon the symptoms due to the true poisonous action of the acid are added to those caused by its immediate corrosive action upon the alimentary canal. The countenance is pale, anxious, and haggard, the upper lip trem-

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bling, the lower jaw relaxed. The surface is bathed in a cold, clammy perspiration. The fingers are semiflexed and rigid, and the nails blue. The eyes are glazed and the pupils contracted. There is sometimes persistent hiccough. The pulse is small and thready, sometimes intermittent or imperceptible. There are general numbness and a sense of tingling or cramps in the upper and lower extremities. Abdominal pain is no longer complained of, although the abdomen may remain tender to pressure; but the patient suffers violent lumbar pains, shooting down into the lower extremities. The respiration is quick and labored. The skin in some cases is marked with an exanthem resembling that of roseola. The urine is frequently retained, and that removed by the catheter contains albumin in large quantity, epithelium, granular or hyaline casts, and crystals of calcium oxalate. Sometimes, in cases of recovery, the urine remains purulent for several weeks.

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Sometimes there are violent spasms of a tetanic character; more rarely delirium. In cases of recovery, spasmodic twitchings may continue for a month.

In exceptional cases (usually, though not always, cases in which a small dose has been taken) the patient rapidly becomes stupid, somnolent, and unconscious. This condition has been known to pass into one of coma, terminating in death (Tidy: *Lancet*, 1872, ii., 41).

Like the mineral acids and alkalies, oxalic acid may cause death secondarily, after partial recovery, by starvation, due to extensive destruction of gastric and intestinal mucous membrane. This was observed in an early case by Fraser (*Edinb. Med. Journ.*, xiv., 1818, p. 607), in which death by inanition followed in fourteen days from the effects of a dose of ℥ ss. (15.5 gm.) of the acid.

The immediate cause of death in oxalic-acid poisoning may be, therefore, either collapse, or paralysis of the heart, or inanition.

Duration.—The duration of a case of oxalic poisoning is usually short if it terminate in death; but if the patient recover the illness is generally protracted through several days. Of 22 cases ending in death, 9 died within half an hour, 3 in from one to twelve hours, 3 in from twelve to twenty-four hours, and, 7 in from two to fourteen days. Of 14 cases terminating in recovery, in which the time of discharge is mentioned, 3 recovered within one day, 4 in from one to five days, 4 in from five to ten days, and 3 in from ten days to three months. The shortest recorded duration of a fatal case is three minutes, the longest fourteen days.

Lethal Dose.—The following tabulation of 51 cases will illustrate the difficulty of fixing this quantity definitely:

Quantity of Oxalic Acid Taken.	Recovery. Cases.	Death. Cases.
Undetermined	5	11
4.00 gm. = (ʒ i.)	1	1
7.75 gm. = (ʒ ij.)	3	1
11.66 gm. = (ʒ iij.)	1	1
15.50 gm. = (ʒ iv.)	6	2
23.33 gm. = (ʒ vi.)	0	2
27.22 gm. = (ʒ vij.)	0	1
31.00 gm. = (℥ i.)	7	7
38.85 gm. = (℥ i¼)	1	0
46.65 gm. = (℥ iss.)	1	0
	25	26

From this it will be seen that one-half of those who have taken over 4 gm. (ʒ i.) have died; and that the deaths and recoveries are nearly evenly balanced with all doses below 30 gm. (℥ i.).

Treatment.—The first indication, and one which admits of little delay, is the neutralization of the acid in such a manner as to bring about the formation of an insoluble oxalate, and thus prevent further corrosion and absorption. For this purpose the alkaline carbonates are useless, because, although they neutralize the acid and thus prevent further corrosion, the salts formed are soluble and as poisonous as the acid itself. The old direction to "scrape the wall" and administer the scrapings, was well enough so long as whitewashed walls were in vogue; but to administer the scrapings of a modern plastered wall is of no benefit, as the calcium sulfate so given is incapable of neutralizing oxalic acid, or of converting it into an insoluble salt. The best antidote is syrup of lime, or a similar preparation of magnesia. Precipitated chalk is more frequently available and may be given, as the corrosion is not sufficiently extensive to render the generation of gas dangerous. For the same reason the introduction of the stomach tube and lavage are not attended with the same degree of risk of perforation as exists in corrosion by the mineral acids. Emetics are rarely called for, as persistent vomiting is one of the most characteristic effects of the poison. In the rare cases, however, in which vomiting does not occur as a result of the poisoning, emetics may be given, but only after early neutralization of the acid. In no case should warm water be given with a view to producing emesis; and, until the acid has been neutralized, the amount of liquid of any kind taken by the patient should be as small as possible. Opium may be given to allay pain, and stimulants in the stage of collapse.

Post-mortem Appearances.—The lips, tongue, mouth, and œsophagus are of an opaque, yellowish-white color, sometimes marked with patches of a reddish hue. The stomach is contracted, and in many cases contains a thick, gelatinous, reddish-brown and acid liquid, somewhat similar to the "coffee-ground" material vomited during life. The peritoneal surface of the organ, as well as the mesentery and the greater portion of the peritoneal surface of the intestines, is marked by blood-vessels filled with dark, fluid blood. The mucous surface of the stomach is strongly corrugated, and in most cases presents a uniform, bright red color in the elevations and depressions, except in so far as it may have been changed to brown, or even black, by post-mortem action. In some cases the mucous surface is, either in part or in whole, pale, opaque, or translucent, and marked with a coarse, ramiform vascularity of the submucous tissue. The mucous membrane, where it remains, is soft, pulpy, and easily detached. Although perforation has been observed, it is of rare occurrence. Crystals of oxalic acid, or of hydropotassic oxalate are not frequently found in the stomach, although Lesser figures a case ("Atlas," t. viii., Fig. 1), in which the patient died within ten minutes; and the almost uniformly pale and much contracted stomach was found plentifully lined with crystals of hydropotassic oxalate. Microscopic crystals of calcium oxalate are, however, found in many cases in the stomach and intestines, particularly in cases in which death has followed, not within a few moments, but in the course of from three to six hours. A microscopic examination of a section of kidney reveals the presence of amorphous and crystalline oxalate in the tubules, even in rapidly fatal cases (Lesser, *loc. cit.*, Pl. vii., Fig. 3).

Analysis.—The parts to be examined are the stomach and intestines and their contents, the liver, kidneys, and urine, also vomited matters.

The contents of the stomach and the vomited matters are strongly acid in reaction, unless antidotes have been administered, in which case they may be neutral, or even alkaline.

In a systematic analysis the acid, or its salts, are to be found in the residue of the portion examined for prussic acid and other volatile poisons, or in the aqueous liquid which has been treated with solvents for the separation of glucosids and alkaloids. If oxalic acid or oxalates alone are to be sought for, the materials are to be treated directly as below.

It must be remembered that the acid sought may be present either in the free state, in combination as a soluble oxalate, or, in consequence of the administration of antidotes, as the insoluble calcium oxalate, or the very sparingly soluble magnesium oxalate.

The substance under examination, if acid, is to be first extracted with water, the solution filtered, the filtrate evaporated over the water-bath, the residue extracted

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with alcohol, the filtered alcoholic solution evaporated, and the residue redissolved in a small quantity of water. The solution so obtained (No. 1) will contain any free oxalic acid which may have been present. The material left undissolved by alcohol in the preparation of solution No. 1 is next to be treated with alcohol, acidulated with hydrochloric acid, the solution filtered and evaporated, and the residue redissolved in a small quantity of water. This solution (No. 2) will contain any oxalic acid which may have been present in the form of a *soluble* oxalate. Lastly, the substance left undissolved by water in the preparation of solution No. 1 is to be treated with a sufficient amount of solution of potassium carbonate (not hydroxid) to render it distinctly alkaline, and boiled for two hours. The solution is filtered and evaporated, the residue extracted with alcohol acidulated with hydrochloric acid, the solution filtered and evaporated, and the residue redissolved in water. This solution (No. 3) will contain oxalic acid, if it were present in the form of an *insoluble* oxalate.

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The tests for oxalic acid are then to be applied to the three solutions.

The urine, contents of stomach, and vomited matters should also be examined microscopically for crystals of calcium oxalate.

The detection of a *mere trace* of oxalic acid can only be of value as corroborative evidence in a case of suspected poisoning by that substance, owing to the normal presence of oxalates in articles of food and in the human economy.

Tests.—1. A solution of a calcium salt produces, in neutral or alkaline solutions, a white precipitate which redissolves in hydrochloric acid.

2. Argentic nitrate solution produces a white precipitate which dissolves in ammonium hydroxid solution and also in nitric acid. If the liquid containing the precipitate be boiled, the latter does not darken. If the precipitate be collected, dried, and heated upon a strip of platinum foil, it explodes.

3. Lead acetate solution, in solutions of oxalates which are not too dilute, produces a white precipitate which is soluble in nitric acid, but insoluble in acetic acid.

Rudolph A. Witthaus.

OXAPHOR. See *Oxycamphor.*

OXFORD MINERAL SPRING.—New Haven County, Connecticut. Post-Office.—Oxford.

Good hotel within one-half mile. This spring has been well known to residents of the neighborhood for many years, but it has only recently been brought to the attention of the public. Its medicinal properties are supposed to have been known to the Indians, as arrow heads and other evidences of aboriginal life are frequently found near it. The spring yields about one and a half gallons of pure, sparkling water per minute. An analysis by Prof. George F. Barker, of the Sheffield Scientific School, in 1873, resulted as follows: One United States gallon contains: Sodium chloride, gr. 0.35; sodium sulphate, gr. 0.49; potassium sulphate, a trace; lithium sulphate, a trace; magnesium sulphate, gr. 0.62; calcium sulphate, gr. 1.61; iron carbonate, gr. 0.91; silica and insoluble matter, gr. 1.33; organic matter, gr. 1.22; loss in analysis, gr. 0.10. Total, 6.18 grains.

The path of the stream can be easily traced by the abundant bright yellow deposit of hydrate of iron. In the short time since this water was brought before the public it has risen high in popular favor as an invigorant and general tonic. It is useful in conditions of debility and anæmia, and in stomach, liver, and renal disorders, etc. The water is used commercially, and is said to be acquiring an extensive sale.

James K. Crook.

OXYCAMPHOR—($C_8H_{14}.CO.CHOH$), a product of the oxidation of camphor—is prepared by reducing camphor orthoquinone with zinc powder and acetic, sulphuric, or hydrochloric acid. It is a white crystalline powder of bitterish, peppery taste, and without odor. It fuses at 204° C. (400° F.), and is soluble in fifty parts of cold water and freely in hot water, alcohol, ether, chloroform, and the oils. Its two-per-cent. solution coagulates albumin, reduces hæmoglobin, and is strongly bactericidal.

To this drug is attributed the special power to overcome dyspnœa by diminishing the excitability of the respiratory centre in the medulla. Physiological experiments with 0.5-per-cent. solutions and clinical usage by Ruttner, Ehrlich, Marlier, and others have demonstrated that oxycamphor tends to lessen the frequency of the respirations, to increase their depth, to slow the pulse, and slightly to increase the blood pressure. It improved the breathing in cases of tuberculosis, bronchitis, emphysema, Bright's disease, anæmia, and heart disease.

Exposed to light and moisture the powder becomes a soft, slimy, sticky, yellowish mass. It keeps fairly well, however, in tablet triturates made with sugar of milk, and is stable in fifty-per-cent. alcoholic solution. This solution, known as *oxaphor*, is given with much water in dose of 0.5–1.0 c.c. (♏ viij.–xv.).

W. A. Bastedo.

OXYGEN.—Oxygen is not recognized in the United States Pharmacopœia as a drug, but yet is used in medicine to a certain extent, generally by inhalation, either of the pure gas, or of the same mingled with from one to four volumes of atmospheric air or of nitrogen monoxide (nitrous oxide gas). Oxygen is a colorless, odorless, and tasteless gas, and is, when pure, distinctly irritant to sensitive parts. Its main medical interest centres upon the phenomena which follow the inhalation of the gas in greater concentration than is the case in the atmosphere. Continuously inhaled, pure, the irritant effects of oxygen are considerable; mice immersed in an atmosphere of pure oxygen die after three days with congested and inflamed lungs. With inhalations too short to excite local mischief, the question naturally arises whether an atmosphere abnormally rich in oxygen does or does not tend to determine abnormal absorption of the gas into the blood, and so a quickening of the oxidations concerned in vital processes. Opposite opinions have been held on this question. The one view (Regnault and others) is that with healthy lungs the blood normally takes from the ordinary atmosphere all the oxygen that it is physiologically capable of absorbing, so that the presentment to it of an air containing an increased proportion of the gas can have no effect on the absorption rate. But a considerable number of experiments and observations of various kinds seem to oppose this view, and lead to the belief that crowding the lungs with oxygen does also crowd the blood with the gas. Thus, during oxygen inhalations granulation tissue has been observed to grow quickly ruddier in hue (Demarquay), expired carbon dioxide to double in amount (Allen and Pepys, Limousin), and excreted uric acid to lessen in quantity, presumably by undergoing oxidation within the system (Kollman). Whichever answer to the question be the true one, no marked symptom pointing to any serious derangement of physiological processes occurs when a moderate inhalation is practised by one in health. The gas, even when pure, is pleasantly respirable, and from fifteen to thirty litres (from four to eight gallons, about) can be inhaled with little other obvious effect than a feeling of general warmth and nervous exhilaration, with occasionally a little giddiness and quickening of the pulse rate. But while the effects in health are comparatively negative, it is far otherwise when an oxygen inhalation is undertaken by one suffering for want of a sufficiency of oxygen because of some impediment to the full exercise of the respiratory function, such as may be caused by asthma, emphysema, cardiac disease, croup, diphtheria, etc. In such case the distress, because of the insufficiency of the air supply, tends to be compensated by the higher oxygenation of the same, and the dyspnœa may be greatly abated, or even, for the time, wholly abrogated. And the relief may persist, of course in keeping with the character of the case, for a longer or shorter time after discontinuance of the inhalation. Similar relief by respiration

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of oxygen is afforded in cases of asphyxia from irrespirable or noxious gases, such as carbon monoxide or the poisoned air of sewers.

The therapeutic applications of oxygen are, first in importance, the administration of the gas by inhalation for the relief of dyspnœa or asphyxia in the circumstances above described. Inhalations have also been practised with the view of quickening the processes of physiological chemistry and so determining better nutrition in chronic cachectic states, such as anæmia, chlorosis, tuberculosis, etc. The results of this latter therapeusis, however, have not been very striking. Under any circumstances the existence of ulceration or active inflammation within the air passages had better be accepted as contraindicating oxygen inhalation, unless the gas be well diluted. In appropriate cases, from four to sixteen litres (one to four gallons, about) may be inhaled at a sitting, two or three times a day, pure or diluted with air, from one to four volumes, according to the urgency of the case. The gas must be known to be pure, in the chemical sense of the word, and is best administered by means of the bags devised for the giving of nitrous oxide gas. But whether the gas be drawn from a bag or from a gasometer, the inhalation should be by means of a mouthpiece so fitted with valves that the products of expiration shall not pass into the apparatus to mingle with the gases to be respired. In order to obtain dilution with air the simplest expedient is to leave the nostrils open to inhale the atmosphere, while the mouth inhales oxygen.

Oxygen has been administered also by passing the gas into the stomach or the rectum, and with reported prompt relief of dyspnœa, the same as when given by inhalation. Four rectal injections of five litres each are said to have been absorbed in an hour. Oxygen has also been used locally for the vivifying of tissues disposed to ulceration or gangrene, with reported benefit. The practice is certainly not a common one in the United States. The gas is applied in jet upon the affected parts.

Oxygen is supplied for medical use in iron cylinders, generally condensed so that a cylinder holding from one hundred to two hundred gallons is of a size easily handled and stored. From such reservoirs a bag or gasometer is charged for the individual inhalations. Where these cylinders are not procurable, oxygen may be obtained by the usual procedure of heating potassium chlorate with admixture of a little manganese dioxide—this addition in some way determining the decomposition of the chlorate at a lower temperature than would otherwise be required. The manganese compound must be free from adulteration with carbon (such as occurs in some commercial samples by the accidental or intentional addition of pounded coal), else a dangerous explosion may result. It is best, therefore, to test an untried sample by heating a little of it with a little potassium chlorate in a test tube, where the small scale of a possible explosion will do no serious mischief. For the making, the mixed substances are heated in a closed retort or flask, from which a tube leads through an intervening wash bottle, containing caustic soda solution, to a gasometer or jar filled with water and inverted in a pneumatic trough, or to the bag from which the inhalations are made. The first portions of gas that come over should be allowed to escape before connection is made with the wash bottle. And this wash bottle is an all-important feature of the apparatus, the passage of the oxygen through soda being necessary to free the gas from contamination with carbon dioxide and chlorine. The connecting tube of the apparatus should be of good size, since the gas, when once it begins to disengage, comes over in great volume. For the same reason the heat should carefully be watched and regulated during the operation, to avoid too furious action. For each litre (about one quart) of oxygen required, 3.46 gm. (about gr. liiss.) of potassium chlorate will be needed. The salt must be well powdered, and mixed with one-eighth of its weight, or thereabouts, of powdered and pure black oxide of manganese. *Edward Curtis.*

OXYQUINASEPTOL.—(Diaphtherin—$C_6H_4[HOC_9H_6NHO]_2SO_2$)—a registered compound introduced as a powerful antiseptic for surgical purposes, but which has not been much employed. It was reported upon by Prof. R. Emmerich, of Munich, at the Eleventh Congress for Internal Medicine, held at Leipsic in 1892.

It forms in amber-yellow transparent hexagonal crystals, which, when powdered, are soluble in one part of water, also soluble in dilute alcohol, very sparingly soluble in absolute alcohol. It melts at 185° F. without decomposition, but is not altered chemically at 212° F.

It is recommended as an antiseptic dressing in surgical practice, and for the treatment of ulcers, wounds, etc. A solution of one-half to one per cent. is said to be sufficiently strong for a lotion or to saturate dressings. Locally it has been employed in solutions as strong as fifty per cent. without any injurious effect.

The sole drawbacks are said to be a tendency to act on instruments, causing a black deposit, and a tendency to discolor the skin and clothing. *Beaumont Small.*

OXYURIS VERMICULARIS. See *Nematoda.*

OZÆNA. See *Nasal Cavities, Diseases of: Chronic Inflammation.*

PACHYAKRIA. See *Acromegaly.*

PACIFIC CONGRESS SPRINGS.—Santa Clara County, California.

Post-Office.—Saratoga. Hotel and cottages.

Access.—Stages connect at Los Gatos with Southern Pacific trains leaving San Francisco morning and evening. Time, three hours and fifteen minutes.

These springs obtain their name from their resemblance to the well-known Congress Spring at Saratoga, N. Y. The Santa Clara Valley is celebrated for its excellent climate and dry, pure, and invigorating air. A large and commodious hotel and several cottages have been established at an elevation of 735 feet above the sea level. The springs are located about one hundred feet farther up the mountainside. The drives about these springs are among the finest in the State. There are on the premises several springs which flow in great profusion. The waters belong to the alkaline-chalybeate class. They are valuable for table purposes. The following analysis was made by Anderson in 1888:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	115.76
Sodium carbonate	120.42
Sodium sulphate	12.95
Potassium carbonate	2.06
Magnesium carbonate	26.34
Magnesium sulphate	14.17
Calcium carbonate	16.03
Calcium sulphate	14.19
Ferrous carbonate	13.87
Alumina	4.50
Silica	3.98
Organic matter	Trace.
Total	344.27

Free carbonic acid gas 44.17 cubic inches. Temperature of water, 50° F.

It will be observed that this water is much less densely mineralized than is that of its New York namesake. The Saratoga Congress Spring contains over 700 grains of solid ingredients to the United States gallon and over 392 cubic inches of carbonic-acid gas. The California Congress waters are, however, much more strongly chalybeate than are those of Saratoga. Their action is decidedly tonic, owing to this large infusion of iron. They are also mildly aperient (from the presence of Glauber's and Epsom salts), diuretic, and anti-acid (from the presence of alkaline carbonates). The springs have gained considerable celebrity in the treatment of anæmia, dyspepsia, liver and kidney troubles, irritability of the bladder, rheumatism, gout, and cutaneous affections. The waters are shipped to all parts of the coast.

James K. Crook.

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PACINIAN CORPUSCLE. See *End-Organs, Nervous.*

PACINIAN CORPUSCLES, PATHOLOGY OF.—Very few observations have been made upon the occurrence of pathological changes in the Pacinian corpuscles.

Virchow noted the possibility of the development of the so-called lamellated fibroma from Pacinian corpuscles, but regarded such origin as being of the nature of a pathological curiosity.

Osler (Proceedings of the Pathological Society of Philadelphia, 1886) reported a case of hemorrhagic pancreatitis in which the Pacinian corpuscles were enormously swollen and œdematous and the neighboring tissue was infiltrated.

Przewoski (*Arch. f. path. Anat. u. Phys.*, Bd. 63) describes five cases of œdema of the Pacinian corpuscles which occurred in mitral insufficiency, in chronic nephritis, in emphysema, and in two cases of chronic pulmonary tuberculosis. In the first two cases general œdema was present, but not in the other three. He claims to have been the first to observe this condition.

Rattone (*Archivio per le scienze mediche*, Torino, vol. ix.) also describes a case of local œdema of the Pacinian corpuscles. In a case of scoliosis, in which no other pathological changes of note were found, the Pacinian corpuscles about the pancreas showed an extreme grade of œdema. He, as did Przewoski, at first took the cyst-like bodies to be cysticercus cysts, but microscopic examination showed them to be Pacinian corpuscles. In a case of fibroma of the mamma, occurring in a young male, he found a much compressed Pacinian body. The chief symptom of the case had been agonizing neuralgic pain, and Rattone believes that this was caused by the changes produced in the Pacinian corpuscle through pressure. There were no evidences of inflammation in or about the corpuscle.

The most extensive observations yet made upon the pathology of the Pacinian corpuscle are those reported by the writer (*Phil. Monthly Med. Jour.*, February, 1899). In nine cases pathological changes were found in Pacinian corpuscles embracing the following conditions: congestion, œdema, hemorrhage, changes in vessel walls, acute and chronic inflammatory processes, mucous and colloid degeneration, hyaline deposit, calcification, and necrosis.

In one case of pulmonary gangrene great numbers of hyaline or cystic bodies, varying in size from a pinhead to a small cherry, were found in the mesentery, particularly in the neighborhood of the pancreas and semilunar ganglia. The majority were transparent, jelly-like, and fluctuating, suggesting parasitic cysts. Microscopical examination showed these to be Pacinian corpuscles in various stages of cystic change. The interstitial tissue of the lamellæ contained large cyst-like spaces in which a mucin- or pseudomucin-like substance was present. These changes were confined to the corpuscles, and were apparently primary. In some of the corpuscles the presence of congestion, small hemorrhages, and small-celled infiltration would appear to justify the diagnosis of a primary inflammation (Pacinitis) of the Pacinian corpuscle.

In a case of chronic parenchymatous nephritis, mitral insufficiency, and general œdema, a similar condition of œdema and cystic change was found, which was regarded as secondary to the general œdema.

In four cases hyaline change of the Pacinian corpuscles was found: in two cases in the peritoneum and mesentery, in the other two in the region of the prostatic plexus. The hyaline bodies showed transition stages to an appearance similar to the lamellated fibroma, as described in the literature. In two other cases similar hyaline bodies were found, but they were so changed that their genesis could not be determined.

In a case of femoral thrombosis chronic inflammatory changes were found in and about the Pacinian corpuscles present in the vessel sheath. The process was regarded as an extension from a chronic inflammatory process involving the sheath of the vessels and the vessels themselves.

In a case of hemorrhagic pancreatitis necrosis, œdema, and hemorrhage were found in the Pacinian corpuscles in the neighborhood of the pancreas. These changes were regarded as secondary to the pancreatic disease, the marked liquefaction necrosis of the nerve structure being due to the action of pancreatic ferments. The involvement of the Pacinian corpuscles and nerve trunks may be the immediate cause of death, as suggested by Osler.

Since the report of these cases the writer has observed four other cases in which pathological conditions of Pacinian corpuscles were found. Œdema and cystic degeneration were observed in the corpuscles in the neighborhood of the pancreas, in a case of valvular disease of the heart with general œdema, and in a case of colitis without general œdema. In a scirrhous carcinoma of the mammary gland a much compressed Pacinian corpuscle was found, completely surrounded by carcinoma tissue. In contrast to the case observed by Rattone this patient had never suffered pain. In a second tumor of the mammary gland, a cystadenofibroma, a much compressed Pacinian corpuscle was found extending across a large cyst filled with serous fluid. Though surrounded on all sides by fluid, the corpuscle showed no change beyond that of compression. The tumor in this case was painful.

It would appear from the above cases that œdema or cystic change is the most common primary, as well as secondary, pathological condition of the Pacinian corpuscles. The exact significance of this condition cannot at present be stated; nor in the primary cases is the genesis of the condition clear. In these cases the œdema is probably to be referred to some local circulatory changes, probably to changes in the blood-vessels of a sclerotic or inflammatory nature. In the other [illegible]es the secondary nature of the affection is clear.

Inasmuch as the physiology of the Pacinian corpuscles is still in doubt, the clinical significance of these changes cannot at present be known. The presence of large numbers of the corpuscles about the pancreas would indicate that they serve some important sensory function, probably relating to intra-abdominal pressure; and we are justified in assuming that any extensive disease of these bodies would produce important disturbances and give rise to clinical symptoms. The intense abdominal pain occurring in acute pancreatitis may be explained by the involvement of the Pacinian corpuscles and the nerve trunks in the vicinity of the pancreas. As Osler has suggested, death in these cases may result from shock caused by such involvement. That compression of the Pacinian corpuscle does not always give rise to severe pain is shown by the case of scirrhous carcinoma of the mamma. This case may, however, be explained by the assumption that the nerve trunks had been destroyed by carcinomatous infiltration, the more resistant corpuscle remaining preserved. The paucity of observations and our lack of knowledge regarding these structures make desirable more careful investigations as to their physiology and pathology.

Aldred Scott Warthin.

PÆONY. See *Ranunculaceæ.*

PAGET'S DISEASE OF THE NIPPLE. See *Cancer. (Clinical.)*

PAGOSA SPRINGS.—Archuleta County, Colorado.

Post-Office.—Pagosa Springs. Hotel and boarding-houses.

Access.—Viâ Denver and Rio Grande Railroad to Amargo, N. M., thence twenty-eight miles by daily stage over a good road to the springs.

This resort is located in a picturesque, heavily wooded mountain region, at an altitude of about seven thousand feet above the sea level. Bear, elk, deer, and wild turkeys abound in the neighboring mountains, and it is said that a basket of trout may be taken at any time without going beyond the village limits. The country is new, but is fast being developed, and hundreds of people from different parts of the United States camp out in the

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neighborhood every summer in order to avail themselves of the salubrious climate and many other attractions to be found here. There is considerable snow in January, February, and March, but during the remainder of the year the weather is clear and beautiful. The summer temperature reaches 90° F. at times, but owing to the bracing atmosphere no discomfort is felt. The nights are always cool. There is but one mineral spring at Pagosa. It is situated on a small elevation and from it the water issues through crevices in various directions. The water supply is quite inexhaustible, as it is estimated that the combined currents from the spring would form a stream three feet deep and six feet wide. Dr. H. G. Haxley, of the springs, furnishes us the following analysis, supposed to have been made under the auspices of the United States Government when it maintained a fort at this point:

PAGOSA HOT SPRINGS.

ONE UNITED STATES GALLON* CONTAINS:

Solids.	Grains.
Sodium chloride	61.81
Sodium carbonate	83.27
Sodium sulphate	150.21
Calcium carbonate	41.76
Magnesium carbonate	6.65
Lithium carbonate	3.28
Potassium carbonate	2.80
Iron protoxide	.16
Manganese protoxide	.11
Calcium fluoride	.30
Calcium phosphide	.03
Silica	.71
Total	351.09

Temperature of water, 155° F. Elevation, 7,000 feet.

* Converted from grams per litre.

The waters are said to possess valuable properties in the treatment of rheumatism, gout, syphilis, and anæmic conditions. Dr. Haxley informs us that he has seen obstinate cases of chronic rheumatism cured or greatly benefited by a two weeks' course of the hot baths.

James K. Crook.

PAIN.—From a restricted philosophical view pain may be regarded as a reaction of the organism, in part or as a whole, to harmful influences; giving a warning in consciousness that some activity prejudicial to the health of the tissues is operative.

The movements of expansion and contraction in protoplasm, the biologists say, are primordial expressions of the pleasure-pain sense; expanding in response to pleasure-giving (healthful) and contracing in reaction to pain-giving (harmful) impulses. These reactions are considered the germ of the idea which by numerous multiplications, complications, and added phenomena have come to make the many-sided figure of the human pleasure-pain sense.

The pain of trauma, in a bruised bone, or the discomfort of a mechanical process, as the pressure of an exudate or transudate, the irritation of an inorganic or organic toxic agent, the pain of ulceration or of necrosis—these are of the types of painful sensations, viewed in a narrow sense, which the physician most often is called upon to treat. But there may be pain in consciousness connected with more complex processes than those just mentioned. The pain of fear, of anxiety, of dread, of anger, even the peculiar pain of the "sick soul" and the ecstatic states, and of other and various emotional conditions, are no less real pain than those of an irritated or injured sensory nerve. Even these manifold and complexly intricate emotional states, however, are posited by the terms of some descriptive psychologists as the results of organic visceral reactions, mostly represented in the sympathetic nervous plexuses and in the extra-cortical or subliminal mental activities.

Of the intricacies and the extraordinary width, breadth, and depth of the pleasure-pain sense only a most extensive study of the ancient and current literature of anthropology, neurology, psychology, and sociology can give an adequate idea, and the present discussion is limited in scope to the narrow field of that which may be termed pain in the common-sense view of the term—the reaction of the sensory nervous system to a prejudicial activity. It will be limited to the painful sensations of the periphery (the epiblastic substances—the skin and external mucous membranes), of those organs and surfaces which are formed by involution of the primary epidermal structures—as the intestinal canal, the bladder, the pleuræ; further, to those pains which occur in the mesoblastic structures—the muscles, the bones, the viscera, etc.

VARIETIES OF PAIN.—From simple discomfort to agony the gradations of pain are many, but a few types seem to be associated with recognizable types of lesion. Two types of pain may be distinguished at the outset—*acute* and *chronic*—indicating in a general way, first, the more violent reaction of the sensory nervous system to an irritant; and, secondly, that of the more prolonged and habitual protest of nature against the harmful influences of a chronic process. Acute pains usually call for immediate diagnosis, if not immediate treatment; chronic pains, as a rule, demand a study of the more involved and intricate processes of nature.

Pain, again, is spoken of as *periodic, recurrent, alternating*, or *continuous*.

As to character, *acute darting* pains are characteristic of the neuralgias, myalgias, and neuritides—such pains are frequently *paroxysmal* or *remitting* in type, coming and going with great suddenness and leaving no trace of their presence, save at times a certain sense of soreness after frequent attacks. Such pains, moreover, are distributed usually in definite anatomical areas, which fact is of the utmost importance in their diagnosis and treatment. In many instances this type of pain is recognized as shifting in its distribution. At one time the nerve distribution in the foot is affected; again, the same nerve area of the thigh, then the leg representation; again, the painful sensations may be distributed over a definite segment area; on one side or on opposite sides of the body.

Colicky Pains are characteristic of affections of the hollow viscera. The stomach colic of poisoning and of cholera morbus, the abdominal colic of flatulency, of distention and obstruction of the intestine, the tenesmus and pain in the ureter and bladder from urethritis, pyelitis, cystitis, etc., are the results of the cramp-like muscular activities of these organs, usually engaged in the process of ejecting, or trying to eject, a harmful occupant. In the diagnosis of these pains the sense of muscular effort is often present in the patient's consciousness and is a useful guide. Careful questioning of a discriminating patient will often reveal much. In the treatment of these conditions the carrying out of nature's indications is rational. Thus, at the present time, catharsis and enteroclysis are more frequently employed for the initial stages of cholera morbus, diarrheas, and dysenteries than are narcosis and muscle paralysis by opium and similar drugs.

Boring or *growing* pains are deep-seated, illy defined pains frequently found in visceral disease. The bones, the muscles, the meninges, the spinal column, the liver, or other deep-seated viscus may be involved. Aneurisms, new growths, and other lesions in these more remote localities are often the cause of *dull* pains. It is usually advisable to regard them at their worst if regrets of faulty diagnosis are to be avoided. Many of the brilliant diagnoses of the specialist may be anticipated by the family practitioner, if sufficient consideration is given to all dull pains of a persistent chronic or remittent nature. The so-called growing pains may be classed in this category and too frequently prove to be precursors of acute or chronic joint lesions, which on development entail much misery and suffering on the young. *Movement* pains are those which are increased by motion of the joints or of the muscles and are indicative of some lesion in these structures.

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Pain Appreciation.—If pain be regarded as a reaction, evidently two factors, at least, are involved in its appreciation. The character or intensity of the inducing agency and the individual's susceptibility. Since each individual's own experience is the only guide to the physician's estimation of the intensity of the painful feeling, much judgment and sympathy are needed correctly to gauge the patient's susceptibility. Pain to many is but an incident. They are either anæsthetic or stoical, either really feeling little or able to control their expressions of pain; others, again, are hyperæsthetic or exaggerational; either they really are extremely susceptible or they possess little or no control over their feelings. At all events the grade of the patient's own feeling is the true measure of the pain for themselves, but it may not be a useful guide in the diagnosis of a disease process.

It has become popular, since the studies of Lombroso and his school, to generalize regarding pain susceptibilities among individuals in certain occupations or professions, or among the peoples of a country. Thus the Teutons are reputed to be relatively non-susceptible; that thieves, prostitutes, and the like are anæsthetic. Such generalizations are founded on the most flimsy evidence and are based purely on half-truths at best. Moreover, the question of control over one's expressions of pain is rarely taken into account by many of these students.

Pain that is acute and severe in character usually causes a well-known picture of contracted muscles, dilated pupils, cold wet hands and feet, a picture closely resembling and indeed inducing at times the well-known act of fainting.

Pain Location.—For the most part the feeling of pain is referred to the diseased area, and when lesions are found to be superficial and within reach it is easy at once to distinguish their true nature and to locate them correctly, and then to apply the proper treatment. When no superficial lesion is found, the question arises whether the pain sensation is in direct relation to an adjacent organ or whether it is a referred sensation from a more remote viscus.

Of the facts which help to a correct judgment the grade of pain intensity is one of the most important. Those pains which are less intense and more illy defined are more liable to be referred pains from a more remote area.

By the researches of Dana and Head* the mapping of areas of referred sensations has become an almost definite matter. Head has shown that a diseased viscus very frequently, if not always, sends sensory impulses to the spinal cord, which impulses are felt as irregular pains, usually dull, at times very acute, in the skin area supplied by the sensory nerve of the spinal-cord segment related to the viscus segment. By means of the work of this author and others many of the earlier charts illustrating referred pains are being revised, and more definite conclusions are now possible, although as yet many of the ascertained facts have more importance in neurological than in general diagnosis.† *Smith Ely Jelliffe.*

PALISADE WORMS. See *Nematoda*.

PALM BEACH, FLORIDA.—This popular and fashionable winter resort is situated in Southern Florida on the east coast, in latitude 26° 57', about two hundred and eighty miles south of Jacksonville. It lies upon a narrow strip of land between Lake Worth and the Atlantic Ocean. The vegetation at this latitude is naturally tropical and luxuriant, and art has added to the natural beauty by parks, gardens, and paths running through groves of palms and tropical trees. Flowers abound, and such tropical fruits as the banana, pineapple, guava, tamarind, and mango are found here. Indeed, nature and art have combined to render this spot peculiarly attractive and fascinating. The accommodations are luxurious and consequently expensive. There are two large hotels affording every comfort, and several smaller and less expensive ones. There are also numerous fine private residences. Many means of recreation are offered the visitor: bicycling through the many beautiful paths; fishing,

FIG. 3728.

rowing, sailing, shooting, surf bathing, swimming in a large salt-water pool, and golf upon the fine and extensive links. Hot salt-water baths are to be had in some of the hotels. Palm Beach is easily and comfortably reached direct by railway from Jacksonville. One is referred to the article upon *Florida* in this HANDBOOK for an extended consideration of the climate of Florida, including this region. In this article will be found the climatic data for Jupiter, which is only seventeen miles north of Palm Beach, and which therefore has essentially the same climate as that of Palm Beach. The average mean temperature (Fahrenheit) for the months of December to March inclusive is: December, 67.2°; January, 63.4°; February, 66.7°; March, 68.8°. The maximum temperature for the same months is: December, 82°; January, 80°; February, 84.7°; March, 85.5°. Minimum, December, 41°; January, 38.5°; February, 39.8°; March, 44.8°. The average relative humidity is 82 per cent. The average number of clear and fair days is: December, 23.9; January, 24; February, 22.1; March, 27.1. The average precipitation is: December, 2.88 inches; January, 3.43; February, 2.72; March, 2.59.

The distinguishing characteristics of the winter climate of Palm Beach are warmth, sunshine, equability, and moisture. It is a warm, moist, marine climate. Such a climate is well suited for elderly and feeble persons, convalescents of a certain kind; for persons affected with neurasthenia or with chronic bronchitis, and for the valetudinarian in general, but not for those who are affected with pulmonary tuberculosis. For one who desires to escape the inclemency and strain of a northern winter and live an outdoor existence in the midst of at-

* Head and Campbell, "Brain," vol. 23, 1900, p. 353.
† Pain: James Mackenzie, M.D., "Brain," Autumn, 1902, p. 368.

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tractive surroundings, and who, moreover, is able to pay for luxurious accommodations, Palm Beach can unqualifiedly be recommended. Further, it is easily and comfortably reached from the North. Good medical service is at hand, which is a matter of the first importance in a health resort. The season extends from December to March.

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Sixty-seven miles south of Palm Beach is *Miami*, the terminus of the East Coast Railway and the port of departure for Nassau, Havana, and Key West. It is a town of about three thousand inhabitants. "The Royal Palm," a large and luxurious hotel, is situated here in the midst of a large tropical park. The climate is essentially the same as at Palm Beach, and much the same sort of outdoor life and amusements are afforded the visitor here as at the former place. *Edward O. Otis.*

PALMYRA MINERAL SPRINGS.—Jefferson County, Wisconsin.

Post-Office.—Palmyra Springs. Hotels and sanitarium.

Access.—Viâ Chicago, Milwaukee and St. Paul Railroad to Palmyra, 118 miles north of Chicago and 20 miles west of Waukesha. The sanitarium stage meets trains.

Palmyra is a pretty little town of 1,000 inhabitants, nestling in the foothills of the famous Kettle Range of Wisconsin. The location is 850 feet above tide-water, and it combines many of the features sought after by the summer seeker for health or recreation. This entire section is favored with a salubrious climate, and is altogether free from malaria. The soil is dry, sandy, and porous, overlying glacial deposits of gravel, which affords the best natural facilities for through drainage. The scenery here is noted for its tranquil beauty and loveliness. In his attractive brochure on "Summer in the Northwest" Mr. W. J. Anderson informs us that the beautiful little Spring Lake, or Palmyra Lake, as it is generally called, "may be classed as one of the gems of Wisconsin. Its bottom is covered with mosses, ferns, and other aquatic plants, which in mid-summer bloom and blossom as a garden. It is fed by numerous mineral springs in the vicinity, and affords an enticing prospect for the angler or the lover of boating." Seven miles distant is the Scuppernong trout pond, which is said to contain millions of trout of all varieties and sizes. Many other beautiful lakes are within easy driving distance, over excellent roads. The Palmyra Springs Sanitarium is delightfully situated on the margin of Palmyra Lake, of which it commands a charming view. This is a substantially built brick structure, four stories in height, containing spacious halls, wide verandas, and all the modern accessories for the health and comfort of its occupants. There are facilities for the administration of electricity in its various forms, massage, etc. The baths embrace salt, shower, shampoo, Turkish, Russian, and natural mineral-water baths, the rooms being spacious and luxuriously furnished. All kinds of facilities for indoor and outdoor diversions are at the option of the guests. Directly opposite the sanitarium is a forty-acre forest of native oaks—the "Sanitarium Grove." Its winding walks and shaded nooks add no little to the attractiveness of the place. At a distance of one mile and a half from the sanitarium is the great Geyser Spring. It is thirty-eight feet in depth and fifty feet across the surface, and supplies ten million gallons of water per day. The water is soft, pure, and palatable, and is believed to possess remedial value. The mineral springs at Palmyra are very numerous. A cluster of half a dozen in the spring park, which could all be covered by a canvas forty feet square, are quite dissimilar in taste, of varying temperature, and of different analysis. One spring is slightly thermal, having a temperature of 72° F.; another, ten feet distant, is a little cooler (62.5° F.); while others vary in temperature from 50° to 52° F. Back of the sanitarium, and four hundred feet from it, is another group, known as Magnesian Springs. They are remarkably pure and free from organic matter. Following are analyses of three of the springs, No. 1 being by Prof. W. S. Haines, of Rush Medical College, Chicago, and Nos. 2 and 3 by Prof Bode, of Milwaukee:

Spring No. 1.—One United States gallon contains: Sodium sulphate, gr. 0.94; potassium sulphate, gr. 0.23; calcium bicarbonate, gr. 15.70; magnesium bicarbonate, gr. 10.94; magnesium chloride, gr. 0.18; iron bicarbonate, gr. 0.5; calcium phosphate, a trace; alumina, a trace; silica, gr. 0.70; organic matter, a trace. Total, 28.74 grains.

Spring No. 2.—One United States gallon contains: Sodium chloride, gr. 0.21; sodium sulphate, gr. 0.64; sodium bicarbonate, gr. 0.16; calcium sulphate, gr. 0.30; calcium bicarbonate, gr. 9.86; magnesium bicarbonate, gr. 7.91; iron bicarbonate, gr. 0.6; alumina, gr. 0.19; silica, gr. 0.61; organic matter, gr. 0.35. Total, 20.29 grains.

Spring No. 3.—One United States gallon contains: Sodium chloride, gr. 0.43; sodium sulphate, gr. 0.40; sodium bicarbonate, gr. 0.18; calcium sulphate, gr. 0.80; calcium bicarbonate, gr. 12.84; magnesium bicarbonate, gr. 10.14; alumina, gr. 0.22; silica, gr. 0.90. Total, 25.91 grains.

These waters all possess mild diuretic and antacid properties. The water of Spring No. 3, being entirely free from organic matter, is well adapted for carbonating and bottling. The numerous topographical, climatic, and other advantages of Palmyra render it a suitable resort for a large variety of ills and ailments. The spring waters exert a beneficial influence, especially in rheumatism and dyspepsia, although their use is also extended to functional hepatic disorders, the early stages of Bright's disease, and to eczema, pityriasis, and other skin troubles. *James K. Crook.*

PANACEA SPRINGS.—Halifax County, North Carolina.

Post-Office.—Littleton.

Access.—These springs are situated three and a half miles from the town of Littleton, at an altitude of 380 feet above the sea-level.

The location is in a beautiful valley surrounded by picturesque hills covered with rocks of immense size, and still clothed in their primeval forest growth of gigantic oaks. The meteorological conditions which prevail here are of a salutary character, there being neither long droughts nor excessive rains. The springs are fifteen or twenty in number and flow about five hundred gallons of water per hour. The following analysis was made some years ago by Dr. H. B. Battle, of the State Experiment Station. The bases and acids only are given: One United States gallon contains: Iron, gr. 2.18; alumina, gr. 0.32; calcium, gr. 1.11; magnesium, gr. 0.20; manganese, gr. 0.01; potassium, gr. 0.70; sodium, gr. 2.23; hydrochloric acid, gr. 0.82; suphuric acid, gr. 0.42; phosphoric acid, gr. 0.53; silica, gr. 1.18. Total, 9.70 grains. (Carbonic acid, large amount; not determined.)

It is evident that the acids and bases would unite in the form of carbonates, chlorides, sulphates, and phosphates.* The waters are very useful in chronic diarrhœa and the debility which usually accompanies the disease. They are highly recommended in the debilitated states attending uterine and ovarian diseases and in restoring anæmic and puny children. *James K. Crook.*

PANARITIUM ANALGICUM. See *Morvan's Disease.*

PANCREAS, ANATOMY AND PHYSIOLOGY OF.—1. Gross Anatomy.—The pancreas is an elongated gland of a reddish-yellow color. The size is somewhat variable in different individuals, but the gland is usually from

* According to E. E. Smith, M.D., Ph.D., of New York, to whom we have submitted this analysis, the combinations would result as follows. In one United States gallon there would be: Sodium chloride, gr. 1.31; sodium sulphate, gr. 0.68; sodium bicarbonate, gr. 0.93; potassium bicarbonate, gr. 1.02; calcium bicarbonate, gr. 4.85; magnesium bicarbonate, gr. 1.21; manganesium bicarbonate, gr. 0.03; iron bicarbonate, gr. 3.98; iron phosphate, gr. 0.82; alumina, gr. 0.31; silica, gr. 1.18. Total, gr. 16.32.

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five to six inches in length, from half an inch to an inch in thickness, and weighs from two and a half to three and a half ounces (60 to 90 gm.).

The pancreas, like the liver, is moulded in shape by the organs with which it is in relationship, so that it is irregularly prismatic in shape, especially in its middle portion or body.

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The pancreas lies in the loop of the duodenum and is hence deeply placed in the abdomen, stretching across the posterior abdominal wall nearly transversely at the level of the first and second lumbar vertebræ, and is almost concealed by the stomach which lies in front of it. Regionally the pancreas lies almost completely in the epigastrium, but the tip of the free end or tail, which comes into contact with the inner surface of the spleen, lies in the left hypochondrium.

For the description of relationships, it is usual to consider the gland as consisting of head, neck, body, and tail, although these parts are not very clearly marked off naturally from one another.

The larger rounded right extremity of the gland forms the head, which accurately fits into and fills the concave

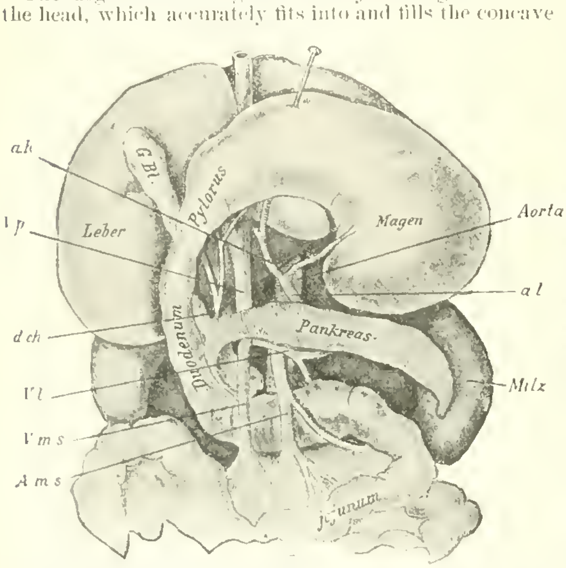

FIG. 3729.—Diagrammatic Picture Showing the Relations of the Pancreas to the Stomach, Duodenum, and Blood-vessels. (After Koerte.) *a.h.*, Arteria hepatica; *V.p.*, vena portæ; *d.ch.*, ductus choledochus; *a.l.*, splenic artery (art. lienalis); *V.l.*, splenic vein; *V.m.s.*, superior mesenteric vein; *A.m.s.*, superior mesenteric artery; *G.Bl.*, gall-bladder; *Leber*, liver; *Magen*, stomach; *Milz*, spleen.

side of the sharp curve formed by the second and succeeding parts of the duodenum. The neck is a portion about an inch in length which curves upward, forward, and to the left, from the anterior portion of the head, to unite it to the body and tail at about a right angle. In this angle are placed the superior mesenteric vessels, which lie in front of the head and are covered, as they pass upward toward the cœliac axis and portal vein, by the neck, which lies in front of these main trunks. The body and tail, which together measure from four to five inches, cannot really be differentiated from each other, the tail being merely the extremity of the body which turns upward toward the spleen.

The inferior vena cava, left renal vein, and aorta lie behind the head of the gland, and the origin of the superior mesenteric artery, the crura of the diaphragm, the splenic vein, left kidney, and suprarenal gland are the chief posterior relations of the body. In front, the pancreas is separated from the overlying pylorus and stomach by the lesser omental sac, and the lower portion of the head of the gland is crossed by the transverse colon and its mesocolon. The transverse mesocolon is attached posteriorly to the lower border of the gland and splits here into two layers, one being reflected upward, over what is known as the anterior surface of the body of the pancreas, while the other passes back over the narrow inferior surface and is then reflected downward, so leaving the posterior surface of the body free from peritoneal investment.

The pancreas is richly supplied with blood from three different sources, which freely anastomose with one another, viz.: 1. By the *superior pancreatico-duodenal* artery, a branch of the *gastro-duodenal* and hence of the *hepatic* artery, which curves round between the head of the pancreas and the duodenum. 2. By the *inferior pancreatico-duodenal*, a branch of the *superior mesenteric*, which courses round the head of the pancreas in the direction opposite to that of the superior pancreatico-duodenal and finally communicates with it. 3. By the *splenic artery*, which in its wavy and tortuous course toward the spleen, grooving the upper border of the pancreas, gives off to that gland many small twigs called the *pancreaticæ parvæ*, in addition to a larger branch near its termination, the *pancreatica magna*, which penetrates the gland and passes back from left to right parallel and close to the chief pancreatic duct.

The main *pancreatic duct* or *canal of Wirsung* runs deeply embedded in the substance of the gland, somewhat nearer the lower than the upper border, from left to right throughout the length of the gland. It is easily distinguished by its white glistening appearance, and the best guide for finding it is the artery which, as above described, runs parallel and close to it. It commences by the union of many small ducts from the lobules of the tail, and, being joined by ducts from the lobules on all sides, increases in size until near its termination at the duodenum, where it measures about one-tenth of an inch. It follows the course of the gland described above, bending downward, backward, and to the right, as it courses through the neck, and passing toward the posterior part of the head where it enters, in common with the bile duct, into the second part of the duodenum, between three and four inches below the pylorus, upon a slightly raised papilla.

A second duct, called the *accessory duct* or *duct of Santorini*, is found in the majority of bodies. This duct is usually much smaller and runs from near the orifice of the main duct to open separately about an inch nearer the pylorus; but in exceptional cases it may be large and take on the functions of a main duct, the extremity of Wirsung's duct being then much smaller than usual. The presence of two ducts arises from the development of the gland as two separate outgrowths from the duodenum.

The smaller of these two outgrowths arises close to the common bile duct, and its original duct forms at a later period the proximal end of Wirsung's canal. The other larger growth arises nearer the pylorus, and the accessory duct of Santorini is formed from the proximal end of its duct. At about the sixth week of development the two ducts fuse, and, the upper duct afterward developing less rapidly, the main pancreatic duct comes to be formed of the central end of the lower duct and the peripheral parts of both the others.

2. MINUTE ANATOMY.—The pancreas is a compound racemose gland which, in its general arrangement and in the appearance of its cells, closely resembles a serous salivary gland. It may be distinguished, however, by the longer, tubular, and somewhat convoluted alveoli, which are often cut in oblique or longitudinal section and then present the appearance of long columns of cells lining the central ducts. This appearance is never evident in salivary gland sections, because their alveoli are not elongated. The ducts also serve to differentiate the pancreas from the salivary glands, for they are much less numerous in the former and the cells lining them do not show any of that longitudinal striation which is present in the cells of the ducts of the salivary glands.

The ultimate branches of the ducts which pass to the individual alveoli are very narrow and are lined by flattened cells.

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The alveoli in the loaded condition of the gland are compactly filled by the charged cells so that no distinct lumen is visible, but after active secretion the cells shrink considerably in size and the lumen becomes obvious.

By special methods of treatment, such as injection under pressure backward from the main duct, or perhaps better by the Golgi method of staining with silver chromate, it can be shown that intercellular canaliculi exist which branch off from the lumen of the alveolus and pass between the constituent cells. The Golgi method, when the result is good, further demonstrates intracellular canaliculi which penetrate into the cells themselves and drain off the secretion from their interior.

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The secreting cells present characteristically different appearances according to whether the gland has been resting and has hence become charged with secretion, or whether it has been recently active and as a result is exhausted of those materials which contribute the solids of the secretion. These materials are deposited in a granular form during the period of rest, and are hence visible under the microscope, and give by their amount an indication of the condition of the gland.

Even in the fully charged condition of the gland the granular deposit never quite fills the cell, a clear finely striated outer zone always being left, which takes stain readily and hence appears deeply colored in prepared sections as compared with the central granular zone.

In the fully charged cell about three-fourths of the cell substance lying toward the lumen is completely obscured by a thick granular deposit which hides the nucleus and the outlines of the cells so that the lines of division are invisible in fresh sections.

The first effect of secretion is an increase in volume of the cells, probably due to water and salts being taken up from the surrounding lymph; but this is quickly followed by a diminution in size, accompanying which there is a rapid diminution in the amount of granular deposit present in the cells. The granules become fewer in number in the central part of the cells toward the lumen, where they are still present, and the outer granule-free zone becomes greatly increased in width and comes to occupy nearly the whole cell. These changes are shown in hardened and stained sections by the greater amount of cell which becomes deeply stained.

As a result of the gradual clearance of the granules from the protoplasm the cell nucleus and its outlines become more clearly visible. These granules seen in the cells do not consist of deposits of the enzymes found in the secretion of the glands, which are described below, but probably of other substances which form precursors of these, the so-called zymogens.

The zymogens are inactive until they have been changed into the free enzymes, as is shown by the fact that neutral extracts of the fresh gland are almost inactive, but become active when treated by dilute acetic acid (one per cent.), or a dilute solution of sodium carbonate (two per cent.) in presence of oxygen.

Recent research has further demonstrated that the fresh pancreatic juice as it flows from the gland duct contains a large percentage of its zymolytic material in the inactive form of zymogens and that it is only in the intestine itself that the change into active enzyme is completed (*vide infra*). In addition to the nucleus a body called the *paranucleus* can be demonstrated histologically in the pancreatic cells. This structure surrounds the nucleus of the cell and is shown by its property of staining more readily than the rest of the cell protoplasm. It is supposed to arise from the nucleus by a process of extrusion, and the view has been advanced that the zymogen granules are manufactured in this part of the cell.

3. Secretion.—The rate of secretion of the pancreatic juice varies with the state of digestion, being most rapid during the earlier periods after a heavy meal and then gradually diminishing. During prolonged inanition the flow practically ceases. It commences toward the end of the next following meal and attains a maximum rate within the first two hours; it then falls off rapidly up to the end of the fifth hour. A secondary increase in the rate then occurs which attains its maximum at about the tenth hour, but is never so high as the first maximum; after this the flow once more falls off and practically comes to a standstill in the eighteenth hour after the meal. The richness of the secretion in ferments is inversely proportional to the rate of flow, the more rapidly secreted fluid being more diluted with water.

These variations in the rate of secretion are probably in part under the reflex control of the nervous system and in part are due to chemical stimulation of the pancreatic cells, by a substance secreted by the cells of the duodenal mucous membrance and carried in the blood to the pancreas.

Regarding the reflex nervous influence upon the secretion, it is probable that the *afferent* channels are connected up to the medulla from the mucous membrane of the stomach and duodenum; at any rate it is an experimental fact that chemical or electrical stimulation of these surfaces causes a flow of pancreatic juice. The chief *afferent* nerve affecting the pancreatic secretion is the vagus.

This fact is rendered somewhat difficult to demonstrate, in the first place by the important disturbances of the cardiac mechanism, and other organs, which follow stimulation of the vagus, and secondly by the fact that the vagus contains both excitatory and inhibitory fibres for the pancreas, and hence the net effect of stimulating the nerve upon the pancreas varies according to the relative excitability of the two kinds of fibres. At times a stoppage of secretion results and at other times an increase in the rate of flow. Until this had been demonstrated many contradictory experimental results regarding the action of the vagus in this respect had been published by different observers.

Pawlow and his pupils first clearly demonstrated that the vagus can act as an excitatory nerve for the pancreatic secretion. These observers got rid of the disturbing influence upon the heart by severing the vagus three or four days before placing the cannula in the duct of the pancreas to observe the rate of secretion and stimulating the peripheral end of the vagus. The cardiac fibres are the first to degenerate and become completely inexcitable at a period when the excitatory fibres of the pancreas are still active. Apparently the inhibitory fibres to the gland cells also suffer early degeneration, for in all cases a positive result of increased secretion was obtained. Similar results were obtained by stimulation of the thoracic vagus below the place of exit of the cardiac fibres from that nerve. Popielski later discovered that the action of the vagus depended upon the rate of secretion which was already going on at the moment when the vagus was called into activity. This observer utilized the discovery of Dolinski, that application of acid solutions to the duodenal mucous membrane causes a copious flow of pancreatic juices (*vide infra*), to study the effects of stimulation of the peripheral end of the vagus during active secretion, and found that a stoppage of secretion was the invariable result.

It is probable, then, from these experiments that the vagus contains secreto-inhibitory fibres for the pancreas, in addition to secreto-motor fibres as shown by Pawlow.

The action of injection of fluids of acid reaction into the duodenum in provoking an outflow of pancreatic juice is a subject which at the present time is exciting a good deal of attention, and although the matter is still *sub judice*, many interesting results have already been obtained.

Popielski found that the effect was still obtained even when both vagi and sympathetics were divided. He further found that the effect was obtained when the stomach was separated from the intestine above the level of the pylorus, but *not* when the section of stomach from intestine was carried out below the pylorus, and from these experiments he came to the conclusion that the action was due to a local nervous mechanism, the nerve

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cells for which lay in the intestinal wall close to the pylorus.

More recently still Bayliss and Starling have discovered that an exceedingly copious flow of pancreatic juice is evoked when an extract of mucous membrane of the duodenum is made with a dilute acid, and then neutralized, filtered, and injected into a vein. This effect follows, according to these observers, even when all nerves to the pancreas have been carefully severed. The result is obtained only by using extracts of the mucous membrane of the duodenum or of the upper end of the jejunum and is not given by exactly similar extracts from other parts of the intestine. The substance giving this effect is not an enzyme or a proteid body, since it is not destroyed by boiling in acid solution. The name of *secretin* has been given to the body by its discoverers, but it has not yet been isolated.

From the foregoing description it is obvious that *secretin* is quite distinct from the peculiar enzyme termed *enterokinase*, which has recently been shown by Delezenne, to exist in extracts of intestinal mucous membrane or in the *succus entericus*. This enzyme can be obtained from *any part* of the intestinal mucous membrane, and, like all enzymes, can be destroyed by boiling solutions containing it.

It acts upon the pro-ferments present in the pancreatic juice, and converts them into the active ferments. Fresh pancreatic juice collected by means of a cannula inserted into the pancreatic duct is practically inert when tested by its action upon fibrin; but when a solution of *enterokinase*, or, in other words, *succus entericus*, or an extract of intestinal mucous membrane, is also added to the mixture the fibrin is then rapidly attacked and dissolved.

Bayliss and Starling regard the *secretion* elicited by the action of acid upon the mucous membrane of the duodenum as being due to a chemical stimulation of the pancreatic cells by *secretin* taken up by the blood from the columnar cells of the duodenum and carried to the pancreatic cells, and not to any nervous action either central or local. According to these authors the main regulation of pancreatic secretion takes place by chemical means through the medium of the blood stream, which acts as a carrier of the stimulating chemical products.

Thus, upon this view, the cells of the mucous membrane of the duodenum during a period of rest, corresponding to the period when the stomach is empty, store up a precursor of secretin which may be termed *prosecretin*. On the passage of acid chyme from the stomach into the duodenum, the cells discharge secretin into the blood stream, and this body being carried to the pancreatic cells induces secretion of alkaline pancreatic juice.

The pancreatic juice so secreted is almost inert, so far as action upon proteid is concerned, until it has become mixed with the *succus entericus* in the intestine. Here the action of Delezenne's *enterokinase* plays a complemental part, changing the pro-ferment into active ferment, for Bayliss and Starling find that the activity of the secretion produced by the injection of solutions of *secretin* into the blood stream is greatly increased by the addition of extracts of intestinal mucous membrane.

It is obvious that the amount of pancreatic flow can thus be nicely regulated to the amount of digestion performed, for the stimulus to secretion will be proportionate to the quantity of acid gastric chyme thrown into the duodenum to cause evolution of secretin from the duodenal cells, and again the stimulus to secretion will be automatically removed when the quantity of alkaline pancreatic juice secreted is sufficient to neutralize the acid which gives the stimulus.

It is a discovery of high importance to our knowledge of pancreatic secretion that a material can be extracted from the duodenal mucous membrane, and peculiar to it alone, which is capable of evoking a copious flow of pancreatic juice, but a few words may judiciously be offered in criticism of the view of the authors that the process is a purely chemical one, and that this method is the most important and naturally occurring one by which pancreatic secretion is regulated.

In the first place, the experiments of Pawlow and Popielski, quoted above, undoubtedly prove that the pancreas possesses a nervous mechanism which is capable of regulating its secretion both in the direction of excitation and in that of inhibition, and this even while a strong application of acid is being made to the duodenum. It is also obvious that no such treatment of the cells of the duodenal mucous membrane with acids can normally occur in the process of digestion as takes place when they are extracted in a test tube with acid. In fact, at the height of pancreatic secretion, the reaction of the contents of the duodenum is normally alkaline, or they possess an acidity due to dissolved carbonic acid only, for the acid of the gastric juice is neutralized at once by the mixture of pancreatic juice and bile into which it is received. Hence there never can be any free acid in the duodenal cells, which must be still less acid than the contents of the intestine, so that any flow of *secretin* from these cells into the blood which may occur cannot be caused by an acid reaction.

Again, it is exceedingly difficult to prove that *secretin* acts directly on the gland cells and not through the central nervous system, even admitting that this substance is normally secreted into the blood stream. For it is experimentally impossible to prove that all the non-medullated nerves passing to the pancreas have been severed; a convincing proof of the peripheral action of *secretin* can in fact be given only by showing a secretory effect of this substance when perfused through an excised pancreas, and this has not yet been given.

In whatever way this peculiar substance found in the cells of the duodenal mucous membrane may eventually be shown to act, there is no doubt, however, that its discovery has awakened a new line of thought as to the mode of secretion of pancreatic juice and probably of other secretions, for there is no reason why the pancreas should be peculiar in this respect. We have also here another beautiful example of that interdependence of one organ in the body upon another, and of the usefulness of the products of the metabolism of one cell for the life work of another, situated in a different part of the body, and apparently not even remotely connected with it.

4. Chemistry of the Pancreatic Juice.—It is impossible in the present state of development of the experimental technique for obtaining pancreatic juice to give any reliable figures as to the quantitative composition of that fluid. The irritation set up by the necessary operations for the collection of the secretion causes the flow, within a few hours, of a paralytic secretion, which is many times more diluted and consequently poorer in organic constituents than that which flows within the first few hours. For this reason it is also impossible to obtain any information experimentally as to the average quantity secreted in the twenty-four hours, and as the tables of total quantities and quantitative composition are quite illusory they are not here quoted.* The secretion obtained immediately after the production of a temporary fistula of the pancreatic duct is a clear, viscid fluid of strongly alkaline reaction, equivalent to 0.2–0.4 per cent. of NaOH, due to the presence of carbonates and phosphates of sodium. It undergoes spontaneous coagulation in the cold, and being very rich in coagulable proteids (eight to ten per cent.), which cannot be distinguished from serum globulin and serum albumin, it undergoes heat coagulation and sets to a solid white mass when heated to 75° C. If kept in a water bath at a temperature of 40° C., its own coagulable proteids undergo digestion by the trypsin present (*vide infra*) into albumoses and peptones, and the secretion is then no longer coagulable by heat. Alcohol precipitates both the proteid and the enzymes.

The inorganic salts present are practically identical with those of blood serum.

* See Schäfer: "Textbook of Physiology," vol. i., p. 366 *et seq.*

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White blood corpuscles showing sluggish amœboid movements are present in the fresh secretion.

Traces of leucin have been detected in the fresh secretion, but tyrosin is absent. The most important constituents of the pancreatic juice from the point of view of the physiological chemist are the enzymes to which it owes its powerful digestive action upon all three classes of foodstuffs.

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There are four enzymes known to be present. These possess in each case all the general reactions which are characteristic of this class of bodies, and hence need not here be detailed (see article on *Enzymes*), and accordingly only the peculiarities of each will be recorded.

No complete separation of these enzymes has as yet been accomplished, that is to say, no one has succeeded in obtaining from the mixture present in the pancreatic juice solutions which contain one enzyme only. Hence the belief that each specific action of the pancreatic juice upon a foodstuff is due to a separate enzyme rests upon the partial proofs, first, that there is no known example of a single enzyme which acts upon two different varieties of foodstuff, and, secondly, that in certain cases, according to the method of extraction used, extracts can be prepared from the gland which are relatively rich in one enzyme and poor in another, although this has not been done for all four. For example, from the pancreatic tissue, after completely drying by alcohol, the diastatic enzyme can be extracted by anhydrous glycerin, while the proteolytic enzyme does not pass into solution.

It is hence extremely probable that four distinct substances or their precursors are present in the gland cells and secretion which have been named as follows: (1) Amylopsin, a diastatic enzyme; (2) steapsin, or pialyn, a steatolytic or fat-splitting enzyme; (3) trypsin, a proteolytic enzyme; and (4) an unnamed enzyme which has the property of curdling milk.

It has been clearly demonstrated that trypsin is present in the gland cells, and also to a large extent in the fresh secretion before it is acted upon by the *succus entericus* in an inactive form, which is known as *trypsinogen*. It is at present unsettled whether steapsin and amylopsin possess similar precursors.

There are two views as to the action of the complementary enzyme called *enterokinase* of the *succus entericus*. One view is that this first attaches itself to the proteid, and renders it in a catalytic fashion more easily attackable by the pancreatic enzyme. The other and more probable view is that the enterokinase acts upon the trypsinogen and sets free trypsin which then attacks the proteid.

Amylopsin.—This can be extracted from the fresh gland by most extractives, such as chloroform water, twenty-five-per-cent. alcohol, to which a trace of acetic acid has been added, fifty-per-cent. glycerin, saturated solution of sodium chloride, saturated boric-acid solution.

Its action upon starches is very rapid, and closely resembles that of other diastatic enzymes. The action is hydrolytic, and leads to the formation of a mixture of achroödextrins and maltose. One part of amylopsin (impure) is capable of hydrolyzing over forty thousand times its weight of starch (see article on *Digestion*).

The action is at a maximum at a temperature of 30°–45° C., decreasing gradually as the temperature is lowered down to 10° C., at which it is stopped, as long as the temperature is kept at that level, but recommences on warming. The temperature of destruction is about 60 to 70° C.

Amylopsin acts best with a neutral reaction or in presence of an excessively minute trace of acid, the optimum according to Melzer coinciding with 0.01 per cent. of hydrochloric acid. By greater amounts of acid than this, not only is the activity lessened, but the ferment is itself rapidly destroyed; it is less susceptible to the fixed alkalies withstanding the action of one per cent. of sodium carbonate, but is rapidly destroyed by free alkalies.

Steapsin.—This enzyme is exceedingly unstable, and hence great care is required in obtaining active extracts from the gland substance. In any case, a good deal of the enzyme is lost in the process of extraction, and hence as shown by Rachford, the fresh pancreatic juice is always more active than any extract of the gland, and should be used in experimenting upon the action of this enzyme. It was formerly believed that this ferment acted only upon a small fraction of the fat of the food, because the action of extracts of pancreas upon fats was so slow and incomplete; but this arises from the great loss of activity in the process of extraction, and it is now known that the steapsin has sufficient power to split up the entire fats (Rachford), and it is probable that fats are taken up in solution (see article on *Digestion*).

That the action is truly enzymic is shown, first, by its stoppage on boiling; and, secondly, by its taking place when bacteria are excluded by the presence of antiseptics.

If extracts of the gland containing steapsin are desired, the *fresh* gland must be taken and extracted with a very dilute (1 to 1,000) solution of sodium carbonate, or a ninety-per-cent. solution of glycerin, containing 1 per mille of sodium carbonate.

Such solutions, or the fresh pancreatic juice, act upon neutral fats, hydrolyzing them, and forming free fatty acids and glycerin. A similar hydrolyzing action has been noted upon other synthetically prepared esters.

The action is increased by the presence of bile (Rachford). The effect here is probably a physical one, the bile salts or bile acids dissolving the fatty acids which are a product of the hydrolysis, and so allowing fresh portions of neutral fat to be attacked.

The optimum temperature is 38° C., and at this temperature the action is twice as rapid as it is at 18° C.

Trypsin.—This enzyme acts upon proteids more powerfully and completely than any other known to us, forming in succession alkali-albumin, deutero-albumose, peptone, and a large number of amido-acids. Primary albumoses do not seem to be formed, or, if they are formed, they at once pass into more completely hydrolyzed forms, and the action is both more rapid and complete than is that of pepsin. The ferment can be extracted by any of the usual extractives from the gland. It is insoluble in strong alcohol or glycerin, and the latter of these two reagents has been utilized for its differentiation from amylopsin.

According to Sir William Roberts its activity goes on increasing with the temperature up to 60° C., and it is destroyed at a temperature of 75° to 80° C. These figures do not agree with those of Biernacki, who found it to be destroyed at a temperature of 50° C. when in solution in five-tenths per cent. sodium carbonate, and when in neutral solution at a temperature of 45° C.

Trypsin acts best in an alkaline medium, the usual optimum given being that of a one-per-cent. solution of sodium carbonate. It, however, can act in a neutral solution or even in the presence of a faintly acid reaction, provided no free inorganic acid is present. A small amount of hydrochloric acid, combined with proteid, does not stop its action, but much acid, *even when combined with proteid*, has a destructive effect.

The Milk-Curdling Ferment.—The presence of a milk-curdling enzyme in the pancreas was first discovered by Kühne, and has since been confirmed by other observers.

More recently the subject has been re-investigated by Halliburton and Brodie, who found that the coagulum produced by this enzyme differs considerably from that obtained by the action of the rennin of the gastric juice. Thus, instead of a jelly-like coagulum which is obtained in the water bath at a temperature of 35°–40° C., a finely granular precipitate is obtained by the action of pancreatic juice or pancreatic extracts, which does not at this temperature interfere with the fluidity of the mixture. But on cooling to the temperature of the room a coherent curd is formed; if this be now heated to body temperature it again becomes fluid, and on cooling a second time it again sets to a clot, and this process can be repeated indefinitely. Further, the coagulation by means of the pancreatic enzyme differs from that by rennin in that it is not prevented by excess of ammonium oxalate, and hence does not require the presence of calcium salts.

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The use of this pancreatic enzyme is difficult to understand, since any milk taken by the mouth would be coagulated in the stomach by the rennin there present. A similar difficulty exists regarding the purpose of rennin in the gastric secretion of fishes and other animals from whose food milk is absent, as also regarding the presence of milk-curdling ferments with the juices of certain plants. A possible explanation is that such ferments may have a less obvious action upon other forms of proteid, a fact which yet remains to be discovered. *Benjamin Moore.*

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PANCREAS, DISEASES OF THE.—The great importance of diseases of the pancreas was not generally recognized by the medical profession until within comparatively recent times, but that pathological alterations of the organ not uncommonly exist was known to all of the older pathologists. That changes in the pancreas sometimes occur in individuals who have diabetes mellitus was first recognized by Cowley in 1788, but prominence was not given to the matter until 1877 when Lancereaux's work was published, and the relation between the two conditions has been recently definitely proven by the experimental work of von Mering and Minkowski. Spiess in 1866 recognized hemorrhage into the pancreas as being a frequent cause of sudden death, and Zenker some years later accentuated this relation; but its great importance was first fully recognized by Draper, who particularly directed attention to it in 1886. In 1889 Draper's fellow-townsman, Fitz, in a most admirable paper, opened up a new field to the clinician in bringing together a great mass of isolated facts concerning pancreatitis, and coordinating them in such a masterly manner that since this time inflammations of the organ have been brought within the list of those diseases which may be diagnosticated. Several years before the appearance of the article by Fitz, Senn, of Chicago, very thoroughly reviewed the subject of pancreatic cysts. In the article that follows the writer wishes particularly to express his indebtedness to the various papers upon this subject written by Fitz, to the chapter on these diseases in Osler's "Practice of Medicine," and to the recent monograph upon the subject by Koerte.

Fatty and Hyaline Changes in the Pancreas, and Amyloid Infiltration.

Fatty Changes.—The fatty alterations that occur in the pancreas may be divided into (*a*) fatty degeneration, and (*b*) fatty infiltration.

(*a*) In many acute diseases, especially in those accompanied by high temperature, *fatty degeneration* occurs in the pancreatic cells. Happily, the condition is one that passes away with its cause, and is not generally supposed to give rise to serious or permanent change in the organ. There is no symptomatology of the condition.

(*b*) *Fatty Infiltration.*—This condition is frequently observed in obese individuals, and is not generally believed to produce any serious interference with the functions of the organ, though cases of diabetes have been reported in which this lesion was present in the pancreatic tissues to a marked degree. In these instances it is likely, as in a case recently observed by the writer, that the fatty changes were secondary to interstitial pancreatitis and that they were not responsible for the diabetic condition.

Hyaline Degeneration.—In a very interesting paper Opie has recently called attention to the fact that diabetes sometimes occurs in which the only alteration found post mortem is hyaline degeneration of the islands of Langerhans in the pancreas. Whether or not there is any connection between the two conditions cannot as yet be stated with certainty.

Amyloid Infiltration.—Amyloid infiltration of the coats of the blood-vessels of the pancreas occurs in those conditions in which this material is being produced in the body. So far as is known it does not give rise to any serious alterations of the pancreatic functions.

Pancreatic Hemorrhage.

Pancreatic hemorrhage is a condition that occurs to a slight degree in quite a number of different affections, but the term is here limited to those sudden and profuse extravasations of blood into the organ that are commonly known as pancreatic apoplexy.

Etiology.—In the vast majority of instances those suffering from severe pancreatic hemorrhage have passed middle life, and the disease appears particularly to affect corpulent individuals. In many instances those who have had the disease have been addicted to the continuous use of alcohol. It commonly occurs also in those who have previously suffered more or less with "indigestion," and in many cases there appear to have been previous mild attacks. It is more common in males than in females. In some instances it has followed injury. As to the exact nature of the condition of the blood-vessels that predisposes to this disease we are still in great ignorance, careful microscopic studies being much needed to elucidate this rather obscure morbid state. It has been assumed by some that syphilitic disease of the blood-vessels is the most common cause of the malady, but adequate proof of this has not as yet been brought forward. That minute hemorrhages occasionally occur in the pancreas as the result of chronic induration of the organ there can be no question, and extravasations of a similar kind are occasionally found in connection with obstructive diseases of the circulation—such as are produced by organic heart lesions, emphysema, and tumors pressing upon the inferior vena cava. Recently Chiari has shown that minute hemorrhages are sometimes produced in the pancreas by what appears to be post-mortem digestion of portions of the organ.

Morbid Anatomy.—In cases of severe hemorrhage into the pancreas the entire organ may be blood-stained, and be either of an almost black, dark purple, or brownish-red hue. In by no means all instances, however, does the gland as a whole present this appearance, as all degrees of hemorrhage are met with from the complete infiltration of the organ to single, minute ecchymotic spots situated in some part of the substance of the gland. In the affected region the pancreas is usually distinctly increased in size, though in some instances it appears to be normal in bulk. The organ may be of normal consistence, distinctly softened, or quite friable. It is of interest to note that in no instance has any one succeeded in finding the blood-vessel from which the hemorrhage came. Under the microscope the tissues of the pancreas may present a practically normal appearance, though, especially in obese individuals, more or less fatty infiltration is generally present. Blood in various stages of disintegration is found both within the interstitial tissues of the organ, and within its parenchyma in the diseased regions. In some instances the tissues of the pancreas present evidences of extensive necrotic change, as was observed by the writer in one instance in which the nuclei of all of the cells in the affected areas entirely failed to take basic stains. It not uncommonly happens that the hemorrhage does not remain confined to the pancreas, but extends into the surrounding retroperitoneal tissues, even so far as the left kidney, and it occasionally forces its way into the fat of the omentum and mesocolon.

Symptoms.—The disease comes on in almost all instances with extraordinary suddenness, the individual having usually been in perfect health previously, though in rare cases the condition is preceded by slight prodromal pains in the upper part of the abdomen. In most instances the pains are confined to the region of the pancreas, but in some cases they may be diffused throughout the abdomen, and have been sometimes mistaken for colic in the beginning. Following the pain there are usually nausea and vomiting of a most persistent kind, and occasionally there is an urgent desire to defecate. Along with these symptoms a profound depression of the vital powers invariably occurs; the pulse is small, feeble, and exceedingly rapid. There is pronounced and oftentimes urgent dyspnœa, the patient tosses from one side of the bed to

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the other, is bathed in cold perspiration, the countenance exhibits great anxiety, and there is every symptom of impending dissolution. In a comparatively short time the abdomen not uncommonly becomes swollen, and tenderness develops in the epigastric region. The temperature is either normal or subnormal. Constipation is quite frequent. If the hemorrhage is at all extensive the patient rapidly grows worse, and death usually occurs within a few hours. There can be no question that recovery sometimes follows the milder forms of the disease.

Diagnosis.—Pancreatic apoplexy is distinguished by the sudden onset, with excruciating pains in the epigastric region, nausea and vomiting, and rapid collapse. It is differentiated from intestinal obstruction by the sudden onset, and by the extreme urgency of the symptoms. In biliary colic the history, the absence of excessive vomiting, and symptoms of collapse serve to distinguish between the two conditions. In gastric and duodenal ulcer perforation is preceded by frequent attacks of severe pain in the epigastric region, tenderness over the site of the ulcer, and the vomiting of blood. Moreover, ulcer generally occurs in anæmic young women.

Prognosis.—In all cases of severe hemorrhage death follows in a very short time, the patient not, as a rule, surviving longer than two or three hours. On the other hand, when the amount of blood effused is small, recovery may occur, though in these cases the condition very quickly becomes one of pancreatitis. Patients have survived even very severe hemorrhages, as is conclusively shown by the fact that recovery has occurred in several instances in which the diagnosis was made by an exploratory incision.

Treatment.—The nature of the lesions in this disease makes it, of course, impossible for drugs in any way to influence the local condition, and the treatment is therefore necessarily entirely of a symptomatic kind. Morphine should be given to relieve the pain, and the collapse should be treated in the usual way by the application of warmth, and by the hypodermatic injection of strychnine and atropine. For the reason that death in this condition cannot be produced merely by the loss of blood, but is brought about by the pressure exerted upon the surrounding nerve structures, it has been suggested that free incisions around the pancreas might relieve this condition, and thus be the means of saving the patient's life.

Acute Pancreatitis.

There are at least three more or less separate and distinct varieties of acute inflammation of the pancreas: (*a*) the acute hemorrhagic, (*b*) the acute suppurative, and (*c*) gangrenous pancreatitis, each of which demands separate consideration.

(*a*) Acute Hemorrhagic Pancreatitis.—By the term acute hemorrhagic pancreatitis is meant that condition of the pancreas in which the hemorrhagic lesion is accompanied by evidences of so-called inflammation. This condition cannot be clearly separated from that of simple pancreatic hemorrhage, the latter merging insensibly into the former.

Etiology.—This disease is much more commonly observed in persons past middle life than in the young, but instances have been reported in which the malady occurred in children, the sufferer in one instance being only nine months old. It is more common in males than in females, though the number of recorded instances of the disease is not as yet sufficiently great to determine its relative frequency in the two sexes with certainty. It occurs more commonly in obese individuals than in those who are lean. In quite a large percentage of the recorded cases the subjects have been alcoholics. Like pancreatic apoplexy this condition has been frequently observed to occur in individuals who had previously suffered for a greater or less length of time with derangements of the digestion, and in some cases there has been a clear history of previous attacks of the malady. It is also noteworthy that many of those who have had the disease had previously suffered for a period of years with unmistakable symptoms of gall-stones and inflammatory states of the gall-bladder. In view of the fact that in conditions of this kind bacteria are always present in the gall-bladder and ducts, the investigations of Hlava, Williams, and Flexner, who produced experimental inflammations of the pancreas by the injection of various bacteria, seem to be of special significance.

Morbid Anatomy.—In acute hemorrhagic pancreatis the pancreas presents much the same macroscopic appearances that it exhibits in pancreatic apoplexy. The organ, wholly or in part, is almost black, of a purple hue, or of a dark red color, and in the affected regions is considerably swollen. The tissues of the gland are in some instances softened and quite friable. The amount of hemorrhage varies in different instances. It may be confined to the head, body, or tail of the organ, or may be diffused throughout its entire extent. Not uncommonly the hemorrhage extends into the retroperitoneal tissues, and is frequently found present in the omentum, mesentery, and mesocolon. The spleen may be enlarged. Within the pancreas itself there are not uncommonly found small areas of a dull whitish opaque appearance that are made up of fat which has undergone a peculiar chemical alteration. This change in the fat is known as *fat necrosis*, and is dependent upon the fat-splitting ferments elaborated in the gland. Williams describes the appearance as follows: "Frozen sections of the white necrotic nodules showed them to be made up of coarse granules and masses, globules and crystals, and a small amount of masses of brown pigment. Many of the opaque masses were about the size and shape of fat cells, and evidently represented altered fat cells. The surrounding tissues were mildly congested; a few small extravasations were noted; the fat cells appeared normal. Sections of the same embedded in celloidin, and stained with hæmatoxylin or carmine, give similar results." It is notewothy that tetroxide of osmium is not reduced by the structures composing these necrotic tissues. It has been shown by Langerhans that the areas of fat necrosis are made up of a substance that results from the combination of lime with certain fatty acids. Osler speaks of a case in which death was the result of Bright's disease, and in which the lobules of the pancreas were entirely isolated by areas of fat necrosis with extensive deposition of lime salts. In hemorrhagic pancreatitis it very frequently happens that areas of fat necrosis are found in the fatty tissues of the omentum, mesentery and mesocolon, and in the adipose tissues situated behind the gland. It should be remarked, however, that minute areas of fat necrosis are sometimes found in the living human being where there is no disease of the organ, and Chiari has shown that post mortem there are often found in the pancreatic tissues minute alterations that appear to be the result of auto-digestion —alterations which bear a close relation to the necrosis that occurs in the fatty structures. Balser, who first accurately described the condition in man, has also shown that it not uncommonly occurs in the fatty tissues around the pancreas in healthy swine. This observation has been recently confirmed in this country by Williams, who has also shown that it occasionally occurs in the abdominal adipose tissues of the cat. It is very interesting to note that experimental fat necrosis in connection with hemorrhage into the pancreas has been produced artificially by a large number of investigators, among whom are to be especially mentioned Hlava, Langerhans, Hilderbrand, Dettmer, Williams, Flexner, Rosenbach, and Opie. These investigators have shown that the condition may be induced in dogs and other animals by the injection, into the pancreas or its ducts, of bacteria, acids or alkalies, by ligation of the organ, by simply injuring it or by injuring it and at the same time infecting it with bacteria, and by the introduction of sections of fresh pancreas into adipose tissue.

Symptoms.—The initial symptoms that usher in an attack of acute hemorrhagic pancreatitis are those of pancreatic hemorrhage. There is a sudden onset with ex-

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cruciating pain in the upper part of the abdomen, vomiting, and all indications of collapse. However, in some instances the disease does not begin with such violent symptoms, there being a period of days or even weeks during which there are slight, oftentimes colicky pains in the abdomen, combined with a certain amount of tenderness; constipation is, as a rule, present. The temperature, which in the beginning may be normal or subnormal, becomes somewhat elevated as the so-called inflammatory phenomena develop in the diseased organ; but, as a rule, the fever does not go above 103° F. About the time that the fever begins, chilly sensations are not uncommonly complained of, and even pronounced chills are occasionally encountered. The pulse is always rapid, and as a fatal termination is approached, it becomes weaker and weaker, and finally uncountable. The respiration is almost in all instances shallow and decidedly hurried. In most cases after the disease has existed for a short time the abdomen becomes distinctly swollen, and is exceedingly tender in the epigastric region. In some instances it has been possible to feel the swollen pancreas through the abdominal walls, though this cannot, as a rule, be accomplished.

Diagnosis.—Although this disease was always overlooked until a comparatively short time ago, the diagnosis, thanks to the brilliant work of Fitz, has been recently made in a large number of cases. Where a previously healthy person is suddenly seized with intense pain in the upper part of the abdomen, with nausea and vomiting, and with pronounced symptoms of collapse, this disease should be always suspected. Of all the conditions simulating acute hemorrhagic pancreatitis, acute intestinal obstruction is perhaps the one that may be most readily mistaken for it; but the former malady may be distinguished by the suddenness of the seizure, by the pronounced symptoms of collapse, and by the absence of distention of the intestine in the early stages. The further fact is of importance that obstruction of the small intestine in the region of the pancreas is very infrequent, and the patency of the large intestine can be always readily determined by inflation. Biliary colic may also be mistaken for pancreatitis, but may be generally distinguished from it by the history of previous attacks, by the situation of the pain, and by the absence of pronounced symptoms of collapse. It should, however, be remembered that several instances of pancreatitis have been recorded in which the patient had previously suffered from biliary colic. In the later stages of acute hemorrhagic pancreatitis inflammatory exudates collect in the lesser omentum to such an extent that the condition somewhat resembles that of pancreatic cyst, but the history of the case and the pronounced septicæmic state that often occurs in connection with it will serve to make the diagnosis clear. In case of doubt the physician may resort to aspiration, which will determine the true nature of the condition with certainty. The symptoms that occur in connection with perforation of the stomach or duodenum, resulting from ulcer, somewhat resemble those which are found in this disease; but generally the two may easily be distinguished by the history of severe pain following the taking of food, the vomiting of blood, and the increased secretion of hydrochloric acid that are so characteristic of the former conditions. Irritant poisons might give rise to some of the symptoms usually observed in pancreatitis, but the history of the case and the absence of the evidences of corrosive action in the mouth and throat and the character of the vomit, will generally serve to make clear the true nature of the condition.

Prognosis.—Although acute pancreatitis is a very fatal disease, there are numerous instances on record in which recovery occurred even from the severer forms of the malady. If the patient survive the first few days of the disease there is always hope for ultimate recovery, though even in these cases a death from septicæmia and exhaustion generally occurs in from two months to a year. In the latter stages abscesses in and around the pancreas not uncommonly occur, and inflammatory exudates often collect in the lesser omentum to a considerable extent. In these instances laparotomy and the establishment of proper drainage are absolutely essential to the preservation of the patient's life, and as we learn to make the diagnosis with more certainty there can be no doubt that fatal terminations will become less and less frequent. Cases have been recorded in which diabetes followed the disease.

(*b*) Acute Suppurative Pancreatitis.—Acute suppurative pancreatitis is a condition that fortunately is rarely observed, it being much less frequent than the hemorrhagic form. Pus may be diffused throughout the organ, or it may be localized. Not uncommonly the neighboring viscera are secondarily affected, and the abscess may perforate into the stomach, into the small intestine, or into the peritoneal cavity. Secondary abscesses in the lesser omentum have in a number of instances been produced, and thrombosis of the portal vein has been noted. The spleen is often enlarged. This disease has in some instances followed injury; but in quite a number of cases, further than that the patient had previously suffered with disturbances of the digestion, the origin of the affection was not apparent. It should also be remembered that this condition may be encountered as a sequel to the acute hemorrhagic form of the malady.

The *symptoms* of this disease are by no means so characteristic as those that are encountered in the hemorrhagic form of the affection; although there is always more or less pain localized in the region of the organ, it is never so intense, and does not come on with such suddenness as in the hemorrhagic form; and vomiting, although quite common, is not so persistent. Intense pain in the sciatic nerves may occur. Patients suffering with this disease very quickly develop the symptoms of sapræmia or septicæmia, usually having irregular rises and falls in temperature, profuse sweats, and chills, and they present the profound depression of the general system that is so characteristic of blood poisoning. In a number of cases it has been possible by palpation to discover, in the region of the pancreas, the presence of a tumor; and this discovery, whenever it can be made, is of the utmost importance from a diagnostic standpoint. Jaundice and sugar in the urine have been noted in some instances.

(*c*) Gangrenous Pancreatitis.—Gangrenous pancreatitis usually follows the acute hemorrhagic form of the disease, and may be partial or complete; it has been known also to follow the suppurative variety of the affection, and has in some instances resulted from injury.

Under these circumstances the pancreas becomes totally or in part necrotic, and the diseased parts are soft, have a foul odor, and present a dark, slaty appearance. In many instances the diseased tissues have completely sloughed away from the remains of the organ; they then commonly lie along with masses of pus and broken-down tissue in the cavity of the omentum. Notwithstanding the extremely dangerous situation in which a patient must, under these circumstances, be placed, instances of recovery after operation are not wanting; and Trafoyer and Chiari have reported cases in which sloughs of the pancreas made their way into the cavity of the intestines, and were discharged from the bowels.

As this condition is usually secondary to acute hemorrhagic pancreatitis, its early *symptoms* are those of this disease. After the necrosis in the tissues occurs there follow septicæmic symptoms, in combination with tenderness in the upper part of the abdomen and evidences of a tumor-like mass in the same situation.

Treatment.—The treatment of acute hemorrhagic pancreatitis in the beginning is that of pancreatic apoplexy. The agonizing pain requires the exhibition of full doses of morphine hypodermatically, and the symptoms of collapse should be treated by the subcutaneous injection of strychnine, atropine, and whiskey, and by the application of external warmth to the body. Following this the treatment should be entirely symptomatic. The diet should be relatively free from fat. The administration of portions of raw pancreas, with the food, has been recommended by some, as the food is in this way brought

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more or less in contact with the pancreatic juices which are so necessary for proper digestion. Diastases are also useful if they be administered immediately after food is taken, as they take the place of the pancreatic juices in a measure. In the suppurative and gangrenous forms of the affection laparotomy offers the best hope for the ultimate recovery of the sufferer. In the latter stages of all forms of the disease the patient requires a supporting, nourishing diet, with the administration of stimulants and tonics.

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Chronic Pancreatitis.

By the term chronic pancreatitis is meant the gradual increase of the fibrous and elastic tissues that are normally found in the pancreas, this change resulting in the compression and ultimate destruction of a greater or less amount of the glandular structure of the organ. Such a chronic inflammation is a matter of very great importance, inasmuch as it is very commonly associated with diabetes mellitus.

Etiology.—Birch-Hirschfeld showed, a number of years ago, that chronic fibroid thickening of the pancreas not uncommonly results from congenital syphilis, and his conclusions have been recently confirmed in a most admirable article by Schlesinger. It has been also assumed by some that acquired syphilis is likewise capable of inducing chronic induration of the organ, but its causal relation to the present disease has not as yet been conclusively shown. Quite a number of cases have occurred in those who have been addicted to alcohol, and the inference therefore seems justifiable that this habit may in some way predispose to this morbid state. There seems good reason to believe that catarrhal conditions of the duodenum, leading to changes of a similar kind in the common and pancreatic ducts, give rise in some instances to this affection, and we have abundant proof that closure of either of these ducts by means of gall-stones, pancreatic calculi, or in other ways, results in chronic indurative change in the organ. Experiments on animals have also shown that ligation of the duct of Wirsung is followed by an increase in the fibrous structures of the gland. "Fibrous thickening of the pancreas is even associated with ulcer of the stomach or duodenum, tumors of the stomach or suprarenal capsule, aneurism of the aorta or cœliac axis, or with disease of the spine" (Fitz). Dilatation and obstruction of the pancreatic duct is not uncommonly the result of chronic induration of the organ. The writer has recently recorded a case in which diabetes quickly followed mumps, and the theory was suggested that an acute pancreatitis was in this case produced by the poison of this disease, and that subsequently chronic changes occurred, giving rise to glycosuria.

Morbid Anatomy.—Fibroid thickening of the pancreas is most frequent in the head of the gland, but the disease may be limited to other parts of the organ, or may involve it throughout. Opie has recently written a number of interesting articles upon the subject of chronic induration of the pancreas, and he recognizes two different varieties of the disease: (1) Interlobular pancreatitis, characterized by the proliferation of fibrous tissue between the lobules which are invaded from the periphery; and (2) interacinar pancreatitis, where the newly formed fibrous tissue is more diffusely distributed between the lobules and individual acini. This writer asserts that the interlobular form of the disease is that variety which follows occlusions of the pancreatic duct, and, although the parenchyma of the gland is in a large measure replaced by fibrous tissue, the islands of Langerhans are for the most part unaffected, and diabetes is but rarely observed. In the interacinar form of the malady the areas of Langerhans are on the other hand quickly destroyed, and in these instances diabetes always occurs. It was suggested many years ago by Laguesse, and later by Schaefer and Diamare, that Langerhans' bodies exert the important function of controlling carbohydrate metabolism, and Ssobolew has recently brought forward as experimental proof of this the fact that after feeding animals with carbohydrates in considerable quantities the cells of the islands became more granular than usual. There is therefore some experimental evidence that Langerhans' islands are in some way associated with the assimilation of carbohydrates. There is even stronger pathological proof of this relation in the human being. The experiments of von Mering and Minkowski, by which the close relation of diabetes mellitus to alterations of the pancreas was so clearly shown, are so well known, and have been so frequently cited, that it does not appear necessary to consider the matter at length in this article. In all cases in which the fibrous change has advanced to any great extent the pancreas is found distinctly diminished in size, and its surface is more or less roughened and nodular; on the other hand, where the changes are not so pronounced the organ may be but little smaller than normal, and its surface may be comparatively smooth. On section its consistence is found to be considerably increased, and its tissues are, as a rule, even paler than normal. The subperitoneal tissues surrounding the pancreas are in some instances likewise thickened. Fatty changes are oftentimes extreme, and, as in a case recently observed by the writer, the entire organ may present the macroscopic appearance of a mass of ordinary fat, though on microscopic examination the fibrous tissues are found to be greatly increased. In some instances these fatty alterations are not so extreme, there being merely small yellowish spots scattered throughout the organ. In some cases hæmatoidin crystals, crystals of fatty acids, and calcareous granules are found scattered throughout the substance of the gland.

The fibrous changes not uncommonly result in constriction of the pancreatic ducts at various points, causing them to appear dilated and tortuous, though this does not always occur.

Symptoms.—Progressive loss of flesh and strength and the various indications of alteration in the digestion are the symptoms that are most commonly observed in chronic pancreatitis. There are usually loss of appetite, belching, pyrosis, nausea, and a sense of weight and fulness in the epigastrium, and occasional vomiting. Diarrhœa very commonly exists, and the fæces are frequently fatty, and may be colorless even when no jaundice exists. The sclerotic changes have in some instances compressed the common duct, in which case jaundice, of course, supervened. In connection with the influence of the pancreatic secretion on the chemical changes occurring in the fatty foods ingested the observations of Mueller are very interesting. He has shown in three cases of pancreatic disease that the fat contained in the fæces was by no means decomposed to such an extent as is the case in health. He found that normally 84.3 per cent. of the fat contained in the stools is split up, forming free fatty acids and soaps; and in a number of instances this percentage was practically that found in the discharges of individuals suffering from other diseases than those of the pancreas. On the other hand, in instances in which the pancreatic secretion does not reach the intestine he found that on an average only 39.8 per cent. of the fat occurred as fatty acids and soaps. It is, of course, obvious that such a pronounced variation from the normal must occur only in those instances in which there is suppression of the greater part, or all, of the pancreatic secretion, and that in cases in which the stenosis of the pancreatic duct is only partial, the proportion of altered fat in the fæces will be considerably greater. It is therefore clear we cannot assume that the greater part of the fat will appear as such in the stools in all cases of pancreatic disease. Notwithstanding this, an analysis of the discharges will probably be found of value in obscure cases. The examination is conducted as follows. The fæces are heated at a temperature of 100° C. until thoroughly dried, and then finally are pulverized. This powder is then treated with alcohol, acidulated with hydrochloric acid, and boiled. This causes the soaps to become again free fatty acids, the neutral fats remaining unaltered. The mass is then thoroughly dried, and is treated with ether for three days in a Soxhlet apparatus. The ethereal extract is then filtered and evaporated, dissolved in abso-

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lute ether, again filtered, dried, and weighed. This determines the amount of neutral fat, and both the free fatty acids and those that were in combination forming soaps. A weighed portion of this mass is then dissolved in warm alcohol containing a small amount of ether, and a few drops of an alcohol solution of phenolphthalein are then added, and the solution is titrated with caustic potash in alcohol. From the results of this titration we estimate the amount of free fatty acids present in the entire residue, and this, subtracted from the total weight of the mass, gives the amount of neutral fat.

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Since the time of Cowley it has been known that diabetes mellitus is not uncommonly associated with alterations in the pancreas, and a large number of observations made within recent times show beyond question that the relation is not an accidental one, and that diabetes is in many cases the result of disease of this organ, interstitial pancreatitis being the lesion most commonly found. The brilliant investigations of von Mering and Minkowski have shown experimentally that diabetes may be produced in the dog and other animals by the extirpation of the pancreas, and instances are not wanting where the removal of the organ in man has resulted in severe glycosuria. The theory has been suggested by Minkowski that the pancreas elaborates "a glycolytic ferment" by means of which the sugars are chemically changed in the body, and that when the pancreas is removed or destroyed, this ferment being no longer present, glycosuria results. It has been thought by others that this experimental diabetes is the result of disturbed tissue-metamorphosis produced by the absence from the intestine of the pancreatic juices—a view supported by the fact that diabetes may follow ligature of the duct of Wirsung. Despite the fact that diabetes frequently follows organic alterations in the pancreas, it is but proper to state that this condition by no means always results; and, further, that there are on record many instances of diabetes in which no changes could be found in this organ. It is of interest to note that Picenti and Gerhardi have claimed that the percentage of indican in the urine is much lowered in diseases of the pancreas.

Diagnosis.—The diagnosis of this disease is exceedingly difficult, for it never gives rise to symptoms that are in any way characteristic. The condition may, however, be suspected when the patient is found to suffer from long-continued derangements of the digestion, loss of strength and flesh, in combination with the presence, in the fæces, of an increased amount of fat, which, according to Mueller, exists in a state of free neutral fat, and not broken up into fatty acids. In conjunction with these glycosuria, when present, is of course of great importance in deciding the true nature of the disease, though it should never be forgotten that this condition may occur when the pancreas is in no way affected. For the reason that salol is not decomposed in the intestine in the absence of the pancreatic juice, the failure of carbolic acid to appear in the urine after the administration of full doses of this drug would be strong presumptive evidence of either the total destruction of the secreting structure of the organ or of the occlusion of its duct.

Prognosis.—As regards recovery the prognosis is, of course, hopeless, for we are acquainted with no means by which the process in the pancreas may be cured or even stayed. However, on account of the fact that the disease progresses very slowly, and that great destruction of the parenchyma of the organ is necessary before pronounced symptoms are produced, those suffering with the affection generally survive for a considerable period of time.

Treatment.—The treatment of chronic pancreatitis necessarily resolves itself into seeing that the patient lives under proper hygienic conditions, takes a sufficient amount of outdoor exercise, and gives the necessary attention to the diet. Inasmuch as fats and starches are digested by the secretion from this organ, it is of much importance that these articles be eliminated in a large measure from the diet of the sufferer, and the necessity for a precaution of this kind is often accentuated by the coexistence of glycosuria. It is practically impossible entirely to withdraw carbohydrates from the dietary. The administration of some diastatic ferment with the food is of decided value, or small pieces of raw pancreas may be substituted, inasmuch as it has been shown that the digestion of foods and starches is greatly promoted by its use under these circumstances. Other symptoms have to be treated as they arise.

Pancreatic Calculi.

Calculi are occasionally formed in the pancreatic ducts where they may remain, or from which they may be discharged through the duct of Wirsung and common duct into the duodenum.

Etiology.—Pancreatic calculi are occasionally encountered post mortem, and there are several instances in which the passage of the stones through the ducts into the duodenum has been diagnosticated in life. The condition, however, is one which is rarely encountered, being much less frequent than cholelithiasis. Concerning the causation of this affection it is generally assumed that catarrhal changes in the ducts most frequently give rise to it, but in all probability it may be also associated with the lithæmic diathesis.

Morbid Anatomy.—The calculi are usually quite small, being, as a rule, not larger than a grain of sand, though instances have been recorded in which stones of this kind were more than an inch in diameter. There may be only a single calculus or there may be large numbers, more than one hundred having been found in a single instance. They are usually rounded or oblong, but they may be quite irregular in form. In many instances their surfaces are smooth, though they may be decidedly roughened. They are usually of a light color, and consist generally of carbonate of lime, though they may be composed of phosphate of lime, or a stone may consist of a combination of the two. In some instances they consist of organic material.

In cases in which the calculi become impacted either in the duct of Wirsung or in the common duct, great dilatation of these canals results, and these distentions may be so increased in size that they present the appearance of being cysts. As a result of the stoppage of the pancreatic duct chronic interlobular pancreatitis is sooner or later produced, and in rare instances suppuration of the organ occurs. Fistulous openings have sometimes resulted, the dilated ducts communicating with the stomach, duodenum, or peritoneal cavity. The irritation produced by these stones is supposed by some to lead to the development of cancer.

Symptoms.—In the few instances in which the passage of pancreatic calculi has been diagnosticated during life, the symptoms came on somewhat suddenly with severe pain in the epigastric region, somewhat to the inner side of the left mammary line. From this point the pain generally extended around the border of the ribs on the left side to the spine, and later radiated into the left shoulder. During the height of the attacks vomiting has been noted, and in the case of Cipriani there were salivation, polydipsia, glycosuria, fatty diarrhœa, fever, and great weakness. Following the attacks thirst and hunger have generally been pronounced. In the case just referred to, there were repeated attacks, and the diagnosis was confirmed by the finding of a stone in the fæces. In the case reported by Poliakoff the patient complained of severe pain in the abdomen for two and a half months, the pain being sometimes accompanied by vomiting. The sufferer developed hunger and thirst, and sugar was found in the urine. The symptoms are not, however, in all instances so characteristic, for in the case recorded by Minnich the patient could not distinguish between attacks of pancreatic and those of biliary colic, he having previously repeatedly suffered from the latter affection.

In those instances in which the calculi lodged in the duct of Wirsung, causing retention of the pancreatic secretion and secondary changes in the organ, the symptoms

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that followed resembled those which occur in chronic pancreatitis. There are similar digestive disturbances, accompanied by loss of flesh and weight, and diabetes occasionally develops. The fat in the fæces is generally increased, and is not split up into fatty acids to the same extent as in health. Microscopic examination of the fæces will frequently show the presence of much undigested food, unaltered muscle fibres being especially numerous. In those instances in which the ducts become greatly dilated a tumor may be occasionally felt in the region of the pancreas, and when this can be done the presence of such a tumor may be considered of the utmost diagnostic importance.

Diagnosis.—The diagnosis of pancreatic colic is made by noting that the patient is suddenly seized with severe pain in the left epigastric region, the pain radiating around the lower border of the ribs to the spine on the left side, and oftentimes passing up into the left shoulder. Vomiting and glycosuria in some instances have accompanied the passage of the stone. After about two hours the pain usually ceases suddenly, and the patient develops marked hunger and thirst. From biliary colic the condition may be usually distinguished by the facts that in the former condition there is tenderness in the region of the gall-bladder, and that the pain is not confined in such a pronounced way to the left side of the body. It cannot be questioned, however, that a diagnosis between the two cannot always be made with certainty. From acute pancreatitis it is distinguished by the facts that the vomiting is not so severe, that the symptoms of collapse are not so pronounced, and that the pain ceases in the course of a comparatively short time.

In those instances in which the excretory duct of the pancreas is occluded, the symptoms will resemble those of chronic interstitial pancreatitis, though the relation of a calculus to the condition may be inferred when there is a previous history of possible pancreatic colic.

Prognosis.—In pancreatic colic the prognosis is good, as under proper exercise and diet the condition that lies at the bottom of the attacks may usually be entirely relieved.

In those instances in which the concretions have lodged in the excretory duct of the organ, the prognosis is much more unfavorable, as sooner or later chronic interstitial pancreatitis develops. In some cases, however, recovery has followed as a result of the establishment of fistulous communications with the neighboring viscera and the consequent discharge of the stone.

Treatment.—For the relief of the intense pain that accompanies the passage of a calculus, morphine should be freely administered subcutaneously; and, if necessary, ether or chloroform may be given. The application of heat to the abdominal wall may be also of considerable service. In the case of Cipriani the patient recovered under the internal administration of hydrochloric acid, a vegetable diet, baths, and gymnastics. It has also been asserted that the hypodermatic injection of 1 c.c. of a one-per-cent. solution of pilocarpine three times a week has resulted in the disappearance of attacks of pancreatic colic. After the stone has lodged in the excretory duct of the organ medical treatment is, of course, no longer of avail; but it seems highly probable that recovery in these instances would frequently follow intelligent surgical intervention.

The treatment of chronic interstitial pancreatitis resulting from the stoppage of the excretory duct of the gland is entirely symptomatic, and is in every way similar to that already recommended for a pancreas which is chronically indurated as a result of any cause whatever.

Pancreatic Cysts.

By the term pancreatic cysts is meant the presence in the organ of collections of fluids due to a variety of different causes. Fitz thinks that many reported cysts of the pancreas were circumscribed collections of fluid wholly outside of the organ.

Etiology.—Pancreatic cysts occur with about equal frequency in the two sexes, as of 121 cases of the disease operated upon by surgeons, Koerte found that 61 were males, 56 females, and in 5 the sex was not mentioned. The affection is rather more common after middle life than before, though instances have been reported in which the disease occurred in an infant six months old. As several cases have been reported in very young children, it is highly probable that pancreatic cysts are occasionally congenital, though the more frequent cause is beyond doubt the obstruction of the excretory duct of the gland. Trauma is also recognized as a frequent etiological factor in the production of cysts of the pancreas, as out of 121 cases collected by Koerte, in 33 instances the lesions had followed blows or injuries. Retention cysts which have developed from the smaller ducts of the gland—through their becoming occluded either by a constriction or by the pressure exerted by a calculus or by a tumor of some kind—are sometimes encountered. In a remarkable case reported by Durante a cyst resulted from the obstruction of the duct of Wirsung by a round worm. Parasitic cysts are sometimes likewise found. It is highly probable that in many of those instances in which pancreatic cysts are supposed to have followed injury the condition is really one of inflammation of the tissues surrounding the organ, with the accumulation of inflammatory products.

Morbid Anatomy.—Cysts may occur in any part of the pancreatic tissues, though they are most commonly encountered in the body and tail of the organ. They vary in size from those that are merely microscopic to enormous collections of liquid, an instance having been recorded in which the tumor contained fourteen quarts of fluid. The cysts may be single or multiple. Their walls are, as a rule, smooth, but in some instances papillary new formations spring from them. The inner walls of the cysts are lined by cylindrical epithelium. The fluid is usually of a clear grayish hue, and is slightly opaque, though not uncommonly it is clear and of a straw color; in a few cases, however, and particularly in those of a traumatic nature, it may be blood-stained. The reaction of the liquid is alkaline, the specific gravity varying from 1.010 to 1.024. In many instances the fluid will emulsify fat, convert starch into glucose, and digest albuminous substances, though not uncommonly, especially in older cysts, these properties are entirely wanting. Under the microscope the fluid is found to contain leucocytes, epithelial cells, cholesterin, and small drops of fat.

In many cases the tumors gradually increase in size at the expense of the parenchyma of the pancreatic structures, and this is sometimes so extreme that the gland may be practically destroyed. As the cyst enlarges it usually pushes the stomach upward and the transverse colon downward, though the latter viscus may lie directly in front of it. In rare instances the cyst lies above the lesser curvature of the stomach and pushes the organ downward; and in other cases it develops below both the stomach and the transverse colon. In some instances the walls of the cysts are firmly attached by adhesion to neighboring viscera. The cysts may rupture into the peritoneal cavity, into the stomach, or into the intestines.

Symptoms.—In quite a number of instances the first evidence of the existence of a pancreatic cyst has been the detection of a tumor-like mass in the abdominal cavity, although, as a rule, before these cysts reach a noticeable size other symptoms manifest themselves and first direct attention to them. In the traumatic cases there are usually in the beginning inflammatory symptoms, consisting of pain, vomiting, and more or less pronounced collapse. In all varieties of these cysts usually the most pronounced symptom is pain, which may occur in attacks lasting only a short time, or may be persistent and continued for weeks, months, or even years. The pains are present in the region of the pancreas, and, as in other affections of this organ, they have a tendency to radiate toward the left side, and into the left shoulder. Not uncommonly these painful paroxysms are accompanied by symptoms of deranged digestion, and

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as the disease progresses the patient loses in weight and strength. As the cysts enlarge they appear as localized prominences in the upper portion of the abdomen, usually in the left hypochondriac region, though they may be present below the navel. The tumors are globular in shape, smooth, and offer considerable resistance. In most instances they are but slightly movable, and are not, as a rule, affected to any great extent by the respiratory act, but instances have been recorded in which they were pedunculated and could be moved into almost all parts of the abdominal cavity. The cysts are, of course, dull on percussion when not covered by the stomach or intestine. The pulsation of the abdominal aorta is not uncommonly transmitted, though the cysts are never expansile. On auscultation a systolic souffle may be distinctly heard in some instances. The tumor by its pressure may seriously interfere with the functions of neighboring organs in addition to its destructive action on the pancreas itself. The pressure in some instances has been so extreme that symptoms of intestinal obstruction have occurred, and jaundice in some cases has been produced. Sometimes the cyst diminishes in size, as in a case reported by Halsted, in which the girth of the abdomen decreased to the extent of twelve inches in ten days. If the entire gland be destroyed, or if its duct be so compressed that the pancreatic juices cannot be discharged, the fæces may contain considerable quantities of fat, glycosuria may be present, and the amount of indican in the urine may be decreased. Salivation, as in other diseases of the pancreas, is sometimes noted.

Diagnosis.—Cysts of the pancreas should be suspected in all cases in which successive attacks of severe pain occur in the epigastric region, especially if they be accompanied by pronounced symptoms of collapse. The diagnosis, however, must always remain problematical until a tumor is discovered in the affected region, in which case, conjoined with the symptoms just referred to, the probability of pancreatic cyst should always be considered. Should doubt exist, aspiration may be resorted to, and the fluid obtained tested for pancreatic ferments; but it should always be remembered that in quite a proportion of cases the fluids that occur in these possess no digestive properties, and on the other hand that other liquids sometimes do. From aneurism the cysts may be differentiated by the fact that even when they show pulsation it is non-expansile, and that in the knee-elbow position it entirely disappears. Collections of fluids in the pancreas may be mistaken for ovarian cysts, but may be generally diagnosed by the facts that in the latter condition the increase in the abdomen is from below upward, and that on aspiration the contents of the tumors are rarely blood-stained, do not emulsify fat, and contain no digestive ferments. Cysts of the gall-bladder differ in that they are continuous with the liver, and that on puncture the fluid found corresponds to bile rather than to the juices elaborated by the pancreas. Solid tumors may be distinguished by the fact that they contain no liquids. Cysts of the lesser peritoneum, or mesentery, are differentiated with great difficulty from like collections of fluid occurring in the pancreas, but the absence of digestive properties in the liquids removed from these situations, and the lack of symptoms indicating interference with the proper performance of the functions of the pancreas may serve to make the diagnosis clear.

Prognosis.—Cysts of the pancreas not uncommonly exist for long periods of time without producing any serious results, but they may cause marked disturbances by pressing upon the neighboring organs. Diabetes is sometimes produced by them, though this is comparatively rare. The particular danger is rupture of the cyst into the neighboring cavities.

Treatment.—Of one hundred and one cases collected by Koerte, which were opened and drained, four deaths followed as a direct result of the operation, and one case ultimately ended fatally from infection of a fistulous tract resulting. In fourteen cases the cysts were extirpated, with twelve recoveries.

New Growths of Pancreas.

Tumors of the pancreas are exceedingly rare, but the neoplasms that occur in the organ are in most instances malignant. Of the tumors that develop in the gland carcinoma is the most common, but sarcoma, adenoma, lymphoma, gumma, and tubercle are occasionally encountered. For the reason that most of the tumors that occur in the organ belong to the group of carcinomata, and inasmuch as the symptoms of other tumors of moment are practically identical with those occurring in this form of the disease, cancer will be alone considered.

Carcinoma of the Pancreas.—Notwithstanding the great amount of work that has been recently done upon the subject of the etiology of cancer, there is as yet no satisfactory explanation of its causation, and we shall therefore have to be contented with pointing out that carcinoma of the pancreas usually occurs between the ages of thirty and fifty, and that it appears to be rather more frequent in men than in women. The rarity of the condition is evident by the fact that in 36,541 post-mortems the disease was found in only 174 instances.

Morbid Anatomy.—Carcinoma of the pancreas may occur in any part of the organ, but its most frequent site is in the head of the gland. The tumor may be very soft, or, when containing much fibrous tissue, of almost cartilaginous consistency. In some instances the neoplasm is circumscribed and remains confined to one part of the organ; but in other cases it is diffused throughout the entire substance of the gland. It may be very small or quite large, sometimes attaining the size of a cocoanut. The disease does not remain confined to the pancreas, but is prone to extend into the surrounding tissues, notably into the walls of the duodenum. The lymph nodes in the vicinity are sooner or later involved, and secondary nodules may occur in the spleen or liver.

Symptoms.—Until the tumor reaches such a size that it can be palpated, the diagnosis of cancer of the pancreas is exceedingly difficult, and is indeed generally impossible, as the symptomatology of the disease in its incipiency is apt to be vague and misleading. In most cases the first manifestations of the affection are disorders of the digestive functions, which in the course of weeks or months are followed by paroxysms of epigastric pain, not uncommonly accompanied by nausea and vomiting. As the tumor increases in size the common duct is in most instances compressed, with the result that jaundice of an intense and persistent kind is induced, and on account of the retention of the bile the gall-bladder is generally greatly dilated. Jaundice sometimes develops slowly, and in other instances with suddenness. On account of the absence of the pancreatic and biliary secretions the fæces are apt to be white, and in rare instances to contain an increased amount of fat. The fæces when examined microscopically are apt to exhibit many undigested muscle fibres, even in instances in which constipation exists. In some cases the urine is found to contain sugar, and indican is said by some to be considerably diminished in amount. As the tumor increases in size it sometimes causes obstruction of the duodenum, with the result that the stomach and upper part of this viscus become considerably dilated. If it be very large it may impede the portal circulation with the production of ascites, or by pressure upon the inferior vena cava dropsy in the lower extremities may be developed. In rare cases hydronephrosis has been produced in the left kidney as a result of the compression of the left ureter. After the tumor becomes quite large it may be felt, especially if perfect relaxation of the abdominal muscles be brought about by the means of general anæsthesia. It should, however, be remembered that the tumor must be quite large in order that this may be accomplished, for it has not been palpated in more than ten per cent. of all cases in which the disease was undoubtedly present. If carcinoma exist the tumor is deeply seated, and is but slightly movable. It may or may not be tender. In some instances the neoplasm causes hemorrhage into the peritoneal cavity or into the intestine, and this may be so profuse as to

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cause death. In the beginning the appetite and general health may be but little changed, and, indeed, increased hunger and thirst may occur, especially if diabetes exist. As the disease progresses the patient, as is usual in all forms of carcinoma, becomes anæmic and loses flesh, which condition may be extreme in the latter stages of the affection. The temperature is apt to be somewhat below the normal.

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Diagnosis.—Carcinoma of the pancreas is most likely to be mistaken for carcinoma of one of the neighboring viscera—the liver, the transverse colon, the pyloric end of the stomach, or the duodenum. From carcinoma of the liver it is distinguished by the facts that in the former condition the disease is in almost all instances secondary to cancer of some of the other abdominal viscera, that it is often associated with enlargement of the liver, and that an ascites frequently exists. The tumor in cancer of the liver is situated somewhat higher up than are those of the pancreas, and it is, as a rule, more easily movable. In both diseases jaundice occurs, but is much more common in cancer of the pancreas. In cancer of the transverse colon obstinate constipation as a result of the obstruction usually exists, and this is generally associated with the production of a large amount of indican, quantities of which appear in the urine. In these cases the tumor is more superficial, and is more frequently movable, and the disease is not accompanied by jaundice. In cancer of the pyloric end of the stomach there is commonly a history of intense pain developing an hour or so after taking food, and examination usually reveals the fact that the stomach is greatly dilated, contains much lactic acid, and but little hydrochloric acid. Not uncommonly it will be found that the patient suffering with this malady has vomited blood freely, and jaundice is not so apt to be present. From cancer of the duodenum it is practically impossible to distinguish carcinoma of the pancreas, as the two conditions commonly give rise to symptoms in every way similar. Cancer arising in either of these situations is, moreover, very apt to extend to the other. The symptoms of cancer of the pancreas that are of greatest diagnostic importance are the presence of a deeply seated but slightly movable tumor in the situation normally occupied by the head of the gland, the existence of intense and persistent jaundice, pain in the affected region, rapid emaciation and loss of strength, diminished excretion of indican in the urine, and especially the presence of sugar in this excretion. The absence of the pancreatic juice in the intestine, according to Mueller, results in the diminished splitting up of the fats ingested, and this, if true, in all probability will prove of much value in enabling us to make the diagnosis in obscure cases. For the reason that salol, when taken by the stomach, is decomposed only in the presence of the pancreatic secretion, the absence of carbolic acid in the urine after the administration of full doses of this drug points to obstructive lesions of the excretory ducts—a condition which is usually present in carcinoma of the organ.

Prognosis.—When surgical interference is not invoked, death in practically all instances results from carcinoma of the pancreas, but the practicability of removing tumors from this organ has been recently clearly shown; and in cases in which the diagnosis can be made early enough, the operation would offer some hope for the life of the patient.

Treatment.—As we have no drugs that act specifically on carcinomatous processes, treatment is to be entirely of a symptomatic kind. Diastases and small pieces of raw pancreas may be administered with the food with advantage, but the only effect that can follow this is an improvement in the digestive functions. In the early stages an operation may be the means of saving the patient's life, as, according to Koerte, recovery has followed in several cases of this kind after the removal of the tumor.

Henry Fauntleroy Harris.

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PANCREAS. (SURGICAL.)—ANATOMICAL CONSIDERATIONS.—The pancreas lies transversely across the upper part of the abdominal cavity, behind the stomach, on a level with the first and second lumbar vertebræ, and three inches above the umbilicus. The head is contained in the loop of the duodenum, the body lies on the crura of the diaphragm. To the left the posterior surface is in contact with the left kidney and suprarenal capsule. The tail touches the lower part of the inner surface of the spleen. Its average length is from five to six inches, and it weighs from two and a half to three and a half ounces.

The blood supply is from the splenic artery and from the inferior mesenteric and hepatic by the inferior and superior pancreatico-duodenal arteries. The blood is returned into the portal vein by means of the splenic and superior mesenteric veins.

The lymphatics terminate in two glands which lie on the superior mesenteric artery. The nerves are branches of the solar plexus which accompany the arteries entering the gland.

The pancreas is a compound racemose gland, soft in texture, and of a pinkish-cream color (Morris [1]).

The secretion of the pancreas is carried by short canals or ducts to the main duct, the duct of Wirsung, which they join at nearly right angles. The duct of Wirsung turns down through the head of the pancreas and opens into the second portion of the duodenum, together with the common bile duct. The lesser duct, or duct of Santorini, collects the secretion from a portion of the neck and head of the pancreas, and opens into the duodenum 2.5 to 3.5 cm. nearer the stomach. Brewer [2] states that the older anatomists were wrong in teaching that the duct of Santorini, or smaller duct, usually atrophied; according to him it is practically always present in the human subject.

The pancreas is developed between the two layers of the posterior mesentery from two offshoots from the intestinal tube just below the gastric dilatation. Brewer [2] calls especial attention to the fact that the pancreas is at this time completely invested by peritoneum, "and only becomes a retroperitoneal organ by the absorption and conversion, into areolar tissue and fat, of the several layers of the posterior mesentery." He then draws attention to the fact that the areolar tissue surrounding the pancreas is continuous with that surrounding the left kidney and the areolar tissue lying behind the colon on the left side.

ACCESSORY PANCREAS.—Tieken states that fourteen cases of accessory pancreas have been reported. This results from lack of fusion of the separate diverticulums. These accessory glands may be found in the walls of the stomach or duodenum, or in the mesentery. It has been suggested that these accessory glands may cause diverticulums of the intestine. They have

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been found at the tips of such processes. The "pancreas minus" is merely an accessory pancreatic lobule springing from the head of the main gland and it usually extends along the wall of the duodenum. Hyatt

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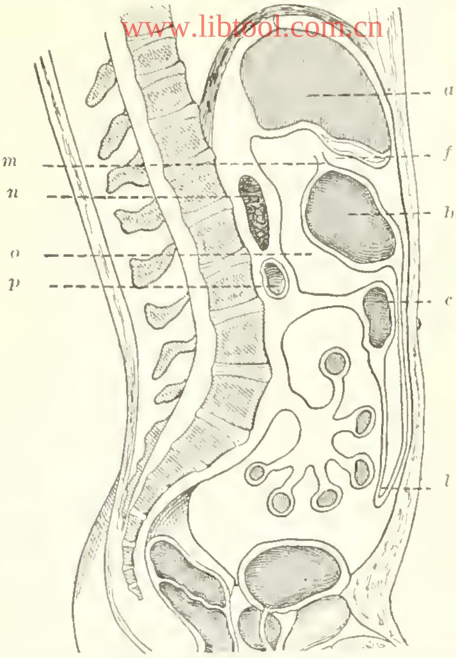

FIG. 3730.—Shows the Normal Relations of the Pancreas to the Stomach, Colon and Peritoneum, as they Appear in a Longitudinal Antero-Posterior Section of the Trunk. (From Kehr.) *a*, Liver; *b*, stomach; *c*, transverse colon; *f*, foramen of Winslow; *l*, omentum; *m*, omentum minus; *n*, pancreas; *o*, bursa omentalis; *p*, duodenum.

speaks of a partial division of the gland by the mesenteric vessels during development. The most important surgical anomaly is described by Tieken as follows: The neck was of normal size, the head somewhat enlarged. "From the head two bands of glandular substance extend forward in such a manner as to surround the lower part of the descending duodenum, forming a complete ring about its circumference. . . . The duodenum is greatly constricted at this portion, and admits the tip of the index finger with difficulty. . . . The duodenum above the constriction is greatly dilated, forming a sacculation nearly one-half the size of the stomach." Similar cases have been reported by Ecker,[10] Auberg,[11] Symington,[12] and Genersich.[13]

"The anatomical relations of the common bile duct and the duct of Wirsung are well known. The common bile duct descends toward the duodenum alongside the head of the pancreas, occasionally embedded in its substance, and comes in contact with the duct of Wirsung, beside which it lies for a short but variable distance before entering the wall of the intestine. The two ducts penetrate, side by side, the coats of the duodenum, and after passing obliquely a distance of about 2 cm. and causing a papilla-like elevation of the mucous membrane, unite to form a short cavity—the diverticulum of Vater. Near its termination at a point where the two ducts are in contact, the common duct becomes constricted, and it is here that a foreign body passing downward, tends to lodge" (Opie[3]).

Both ducts may enter the duodenum independently of each other and the hepatic duct. In one case the duct of Santorini entered the stomach.

The pancreas is a fixed organ and does not descend during forced inspiration. Nevertheless, it has been found in diaphragmatic hernias, in congenital umbilical hernias, and in Band's[4] case the duodenum, pancreas, and a portion of the ileum and colon were invaginated into the descending colon.

Total extirpation of the pancreas in animals is usually followed by true diabetes, and partial extirpation by temporary or alimentary diabetes.

Persistence of fat in the stools in the absence of jaundice and diarrhœa is an indication of disease of the pancreas, particularly when accompanied by great emaciation.

TRAUMATISM.—The pancreas, from its position, is seldom injured alone. The liver, stomach, and transverse colon lie in front, and if the liver should happen to be enlarged and if the stomach and colon should be full at the time when the injury occurred, the pancreas could hardly escape a frontal attack. It might possibly be injured from behind from a penetrating wound or from a fractured vertebra. On the other hand, the pancreas, as mentioned by Robson,[5] is soft in consistence and easily bruised. The lobules are not well supported as in the parotid. Blows upon the abdomen or a kick or a fall against a hard object may, under certain circumstances, injure the pancreas. Robson relates the case of a butler who slipped and fell against a knife board projecting from the end of a table at which he was working. The blow was not severe, the man did not even fall to the ground, but acute hemorrhagic pancreatitis followed and the patient died. An exploration for peritonitis followed by an autopsy, revealed the true cause of death. Generally the neighboring organs, the stomach, colon, liver, spleen, and lungs are injured at the same time.

The diagnosis of injury to the pancreas alone is impossible. It can only be inferred from the nature of the accident and from symptoms of shock and hemorrhage. After the abdomen is opened, injuries to neighboring organs will probably be found in addition to that of the pancreas. If the pancreas is torn, an attempt should be made to close the rent by stitches. Hemorrhage may be controlled by gauze packing. It is obviously inadvisable to ligature the superior mesenteric artery. Repair may take place; cysts may subsequently develop. Gangrene of the pancreas has followed injury to the parenchyma.

Perforating wounds of the pancreas are not common. Koerte has collected six cases. They generally result from gunshot or stab wounds, and are nearly always fatal from the complications, such as injuries to the stomach, spleen, lungs, or liver. A definite diagnosis can be made only by an exploratory incision. If the compli-

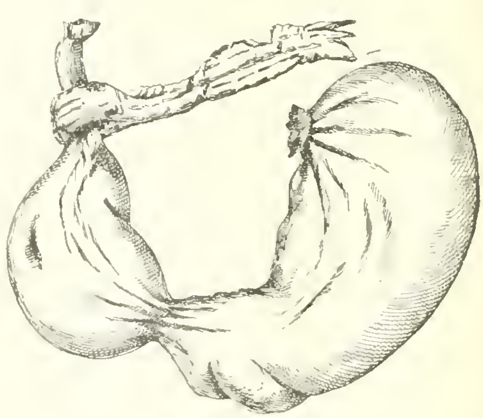

FIG. 3731. Annular Pancreas with Sacculation of the Duodenum. (From Tieken.)

cating injuries and the condition of the patient permit, the wound in the pancreas might be closed. The most perfect asepsis should be attained.

Prolapse of the pancreas is difficult to understand, but cases are reported by Kehr.[4] The tail is the most movable part of the organ. It may be replaced and main-

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tained in position, until adhesions have formed, by sterilized gauze packing.

As hemorrhage of the pancreas (or pancreatic apoplexy), acute hemorrhagic pancreatitis, and fat necrosis, are affections which belong to the domain of the physician rather than to that of the surgeon, the reader is referred, for information with regard to them, to the article immediately preceding this.

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Necrosis of the Pancreas.—Necrosis or gangrene of the pancreas may result from different causes. The whole gland may necrose, but more frequently the necrosis involves only a portion. The tail and body are often involved in this process. In other cases the affected areas are numerous and small. The necrotic area may be infolded by peritoneum and ultimately an abscess may form at this point. In two cases reported by Chiari recovery ensued after a portion of the pancreas had been passed per rectum. "In other cases the pancreas is converted into a dark, slaty-colored mass lying nearly free in the omental cavity or attached by a few shreds" (Osler).

The causes of necrosis are to be found in inflammatory suppuration and hemorrhagic conditions of the pancreas itself. It may arise from infections entering from the intestine or through a perforating ulcer of the stomach, as in a case reported by Chiari.[20] Syphilitic disease of the blood-vessels and arteriosclerosis are also assigned as causes. Fitz and Koerte have reported about forty cases. A fatal ending is common.

Symptoms.—Many pathological lesions of the upper abdominal region are closely simulated by necrosis or gangrene of the pancreas. A very careful study of the clinical history may throw light on the case. Perforating ulcer of the stomach, gall-stone colic, or perforation of the bile passages may give rise to similar symptoms. A diagnosis of intestinal obstruction has been made on several occasions and laparotomies have been performed without, of course, revealing any obstruction. Pain, tenderness, vomiting, and collapse are present in severe cases, and later, with the formation of pus around the necrotic area, there will probably be an intermittent temperature, a dry tongue, and a feeble pulse. If the patient survives there may develop such complications as peritonitis, pulmonary embolism, metastatic pleurisy, pericarditis, leptomeningitis, and pyæmia. The different courses taken by the pus after abscess for mation will be referred to under Suppurative Pancreatitis.

Diagnosis.—A definite diagnosis is possible only after a portion of the necrotic pancreas has been passed per rectum or found by exploratory incision. Kidney lesions might be excluded by an examination of the urine.

Treatment.—During the acute stage but little can be done except to relieve pain; and, if collapse is present, stimulants may be administered judiciously. After encapsulation and pus formation have taken place, surgical interference may be indicated. The abscess may be approached from behind, through the loin or through the pleura, or by an anterior incision through the abdominal wall. Some patients remain well, but diabetes has occasionally developed a year or two afterward.

Acute Suppurative Pancreatitis.—In 1688 Blancard reported finding small abscesses in the pancreas of a child that had died of variola, and cases have been described in increasing number during recent years. Osler[14] has analyzed 46 cases; of these 28 were men and 11 were women. The age was given in 30 cases. The greatest number occurred between the ages of twenty and fifty, the largest number, 11, between twenty-one and thirty. There may be one or innumerable abscesses. Several small ones may coalesce and form one large abscess. In 24 cases there was a single abscess and in 14 numerous small ones (Osler).

The causes are divided, by Dieckhoff, into three groups. In the first the infection is brought to the pancreas by the blood stream; in the second, the infection comes from some adjacent focus, as, for example, the base of a stomach ulcer which has become adherent to the pancreas before perforating; in the third, the infection passes in from the duodenum through the ducts of Wirsung or Santorini. It is now quite generally thought that the cause is an infection. The colon bacillus, first found by Welch in the pancreatic ducts, and many varieties of micro-organisms, are now known to be present in the pus. In some cases there is a history of gastroduodenal derangements and of pancreatic and of biliary calculi. Thrombosis of the portal and splenic veins with abscess formation in the liver and spleen are not uncommon. The spleen may not be enlarged even when the splenic vein is obliterated. Inflammation of the peritoneum in the immediate neighborhood is common, that of the peritoneum below the transverse colon rare. When that covering the diaphragm is involved the inflammation may extend to the pleura and pericardium (Fitz).

The abscess formation is seldom confined to within the capsule of the pancreas. Outside the pancreas the pus may collect between the layers of the mesentery or omentum, or in the lesser peritoneal cavity (the foramen of Winslow being closed), or it may extend back into the loins. Sometimes it burrows down behind the descending colon to the pelvis (Koerte). Fat necrosis is rare in suppurative pancreatitis (Fitz).

Symptoms.—The onset is generally sudden and characterized by severe pain in the epigastrium. The pain and tenderness may be referred to one or the other side of the median line if the lesion is limited to the tail or head of the organ. In some cases there is no pain. Vomiting is usually present. There may be constipation or diarrhœa, sometimes colliquative. The temperature varies. Absence of fever is rare. Chills are frequently present. According to Fitz more or less jaundice is present in one-fourth of the cases. Albumin and sugar in the urine are sometimes found, but fat in the stools seldom.

Koerte in four of his cases observed a grayish-brown discoloration of the skin. In one case Bloodgood[22] observed a leucocytosis of 19,000, tumor formation, blood and pus in the stools.

Diagnosis.—The diagnosis of an abscess confined within the pancreas is impossible. The symptoms are not distinctive. The discovery of a tumor in the pancreatic region is suggestive. If by inflating the stomach and transverse colon it can be demonstrated that the tumor lies between them and is free from either, it would be evidence of pancreatic origin. The absence of any clinical history of gastric or duodenal ulcer and the presence of a history of gall-stones would be suggestive. Fluctuation is seldom to be directly made out. If there is bulging in one loin and an examination of the urine gives no evidence of kidney lesion, Koerte thinks it might be justifiable to use an exploratory needle. The diagnosis is generally made by an exploratory incision.

Kehr[23] states that in the great majority of cases the course is chronic. Cases are reported which have run a course of nearly a year. On the other hand, some cases are very acute and end fatally within a few days. Abscess may be said to be always fatal unless the pus escapes spontaneously into the stomach or intestine, or is evacuated by the surgeon. Koerte[24] emptied these abscesses through an incision in the loin and in other instances by anterior incision. The lumbar incision is to be chosen when there are indications that the pus is near the kidney. The anterior incision should generally be made in the middle line. If, however, a palpable tumor lies to one side, the incision is best made over the prominence. If the anterior wall of the sac is adherent to the anterior abdominal wall the cavity may be washed out and packed with gauze; otherwise great care should be taken to prevent the spread of infection by careful packing with sterilized gauze pads. If possible the wall should be sutured to the abdominal incision. If this is not feasible careful packing with gauze around a large drainage tube, or the building of a drainage canal from omentum, is the only resource. The operations are very simple. If, however, the abscess is confined within the capsule of the pancreas, the operation, as remarked by Boeckel,[25] is more delicate, laborious, and restrained; delicate, because the pancreas is deeply situated and is surrounded by numerous important vessels the wounding or ligaturing of which might prove

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fatal (superior mesentericus); and restricted, because only a small portion of the pancreas can be removed with safety and freedom from the danger of a fatal diabetes.

CHRONIC PANCREATITIS.—Although suppurative pancreatitis may run a slow and chronic course, the term chronic pancreatitis is used to designate a hardening of the pancreas, with enlargement or shrinking. Perhaps the terms hypertrophic cirrhosis and atrophic cirrhosis would be appropriate. A part or the whole of the gland may be involved. Opie[26] recognizes two varieties. In the interlobular form the inflammatory process is localized chiefly at the periphery of the lobule; in the interacinar the process is diffuse, involving the lobules and separating individual acini. Of great interest is the relation of chronic pancreatitis to the islands of Langerhans and the occurrence of diabetes. The islands of Langerhans, as defined by Opie, are composed of cells having the same origin as those of glandular acini, but forming structures which are independent of the secreting apparatus, and in intimate relation with the vessels. In the splenic end of the cat's pancreas they have a definite position within the lobule, each of which contains one of those structures. In the human pancreas they are more numerous in the splenic extremity than elsewhere. Opie claims that prolonged stimulation of the gland does not, as claimed by Lewaschen, transform groups of acini into islands of Langerhans.

In the interlobular variety of chronic pancreatitis the islands of Langerhans do not usually suffer, nor do they when the infective agents come by way of the ducts with which they are not connected. In the intralobular or interacinar variety they may atrophy as the result of pressure. In this way the presence or absence of sugar in the urine in diseases of the pancreas may perhaps be explained.

Etiology.—The causes of chronic pancreatitis are not satisfactorily determined. They are probably varied. Undoubtedly localized indurations may arise from lesions of the neighboring organs, such as ulcer of the stomach or duodenum. A general involvement of the gland may result from hæmatogenous infection, from a mild form of acute pancreatitis, from diseases of the blood-vessels, or from obliterating endarteritis. Opie[26] reports two instances of congenital syphilitic pancreatitis in which the patients died respectively three and four hours after birth. In one of the cases it was believed that the disease represented an active stage of a chronic inflammatory process; in the other the process was more advanced and was no longer active. The islands of Langerhans were surrounded by newly formed stroma, but in neither case were they invaded by it.

Clinical experience would seem to indicate that in the majority of cases the condition arises from an infection entering through the ducts, secondary to a gastroduodenal catarrh and a complete or partial stasis of the flow of the pancreatic secretion. Numerous operating surgeons have noticed the frequent association of pancreatitis with cholelithiasis. The pancreatic duct may be completely or partially obstructed by a gall stone or a pancreatic stone; the result may be either a narrowing or an obstructive dilatation. The enlargement and hardness found at the operating table have often given rise to a diagnosis of malignant disease. Alcohol has been thought to be a cause. The disease seldom occurs in drunkards, and when it does it is probably secondary to a gastroduodenal catarrh. It may follow mild traumatism.

Pathological Anatomy.—The characteristic picture is the fibrous thickening of the connective tissue generally throughout the gland or only in limited areas. The head of the pancreas may be much enlarged and of stony hardness. In other instances the gland is diminished in size from contraction of the interstitial tissue. The surface is sometimes smooth and sometimes nodular and of a gray color. There may be an associated condition of fatty or calcareous degeneration. The duct of Wirsung may be dilated, tortuous, or of normal appearance.

Symptoms.—There are no pathognomonic symptoms of chronic pancreatitis. Its presence has usually been discovered during operations or in the autopsy room. Disorders of digestion, pyrosis, vomiting, pain and tenderness in the epigastrium, constipation or diarrhœa, and emaciation are the symptoms usually present and they are certainly not distinctive. There may or may not be some elevation of temperature. Icterus may be present if the common bile duct is pressed upon. Sugar may be present in the urine. Fat in the stools is rare and lipuria still more rare. Walker has shown "that the absence of pancreatic secretion from the intestine, although bile were present in the intestinal canal, led to pale-colored stools." Mr. Cammidge has found "that if the urine of patients suffering from pancreatic disease be boiled for a short time with an oxidizing agent and then the phenyl hydrazin test performed, an abundant crop of delicate yellow needles arranged in sheaves and rosettes was produced" (Robson[5]). A histological examination of the blood may show marked diminution in the number of blood plates. The presence of a hard, palpable, immovable tumor in the region of the pancreas would be a very important symptom.

Prognosis.—The prognosis is grave. Many patients, however, known to be the subjects of chronic pancreatitis, live for years in good health, and the same remark is true of patients who have lost a part of their pancreas through suppuration and necrosis. Experiments upon animals harmonize with clinical experience; some animals can live with one-tenth of their pancreas. The association of syphilis, arteriosclerosis, or obstructive heart lesions would render the prognosis less favorable.

Treatment.—"The treatment of chronic pancreatitis is by abdominal section and drainage; but in this case the drainage is indirect and is obtained by draining the gall-bladder by cholecystotomy, cholecystenterostomy, or duodenocholedochotomy. The exact line of treatment cannot be determined until the abdomen is opened, and for this purpose I prefer, as in all my gall-bladder operations, a vertical incision through the upper part of the right rectus, splitting that muscle to whatever extent is necessary in order to obtain a good view of the diseased region, and to afford plenty of room for manipulation.

"If merely cholecystotomy on a distended gall-bladder is necessary, an incision of one or two inches will suffice; but if the gall-bladder be contracted or if the ducts have to be attacked, an incision of from four to six inches will be required; and if the several layers of the abdominal wall are sutured separately, there is no fear of subsequent hernia. This I can affirm by ample experience. It saves much unnecessary dragging on the parts when operating on the common duct or duodenum to have a free incision, and there is no retractor equal to the hand of a skilled assistant, who with a flat sponge interposed between the spread-out fingers of his left hand and the viscera, will at the same time afford the operator a good view of the field of operation, and with his right hand help in the further steps of the operation.

"If the right costal margin or the edge of the liver be obstructing the view, another assistant may with advantage retract it either by digital manipulation or by means of a wide retractor with a long handle, so that he can stand back a little and avoid embarrassing the operator.

"As a matter of experience I seldom find a second assistant necessary. A sponge in the pouch to the right of the common duct, and one pushed down over the right kidney, help to catch all escaping fluids and to keep the peritoneum clean. When the ducts or the duodenum are opened, sterilized gauze pads are employed to mop up the fluid as it escapes, but none of these is allowed to remain even temporarily in the abdomen. When there are gall-stones present they should be removed, unless the patient is too ill to permit of the complete operation; but in every case drainage must be secured, if possible by cholecystotomy, as in nearly all my successful cases. Moreover, the drainage must not be stopped before the bile has become healthy, and not before the greater amount of bile is being passed by the bowel, which will be certain to occur as soon as the swollen pancreas has subsided, if the duct be otherwise clear of obstruction.

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"It might be thought that cholecystenterostomy would be the ideal operation in these cases, but experience says that it is not; for instance, in one of my cases the operation brought so much relief that a cure was being anticipated, yet in the third month relapse occurred and death ensued, apparently simply owing to closure of the new opening between the gall-bladder and duodenum. In one of Mr. Barling's cases in which the gall-bladder was joined to the duodenum, he states 'that although the symptoms were relieved, enlargement of the pancreas persisted.'

"Possibly in some cases the manipulations of the indurated tumor may have detached calculi impacted in the pancreatic duct, and thus led to a subsidence of the pancreatitis, then to an opening of the common duct by the relief of tension, and so to a cure of the patient. The simulation of malignant disease of the head of the pancreas by chronic interstitial pancreatitis would make one hesitate to decline operation in any case of distended gall-bladder, where the patient is in a condition to bear it, or even in any case of chronic jaundice without distention of the gall-bladder, where the general strength is deteriorating as, though it should be recognized that if the disease be really malignant, very little good will be done, and life may even be shortened or only prolonged for a short time; yet if the disease prove to be chronic pancreatitis, a real and permanent cure may be brought about. If a calculus be felt embedded in the head of the pancreas or impacted in the pancreatic duct, it may be reached through the second part of the duodenum by laying open the papilla and exploring the duct, or by dividing the peritoneum passing between the duodenum and hepatic flexure of the colon, and then cutting through the overlying pancreas on to the concretion. If the papilla common to the bile and pancreatic ducts be incised in the duodenum, it does not require suture; and in the cases in which I have explored the ducts by the duodenal route there has been no serious hemorrhage. The anterior duodenal opening only requires closing by a mucous and serous suture. Drainage of the right kidney pouch for from twenty-four to forty-eight hours is advisable, though not always necessary, and this is best done by a stab wound at the most dependent part.

"The result of treatment in this class of cases has been most encouraging, as out of twenty-two cases operated on only one died directly from the operation, and in that case the patient's life was only very slightly shortened, since he was reduced to the last stage of exhaustion before surgical operation was sought. Of those recovering from operation, with the exception of two who died a few months later, complete and perfect recovery ensued. These results contrast very markedly with the surgical treatment of cancer of the pancreas, where nearly half of the cases operated on have died directly as the result of the operation, and in those who have survived life has only been prolonged for a comparatively short time."

The above is from Mayo Robson's address before the American Surgical Association in 1901.

Another very important point has been raised by Mr. Robson, and that is the tendency to troublesome hemorrhage during operation in cases of chronic pancreatitis, particularly when associated with jaundice. This was at one time thought to be due to the cholæmia. The suggestion that it is due to the glycerin set free in fat necrosis is not generally accepted. He has found the exhibition of chloride of calcium most useful as a prophylactic. He administers calcium chloride in thirty- to sixty-grain doses, thrice daily, for from twenty-four to forty-eight hours previous to operation; and by enema in sixty-grain doses, thrice daily for forty-eight hours afterward. This he nearly always finds successful in correcting the hemorrhagic tendency.

The close association of pancreatitis and angiocholitis is confirmed by Ferguson, of Edinburgh, who observed in cases of death that he could express a few drops of pus from the duct of Wirsung. It would seem that the indirect drainage of the pancreatic ducts was as rational and successful as drainage of the bile pasages in infective conditions. Kehr has suggested an anastomosis between the intestine and the duct of Wirsung. The technique would be very difficult.

Cystic Tumors of the Pancreas.—Cysts of the pancreas are rare; their nature and origin are obscure. It may be said that probably the majority are retention cysts. The most common cause is generally thought to be chronic indurative pancreatitis. The connective tissue in some part of the gland so presses upon or so distorts the excretory duct that the outflow from a part of the gland is arrested. Senn thinks that in addition there is an alteration in the character of the secretion whereby it becomes no longer absorbable. Another cause may be the obstruction of the duct of Wirsung from pressure of neighboring organs, as for instance from a stone in the common bile duct, or from an obstructive swelling of the duodenum at the point where the duct enters. A catarrhal inflammation of the duct of Wirsung may cause obstruction. A new growth in the head of the pancreas may act similarly.

Minier suggests that cystic degeneration may occur in the pancreas in much the same way that it does in the kidney, testicle, and mammary gland. That cysts may result from hemorrhages into the pancreas is not yet proven. The frequent finding of blood in the cyst contents has suggested this cause. It is probable that small hemorrhages may be entirely absorbed, leaving only a pigmented stain (Orth). On the other hand, it is quite probable that hemorrhages may occur into cystic tumors, and it is generally thought that most bloody cystic tumors of the pancreas are in origin retention cysts. Trauma is also assigned as a cause. Cysts are more frequent in the tail than in the body or head of the pancreas. In an analysis of 134 cases Osler[14] found in 90 cases that the situation was not given; in 14 that the whole pancreas was involved; in 15 the tail; in 11 the head; in 4 the body. Koerte[27] states that of 121 cases operated upon by surgeons, 60 were in males and 56 in females; in 5 the sex was not given. Sixty-six of the cases occurred in the fourth decade.

There may be multiple cysts. This should be borne in mind when considering the prognosis and possibility of recurrence. Pancreatic cysts vary greatly in size. Those found in autopsy rooms are usually comparatively small. Surgeons report, however, that some of the cysts contain from 1 to 20 litres. The fluid is generally of a light-brown coffee or reddish-brown color, seldom clear (Osler). Gussenbauer found in the fluid altered red and white blood cells and pigment. Fresh blood has also been found. The chemical reaction as a rule is alkaline, but may be neutral or acid, with a specific gravity of 1.007–1.028.

The lining of the cyst wall may be smooth or sacculated; it is generally surrounded by blood-vessels. In developing the cyst may assume very variable relations to adjacent organs, particularly the liver, stomach, and transverse colon. It may lie behind and push forward the stomach; it may project between the stomach and liver; it may appear between the stomach and transverse colon, or lie behind the colon. The displacement of these organs is sometimes very great. In one instance the transverse colon was pushed down behind the symphysis pubis. Besides the displacement and dragging of the viscera mentioned, other serious complications may arise from the pressure of the tumor. The common bile duct may be so pressed upon that jaundice results. Pressure may cause obstruction of the duodenum or ureter, and cases are reported of pressure resulting in ascites.

There are no symptoms which can be called characteristic of cystic tumor of the pancreas so long as it remains small and not palpable. As might be expected, from what is known of its etiology, there is generally a history of indigestion, of indiscretion in eating and drinking, and occasionally of trauma. Pain in the epigastric region is common, its severity depending on the situation of the tumor and its rate of growth. There may be nausea and vomiting. The vomitus may contain blood if it occurs subsequently to rupture of a cyst into the stomach. If

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rupture into the intestine occurs, blood may appear in the stools. There is sometimes very great and rapid loss of weight. Pancreatic salivation (increased flow of saliva) is rare. Sugar in the urine would indicate very extensive

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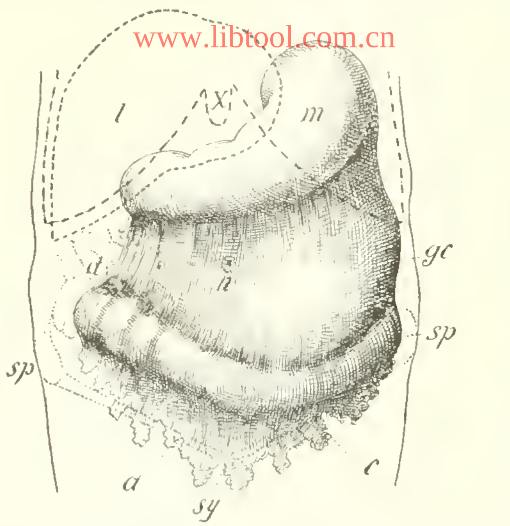

FIG. 3732.—Showing the Appearances which were Presented, in a Case of Large Pancreatic Cyst, when the Abdomen was Opened and its Contents Freely Exposed to View. The cyst, in its growth, had forced its way forward between the stomach and the colon, and was putting the ligamentum gastrocolicum upon the stretch. (After H. Kehr.)

cirrhosis of the gland. Fat in the stools is seldom found. Icterus may result from pressure. The development of a palpable tumor is the most suggestive symptom. The discovery of ferments in the sac contents is noted.

Diagnosis.—Clearly a cyst of the pancreas can be recognized only after it has reached a size that can be palpated. A palpable cyst is the most easily diagnosed of all the diseases of this deeply situated gland. The presence of a fixed fluctuating tumor in the median line above or below the umbilicus should certainly suggest pancreatic cyst.

The first fact to be clearly established is the relation of the tumor to the adjoining viscera, especially to the stomach, colon, and intestines. The inflation of the stomach and colon with air or gas will give great assistance in the determination of this relationship. If the cyst has passed forward between the stomach and colon, pushing before it the gastrocolic omentum, a clear percussion note should be heard above and below the tumor if it is a large one; and if it is small, the distended stomach and colon may meet together in front of it. If the tumor projects forward below the liver and above the stomach, the dull percussion note of the liver may be continuous with that of the tumor. The difficulty of differentiating a pancreatic cyst thus placed from a distended gall-bladder or an echinococcus cyst, or other fluid collection connected with the liver, would be very great, and probably could be accomplished only by examination of the contents removed by a Pravaz syringe. Possibly by examining the patient in the erect position, a line of tympany could be found between the liver and cyst. A pancreatic cyst would not move during inspiration or expiration.

If the tumor projected forward below the colon, the dull note of the tumor should be easily elicited between the tympany of the colon above and that of the small intestines below.

It may grow behind and push forward the stomach, or it may pass forward between the layers of the mesocolon, in which case the stomach or colon would lie immediately in front of the tumor. When so situated it is generally possible, after inflation, to establish the mobility and freedom of the stomach or colon from involvement in the body of the tumor.

The differential diagnosis between a cystic tumor of the pancreas and a solid tumor of the spleen should not be difficult. To differentiate a cyst springing from the tail of the pancreas from an echinococcus cyst of the spleen—the only cystic growth involving the spleen—may be very difficult, and perhaps impossible except by an examination of the cyst contents.

Great difficulty may be found in differentiating between a pancreatic cyst and hydronephrosis. In hydronephrosis the bulging is generally in the lumbar region. There may also be a history of renal colic, of the passage of a renal calculus or blood, or other urinary derangement. An examination of the urine may throw light on the case. A cystoscopic examination of the bladder might show that no urine was entering from that side.

From large ovarian cysts the history should show that the growth began low down and laterally. Cysts of the mesentery are movable. Aneurisms of the aorta or its branches are pulsating and expansile.

The aspiration of cysts for diagnostic purposes is a questionable procedure. There is always a danger of puncturing a flattened-out overlying viscus, of wounding some abnormally placed vessel—and the walls of a pancreatic cyst are sometimes very vascular,—or of permitting the escape of infective contents,—as, for instance, hooklets in the case of echinococcus cysts,—or of pathogenic organisms. An exploratory incision is now so safe that it is to be recommended as an almost universal rule in place of puncture. When the fluid is obtained, its examination may be far from satisfactory. The ferments may be present, but diastatic and fat-emulsifying ferments occur in various other exudates. The only positive sign would be the presence of the ferment which digests fibrin and albumin, and it is often absent. The presence of blood would be very suggestive. It occurs, however, in ovarian cysts with a twisted pedicle. Küster thinks the presence of fat globules is characteristic of

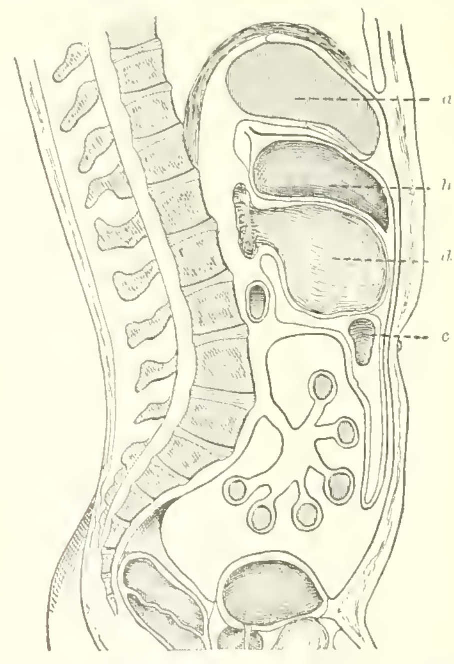

FIG. 3733.—Shows the Relations which the Pancreatic Cyst Bears to the Neighboring Organs in the Majority of Cases. (From Kehr.) *a*, Liver; *b*, stomach; *c*, transverse colon; *d*, pancreatic cyst.

pancreatic cyst. "A remarkable feature often noticed has been the transitory disappearance of the cyst. In Halsted's case the girth of the abdomen decreased from

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forty-three to thirty-one inches in ten days, with profuse diarrhœa. Sometimes the disappearance has followed blows" (Osler).

Prognosis.—The rapidity of the growth of pancreatic cysts is difficult to ascertain, because the date of their commencement can seldom be determined. They are

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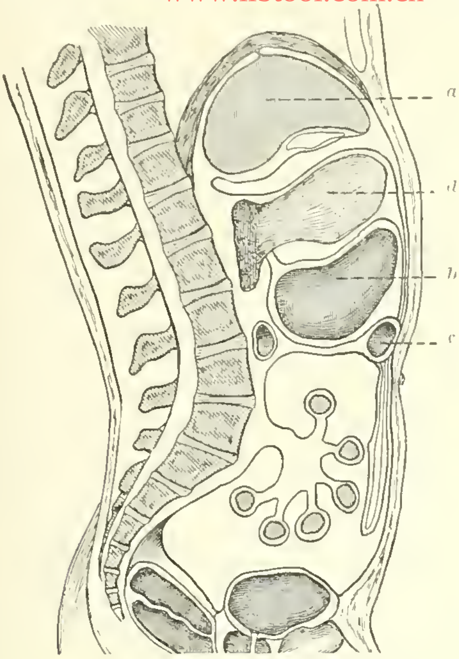

FIG. 3734.—Shows the Relations which the Pancreatic Cyst Bears to the Neighboring Organs in a Smaller Group of Cases. (From Kehr.) *a*, Liver; *b*, stomach; *c*, transverse colon; *d*, pancreatic cyst.

probably of slow growth as a rule. When following trauma or acute inflammatory processes, however, they may develop into palpable tumors in two or three weeks. Their duration is also uncertain; instances of their being present for thirty or forty years are reported. They sometimes rupture spontaneously into the stomach or intestine, as evidenced by the vomiting, or passage by rectum, of a quantity of bloody fluid. Their occasional disappearance and reappearance may possibly be explained by the assumption that in this way they periodically empty themselves into the stomach or intestine. Echinococcus cyst of the spleen is very rare. One case is reported by Heller. Rupture of a pancreatic cyst may occur into the peritoneal cavity.

Treatment.—Medical treatment is useless. Preventive treatment can influence only the most common cause of cyst development, viz., chronic indurative pancreatitis. The surgical methods which have been adopted are, puncture, application of caustics to the cystic cavity, emptying of the cyst and stitching of the cyst wall to the abdominal incision at one or two operations, opening and drainage of the cyst through a lumbar incision, and excision of the cyst wall, partially or wholly.

Puncture of the sac is to be condemned for the reasons given in the paragraph on diagnosis, and because it is insufficient.

The application of caustic to the interior of the sac wall in the case reported proved fatal.

The method which has been employed in the greatest number of cases is that first adopted by Gussenbauer, viz., the opening and emptying of the sac followed by immediate suture to the edges of the abdominal incision and drainage by means of gauze or drainage tube, or both. The incision is best made over the most prominent part of the tumor. The cyst wall should be very carefully uncovered, as far as possible, by blunt dissection. Great care should be exercised in the ligature of overlying vessels, that none essential to the blood supply of the colon are interfered with. The wall of the sac is sometimes very thin and must be handled gently.

After carefully protecting the peritoneum by the placement of sterile gauze pads, the cyst may be incised or punctured with a trocar having a tube attached to convey the fluid into a receptacle. After the cyst wall is stitched to the abdominal incision the cavity should be packed with strips of plain sterilized gauze; iodoform gauze is to be avoided, as there is a possibility of iodoform intoxication. The fluid that escapes tends to irritate and digest the skin. This should be prevented by a liberal use of zinc ointment. Boeckel[25] reports ninety-nine cases treated by this method, with ninety-two recoveries and seven deaths.

The subsequent history of these cases in some respects is satisfactory. The nutrition improves wonderfully and quickly, although pancreatic juice may continue to flow from the wound. There is sometimes great difficulty in getting the fistula to close. If it does not close in five or six weeks it may remain open for years. When the opening persists, closure may be effected by the application of nitrate of silver or chloride of zinc.

The above method carried out in two stages has not been adopted in as many cases, but the results have been very good. Boeckel[25] reports sixteen cases and sixteen cures.

Drainage through a lumbar incision is indicated only in those cases in which the cyst lies far back in the loin. An anterior exploratory incision may show this to be the best route by which to approach the tumor.

Complete excision of the sac wall, while perhaps the ideal method, is possible only when the sac wall is well

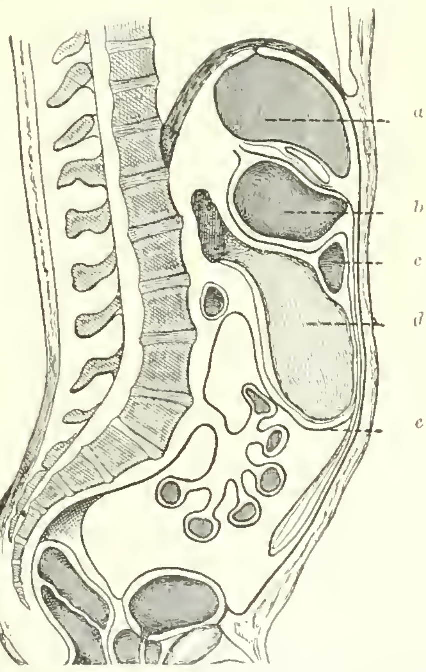

FIG. 3735.—Represents a Case in which the Pancreatic Cyst has Developed between the Laminæ of the Mesocolon, coming Forward between the Transverse Colon and the Small Intestines. (From Kehr.) *a*, Liver; *b*, stomach; *c*, transverse colon; *d*, pancreatic cyst.

defined and not too closely united by adhesions to the neighboring organs. If the cyst is pedunculated, its total extirpation might be indicated. The difficulty arises in dealing with the adhesions, the blood vessels, and the point of origin from the pancreas. The vessels are generally numerous and large. Another great diffi-

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culty is to avoid injuring or tearing vessels essential to the nourishment of the colon. Koerte has collected 21 cases with 6 deaths. In 7 cases the difficulties were so great that the operation could not be completed; of these, 4 died. Boeckel reports 25 cases of total or partial excision, with 21 cured and 4 deaths. If the sac is excised, the space from which it has been removed should be packed with gauze and drained through the abdominal

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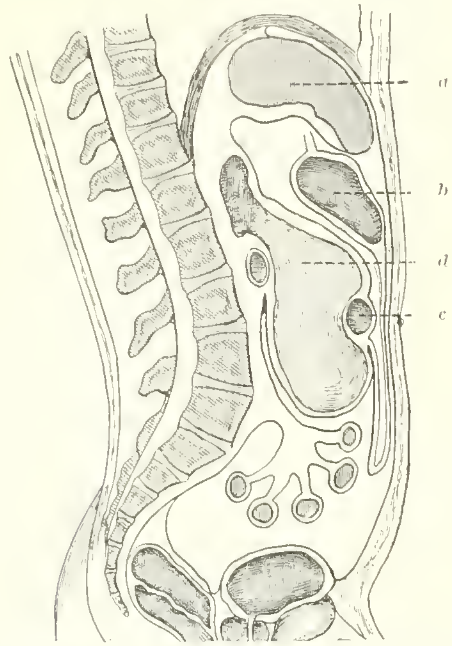

Fig. 3736.—Shows the Cyst Developed Between the Laminæ of the Transverse Mesocolon. The colon lies directly in front of the cyst. (From Kehr.) *a*, Liver; *b*, stomach; *c*, transverse colon; *d*, pancreatic cyst.

incision, or through a stab wound in the loin. It may be said that excision should be undertaken in favorable cases only, when adhesions are absent or are easily separated by blunt dissection, and when the blood-vessels involved in the sac wall are small and unimportant. It is certainly a much more grave operation than the simple incision and drainage of the sac.

Tumors of the Pancreas.—Tubercle, gumma, lymphoma, and sarcoma may occur in the pancreas, but they are very rare. Primary carcinoma of the pancreas is stated by Willigk and Lebert to occur in about six per cent. of all cases. It is more frequently found in the head than in the tail or body of the gland. The most common variety is scirrhus.

The *symptoms* are at first exceedingly indefinite. Later, fatty diarrhœa and vomiting occur, with tenderness on pressure over the gland. Jaundice is an early symptom, and is more persistent and less variable from day to day than when due to stone. The stools are persistently clay-colored. In obstruction from stone the color may vary. Diabetes is seldom present. An important diagnostic point, according to Courvoisier and Ecklin, is the condition of the gall-bladder. In stone the gall-bladder is usually small and shrunken, while in carcinoma it may be very much distended and palpable as a tumor. When stone and carcinoma exist together the difficulties in diagnosis are very great. An examination under an anæsthetic should be of great assistance. Emaciation is rapid and extreme. A palpable tumor is seldom found until the disease and its attendant emaciation are well advanced. The examination of the stomach contents, together with the comparatively good functionating power of that organ, should enable one to exclude carcinoma of the stomach. The tumor sometimes becomes adherent to the stomach, and in some cases the disease has perforated the stomach wall. Hæmatemesis might give evidence of this complication.

Treatment.—The treatment of carcinoma is most difficult and unsatisfactory. In the primary course of the disease the diagnosis is wellnigh impossible. If the disease is localized in the tail, its removal may in favorable cases be feasible; but extirpation of the whole gland, even if the patient recovered from the operation, would be followed by a fatal diabetes. Extirpation of the head of the gland presents technical difficulties that are almost insurmountable. There is the danger of injuring the vessels necessary for the nourishment of the colon, duodenum, and spleen; and if both of the pancreatic ducts are tied, diabetes and atrophy of the remaining gland tissue follow. There is also the difficulty of dealing with the common bile duct. Cholecystotomy may give relief from the icterus; and if there is great pressure on the duodenum, a gastro-enterostomy would relieve the obstructive symptoms, vomiting and inanition. Koerte reports ten cases of operation on solid tumors of the pancreas with six recoveries.

Pancreatic Calculi.—Pancreatic calculi may be single or multiple. They are composed of carbonate of lime and phosphates. In shape they may be round, oval, or angular, and in color an opaque white. Osler states that in one thousand autopsies at the Johns Hopkins Hospital there were two cases. In 1885 Johnston collected thirty-five cases in the literature. They had been found in the pancreatic ducts and in pancreatic cysts and abscesses.

As to their *ætiology* but little is known. They may result from inspissation of the secretion or from an obstruction in the ducts, or be due to some undetermined action of bacteria. Probably, as in the liver, both slowing or obstruction in the outflow of the secretion and bacterial infection are etiological factors.

The results are found in the gland itself. They are: inflammatory indurations, cyst and abscess formation, a predisposition to the development of malignant disease, and obstruction to the common bile duct from pressure upon, or the blocking of, the ampulla of Vater at the duodenal opening.

A definite *diagnosis* is seldom possible. The pain could not be differentiated from gall-stone colic. Pain in the left hypochondrium is thought to be suggestive of pancreatic calculus. Pain, vomiting, fatty stools, diabetes, and the passage of carbonate of lime stones would render the diagnosis probable. Carbonate of lime calculi, however, are sometimes formed in the intestines.

A stone might be removed from a cyst or abscess or from a dilated duct. If jaundice is present and the obstruction cannot be found and removed, cholecystotomy would be indicated. *George E. Armstrong.*

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PANCREATIN.—Pancreatinum. "A mixture of the enzymes naturally existing in the pancreas of warm-blooded animals, usually obtained from the fresh pancreas of the hog (Sus scrofa Linné; class, Mammalia; order, Pachydermata). A yellowish, yellowish-white, or grayish amorphous powder, odorless, or having a faint, peculiar, not unpleasant odor, and a somewhat meat-like taste.

"Slowly and almost completely soluble in water, insoluble in alcohol.

"Pancreatin digests albuminoids, and converts starch into sugar; prolonged contact with mineral acids renders it inert.

"If there be added to 100 c.c. of tepid water contained in a flask, 0.28 gm. of pancreatin and 1.5 gm. of sodium bicarbonate, and afterward 400 c.c. of fresh cow's milk previously heated to 38° C. (100.4° F.), and if this mixture be maintained at the same temperature for thirty minutes, the milk should be so completely peptonized that if a small portion of it be transferred to a test tube and mixed with some nitric acid, no coagulation should occur.

"Peptonized milk, prepared in the manner just described, or even when the process is allowed to go on to the development of a very distinct bitter flavor, should not have an odor suggestive of rancidity."

The pancreas contains four distinct enzymes which are known by their action: the proteolytic—trypsin; the diastasic—amylopsin or diastase; the milk-curdling; and the fat-splitting. No one of these ferments has been isolated. The proteolytic enzyme converts proteids with equal or greater facility than pepsin, but it differs from pepsin in respect to the media in which it exerts its activity, and also in respect to the final products of its action. Trypsin bears no relation to an alkaline medium which corresponds to the dependence of pepsin upon acid; it acts with equal facility in a neutral or a faintly alkaline medium. Alkalies, more particularly sodium carbonate or bicarbonate, up to one per cent. of the digesting mass, are generally stated to be most favorable to the action of trypsin: the writer, however, has not found in digestion in vitro that sodium bicarbonate in 0.1 per cent. to 1 per cent. has given better results than parallel tests in which the alkali was omitted, while more than traces of free alkali were found unfavorable. Trypsin in antiseptic solutions (with thymol) containing as small an amount as 0.1 per cent. anhydrous sodium carbonate, has been found to undergo rapid deterioration at ordinary room temperature. While the pancreas juice obtained from living animals is alkaline, the pancreas gland, as soon as it may be conveniently treated upon removal from the recently killed animal, will be found to give an acid reaction. Aqueous infusions, glycerin or hydro-alcoholic extract, from such gland are invariably acid to litmus, and the acid present in these solutions does not in the slightest degree interfere with the pancreas enzymes in vitro; this acidity is reasonably to be attributed to nucleic acid, and undoubtedly the proteid is bound up in the cell with acid. The ash is invariably acid, containing phosphoric acid and potash, presumably acid phosphate. Minute percentages of mineral (0.03 per cent. HCl) and organic (0.25 per cent. acetic) acids do not interfere with the action of trypsin, but have been observed slightly to enhance it. Furthermore, the latent mother ferment, trypsinogen, is developed by the influence of the acid constituents of the gastric juice, and probably likewise of foodstuffs, for in the treatment of the gland itself it is found that the addition of minute amounts of organic acids yields the ferment in an active form from the trypsinogen. Trypsin, however, is very sensitive to more than traces of free mineral acid, 0.1 per cent. to 0.15 per cent. HCl destroying it immediately, and subsequent neutralization failing to revive it. So far, therefore, as may be gathered from these facts there is no evidence in support of the impression which has gained so much credence—that pancreatin depends upon an alkali for activity or in any way bears such a relation to an alkali as pepsin does to acid.

Trypsin converts native proteids into soluble and diffusible forms of albumoses and peptones which differ in no known way from those derived from peptic action, and causes by prolonged digestion a further cleavage of these proteids into simpler nitrogenous bodies—the amido-acids, leucin, tyrosin, etc., and hexone bases, ammonia, etc. Recent researches have led to the opinion that the development of these proteids into these crystalline bodies is essential to their complete utilization in nutrition.

Trypsin exhibits a special affinity for the digestion of certain native forms of proteids—fibrin, muscular tissue, both raw and cooked; these are promptly digested by the trypsin, whereas its action upon coagulated egg albumen is very slow in comparison with that of pepsin.

The products of peptic digestion (those intermediary between raw proteid and true peptone, syntonin and albumoses) are likewise, after neutralization, quickly converted into peptone by trypsin. Rapidity of action seems to be the natural function of trypsin. It exhibits a peculiar affinity for the casein of milk, as natively existing in milk, peptonizing this proteid with great celerity without the intervention of an alkali.

Certain differences in the physical phenomena observed in tryptic and peptic digestion have led some to suppose that trypsin exerts a peculiar erosive action. The swelling of tissue, the gelatinous character which fibrin almost instantly assumes under pepsin acid digestion, is not to be accounted for by any peculiar action of the pepsin itself; it is due to the influence of the hydrochloric acid which combines with raw proteins to form syntonin—this being very penetrable by the enzyme. In fact, one is struck with the similarity in adaptation to digestion, between gelatinous starch and this swollen, gelatinous fibrin. Boiled albumen presents no visible difference in its digestion with trypsin or with pepsin, for the acid does not swell the coagulated albumen. Trypsin (like pepsin) acts only by effecting the solution of the surface exposed—by conversion into more soluble forms.

A peculiar effect of trypsin upon milk is the conversion of casein into a form which becomes coagulable at the boiling point. This partially peptonized casein has been termed "metacasein," which, upon more complete conversion, loses its coagulability. This behavior of milk has been suggested (Roberts) as a convenient means of testing the activity of pancreatin, simply by ascertaining under certain conditions the time at which this "onset" point of conversion occurs. This is an extremely interesting reaction, and significant of the peculiar nature of casein, which, unlike other forms of native proteid, is not coagulable by heat, probably owing to its peculiar combination with inorganic constituents, losing this characteristic, after a certain amount of digestion and again becoming non-coagulable like other peptonized proteids. By rendering milk slightly alkaline by the addition of sodium bicarbonate or potassium bicarbonate, this metacasein reaction is prevented, and the milk then at any period of peptonization may be heated to the boiling point without curdling.

The starch-converting ferment of pancreatin, commonly known both as amylopsin and as diastase, very rapidly liquefies starch paste, converting starch into maltose. Raw or uncooked starch is similarly converted, though less rapidly, the action being proportionate to the diffusion of the starch, to the surface presented to the digestive ferment, completely cooked gelatinous starch being with great facility brought into complete contact.

The products of pancreas digestion of starch are apparently identical with those of diastase from other sources—the achroo-dextrins, dextrins, and maltose. Amylopsin is extremely susceptible to the influence of chemical reagents. Its action is not enhanced in the slightest degree in alkaline media; indeed, it is greatly enfeebled by free alkali; it is also weakened by acids (mineral and organic) beyond a very slight percentage. Acids which tend to promote the development of trypsin exhibit no corresponding behavior on amylopsin. In vitro, in neutral media, or as found in its normal association with the acids of the pancreas gland or in extracts or

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infusions therefrom, amylopsin exerts enormous energy in the conversion of starch. It no doubt exists preformed in the pancreas gland, and there is ground for the belief that it differs in its constitution from the proteolytic enzymes.

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The fat-splitting or emulsifying ferment of pancreatin (steapsin or lipase) is the most delicate of the enzymes; it is rapidly destroyed by all acids, except the fatty, and by strong alcohol. Steapsin rapidly liberates the fatty acids, and this can be very readily observed by the addition of a few drops of a neutral solution of pancreatin to a neutral solution of butter in ether, to which a little litmus has been added. The nature of the ferment, its susceptibility, and the so far insuperable difficulty of separating it in any degree from the other ferments of the gland, complicate its study and have precluded the establishment of accurate, conclusive data concerning it.

The coagulating ferment behaves in a manner similar to that of the rennet. When added in a sufficient quantity to pure milk at a temperature of 100° F., the characteristic milk curd is almost instantly formed. This casein curd, however, is not permanent, and cannot be separated so freely as that obtained by the action of rennet; if the milk be maintained at an ordinary temperature the trypsin will rapidly attack the casein, and by stirring the mass, solution can be readily effected.

The milk-curdling ferment often escapes detection owing to the rapid peptonizing action of trypsin upon the casein.

Although pancreatin is officially defined as "a mixture of the enzymes naturally existing in the pancreas," no official test is given for other than the proteolytic ferment, and this is determined by its action on milk under conditions which are approximate to those commonly employed in the preparation of peptonized milk. The provision against the development of rancidity in peptonized milk is especially important, for pancreatin, which produces this result, is distinctly objectionable,—it yields a milk which is unfit for food, especially for the sick.

The term "pancreatine" in the past has been applied to indefinite preparations of the pancreas and more often identified with the emulsifying ferment—the function of the gland which was first observed and thought to be its chief and important characteristic. The official adoption of this title, however, now makes it applicable only to a product which contains all the pancreas enzymes. This of course is in distinct opposition to scientific nomenclature of the enzymes, for the term might best be applied to some one particular ferment, in conformity with the use of pepsin for the proteolytic ferment of the stomach.

"Pancreatine" was originally applied to the starch-converting agent of the pancreas juice by Bouchardat and Sandras, to the ferment obtained by them from infusion of pancreas with water and precipitated with alcohol.

The pancreatic enzymes, certainly the proteolytic, amylolytic, and curdling, are freely soluble in water, and are readily extracted from the gland by infusion, by dilute glycerin, by hydro-alcoholic menstrua. It is not possible, however, to prepare a liquid extract of the gland which will retain for any lengthy period all the several, chief enzymic properties of the pancreas. Whatever the reaction of the mingled ferment solution may be whether due to the fresh gland acid constituents or to added acid or alkali, the diastase especially loses its activity. This will either be due to unfavorable reaction or to the influence of the trypsin, should the conditions be favorable for its action. The pancreatic liquors (originally suggested by Roberts) have not been found by any means so effective and agreeable and convenient for general purposes, especially for the peptonization of food, as the extract in a dry form. The activity of pancreatin, whether in a dry or a liquid form, simple or in combination with other agents, is readily tested by applying it to the digestion of proteids in an alkaline medium (a procedure which differentiates tryptic action from that of pepsin); and its effect upon starch may be tested by the very simple method which establishes the presence of diastase,—by its action on starch mucilage at 100° F. The proteolytic ferment may be tested upon fibrin or milk, using the United States Pharmacopœia test. Negative reaction in any respect with these tests is absolute evidence of the absence of the ferment which is thus to be indicated.

Pancreatin is so susceptible to change and enfeeblement that it should not be prescribed in solution with soluble chemical agents—mineral acids or alkalies. Pepsin-acid solutions are particularly incompatible with pancreatin; even that degree of acid which is suitable for the preservation of the pepsin weakens the activity of the pancreatin, and this is increased by the influence of the pepsin, under the commercial conditions to which a pharmaceutical product must be submitted, and for which it must be suitable by a reasonable degree of permanency. Alkaline agents are indicated and freely prescribed with pancreatin, and this is best accomplished in dry mixtures—tablets, capsules, powders, etc. While in certain conditions, for instance, in the peptonizing process, the salts of the alkalies (sodium bicarbonate, etc.) fulfil a useful purpose, alkaline solutions of pancreatin do not retain their activity at ordinary temperature; they are suitable only for immediate use.

The liquid preparations of the pancreas gland, therefore, should as a rule be prescribed alone, separate from the remedies to be used in association. In the dry form, however, complete freedom of combination of any remedy indicated is afforded, for the dry enzymes are very stable.

The whole relation of the enzymes of the different digestive glands mixed in artificial solutions may perhaps best be summed up by this fact: that the ferment for which the reaction of the solution is most favorable will exert an injurious action upon the other enzymes; in other words, the *active* enzyme-proteid will convert the other enzyme-proteids which are in the unfavorable environment.

Therefore, from a pharmaceutical standpoint, we have to keep strictly to the ascertainment of conditions which are favorable to the extraction and production of these enzymes in a form of reasonable stability, and to the avoidance of incompatibles, these being simply agents which are positively known to injure the ferment in vitro; and to the adoption of certain definite standards of activity, and the development of proper methods for utilizing their digestive properties either in laboratory operations or in the artificial digestion of peptonized food for the sick. It must be ever considered that these data do not by any means offer a clear picture of, or arbitrary conclusion as to, the relation of the enzymes in the whole digestive scheme, where the enzymes in natural association are mingled under exceedingly complex conditions; first as to the influence of the constituents of the juices on the several enzymes thereof; secondly as to the influence of each secretion in its entirety upon the other, and as to the influence of the food constituents in their native form and as converted by gradual and successive digestive changes.

The study of the enzymes in vitro and of the entire digestive secretions warrants the conclusion that the ferments bear a different relation to, and influence upon, each other when mixed together simply with water and with reactions obtained by acids or alkalies, than they do in their physiological interaction. For instance, pancreatin will continue to act in an alkaline medium in the presence of food, and pepsin will continue to act for a long time in the presence of acid albumin, while aqueous solutions of these ferments of the same degree respectively of alkalinity and acidity by simple exposure to ordinary conditions of temperature are rapidly deteriorated.

Pawlow, after his recent elaborate and original studies of the digestive secretions, calls especial attention to the importance of his experiments concerning the "interaction of the digestive juices." He says: "Hence the chemical agencies of digestion form an alliance of a complicated nature in which the individual members are linked together mutually to relieve and support each other"; and he insists that it is indispensable in physio-

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logical inquiry to bring into view the "whole train of normal occurrences"; that "to constantly remember that all parts of the organism work together sheds a bright light over the special field under review."

No official method is given for pancreatin. It is commonly obtained by mechanical and chemical means—by the precipitation of an infusion, or a mixture of the pancreas gland with water freed as much as possible from the fat and connective tissue by mechanical means, this mixed with alcohol in excess, and the precipitate collected, expressed, and dried. Pancreatin is also prepared from the animal pancreas by freeing the gland in so far as possible from connective tissue and fat by careful trimming, reducing to pulp, passing through a sieve, desiccating and powdering, and further purifying by extraction with suitable solvents of fat, coloring matter, etc.

A liquid diastasic extract of the gland may be obtained by treating the pancreas as soon as possible after removal from the animal, the gland meanwhile kept refrigerated, in which state the trypsinogen remains unchanged; rapid extraction and clarification yield the amylopsin in an exceedingly active form, and by repeated filtration an agreeable, efficient pharmaceutical product is finally obtained.

Pancreatin as a remedy in intestinal indigestion is usually administered in two- to five-grain doses, about three and a half hours after meals and at bedtime, in capsules or tablet form. It is also given with soda bicarbonate (ten grains) an hour or so before breakfast or at bedtime, taken in a glassful of water as hot as can be conveniently sipped, say, 115°–130° F., this particularly in catarrhal conditions and in biliousness. Pancreatic extract with oxgall, ipecac, and bismuth has gained repute in disorders of intestinal digestion. The elixir or essence of amylopsin is much used as a remedy in salivary or intestinal indigestion; in the former case it is given immediately before food, or mixed at table with farinaceous food. Inasmuch as the full pitch of gastric acidity does not appear until about half an hour after eating, this diastase certainly has the same physiological conditions for its activity as that normally mingled with the food in the saliva. The diastasic essence is given at the completion of stomach digestion to promote intestinal starch digestion.

In the artificial reinforcement by pancreatic ferments, the essential consideration is obviously to protect them from action *in gastro;* and clinical experience, with the various expedients used, has shown that the pancreatic ferments exert distinctly beneficial action.

The pancreatic ferments are peculiarly and happily fitted for the preparation of partially or completely digested foods for the sick; under their influence and by very simple means and methods, the chief and complete foods of almost every variety are readily peptonized in the household. These foods may be so prepared as to convey the ferments in an active form, thus promoting further digestion, or the digestive agent may be destroyed at any desired stage by raising the temperature of the food to 160° F., or, more simply, to the boiling point.

Special products and devices, such as peptonizing tubes, are much used; milk, either cold or by the warm process, is thus adapted to the varying requirements. The peptonized milk gruel deserves more extensive use, as the simultaneously converted farinaceous foods—wheat, arrowroot, etc.—increase the nutritive value and convey a very agreeable taste, masking that of the milk. Porridge of oatmeal, wheat, etc., is easily made more digestible by adding, at the proper temperature, a small quantity of the diastasic essence to a portion as served at the table; for the aged and for infants this is an efficient method. (See also article on *Dietetics.*)

Trypsin as a surgical solvent is peculiarly serviceable in cases in which acid is undesirable or alkali necessary; in such situations, and where fluid cannot readily be kept in contact, the trypsin powder is preferable, adhering as it does to moist surfaces, and being thus exceedingly active; in nasal diseases, in diseases of the throat, urethra, etc., the trypsin powder is successfully applied. By its use in diphtheria, great relief is often afforded to the distressing local manifestations, in addition of course to the specific constitutional treatment. The pancreatic extract has been used with marked success as a solvent in abscess cavities of the liver, hip joint disease, etc.

Trypsin is used as the essential agent in the preparation of an artificial human or humanized milk from cow's milk, for the reason that cow's milk proteids, under the regulated influence of the enzyme, become practically identical in solubility with the proteids of human milk; in consequence of this change a cow's milk mixture with percentage composition adjusted to the standard of human milk becomes notably thinner, of a grayish-yellow color, and acquires a marked resemblance to human milk in physical and physiological characteristics and deportment with all reagents. This milk so converted by trypsin gives minute, diffusible coagula with gastric juice, and with acid of normal gastric percentage; it corresponds in digestibility in vitro to human milk with pepsin and acid, and is not coagulated by rennet. The enzyme itself, as the physiological factor in the process, is instantly destroyed by simply heating the milk to 160° F. or by boiling it after the enzymic action has been utilized; the enzyme thus becomes so much inert proteid, so minute in amount as to be a negligible quantity in the food and quite incapable of in any way influencing the digestibility of the milk.

This use of the enzyme in infant feeding is based on the unquestionable postulate, confirmed by all data, chemical, physiological, and clinical, that the radical difference in digestibility and deportment between cow's and human is milk attributable to the nature of their respective proteids—largely casein in cow's milk, and soluble, non-coagulable peptone-like proteids in human milk; it is also based upon comparative analyses and observations of this humanized milk and many specimens of average, normal human milk. Theoretical objections based upon presumed defects in this method, as presenting a food unnaturally digestible or conveying a digestive agent, are obviously erroneous in view of the foregoing facts. The enzyme may, however, be so used as to secure a degree of digestibility beyond the normal where this is required, by simply prolonging the subjection of the casein to the proteolytic agent or the enzyme administered in the food, by chilling the milk instead of pasteurizing or sterilizing it when the desired degree of digestion is accomplished. In fact, this is like the use of the enzyme as a means of aiding the digestion of mother's milk itself by giving pancreatin in a few one-grain doses immediately after nursing.

Benjamin T. Fairchild.

PANCREON is a combination of pancreatin with tannic acid, said by Gockel to possess the tryptic, amylolytic, and emulsifying powers of pancreatin, but to be unaffected by the gastric juice. Out of 100 gm. of albumin subjected to the action of 1 gm. of pancreon for fifteen minutes at 40° C. (104° F.) in a weak alkaline medium, 85 gm. were digested. The dose of pancreon is 0.3–0.5 gm. (gr. v.–viij.) three times a day.

W. A. Bastedo.

PAPAW JUICE.—*Papaya. Carica.* The milk juice obtained from the nearly ripe fruit of *Carica Papaya* L. (fam. *Papayaceæ*).

This interesting plant is the well-known melon tree of tropical America, now widely introduced into other tropical countries. All of its parts contain a latex or milk juice, which is more abundant and more milky in the nearly ripe fruit than elsewhere. This milk juice possesses a bitterish and very acrid taste, is irritant to mucous membrane or to the abraded skin, and has considerable detergent power. It possesses the property of peptonizing albuminous substances, after the manner of trypsin, and of softening an additional portion which is not truly peptonized. By reason of its possessing this property, it has been largely used in its own home for application to tough meat to render it more palatable and

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digestible, a fact which has led to its examination by chemists and physicians with a view of determining its availability for use as a digestant. Its digestant principle has eluded isolation, as have all similar substances. It has been found possible, however, to concentrate the activity in a peculiar extract called caricin (Moncorvo), papain (Wurtz), or papayotin (Peckolt), which is extracted with water, the solution filtered and the filtrate precipitated with alcohol, and perhaps again dissolved and reprecipitated for somewhat further concentration. The fresh juice, which consists largely of water, yields also considerable resin, divisible into two portions, nearly five per cent. of a kind of caoutchouc, a little fat, malic acid, leucin, tyrosin, and other unimportant matters. The leaves, from which the papain can also be obtained, yield the crystalline alkaloid *carpaine* ($C_{14}H_{25}NO_2$), which is most abundant in the young leaves, constituting about one-fourth of one per cent. of their weight when dried. The seeds, which are pungent and which are used for their tænicidal properties, contain a resin which shares the pungency, though the latter is said to be due to a volatile principle allied to the volatile oil of mustard.

Action and Uses. Since about the year 1880, great attention has been given in Europe and America to attempts to employ papain as a digestant. Reports as to the energy, and even as to the manner of its action, vary most widely, even when presented by careful experimenters, and the conviction is forced that the market preparations employed by them must have differed in character. It appears very likely that some of these preparations were mixtures of different digestive ferments, the results being such as might be expected from an admixture to the papain of pancreatin or pepsin. Much of the information which has been supplied to physicians, and which has found its way into professional journals and books, has been smuggled under the guise of scientific literature from interested commercial sources.

It has been definitely established that as a digestant papaya is wholly proteolytic. It disintegrates, softens, and liquefies albumen in the form of white of egg, musculin, fibrin, and casein, and considerable of the product is peptonized. This action takes place in an alkaline or neutral medium. Davis (1893) and Hobein (1894) have shown that it is inactive in an acid medium, the papain employed by the second-named authority having been prepared by himself from papaya. Fairchild, using specimens the identity and purity of which were authenticated by himself, has fully confirmed this conclusion. Nevertheless, some eminent authorities claim that there is a slight activity in acid media. Dr. Lafayette B. Mendel, who takes this view and who has made special researches in this direction, has furnished us with the following account of the products of papain digestion:

"The products of the reaction of papain with proteids consist in large part of proteoses. Peptones—*i.e.*, compounds not precipitable with ammonium sulphate, but still giving the biuret reaction—are also formed. The papain proteoses resemble the related products obtained by gastric digestion. Regarding the occurrence of further products of proteolysis, such as leucin, tyrosin, tryptophan, and other characteristic derivatives of tryptic digestion the evidence is somewhat uncertain. Underhill and the writer have usually failed to find leucin, tyrosin, and tryptophan in appreciable quantities, at least under conditions in which they are readily formed in large quantities by other tryptic enzymes. Emmerling has succeeded in isolating small quantities of these substances from the products formed after very prolonged digestion, although even under such conditions proteoses predominate. Papain accordingly resembles trypsin in dissolving proteids in media of various reactions, thus differing from pepsin; its resemblance to the latter lies in the similarity of the products formed by the two enzymes. Harlay has made comparable observations with the enzyme of the related *Carica hastifolia*. Kurajeff has found that commercial preparations of papain induce the formation of peculiar proteid precipitates in solutions of proteoses such as the widely used 'Witte-pepton.' The reaction corresponds with that described for rennin as 'plastein formation,' by Danilewski and his co-workers. The importance of this proteid-clotting or precipitating function of enzymes can only be conjectured at present. Thus it may play a rôle in proteid synthesis and regeneration; and the significance of such an enzyme in plants at once becomes apparent. On milk papain preparations exercise a clotting or curdling action. Whether these properties are all due to the same enzyme, or whether more than one unorganized ferment is present in the plant, are questions which have not yet been settled."

Riedel, who in 1894 made a very elaborate series of experiments to determine the most favorable conditions for the activity of papain, concluded that the most favorable temperature was about that of the body; that one part of papain to one hundred of albumin was the most favorable proportion; that the more concentrated the papain solution the greater the activity, and that the capacity of papain for digesting egg albumen was about one hundred times its own weight. The answer to the last question depends naturally upon the degree of concentration of the papain; yet it has been found impossible to carry this concentration more than a little way. The activity of a definite portion of the dried papaw juice itself is much greater than that of the papain extracted from it; a single instance is recorded in which such a juice, very carefully prepared, digested one thousand times its own weight. The difficulty is that this action is extremely variable; so much so that it is not at all probable that commercial dried papaw juice could ever be brought to a uniform standard of strength.

As a general statement, it may be said that a good average sample of papain is capable of digesting from fifty to one hundred times its own weight of albumen, under favorable conditions. It is also very noteworthy that it loses its power rapidly upon being kept. If kept with ordinary care in well-stoppered vials it will ordinarily have but little value at the end of a year.

As to whether papain possesses any diastasic action in the conversion of starch, we have also discordant reports, but are obliged to conclude that it has none. As to its milk-curdling power, it certainly possesses a small and variable degree; but this is of a peculiar character, the process and the coagulum differing distinctly from those resulting from the use of rennet.

Papaya is a powerful irritant to denuded tissues and to mucous membrane. So powerful is this action that if a large amount be taken into the stomach in concentrated form it acts as an irritant, or even as a caustic emetico-cathartic poison. Applied to a raw surface it acts as an escharotic, and is very apt to be followed by putrefactive processes. Papain, prepared as above described, is less active in this direction, though still irritant. Desjardins states that the irritant property is almost completely destroyed by boiling, which also produces a new substance, having a powerful lumbricidal action, similar to that of the seeds.

The principal native use of papaya has been stated above. Owing to its locally stimulant action, it has also been used as a cosmetic, to remove pimples and similar roughnesses from the skin, and to produce a smooth, healthy surface. Its irritant properties have been utilized in the form of caustic applications to cancerous and other morbid tissues, but the practice cannot be considered good. Its dissolving action upon albuminous substances has been utilized by applying it to diphtheritic membranes. For this purpose a five-per-cent. solution, preferably made alkaline with 0.5 per cent. of bicarbonate of soda or potash, is applied at short intervals with a brush, or in the form of a spray. The results appear to be highly irregular and uncertain. A similar solution, but twice as strong, is applied to warts, corns, and other cutaneous indurations. Almost its entire use in Europe and America is for internal administration as a digestant, either alone or combined with other ferments. Owing to its irritant effect it should be administered when the

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stomach is full of food, and dilution with milk-sugar or other neutral substance is desirable. Opinions differ widely as to the dose, but the best evidence is in favor of the use of a considerably larger dose than that of official pepsin. Where there is an irritable condition of stomach or bowels, the dose should be reduced, and the drug should not be used in case of an inflammatory condition of those organs.

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Allied Drugs.—The juice of the fruit and leaves of the pineapple has similar properties and uses, already referred to under *Bromeliaceæ*. *Henry H. Rusby.*

PARA-ACET-AMIDO-PHENOL ETHYL CARBONATE, a tasteless, white, crystalline powder, insoluble in water and readily soluble in alcohol, is administered in dosage of 0.5 gm. (gr. viij.) as an antipyretic, analgesic, and hypnotic. *W. A. Bastedo.*

PARA-CHLORALOSE. See *Chloralose*.

PARACHOLIA.—The term used by Pick to designate the hypothetical secretion-anomaly by which the bile leaves its accustomed channels and passes into the blood, giving rise to icterus. By a number of recent writers icterus is regarded as due to a diseased condition of the liver cells, the process being analogous to the secretion of albumin in diseased conditions of the kidney cells. Normal liver cells should secrete bile into the bile vessels, and urea and sugar into the blood capillaries. According to Minkowski it is, therefore, not without analogy that the liver cells in diseased conditions should give off the bile into the blood-vessels. Such a process is designated by him as *parapedesis*. Liebermeister and Pick also explain many forms of icterus as due to functional disturbances of the liver cells, either with or without evident anatomical changes, the former designating such a disturbance as *diffusion* or *akathectic icterus*, the latter as *paracholia*. Pick believes that the pathogenesis of the obscure forms of icterus may be explained by this hypothesis. He accordingly distinguishes three classes: *nervous paracholia*, *toxic paracholia*, and *infectious paracholia* (*Wiener klin. Wochen.*, 1894). *Aldred Scott Warthin.*

PARADISE SPRING.—Cumberland County, Maine. Post-Office.—Brunswick. Hotels and inns.

This spring is located about one mile from the centre of the village of Brunswick and five hundred feet from the Androscoggin River. It is reached by way of the Maine Central Railroad to Brunswick, and thence by Jordan Avenue. The country about the place is level—a sandy plain, covered by pines extending to beautiful Casco Bay, three miles distant. Concerning the meteorological conditions prevailing about Brunswick, we are indebted to Prof. Leslie A. Lee, of Bowdoin College, for the following description: "The climate of Brunswick is peculiarly agreeable. Fair weather predominates, the annual number of cloudy days averaging not more than eighty-six in a long period of years. The prevailing winds are from the southwest during the summer and from the northwest during the winter. On this account the air is much drier than would be expected from the proximity of the village to the sea, and fogs rarely occur."

Scattered throughout the town are large areas of pine forests, which give a resinous and balmy quality to the air. The average annual temperature is 44.40° F., rising to an average of 65.11° F. in the summer, and falling to a mean of 22.63° F. in the winter. The temperature of the spring water is about 45° in summer and 43° F. in winter. The outflow of water is abundant, being estimated at twelve thousand gallons per day. The following analysis was made by Prof. Henry Carmichael, of Bowdoin College: Reaction neutral. One United States gallon contains: Silica, gr. 0.38; iron oxide, a marked trace; calcium sulphate, gr. 0.06; calcium carbonate, gr. 0.07; magnesium carbonate, gr. 0.06; sodium chloride, gr. 0.02; sodium carbonate, gr. 0.36; potassium chloride, gr. 0.04. Total, 0.99 grain.

A more recent analysis by State Assayer Franklin C. Robinson shows a somewhat larger proportion of solids, viz., 1.05 grains per United States gallon of inorganic salts. The water is remarkably free from organic matter, containing, according to Robinson's analysis, but 0.07 of a grain per United States gallon. This organic matter was found by examination to be of vegetable origin, only a minute trace of nitrogenous material being detected. The water is excellent for table use, and has been supplied to the students of Bowdoin College for some time past. It is used commercially. *James K. Crook.*

PARAFFIN INJECTIONS. See *Reparative Surgery*.

PARAFFIN-XYLOL is a solution of 1 gm. of paraffin in 10 c.c. of xylol, and is used as an antiseptic varnish for the hands in surgical operations. *W. A. Bastedo.*

PARAFORM—paraformaldehyde, triformol, trioxymethylene $(HCOH)_3$—is a polymer of formaldehyde occurring as a white, insoluble, crystalline powder. It tends to decompose slowly with the production of formaldehyde gas, and, when acted upon by heat, as in some of the formaldehyde generators, may evolve the gas rapidly and in large quantities. On account of its slow and steady evolution of formaldehyde, it is used by physicians as an intestinal antiseptic and by dentists for disinfecting cavities. The dose is 0.5–1 gm. (gr. viij.–xv.). Unna prescribes: ℞ Paraform 2 gm. (gr. xxx.), ether 2 c.c. (♏ xxx.), and flexible collodion 15 c.c. (℥ ss.) as the best application for pityriasis versicolor, erythrasma, and other saprophytic skin diseases. Meuse uses a three-per-cent. paraform collodion as a slow caustic for warts and other small cutaneous growths.

Paraform enters into the composition of eka-iodoform. *W. A. Bastedo.*

PARAISO HOT SPRINGS.—Monterey County, California. Post-Office.—Paraiso Springs. New Cottages.

Access.—Take 8:15 a.m. Southern Pacific train from the corner of Third and Townsend streets, San Francisco, reaching Soledad station at 1:43 p.m. Thence by stage a drive of one hour and a half to the springs.

"Paraiso Springs," says Mr. E. S. Harrison in his history of Monterey County, "were the property of the Mission Soledad, which lies about five miles northeast of the springs. The title of the present owner was obtained from the Church of Rome, to which a patent was granted by the Mexican Government in 1778. In the records of the Mission Soledad the healing and invigorating qualities of these waters are duly set forth. The springs are situated in a picturesque alcove of the Santa Lucia Mountains on the western border of the Salinas Valley, about one hundred and fifty miles south of San Francisco. The altitude of the location, being nearly one thousand feet above the valley, renders the atmosphere dry, bracing, and invigorating. Below the resort, and for miles beyond, the eye scans the fertile valley, traversed by the grand Salinas River and Arroyo Seco, and the far-away Gabilan Mountains, forming a picture of great charm and glory. The commodious hotel and cottages combine all the luxury and comforts that can be found anywhere. On the premises are several valuable springs flowing about two thousand gallons of water per hour, and consisting of sulphur, soda, and iron waters. The temperature of the springs varies from 100° to 118° F. We give below the analyses of the waters of the two principal springs, the Paraiso Sulphur Spring and the Great Paraiso Hot Soda Spring.

The Paraiso Sulphur Spring.—According to the analysis made by Dr. Anderson in 1889, one United States gallon contains: Sodium chloride, gr. 2.76; sodium carbonate, gr. 1.15; sodium sulphate, gr. 37.10; potassium sulphate, gr. 0.83; magnesium carbonate, gr. 6.09; magnesium sulphate, gr. 2.19; calcium carbonate, gr. 0.89; calcium sulphate, gr. 4.40; ferrous oxide, gr. 0.73; silica, gr. 2.55; organic matter, gr. 7.35. Total, 66.04 grains. Gases: carbonic-acid gas, 2.04 cubic inches,

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sulphureted hydrogen, 9.25 cubic inches Temperature, 114° F.

This is said to be one of the best bathing waters on the coast.

The Great Paraiso Hot Soda Spring.—One United States gallon contains: Sodium chloride, gr. 3.37; sodium carbonate, gr. 5.06; sodium sulphate, gr. 34.60; potassium chloride, gr. 0.32; potassium sulphate, a trace; magnesium carbonate, gr. 0.75; magnesium sulphate, gr. 1.10; calcium carbonate, gr. 1.30; calcium sulphate, gr. 6.45; ferrous carbonate, gr. 0.89; alumina, gr. 0.56; silica, gr. 2.90; organic matter, gr. 4.15. Total, 61.45 grains. Free carbonic-acid gas, 2.95 cubic inches. Temperature of water, 118° F.

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Qualitatively this water closely resembles the famous Carlsbad Sprudel water, but is less highly mineralized. Thousands of visitors, invalids, and pleasure-seekers visit Paraiso Springs yearly, and the excellence of the mineral waters, the salubrity of the climate, and the picturesqueness of the location bid fair to make Paraiso one of the most prominent health resorts in California.

James K. Crook.

PARAKERATOSIS. See *Cornification.*

PARALDEHYDE.—Parethylaldehyde: $3(C_2H_4O) = C_6H_{12}O_3$. Paraldehyde is a polymeride of common ethylic aldehyde, producible by the action of a considerable number of substances upon such aldehyde. Paraldehyde is, at ordinary temperatures, a liquid, colorless, of a burning taste and powerful and penetrating ethereal odor. It dissolves in 8.5 parts of cold water and in 16.5 parts of boiling water. It mixes in all proportions with alcohol, ether, and fixed or volatile oils. At 0° C. (32° F.) paraldehyde solidifies to an ice-like crystalline mass, or may crystallize in distinct prisms. It should be kept in well-stoppered, dark amber-colored bottles, in a cool place. Paraldehyde is peculiar among ethereal bodies for possession of the property of determining *sleep*, with a minimum of by-effects. The sleep produced by the medicine seems a quite perfect imitation of natural slumber, since the subject under the influence of the hypnotic is as easily awakened as from ordinary sleep. No worse derangements occur from the medicine than a little dryness of the throat and thirst, and a trifling reduction of pulse rate and arterial tension. The most disagreeable circumstance attending the use of paraldehyde is a persistence of the taste of the drug upon the palate, and of the odor in the breath, often for a number of hours after the taking. Also it may disorder the stomach. The sleep produced by a perfectly legitimate dose of paraldehyde may begin within fifteen minutes after the swallowing, and last five, six, or seven hours. The medicine is used exclusively for the procurement of sleep, and is applicable, without special contraindication, for any case in which that therapeusis is proper. A quantity of from 2 to 4 gm. (from ♏ xxx. to lx.) is the average dose, and the same is best given dissolved in 30 gm. (fl. ℥ i.) of an aromatic water, sweetened.

Edward Curtis.

PARALYSIS.—The term paralysis, in its more limited sense, denotes complete or very pronounced loss of muscular power. The term paresis is sometimes employed to designate lesser degrees of loss of power. Paralysis is the result of functional or organic changes in the nervous system (central or peripheral), but in a comparatively rare group of diseases it is due to primary changes in the muscular fibres (pseudohypertrophic paralysis and allied forms).

Loss of muscular power may vary widely in its distribution. When confined to a single limb or part of a limb, it is known as monoplegia; when it involves one side of the body it is called hemiplegia. If the hemiplegia is present on both sides of the body, the term diplegia is used. Paraplegia is paralysis of both lower limbs (usual form), of both upper limbs, or of all the limbs.

In ascertaining the existence of paralysis of any part of the body, we must not be satisfied with merely noting the absence or diminution of motion in the suspected part. We must also make sure that there is no mechanical obstruction to motion, such as ankylosis, fracture or dislocation, and that it is not inhibited by pain. Furthermore, the patient must be in a condition to understand our directions. Even when the patient is profoundly comatose, we may usually diagnose the existence of paralysis by noting the increased resolution and flaccidity of the parts when compared with the corresponding ones on the opposite side of the body.

Various instruments, called dynamometers, have been devised to test the amount of muscular power, but they are unnecessary for practical purposes and for the most part unreliable. If the paralysis is very marked, the loss of function is forthwith noticeable. If the loss of power is not so pronounced, the patient is directed to overcome the resistance to various movements offered by the physician. For example, in order to test the power of the quadriceps femoris the patient is directed to flex the thigh on the abdomen, against the resistance offered by the physician. This is then compared with the resistance offered on the healthy side (it must not be forgotten that the right limbs are usually somewhat stronger than the left). In cases of paraplegia we must rely upon our knowledge of the degree of resistance which should be offered normally, taking into consideration the muscular build and habitus of the patient, his general nutrition, intelligence, etc.

We must always be on our guard against mistaking paralysis for the immobility due to painful affections. For example, a case of acute articular rheumatism in a child was sent to us with the diagnosis of paraplegia, the apparent paralysis being due merely to the pain in the joints.

We must next determine whether the paralysis is functional or organic. Functional paralysis is usually hysterical and the general condition of the patient exhibits the evidences of that neurosis. Hysterical paralysis rarely affects individual nerves. It generally involves muscles in functional groups, not according to strict anatomical distribution. Some symptoms are usually found which point directly to a non-organic origin. For example, in the recumbent posture the paralyzed legs may be capable of certain voluntary movements, or they may be moved involuntarily during excitement, while on attempting to walk the loss of power may appear absolute. Furthermore, hysterical paralysis is often preceded by undoubted hysterical seizures, and it may change very rapidly in degree. Sensory disorders are very common and, like the loss of motion, are not confined strictly to the anatomical distribution of individual nerves. They consist very often of hemianæsthesia, accompanied by concentric narrowing of both fields of vision.

The differentiation of peripheral from central paralyses is usually not a difficult matter. The muscles affected in the peripheral forms are supplied by one or more nerves, and a knowledge of the functions of the muscles will enable us to recognize these nerves. As the majority of the motor nerves are mixed in character, the distribution of the attendant sensory disturbances will aid still further in localizing the lesion. In mild cases there may be no change in the electrical reactions of the muscles; in severer cases there may be all possible gradations between simple diminution of electrical irritability and complete degeneration reaction. The latter is also observed, however, in certain forms of spinal-cord disease.

Atrophy of the muscles is common in peripheral paralysis, but extremely rare in cerebral paralyses; it is a constant symptom of diseases of the anterior horns of the spinal cord.

Paralysis of spinal origin usually takes the form of paraplegia, and is attended not infrequently by interference with micturition, defecation, and the sexual function. The limbs may or may not undergo atrophy, and they exhibit the degeneration reaction, according as the anterior horns are implicated or not. The patella reflexes may be lost, but if the lesion is situated high up in the cord, the tendon reflexes as well as the cutaneous reflexes may

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be greatly exaggerated. Contractures are apt to develop, and are perhaps more pronounced than in any other forms of disease.

Cerebral paralysis is usually hemiplegic in character, and its onset is generally attended by symptoms of apoplexy; sensory symptoms are subsidiary. Hemianæsthesia is sometimes present at the beginning of the seizure, but usually disappears in a few days. The paralyzed muscles rarely undergo atrophy and the electrical reactions are unchanged. Contracture of the muscles develops after a while and, like the paralysis, is more marked in the upper limb.

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In the majority of cases the diagnostic features described above will enable us to locate the lesion which has produced the paralysis, but in exceptional cases a probable diagnosis alone can be made, after giving due weight to the attendant symptoms, etiology, etc.

The prognosis and treatment of paralysis will depend upon the primary disease, and will be considered in the various special articles. *Leopold Putzel.*

PARALYSIS AGITANS.—(Synonyms: Shaking palsy, Parkinson's disease.)

Etiology.—Paralysis agitans is one of the diseases of advancing years, and the large majority of cases develop after the age of forty to forty-five years. It is a mistaken idea, however, to regard it as an indication of senility. In a few exceptional instances the disease has begun at a much earlier period, and cases have been reported at the age of twenty, seventeen, twelve, and even three years. It is very often difficult to determine the exact period at which it begins, because the inception is usually very gradual and is often unnoticed by the patient.

Unlike other neuroses, heredity plays a very slight part in this affection. Only a few cases have been reported in which other members of the patient's family suffered from this or some other form of nervous disease.

Paralysis agitans is a rare disease. Among 4,600 patients under my observation, during a period of eleven years, at the Clinic for Nervous Diseases in the Bellevue Outdoor Department, there were 30 examples of paralysis agitans, 19 of which occurred in males, 11 in females.

It has been said that the Anglo-Saxon race is especially predisposed to the disease. At all events there can be no doubt that reports of cases are comparatively rare in the otherwise very prolific German literature on nervous affections. We may also state, with regard to New York, that the disease is frequently mistaken here for senile tremor or multiple cerebrospinal sclerosis.

Prominent among the exciting causes stands emotional excitement, usually of a depressing nature, such as fright and anger. Several cases of this kind were observed among the inhabitants of Metz and Strasburg during the sieges experienced in the Franco-Prussian war. Lorain (*Arch. de Méd.*, vol. i., 1875, p. 214) reports the following striking example: A girl, aged seventeen, was frightened by the bursting of a shell in the cellar in which she had taken refuge during the siege of Paris. This was followed immediately by tremor of the right arm, which soon extended to the rest of the body. At the end of five years she was still suffering from paralysis agitans.

Long-continued worry and grief appear to act in the same way as sudden emotions.

Living in damp rooms, or protracted exposure to wet and cold, is also said to give rise to the disease, and in our experience this has seemed to be the most efficient of all the etiological factors. Some patients inform us that the tremor began immediately or shortly after catching cold, from a single exposure to wet or cold, but it is doubtful whether there is any real connection between the two events.

A number of cases have been reported in which the disease had a local origin in an injury to the arm or leg (sometimes, perhaps, as the result of a peripheral neuritis). In such cases the tremor begins usually in the injured part, but then spreads to the rest of the body and pursues the ordinary course of paralysis agitans.

Ball claims that paralysis agitans and insanity are associated more frequently than is commonly believed. The insanity, according to this writer, is always of a depressive character, generally melancholia, with suicidal impulses and numerous hallucinations. In some cases a condition of dementia and of "demi-stupor" predominates.

Clinical History.—When the disease begins slowly, as usually happens, it is sometimes preceded by prodromes. These consist of wandering pains in different

Fig. 3737.—Position of the Body in Paralysis Agitans. (From Seiffer: "Diagnostik u. Therapie d. Nervenkrankheiten.")

parts of the body, occasional formication, or a feeling of weakness in the parts that are attacked at a later period by the tremor. In some instances the tremor does not remain constant after its first appearance, but subsides at times until again provoked by some exciting cause. In rare cases the disease begins suddenly, as we have seen in the section on etiology, and may spread quite rapidly to the entire body.

In the majority of cases tremor first appears in an arm or leg (usually the former), and then extends to the other limb on the same side. After a longer or shorter time (sometimes several years) it spreads to the other side of the body, generally attacking the latter in the same order. The head and trunk may also become involved. Charcot claimed that the apparent tremor of the head was always the result of the transmission of the movements of the trunk and limbs. This has been disproven by numerous cases, and several instances have fallen under our own observation. In rare cases the tremor first attacks the arm of one side and the leg of the opposite side, or it assumes a paraplegic form, involving both lower limbs. But sooner or later it extends to the rest of the body.

Coincidently with the tremor (in some cases even preceding it) the muscles of the body acquire a certain degree of rigidity, and the body assumes a peculiar, almost pathognomonic, position, as shown in Fig. 3737.

The motor power of the limbs remains comparatively unchanged for a long time, even for many years, but in the last stages general paralysis sets in. Sensation is unaffected throughout the entire course of the disease. The

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reflexes are unchanged. Unless life is terminated by some intercurrent disease, the patient finally lapses into a condition of mental hebetude, becomes bedridden, and loses power over his limbs; then the functions of the bladder become impaired, bedsores develop, and finally death ensues.

We will now enter into a more detailed examination of the various symptoms.

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The tremor, which is one of the most striking features of the disease, and the one from which, in fact, it derives its name, consists of very quick, uniform, and limited excursions of the affected parts during repose. There are usually four or five oscillations in a second. In the first stages the patient is able to control the tremor for a time by an effort of the will, or by executing a voluntary movement of the parts. But, as the disease advances, this power is diminished, and, finally, while the patient may, for a very brief interval, moderate the severity of the tremor, a voluntary effort is soon followed by increased violence of the movements. The tremor subsides during sleep, but the patients are very restless at night and do not remain long in one position. The cessation on voluntary effort was regarded by Charcot as a pathognomonic differential sign, distinguishing the disease from the tremor of multiple sclerosis. But Westphal has reported a case in which the tremor of sclerosis presented the same characteristics as that of paralysis agitans; and a similar case, in which an autopsy was obtained, has come under my own observation. Magnan has also reported a case of paralysis agitans, in which the movements did not occur unless the patient performed some voluntary act which required a certain degree of attention on his part. As a rule, the fingers and forearm are the parts most affected; next follow the foot and leg. In the large majority of cases the head also presents rhythmical movements, but these are generally conveyed from the trunk and limbs. In not a few cases, however, certain of the facial muscles, particularly of the lips and chin, present tremulous movements similar to those of other parts. In still rarer cases the tongue, when protruded, also presents oscillatory movements, but these are never so pronounced as in other muscles.

Rosenberg has reported a rare case of tremor of the velum palati and epiglottis. The laryngoscope showed that the vocal cords came together, promptly on phonation, but the tension of their edges changed, the gap between them being sometimes linear, sometimes a broad ellipse. The body of the vocal cords showed twitching movements, which had the same rapidity as the general tremor. When the patient was directed to hold a note as long as possible, a rhythmical change from high to low pitch became noticeable.

The appearance of the body, when the disease is fully developed, is highly characteristic, and, indeed, almost pathognomonic.

The face has a peculiarly stolid, rigid appearance. The eyes have a dull, lack-lustre look, and their movements are slow, as if the muscles were rigid like those of the face and rest of the body. Two cases have been reported in which so called ocular lateropulsion was observed. The patients, while reading, experienced a certain amount of difficulty in directing the gaze from the end of one line to the beginning of the next line. This is most noticeable if the reading matter is arranged in columns. When they have arrived at the end of a line, the eyes involuntarily seek the corresponding line in the next column, because the ocular muscles cannot be moved with the normal rapidity.

The facial muscles have lost their emotional play almost entirely, and the face therefore looks as if covered with a mask. At times the muscles of the mouth and chin present tremulous movements similar to those observed in the extremities. The mouth is sometimes kept slightly open, and the saliva may dribble constantly in advanced cases. Speech is slow, labored, and extremely monotonous. It sounds as if the muscles of speech had to overcome some unusual resistance before the words can be enunciated. The speech is unchanged by emotional excitement, and, if we may use the expression, appears to be covered by a veil. According to Buzzard, the piping voice of old age is really a symptom of paralysis agitans, and not of senility. In certain cases the words sound as if they were jolted out of the patient's mouth, like the conversation of an unskilful rider while on horseback.

The head is held forward, and the chin may even be closely approximated to the sternum. The muscles of the neck are usually rigid and offer considerable resistance to passive motion. Three cases, I believe, have been reported in which the head was drawn backward instead of forward. A fourth one has come under my observation. In some cases the muscles of the neck present independent tremor, but their movements are usually conveyed from the trunk. In the latter event the head will remain quiet if the movements of the body are forcibly restrained. The trunk is generally in a condition of anteroflexion, as shown in Fig. 3737. The arms are usually drawn slightly forward, and the elbows are slightly separated from the side of the chest. The forearms are strongly flexed, partly pronated, and they ordinarily lie across the abdomen. These parts are in a state of constant tremor, though this is not so vigorous as in the hands. The fingers are usually flexed, the thumb is adducted, and also very slightly flexed. The thumb and index finger are continually moving to and from one another, as in the act of writing, or making pills; the other fingers are in a condition of constant fine tremor. In other cases the position of the fingers resembles that of arthritis deformans, but the joints are not swollen as in the latter disease.

The lower limbs are moderately flexed at the thighs and knees, and the latter are drawn inward. The feet are in the position of equino-varus. The toes are extended at the first phalangeal joint and flexed at the other phalangeal joints.

The patient's gait is also very characteristic. Upon attempting to rise from a chair a certain amount of difficulty is experienced, as if he were compelled to overcome some resistance. He stands still for a moment, as if to steady himself, and then makes short, shuffling steps. The gait gradually increases in rapidity, and may soon pass into a sort of slow dog-trot. In many cases the patient loses his balance and falls, unless supported. Others measure with the eye the distance between the starting-point and their objective point, and learn to regulate their muscular effort in such a way as barely to reach their destination in safety. This so-called festinating gait has been attributed by most writers to the forward displacement of the centre of gravity of the body, so that the body is, as it were, hurried along in order to catch the centre of gravity. This explanation is insufficient, as is shown by the phenomena of propulsion and retropulsion. In some cases, if, while the patient is standing still, slight traction in a forward direction is exercised upon his clothes, he will be irresistibly impelled to move forward in the peculiar manner described above (propulsion). In rare cases, if the traction is exercised backward, the patient will move in this direction in a similar manner (retropulsion). In still rarer cases, the patient exhibits a tendency to move to the side (lateropulsion). In retropulsion, indeed, he is moving in a direction opposite to that of the action of the centre of gravity. Retropulsion and propulsion have also been regarded as forced movements, like those produced by irritation of the cerebral peduncles.

The muscular power of the patient is not much diminished until he becomes bedridden, but he is very easily tired by muscular exertion. Furthermore, an unusually long time elapses before the patient is able to execute any voluntary movement, and when this has been begun it cannot be discontinued as abruptly as in health. This may be readily detected by directing the patient to squeeze one hand firmly and rapidly, and comparing this action with that of a healthy individual. Although the difference is often quite decided, the dynamometer may fail to reveal any real loss of power.

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Paralysis Agitans.

Many patients suffer constantly from a feeling of heat in the skin, or from sudden flashes of heat. In addition, they complain of an indefinable internal restlessness which impels them to change position very frequently. This is often very distressing at night, since many of the patients are unable to turn voluntarily from side to side on account of the rigidity of the muscles of the trunk.

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The cutaneous and tendon reflexes and sensation are unaffected, but in a few cases increase of the knee-jerk has been reported. The sufferer may complain occasionally of pains in the limbs, but the pains are felt chiefly in the back. As the disease advances, the muscular power of the patient is gradually impaired, and finally he is compelled to remain in bed. Then bedsores may develop, the sphincters of the bladder and rectum become paralyzed, and the patient dies of exhaustion. In these cases the mental powers are also apt to undergo very marked deterioration.

Probably in the majority of cases, however, death is the result of intercurrent diseases, among which pneumonia seems to play an important part.

In rare cases paralysis agitans runs its course without tremor. Such patients present all the other evidences of the disease—muscular rigidity, characteristic position of the body, festinating gait, speech disturbances, the sensation of superficial heat, etc.—but the tremor is entirely absent, or is observed only at times to a mild degree.

Within the last few years a few autopsies have been made with the aid of the most approved methods of examination. Kelscher found that the ganglion cells of the cord were strongly pigmented, with granular degeneration in places; degeneration of the nerve fibres, particularly in the posterior columns and in the peripheral nerves; in places the muscular fibres exhibited atrophy and fatty or hyaline degeneration. The interstitial tissue in the cord, the peripheral nerves, and the muscles was increased; the glia of the spinal cord, especially in the cortical layer and around the vessels, was thickened, particularly in the posterior and lateral columns. The walls of the vessels showed thickening, in places miliary aneurisms and hemorrhages.

Sander found, in addition to glia proliferation in the white substance, a similar condition in the gray matter throughout the cord; this was most pronounced in the anterior horns and in Clarke's columns. There were marked arteriosclerotic changes in the finest vessels, with periarteritic and endarteritic processes. In the parts most severely affected there was distinct degeneration of the medullary sheaths of the nerve fibres.

Dana found connective-tissue proliferation in the region of the oculomotor nucleus, very marked atrophy of the cells of the nuclei of the ninth, tenth, and eleventh nerves, and slight atrophy in the facial nucleus; also thickening of the spinal pia mater, dilatation and thickening of the walls of the vessels, especially in the anterior horns of the cord, with atrophic changes in the ganglion cells.

It is very probable that all of the changes found in these autopsies are non-specific in character. They are similar to the senile changes which are commonly found in the central nervous system, and which have also been observed in chronic alcoholism.

Nor must it be forgotten that not a few carefully observed cases have shown entirely negative findings. Hence the disease must still be regarded as a functional neurosis.

Diagnosis.—When the disease is fully developed the diagnosis is extremely easy. But in its early stages it may be mistaken for multiple cerebrospinal sclerosis, senile tremor, or toxic tremor, especially after mercurial poisoning.

Multiple sclerosis is distinguished by the following symptoms: The tremor is coarser and not so rhythmical as that of paralysis agitans, and, with the exception of very rare cases, it occurs only during the performance of voluntary movements. The characteristic position of the body and the peculiar appearance of the face are wanting, while nystagmus, diplopia, and various other cerebral symptoms of serious import are present.

Senile tremor may be as uniform and fine as that of paralysis agitans, but it generally begins in the muscles of the head and neck, and is uninfluenced by repose or motion. The head may be bent forward, but rather as the result of bowing of the back. The patient does not suffer from the peculiar restlessness of paralysis agitans, and the muscular rigidity incident to the latter is wanting. There are also other evidences of senility in the general condition.

In mercurial tremor, examination will always show that the affection has been preceded by the buccal symptoms of mercurial poisoning. The disease is also attended by greater impairment of muscular power and general prostration. The tremor is much more marked during action than during repose. In severe cases it is said to be attended at times with profound deterioration of the mental faculties. This affection appears to be extremely rare in New York, and the very few cases which have come under my observation have occurred in looking-glass makers.

Post-hemiplegic chorea sometimes appears as a fine muscular tremor, and at first sight may be mistaken for paralysis agitans, especially in view of the fact that there is considerable restoration of muscular power in the paralyzed side before the tremor begins. In addition, there is always rigidity of the affected parts. But the clinical history shows that the disease began with an apoplectic attack, and, in addition, the tendon reflexes are always exaggerated. Finally, the subjective symptoms of paralysis agitans are wanting.

Prognosis.—No authentic case of recovery from this disease has been heretofore reported. Indeed, recovery might be looked upon as convincing proof of an error in diagnosis.

During the first stages of the disease temporary remissions sometimes occur, but after a time it shows slow but uninterrupted progress.

The patients usually die of an intercurrent disease, and in many cases life does not appear to be shortened by the malady. Cases have been reported in which it continued for more than thirty years.

Treatment.—The most that can be hoped for from treatment is to produce a certain degree of palliation of the symptoms. In our own hands slight benefit has been derived, in a few cases, from the use of galvanism, nitrate of silver, hyoscyamine, and prolonged rest in bed. Electricity has been employed by me in the form of the constant current of moderate strength, one electrode being placed on the upper cervical spine, the other on the lower dorsal region; sittings three times a week, each one of from five to ten minutes' duration. This plan of treatment must be continued for a long time in order to produce any good results whatever. Nitrate of silver may be given in pill form for a year or more consecutively, but it is well to intermit its administration from time to time. The dose may vary from gr. $\frac{1}{6}$ to gr. $\frac{1}{4}$ t.i.d.

Hyoscyamine sometimes produces very rapid and brilliant temporary results in diminishing the tremor. Even when the tremor is very violent and widespread, it may subside almost completely in a few days. The initial dose should not exceed gr. $\frac{1}{100}$, but this may be gradually increased until the physiological effects are produced. But unfortunately the good effects of this remedy cease as soon as it is discontinued, and it does not seem to us to be entirely safe to give it continuously in sufficient doses for any length of time.

Absolute rest in bed may also exert a favorable influence, but it is very difficult, on account of the great restlessness of the patient, to secure his consent to prolonged treatment in this way. Suspension has been employed in treatment, but its effects appear to be very fleeting, and in some cases it produced harmful results. In the majority of cases we are finally compelled to resort to morphine in order to relieve, in a measure, the sufferings of the patient. *Leopold Putzel.*

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PARALYSIS, ARSENICAL.—Paralysis due to arsenical poisoning is not very rare. The larger number of cases have the appearance, and are, doubtless, mere instances of multiple neuritis. Most text-books do not allude to arsenical paralysis otherwise than by simply mentioning arsenic as one of the causes of multiple neuritis.

Etiology.—Usually the paralysis results from acute arsenical poisoning, the poison being taken either designedly or by accident. The paralysis corresponds in some measure to the intensity of the general poisoning. Not infrequently the paralysis follows the repeated administration of the drug. It has been observed after the ordinary medicinal doses: for instance, after taking from three to ten drops of Fowler's solution three times a day for a number of weeks. In these instances the paralysis is usually of a mild grade. A few years ago there was quite an epidemic of arsenical paralysis in some British towns, Liverpool, Manchester, and other places, which occurred in drinkers of beer, the examination of which revealed the presence of arsenic. In these instances the alcohol may also have played a part in producing the paralysis, but the sufferers were mostly moderate drinkers, and the pain attending the paralysis was more severe than that usually found with alcoholic neuritis.

Paralysis occurs, but less frequently, from the external use of arsenic (salves, baths, etc.), and from contact with fabrics (wall paper, carpets, and artificial flowers) which contain arsenic. Barton reports two cases, in husband and wife, with paralysis following acute poisoning, the man having for some years been rubbing a mixture of four parts of arsenic and three parts of plaster-of-Paris into the skins of animals and birds, while his wife cleaned the room twice a week. Similar cases, from dealing in stuffed birds, working with arsenical draperies, or living in rooms where there were draperies or wall paper containing arsenic, have been reported.

Symptomatology.—In cases of acute poisoning the paralytic manifestations appear shortly after the disappearance of the severe gastro-intestinal disturbance. Paralysis of twenty-four hours' duration immediately after the ingestion of the arsenic has been spoken of, but must be rare or must escape detection. The onset of the paralysis occurs usually from several days to several weeks after the poison has been taken. It is commonly preceded by sensory symptoms, tingling, numbness, intense pains, etc. The paralysis itself begins more or less gradually. Not uncommonly its onset is not observed, but when the acute symptoms have subsided and the patient attempts to get out of bed, it is found that he cannot walk or cannot hold anything in his hands. Occasionally the paralysis is complete, or at least no longer progressive, at an early period but usually some weeks elapse before it reaches its greatest intensity. Almost always, when observed from the beginning, it has been found to commence at the distal ends of the extremities, the fingers and toes, usually first in the lower extremities, and thence extend upward The parts below the knees and elbows are most profoundly paralyzed. In bad cases the muscles of the thigh are also paralyzed, and not infrequently the trunk is more or less paretic. The extensor muscles—the radial group in the upper and the anterior tibial group in the lower extremities—are, as a rule, most profoundly affected When the paralysis is complete the paralyzed muscles are quite flaccid, and we find wrist-drop, foot-drop, etc. At a later period there are very frequently contractures, more or less strong, affecting particularly the least paralyzed muscles. Tremor, often fibrillary in character, is not infrequently observed in the affected muscles. The paralysis just described, affecting the four extremities, the lower more than the upper, is that usually found. In rare instances it is otherwise distributed; sometimes in hemiplegic, and more rarely in monoplegic form. In almost all instances we find great loss of flesh and a general wasting, in addition to pronounced atrophy of the paralyzed muscles. The electrical reactions are those of peripheral paralysis. The reaction of degeneration becomes more or less pronounced a few days, or a few weeks, after the occurrence of the paralysis. At a later period, if the paralysis be profound, all electrical reactions may cease. In some instances slight changes in the electrical reactions may be observed before there is any manifest paralysis, particularly in so far that it requires a stronger faradic current than usual to produce muscular contractions. In lighter cases such electrical responses, especially in the anterior tibial group of muscles, may be the only indication of incipient paralysis.

The sensory symptoms are at times even more pronounced than the motor paralysis. These symptoms are paræsthesiæ of various kinds, tingling, numbness, coldness, etc.; pains, tenderness, and anæsthesiæ. As a rule the tingling and numbness, and very frequently the pains, precede the paralysis. The pains are often intense and constitute the most distressing symptom of the disease. They are usually described as burning, cutting, boring, etc., and are often accompanied by sudden starts, cramps, or spasmodic movements of many muscles of the body. They are usually more or less paroxysmal, and are likely to be worse at night and to keep the patient awake. They occur most frequently in the feet and hands, sometimes appear to be in the joints or bones, and occasionally are in the course of the nerves. Tenderness of the affected muscles is also a common and prominent symptom. The tenderness may be so great as to make the handling of the patient extremely painful. In some instances the tenderness is observed to be in the course of the nerves, but generally it is so diffused that it is hard to state that it is especially over the nerve tracts. Often hyperæsthesia or hyperalgesia is observed, although this may be only an expression of the great tenderness. Loss of or impaired sensation, anæsthesia, is also a common symptom. It is found most frequently in the feet and hands, and especially in the finger tips and toes or soles of the feet, although it corresponds somewhat to the extent of the motor paralysis. Rarely it occurs only in the distribution of certain nerves. Anæsthesia is found in all bad cases of paralysis, and not infrequently in mild cases. Loss of tactile sensation is most common; the loss of the senses of temperature and of pain is also common; and muscular sense is not infrequently impaired. The knee-jerks are usually abolished. This is often true even when the paralysis is slight. Vaso-motor and trophic symptoms, such as œdema, particularly in the feet, profuse perspiration, loss of nails and hair, pigmentation of the skin, herpes, and muscular atrophy, are common.

On the other hand, the cranial nerves and bladder are very rarely affected. In some instances the pulse is more rapid than seems consistent with the patient's general condition; a fact which may be due to an affection of the vagus or of the cardiac ganglia.

As has already been stated, usually several days or several weeks elapse before the disease reaches its acme. Then after an interval, which may be of only a few days' duration, but which sometimes runs into months, the patient begins to improve. The anæsthesia begins to disappear before the motor paralysis. It disappears in the reverse order of its appearance; first from the trunk and the upper part of the extremities, remaining longest in the fingers and toes. The motor paralysis disappears in the same manner: first in the upper part of the extremities, then in the muscles below the knees and elbows. The flexors usually improve more rapidly than the extensors, until finally the only motor symptoms which remain, in the mild cases, are paralyses of the extensors of the feet and toes, and of the extensors and small muscles of the hand. At a late period there are liable to be contractures in the still paralyzed parts. The pains also become modified in intensity after the lapse of some time, but unfortunately they are likely to persist with a greater or less degree of severity throughout the whole course of the disease. The vaso motor and trophic symptoms (œdema, pigmentation of the skin, etc.), usually disappear at a comparatively early period. The whole duration of the disease is extremely variable. Alexander puts it as from eight days to a number of years. It may be stated in general that mild cases usually get well within

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six months, possibly in an even shorter time, whereas in severe cases one or two years elapse before there is complete recovery, or, in those cases in which a cure remains incomplete, before there is a definite cessation of improvement.

In some cases of arsenical paralysis muscular incoordination, ataxia, is a more prominent symptom than paralysis, and to this group of cases the term pseudotabes has been applied. The pains, anæsthesia, absence of knee-jerks, together with the ataxia, make that term seem very appropriate.

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The disease so far described is that following acute arsenical poisoning. In some cases following chronic poisoning the symptoms are much the same, only the onset is likely to be less sudden and the symptoms less severe. In other chronic cases the symptoms are very slow in appearing, and may have been in part masked by those of gastric irritation. The pains are likely to be proportionately greater, and the paralysis slight in degree. But, even when the paralysis is slight, the changes in the electrical reactions are likely to be found. In such instances the motor manifestations may be rather like those of ataxia than of paralysis. Sometimes a sense of profound prostration is the only indication of motor impairment.

There is another class of cases in which the poisoning appears to have been exceedingly slow and insidious. The symptoms in these cases are usually very obscure, and the cause is commonly to be found in arsenical wall papers or the like. Among the symptoms are, gastro-intestinal irritation, neuralgia, headache, insomnia, general prostration, mental depression, impairment of memory and mental endurance, and epileptiform convulsions. As this article is devoted to the subject of arsenical paralysis no further attention will be given to this class of cases.

Pathology.—In the larger number of cases examined only neuritis was found. In a few instances disease has been found in the central nervous system, in the spinal ganglia, in the cord, and even in the brain. Experiments have been made on various animals, but the results are not all in accord. In some instances neuritis only, in others, inflammation in the spinal ganglia, in the anterior cornua of the cord, and in other parts of the central nervous system was found. The probability is that the peripheral neuritis and the affection of the central nervous system, when present, occur at the same time, but that neuritis is the more frequent and of a higher grade of intensity. The clinical picture indicates that the characteristic condition in most instances is multiple neuritis, and if further pathological changes are present they do not contribute to the symptoms presented.

In those rare instances of incontinence of urine, etc., and those with profound and lasting paralysis, the symptoms are probably due to central disease.

Diagnosis.—When it is known that the patient has been poisoned with arsenic, as is usual in acute cases, the cause of the resulting paralysis is apparent. When there is no such knowledge, the history of severe acute gastro-intestinal disturbance preceding the kind of paralysis just depicted should be almost enough to make the diagnosis certain. The picture of the paralysis is fairly characteristic. The four extremities are usually affected, the lower ones being more often and more extensively involved than the upper ones. The paralysis is always greatest in the digital extremities and is attended by atrophy and altered electrical reactions. In addition there are the intense pain and extreme tenderness, and the absence of knee-jerks, of bladder symptoms, and of bed sores.

When the paralysis is less marked, and the whole array of symptoms less conclusive, the greater prominence of the sensory symptoms and the presence of altered electrical reactions in the slightly paralyzed muscles (in this instance it requires a very careful examination to reveal such reactions) may arouse a suspicion of the true condition.

The cases with ataxic gait may suggest locomotor ataxia as the correct diagnosis, and Seeligmueller mentions a case of his own which was falsely looked upon as one of locomotor ataxia. The severe pains and lost knee jerks heighten the resemblances of the two diseases. But with careful examination such errors will rarely occur, for it will usually be found that the difficult gait is rather paretic than ataxic; and, furthermore, symptoms on the part of the bladder and the eyes (such common and early manifestations in locomotor ataxia) are absent.

In cases of chronic poisoning the detection of arsenic in the urine may assist materially in the diagnosis. In acute cases the arsenic has usually been eliminated before or soon after the paralysis appeared.

Prognosis.—Mild cases may get well in a few months, though rarely in less than six; but when there has been profound paralysis, recovery cannot be expected in less than one or two years.

In not a small proportion, possibly in one-fifth, of the cases of extensive paralysis, complete recovery does not take place.

Treatment.—The treatment is that of multiple neuritis.

Philip Zenner.

PARALYSIS, DIPHTHERITIC.—This is paralysis which occurs during or after diphtheria, and is due to changes in the nerves or muscle fibres.

The statistical frequency of diphtheritic paralysis has varied greatly according to different writers. The American Pediatric Society's collective investigation[7] showed that it occurred in 9.7 per cent. of all cases of diphtheria. This is rather low, some figures running as high as twenty-five per cent. or even higher. It is probable that at least ten per cent. of all cases of diphtheria in private practice, properly treated, may be expected to show this complication.

Etiology.—That the pathological lesions upon which the symptoms of diphtheritic paralysis depend are due to the action of the poisons of the disease on certain of the tissues there can be no question, since both the lesions and the symptoms have been produced experimentally in animals by the injection of the toxins.[1,2] Paralytic symptoms may follow diphtheria of all degrees of severity, and instances in which it has complicated cases so mild that the causative sore throat has been unnoticed or forgotten by the patient are sometimes seen in large clinics. As to whether it is more common after the severe cases than after the mild ones there is a difference of opinion. Gowers[3] and Henoch[13] believe that its frequency does not depend upon the severity of the original disease. Goodall[8] and De Gassicourt believe that it does. The former reports a series of cases which seem to show that its frequency is greatest in the cases showing the most extensive membrane.

The influence of the antitoxin treatment upon the frequency of the paralysis is also a matter of doubt. Certain statistics have shown that the use of this remedy has been followed by an increased number of cases of paralysis; but such studies are misleading, since under the use of this method there are many severe cases of diphtheria which recover and have paralysis,—cases that would otherwise die before the time at which the palsy generally begins. It is said that the condition is comparatively rare among cases in which the larynx is the part mainly affected by the diphtheria. Males appear to be slightly more susceptible than females. As to age, Gowers[3] agrees with Landouzy that adults are much more frequently affected. Goodall[8] and Ross[14] find that it is relatively more common in children.

Pathology.—Lesions are found in the central nervous system, in the peripheral nerves, and in the muscles, but there is no doubt that the dominant lesion—the one upon which the clinical picture, at least so far as the peripheral palsy is concerned, mainly depends—is degeneration of the lower motor neurones, *i.e.*, peripheral neuritis. According to J. J. Thomas and others who have made careful studies of the nervous system, using modern histological methods, the process is one of fatty degeneration, which begins in the myelin sheaths. The axones afterward become beaded, break up and disappear. Both

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motor and sensory nerves are affected. These changes would appear to be much more frequent than the palsy, since they are very generally found at autopsy, even though no paralysis has been noted before death. In all of Thomas' cases the vagus nerve showed more or less marked degeneration. Others have observed the same thing, as well as similar changes in the cardiac plexus, the fifth cranial nerve, the muscles of the larynx, and elsewhere.

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The effect of the toxic substances is not confined to the peripheral nerves, as there is a diffuse parenchymatous degeneration of the nerve fibres of the spinal cord and brain. Several observers, notably Bikeles, have found that these changes were most marked in the posterior columns and in the posterior nerve roots, a fact of interest in connection with those cases which show ataxia as a symptom. As to the effects on the nerve cells opinions differ, some authorities even considering that the characteristic symptoms are due to primary degeneration of the motor nerve cells in the anterior horns, rather than to changes which are primary in the peripheral nerves. The weight of evidence is strongly against this view, however, and the changes in the nerve cells are probably of relatively slight importance and degree. The brain and cord often show hyperæmia, and in rare cases myelitis or hemorrhages, the latter sometimes being severe. But the symptoms in most cases depend on changes in the peripheral nerves rather than in the central nervous system.

Of the muscles, the one in which the changes are of the greatest clinical significance and in which they have been most carefully studied is the heart. According to Councilman, Mallory, and Pearce[6] degeneration in the myocardium is one of the most common conditions found in diphtheria. The simplest form is fatty degeneration, which is found in the majority of all cases, and which seems to precede the more advanced forms of degeneration which lead to complete destruction of the muscle fibres. In these there is destruction of the sarcous elements, which become swollen, broken up, and converted into hyaline masses. The degeneration may become so extensive as to account fully for the impairment of the heart's action. Acute interstitial lesions are also found, and occasionally cardiac thromboses and less important vascular lesions.

Changes are also observed in the skeletal muscles. It is probable that, as Baginsky[3] believes, the paralysis of the palatal muscles represents a myositis due to the direct effects of the membrane in their close proximity, rather than a neuritis. But we must also remember that the vagus nerve, which supplies these muscles, is almost always involved. Councilman, Mallory, and Pearce[6] observed marked fatty degeneration of the tongue, diaphragm, and various muscles of the extremities, and they conclude: "It seems probable that in all cases where fatty degeneration of the heart and nervous system has occurred, a similar change will be found in the skeletal muscles."

The changes produced in the nervous system by diphtheria are thus summed up by Thomas:[4] "(1) A marked parenchymatous degeneration of the peripheral nerves, sometimes accompanied by an interstitial process, and hyperæmia and hemorrhages. (2) Acute, diffuse, parenchymatous degenerations of the nerve fibres of the cord and brain. (3) No changes, or but slight ones, in the nerve cells. (4) Acute parenchymatous and interstitial changes in the muscles, especially the heart muscle. (5) Occasional hyperæmia, or infiltration, or hemorrhage in the brain or cord; in rare cases severe enough to produce permanent troubles, such as the cases of multiple sclerosis and of hemiplegia which have been observed. Finally, the probability that the cases of sudden death from heart failure in diphtheria during the disease or convalescence are due to the effects of the toxic substances produced in the disease upon the nerve structures of the heart." The changes produced in the nervous system, then, involve chiefly the lower (spino-muscular) segment of the motor path.

The SYMPTOMS in the ordinary peripheral form of paralysis may begin as early as the fourth day, while the patient is still ill and while the membrane is still present, or they may be delayed for many weeks. The usual time is from one to three weeks after the disappearance of the membrane.

The distribution of the paralysis may be judged from the following figures of the American Pediatric Society's[7] 189 collected cases: Throat, 124; extremities, 22; eyes, 11; respiratory muscles, 5; heart, 32; neck, 1; general, 8. Ross[14] collects 171 cases, distributed as follows: Palate, 128; eyes, 77, of which 54 involved the muscles of accommodation; legs, 113; arms, 60; trunk or neck, 58; respiratory muscles, 33. In Goodall's[5] 125 cases the palatal muscles were involved 102 times, the ciliary muscles 56 times, the legs 52 times, the external ocular muscles 26 times, the arms 21 times, and the pharyngeal muscles 11 times. Obviously the throat is the region most often affected and the eyes and extremities next. When the extremities are involved the disease is characteristically more common in the legs than in the arms, which, in severe cases, are involved later.

The symptoms begin gradually, and usually a number of different parts are involved successively, improvement taking place in one while the disease advances in another. It most commonly begins in the throat, and the palate may be the only part affected. As a result of the involvement of the palate the nasal cavity is not shut off from the nasopharynx in swallowing or in speaking. The child is observed to regurgitate its food, a symptom which may become so severe that deglutition is impossible. The voice becomes nasal in character. Extension to other muscles of the throat and mouth may lead to inability to blow, whistle, suck, or gargle. The muscles are bilaterally or rarely unilaterally involved. Paralysis of the constrictors of the œsophagus is evidenced by the entrance of food into the glottis. Cough, hoarseness, aphonia, and paroxysms of dyspnœa are seen when the larynx is involved. There may be difficulty in articulation or in protruding the tongue. Facial paralysis is rare, as is also paralysis of the tongue or œsophagus.

When the eyes are involved dimness of vision for near objects is noted, and is due to loss of the power of accommodation from paralysis of the ciliary muscles. The patient usually first complains of dimness of vision. The failure of accommodation reaches its height in a few days and generally lasts two or three weeks. The pupil may be dilated. Ophthalmoplegia externa—squint or double vision—and ptosis are rarer. Sometimes most or even all of the muscles of the eyes become paralyzed. Involvement of the hearing, taste, and smell are recorded, but are rare.

When the extremities are involved there is gradual loss of power, beginning almost always in the legs, afterward extending to the arms in severe cases or even to the trunk and neck, so that in the worst cases the patient becomes a helpless mass. But such cases are rare, and the loss of power is seldom absolute. The distribution is usually symmetrical. In contrast to the alcoholic form of neuritis subjective sensory symptoms are ordinarily slight. There may be numbness, tingling, hyperæsthesia, or anæsthesia; but in most cases these symptoms cause little distress. According to Gowers[3] anæsthesia is always most severe toward the extremities of the limbs, and he mentions cases in which sensation was lost only in the finger-tips. As in all forms of degeneration of the lower motor neurone, the muscles become flabby and atrophy occurs. The knee-jerks are commonly lost, and lost reflexes are sometimes the only evidence that the nerves of the extremities are involved. It is said that in some cases they are retained. During convalescence there may be increased knee-jerks and ankle clonus.

The electrical reactions are variable; according to Northrup so much so that they are of little value in diagnosis or prognosis. As a rule they are altered, the muscles showing decreased reaction to faradism with the reaction of degeneration, and the nerve trunks showing

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decreased irritability to both currents.[3] The bladder and rectum are rarely involved.

Reference has already been made to the occurrence of ataxic symptoms in diphtheritic paralysis, and to the view of Bikeles, which explains them as due to degeneration of the posterior columns of the cord. These symptoms are clumsiness in the use of the limbs and unsteadiness in walking. The gait is sometimes distinctly ataxic as in true tabes. The Romberg symptom is prominent. Lack of knee-jerks and sluggish pupillary reactions complete the picture, which, however, is often masked by the muscular weakness.

One of the most serious complications of diphtheritic paralysis is extension to the muscles of respiration. It occurred in 33 of Ross' 171 cases,[14] and 21 times in 275 cases reported by Meyers.[17] Either the diaphragm or the intercostals may be involved. The average time of onset in Meyer's cases was the thirty-seventh day, but it occurred as early as the eleventh and as late as the fiftieth. Dyspnœa is a marked symptom, and is seen in the form of asthma-like paroxysms or in spasmodic attacks due to the accumulation of mucus. There are anxiety and mental distress with a sense of impending suffocation. When the diaphragm is involved abdominal breathing is reversed, the abdomen sinking in on inspiration, and *vice versa*.

The symptoms of cardiac paralysis occurring in diphtheria are of the greatest importance, owing to their frequency, seriousness, and bearing upon questions of treatment. Their exact cause is a matter of doubt. Changes are found at autopsy both in the myocardium and in the nerves controlling the heart. As has already been said, the myocardium may show degeneration sufficient to account in full for all the symptoms. Some, however, believe that the nerve changes are primary. Thomas and Hibbard,[10] in an exhaustive investigation of the subject of heart failure in diphtheria, favor Hesse's view,[18] that heart failure results directly from the effects of the poisons of the disease rather than from the degenerative processes which they cause in the tissues; but they consider that these toxins act through the nervous mechanism. It seems probable that the origin of the heart symptoms may be due either to changes in the myocardium or to changes in the nerves controlling the heart, or to the effects of toxins on the nerve centres. In any given case the exact cause of heart failure can be stated only after death, but it seems fair to suppose that those due to the direct effect of the diphtheritic poisons will occur early in the disease, just as they do in other acute conditions, while those due to organic degenerations may occur later.

Cardiac symptoms are observed in diphtheria at a relatively early date as compared with the other palsies; according to Woodhead,[15] mostly between the fifth and tenth days. The average in Meyer's cases[17] was the seventh. But sometimes they arise late in convalescence. Occasionally they are overlooked, and sudden death after slight over-exertion takes place in a case apparently well. As a rule, some abnormal condition of the pulse first calls attention to the heart. It is unusually rapid or unusually slow, or oftener it is irregular or intermittent. The heart, when mapped out by percussion, generally shows some enlargement. Systolic murmurs, most of which are temporary, may be heard. Pallor, cold extremities, dyspnœa, and cardiac distress are noted. Vomiting is an important symptom, whose occurrence, unless otherwise explained, in diphtheria should always call attention to the heart. Its association with cardiac failure is supposed to depend upon the common relationship of the vagus nerve to both the heart and the stomach. Death may occur within twenty-four hours after the onset of cardiac symptoms, or, as has already been said, it may take place suddenly without warning. In most of the heart cases there is evidence of paralysis elsewhere.

Brodie,[19] as a result of animal experimentation, and Biernacki[20] from clinical observation, consider that the fall of blood-pressure occurring in diphtheria is a result of paralysis of the muscular walls of the vessels. It is a question, however, whether the action is local or central, and to what extent impairment of the heart's action is responsible for the phenomena noted.

There are other forms of paralysis which are sometimes associated with diphtheria, but they occur more rarely and they need but brief mention. One is sudden cerebral hemiplegia, due generally to embolism, more rarely to hemorrhage or thrombosis. Meningitis is sometimes a sequel of diphtheria, and cases of multiple sclerosis have been reported by Schönfeldt. The paralytic symptoms which they cause could hardly be mistaken for the common form.

Diagnosis.—This depends on the recognition, during an attack of diphtheria or in convalescence from the same, of a peripheral neuritis or, in some cases, of a myositis. The most significant peculiarities of the diphtheritic form of neuritis are the frequency of involvement of the throat and eyes, the process often beginning in the former, the symmetrical distribution, the tendency to involve the legs before the arms, the slightness of sensory symptoms, and the frequency of cardiac manifestations.

In making the differential diagnosis other forms of peripheral neuritis must be excluded, especially in cases in which the causative diphtheritic infection has escaped recognition, in which more than one cause is present, or in which the palate and eye symptoms have been slight or lacking. The chief forms of neuritis to consider are those due to alcohol and to lead. Alcoholic neuritis is rare in children, does not involve the throat, and has more prominent sensory symptoms. Other evidences of alcohol are usually present. Lead palsy begins generally in the arms, involving the extensors and giving the characteristic wrist-drop. It is usually associated with other evidences of lead poisoning, such as the blue line on the gums, the cachexia, colic, traces of lead in the urine, and granular degeneration of the red corpuscles of the blood. Other forms of neuritis may be ruled out on similar lines. Mixed forms occur, but in such cases, apart from questions of prophylaxis, the cause is rather of academic than of practical importance. Cases of diphtheritic paralysis showing marked ataxia may be mistaken for tabes dorsalis. The post-diphtheritic disease, however, develops more rapidly; true lightning-like pains are not experienced; and the loss of motor power with atrophied and flabby muscles is absent in true tabes. Acute poliomyelitis is also of importance. Here the onset is more acute, paralysis is not symmetrical, and the sensory symptoms are lacking. Hysterical palsy seldom involves the palate, as diphtheritic paralysis almost always does. In hysteria the knee-jerk is retained. The greatest difficulty arises in cases in which a true diphtheritic paralysis is combined with hysteria.

Prognosis.—This will depend upon the site of the paralysis, the severity of the case, and the previous condition of the patient. Of Goodall's 125 patients 17 died: 4 in the acute stage of diphtheria; 6 fatal cases were cardiac, 4 respiratory, 2 vomiting and cardiac, 1 convulsions.[5] Of Ross' 171 patients 45 died: 8 from intercurrent diseases, 8 from sudden syncope, 10 from heart failure, 14 from respiratory paralysis, and 2 from the aspiration of food into the trachea.[14] According to Gowers, the sooner the paralysis begins after the diphtheria the greater the danger to life.

Paralysis of the extremities of itself causes little danger to life, and recovery may be predicted, even though it may be months before power is completely restored. The duration is often from six to eight weeks. The loss of knee-jerks is generally the last sign to disappear. In the throat cases there are two sources of danger. The first is that arising from the frequency with which palatal involvement is associated with heart symptoms. The second danger arises from the difficulty of deglutition, patients dying from inanition on this account, or from the aspiration of food into the trachea with resulting asphyxia or bronchopneumonia. In respiratory cases the outlook is always more dubious. Meyers[17] reports 21 patients affected with diaphragmatic palsy, of whom 11

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died, this being 13.7 per cent. of all deaths from diphtheritic paralysis in his series.

Cardiac paralysis is even more fatal. Statistics are of little value, as different observers vary so greatly in the criteria upon which they base their diagnoses. All 32 cases collected by the American Pediatric Society [7] were fatal. Hibbard [11] reports 47 per cent. of deaths in cases with irregular pulse. Vomiting during convalescence from diphtheria generally means heart failure, is an unfavorable sign, and occurred in over half of Hibbard's fatal cases. According to Burrows [12] it is especially to be feared when it occurs in a patient whose heart is irregular, or who presents other evidences of nerve degeneration. A very slow pulse is also unfavorable, especially in children. The patients may die within twenty-four hours of the onset of cardiac symptoms, or later during an exacerbation. Sudden death from heart failure without previous symptoms may occur in the acute stage, or it may suddenly and unexpectedly terminate a case after convalescence has appeared to be completed.

Treatment.—The varying results of statistical studies as to the effect of antitoxin have already been mentioned in connection with the subject of etiology. It seems probable that the early and vigorous use of antitoxin in any given case will decrease the likelihood that this complication will occur, but only in so far as it lessens the severity and duration of the causative disease. That this view is correct is proven on the experimental side by the work of Ransom,[1] who shows that doses of the toxin capable of producing paralysis in animals are neutralized in this respect by antitoxin injected simultaneously and modified, though not prevented, by large enough doses given from fifteen to twenty-two hours after those of the toxin. On the clinical side the report of the London Clinical Society [21] shows that the frequency of paralysis as a complication of diphtheria is less when antitoxin is used on the first two days of the disease than when its use is delayed. After the injury to the nerves or muscles has been done, it is not probable that antitoxin will have any effect in restoring them to the normal condition. The same conclusions probably hold in regard to the heart manifestations. In other words, antitoxin, given early and in large doses, has some value as a prophylactic in preventing the paralytic complications of diphtheria.

On the peripheral neuritis no form of treatment has much effect. The case should be managed like a neuritis from any other cause. Rest, careful nursing, liberal diet, tonics, massage, and electricity are of some value. Strychnine is much used, but its influence in restoring the degenerated nerves and muscles to their normal condition is at least questionable. In palatal, and especially in pharyngeal and laryngeal cases, great care should be taken in feeding the patient to prevent the entrance of food into the larynx. The œsophageal or nasal tube may be used if needed, great care being taken to avoid introducing it into the larynx and to get the end well below the glottis. In some cases it will be better to feed by the rectum. Forced feeding had better not be delayed in hope that the child will begin to eat, especially in cases in which the patient is much debilitated by a severe attack of diphtheria. Proper and sufficient nourishment is of importance both in the treatment of the general depressed condition and in that of the paralysis.

One precaution should be insisted upon. Every case of diphtheria should be watched closely for the occurrence of cardiac or respiratory symptoms, especially when evidences of palatal paralysis are present. Thomas and Hibbard [10] advise that every case of diphtheria, however mild, should be kept in bed till the throat is clear, and, if there has been any prostration, for at least two weeks more. After four weeks with no heart symptoms there is little danger. If heart symptoms arise, the greatest care must be taken to keep the patient quiet, morphine being used for this purpose if needed. Careful feeding is of importance. Medicines are of value only in meeting special symptoms. Alcohol, digitalis, and strychnine may be of service. In the respiratory cases strychnine is the most valuable remedy. Electricity may also be used. *Ralph C. Larrabee.*

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(For further bibliography consult the articles of Northrup, Ross, and Thomas.)

PARALYSIS, FACIAL. See *Facial Paralysis*.

PARAMUCIN.—Mitjukoff has obtained from the mucoid contents of ovarian cysts a mucin-like substance, which differs from *pseudomucin* and *mucin*, chiefly in the fact that without previous boiling with dilute mineral acids it will reduce an alkaline solution of copper. ("Ueber das Paramucin," *Arch. f. Gyn.*, Bd 49, 1895.)
Aldred Scott Warthin.

PARAMYOCLONUS MULTIPLEX.—(Synonyms: Myoclonus multiplex, Myoclonia, Polyclonia.) Originally described by Friedreich [1] in 1881, this disorder has been recognized by clinicians in Germany, France, Italy, England, and America. Its existence as a disease has been questioned, some asserting it to be a variety of hysteria, others of chorea. Still others cut the Gordian knot by claiming that both a true form and a hysterical form of the disease exist. However, the preponderance of authority as well as of evidence at the present day appears to favor its validity as a clinical entity.

It is a rare disease. Gowers [2] states that he was able to collect but fifty-two cases in the literature up to July, 1895, of which only thirteen were considered by him true examples.

One of the best accounts of the disease accessible to American readers is that of Starr,[3] which is also accompanied by a bibliography.

The disease is characterized by paroxysms of clonic muscular contractions, shock-like, bilateral, and symmetrical as regards the two sides of the body. The individual contractions are frequent, varying in rate from thirty to one hundred or more per minute. The duration of the paroxysms may vary between five or ten minutes and some hours. Likewise the frequency of paroxysms in a day may vary from one or two to twenty or more. The muscles affected in typical cases are the intrinsic truncal muscles and those connecting the trunk and extremities; those moving the face, hands, and feet being seldom, if ever, affected (see Fig. 3738). In one case observed by the writer,[5] the diaphragm and laryngeal muscles were involved at times, causing short, sharp, involuntary exclamatory sounds.

Negative characteristics are: consciousness is not affected; mental defects are absent as a rule, but, if present, are transient; voluntary movements of the face, hands, and feet are not abolished, even during a paroxysm, though the muscular power is much reduced; elec-

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trical changes of degenerative significance are absent, as is fibrillary twitching. Sensation is not diminished or lost, but a decided hypersensibility to sound and touch has been observed by the writer in one case.[5] A profound sense of fatigue was also noted in that case. The convulsive movements cease during sleep, and are brought on, or, if present, increased in violence by emotional excitement, by irritation of the skin, by cold, etc., and by manipulative procedures generally.

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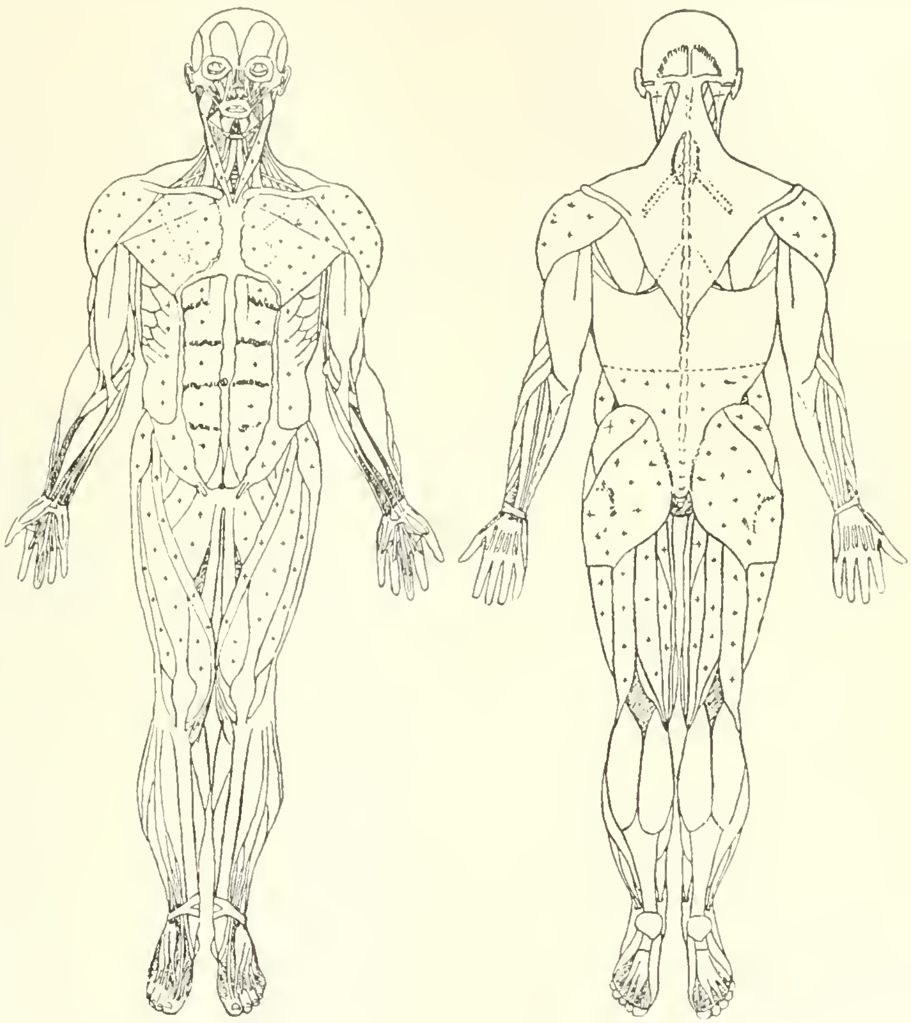
Oppenheim[4] recognized a hysterical type as distinguished from the true form, but admits the difficulty of separation.

Unverricht, Weiss, Kreiver, and Sepilli (quoted by Oppenheim) describe cases of a familial type and associated with epilepsy (*loc. cit.*).

CAUSATION. — The patients are usually neurasthenic. A majority of cases reported were of the male sex. The ages of patients have varied between thirteen and forty-eight. Mental worry, fright, injury, and physical strain are accredited causes. Of two cases reported by the writer one was attributable to mental worry combined with la grippe. The other was distinctly due to fright. A third case, observed by the writer through the kindness of Sir William Gowers, followed a fall from a considerable height without palpable injury. Fry's case[6] was due to overexertion, Starr's[3] to strain in lifting. Removal of the thyroid in dogs is said sometimes to cause symptoms of this disease.



A.—Front View. *B.*—Rear View.

FIG. 3738.—*A* and *B*. Paramyoclonus Multiplex. Distribution of myoclonic spasm indicated by plus marks.

The PATHOLOGY is unknown. Autopsy in one case (Schultze) revealed no nervous changes. Friedreich, who was the first to describe the disease, believed it to be based on overexcitability of the spinal motor elements. Some have surmised that the cause of the faulty action lies in the muscles themselves or in an abnormal state of the nerve endings. To the writer its psychic antecedents, marked hemiplegic preponderance at times (in one case); its aggravation by mental and emotional states; the marked, though transient, mental changes in two cases; and the heightened muscle reflexes, would all suggest that the disease is to be viewed as the visible expression of a state of "*inhibitory insufficiency*," probably cortical in seat.

DIAGNOSIS.—This is to be based on "the sudden shock-like character of the muscular contractions, their bilateral symmetry, and the comparative freedom of the extremities." (Gowers.[7]) This view is also concurred in by Walton[8] in a recent paper on the myospasms in general. Hysteria is ruled out by the absence of the stigmata and of the characteristic emotional state. There appears to be no tendency to simulation or desire for sympathy in paramyoclonus. Chorea is excluded by the non-involvement of the face and hands. Dubini's "electrical chorea," a disease endemic in a certain locality in Italy, is to be separated by its unilateral beginning, nerve and muscle degeneration, and a fatal termination in a few months.

The PROGNOSIS is variable, according to different authors. Friedreich reported that some of his patients recovered. Oppenheim considers the prognosis grave. In all the American cases reported to date the patients have recovered. Relapse may occur, but does not preclude ultimate recovery.

The duration may vary from three or four months to a year or more. In one of the writer's cases the convulsions ceased on the one hundred and second day, but recurred in twenty-four hours, to disappear again in eight days. There has been no recurrence to date (four months). In the case reported by Starr (*loc. cit.*) the patient recovered in about a year, as did also the patient in the first case reported by the writer.[5]

TREATMENT.—The drug treatment followed has been

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so diverse as to suggest that it has had little to do with the recovery. Chloral, bromides, hyoscine and other sedatives, arsenic, quinine, thyroids, and galvanism have all been followed by improvement and recovery. The factors of rest, feeding, and time would appear to be the important ones. Sedatives may be used to mitigate the severity of the spasm and promote the patient's comfort.

Nutrient medication, in the form of glycerinophosphates, iron preparations when indicated, and supporting measures generally, are advisable.

F. W. Langdon.

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PARAPHIMOSIS. See *Sexual Organs, Male, Diseases of.*

PARAPLEGIA.—The term paraplegia specifies a symptom, not a disease. It indicates, in the first place, an impairment of motility, namely, akinesis or paralysis, and secondly, paralysis of a certain distribution. Thus, it is customary to indicate a paralysis involving one of the extremities by the term *monoplegia*, a paralysis of both extremities on one side of the body, that is to say, of longitudinal or unilateral distribution, by the term *hemiplegia*, while a transverse distribution or symmetrically bilateral paralysis of the body is classified as a *paraplegia* (para, Gr. παρα, side by side). Usually, the lower extremities and the caudal portion of the body are the parts involved. The term is not restricted, however, to paralysis of these parts alone, but may be applied to the involvement of any transverse section of the body. When the upper extremities are involved, the term *cervical paraplegia* is applied. In this condition, usually, though not always, paralysis extends to all parts below—caudad. The term *hemi-paraplegia* refers to paralysis of one lower extremity, accompanied by anæsthesia of the opposite member. It is, strictly speaking, a crural monoplegia. The term double hemiplegia is synonymous with cerebral paraplegia, both indicating a paraplegia of intracranial origin, involving the cerebral motor tracts. The term ocular paraplegia has been used, rarely, to indicate paralysis, in both eyes, of symmetrical ocular muscles. The term diplegia is to be preferred in cases in which a single pair of nerves on each side is paralyzed; as facial diplegia, instead of facial paraplegia. Jaccoud introduced the adjective *paraplegiform* to indicate bilateral disturbances of motility other than true paresis or paralysis, but which resemble the latter in disturbance of locomotion; as, for example, that produced by incoordination, and spastic conditions.

In paraplegia (it being defined as paralysis of a certain distribution) we have an important symptom of various pathological conditions, forming by its association with other symptoms some of the most striking clinical pictures of disease. Its proper study involves the consideration of the localization of function, the impairment of which produces paraplegia; the nature of the pathological process causing such impairment; the variations in disturbance of function due to involvement of different segments of the body; the other symptoms which may accompany it; and the diagnostic and prognostic significance of the grouping of such symptoms, together with indications for remedial measures.

From this standpoint paraplegia forms a convenient centre from which may be analyzed a great number of diseases of the nervous system, mostly of spinal origin, but also including some cerebral and peripheral nervous affections. As we have a motor impairment to consider, the motor tracts of the nervous system must be called to mind. From their periphery in the motor end-plates they pass through the mixed peripheral nerves, the anterior roots of the spinal cord, the root zones in the anterior columns, to the anterior cornua of the cord, where the motor nerve fibres are supposed to terminate in cells arranged in groups or scattered through the gray matter of this portion, and by means of which they form reflex connections with sensory nerve tracts, commissural connections with the motor tracts of the opposite half of the cord, and with different levels of the cord above and below; and, in addition, connection with the motor tracts in the lateral columns of the cord known as the crossed pyramidal, cerebral, or voluntary tracts, and the direct pyramidal tracts in the anterior columns. After decussation of the crossed pyramidal tracts in the medulla, both crossed and direct tracts pass through the anterior (ventral) portion of the pons, continue through the crura cerebri, then upward, forming a part of the internal capsule, and on to the so-called cortical motor areas. Associated tracts through the cerebellum, the cerebral ganglia, and the nuclei of the cranial motor nerves complete the system. In order to produce paraplegia, not only must some part of this motor system be affected, but the lesion must be symmetrically bilateral, must involve both halves of this duplex system. The general division may be made, therefore, into peripheral, spinal, and intracranial (cerebral) paraplegia. The divergence of the right and left motor tracts in their peripheral and cerebral por-

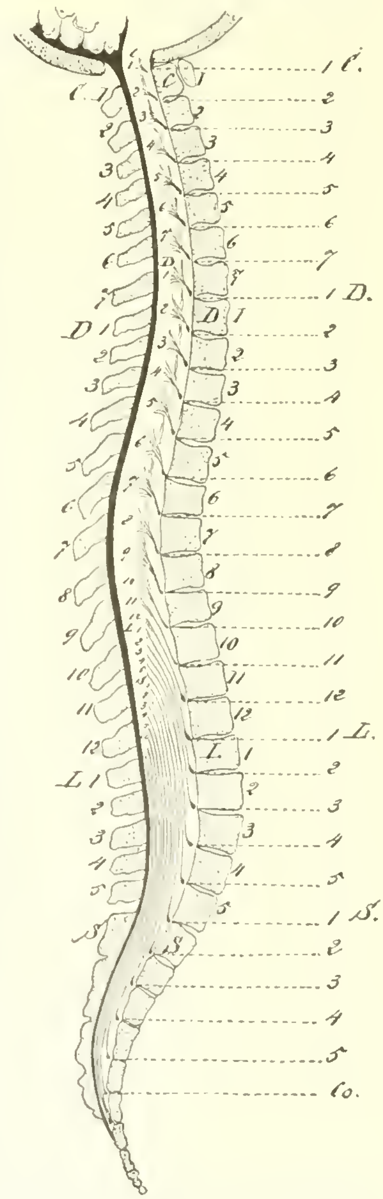

FIG. 3739.—Diagram Showing the Relations of the Spinous Processes to the Bodies of the Vertebræ, and of these to the Points of Origin of the Spinal Nerves. (From Gowers.)

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tions, and their approximation in the spinal cord, medulla, and pons, admit of their frequent bilateral involvement from lesions in the latter regions, and but rarely in the first-named divisions. Consequently, the lesion producing paraplegia is usually a spinal-cord lesion. Yet it is possible to have a tumor develop in the longitudinal fissure www.libtool.com.cn between the hemispheres, which will involve the motor areas for the legs in each hemisphere, thereby producing a symmetrical and bilateral paralysis of the lower extremities, namely, a cerebral paraplegia. On the other hand, it is now well known that a peripheral paraplegia may be produced by a multiple neuritis involving the peripheral nerves of both lower extremities in such a symmetrical manner as closely to resemble spinal-cord lesions. Compression within the spinal cord of the bundle of peripheral nerves known as the cauda equina may also give rise to paraplegia. In the latter case, and also in multiple neuritis, we have the phenomena which attend irritation or destruction of a mixed nerve, namely, motor, sensory, and trophic disturbances in the parts supplied by the nerves involved. But motor, sensory, and trophic disturbances may also occur when the lesion is in the spinal cord, provided it be extensive enough to involve both motor and sensory tracts, and at a level from which the upper or lower extremities receive their motor innervation, namely, the anterior cornua in the cervical and lumbar enlargements. Lesions between these enlargements, or above the former or below the latter, do not produce the trophic disturbances which result in degeneration of peripheral motor nerves of the extremities, and the consequent atrophy of the muscles which they supply; although voluntary power and sensation may be lost through interruption of the cerebral motor and sensory conducting tracts traversing the section of the cord involved by disease.

Myelitis affecting the entire transverse area of the cord, but limited in its longitudinal extent to some portion between the cervical and lumbar enlargements, commonly known as transverse dorsal myelitis, furnishes an example of this form; while involvement of the lumbar enlargement will serve as a type in which motor degeneration and atrophy are added. Similar results may follow a meningitis, or meningo-myelitis involving the sensory and motor nerve roots or root zones at the level of the lumbar enlargement. Paraplegia, unaccompanied by loss of sensation, may be conceived of in case the meningitic or myelitic process remains limited to the anterior periphery of the cord, or to the anterior horns of the lumbar enlargement, by which the motor tract would be involved and the sensory tracts escape implication.

A similar process affecting the cord at its cervical enlargement alone might produce bilateral paralysis of the upper extremities without involving the lower extremities, as long as the myelitic process did not extend deeply enough to invade the pyramidal tracts in the lateral columns. Should it so extend, however, the lower extremities would exhibit paraplegia without loss of sensation and without muscular atrophy; while with a complete transverse lesion at the cervical enlargement loss of sensation in all parts below the upper extremities would be added, but still without degenerative atrophy in the lower part. The meningitic process might be extensive enough to involve both cervical and lumbar enlargements, affecting chiefly the anterior periphery of the cord, producing a paraplegia involving both upper and lower extremities with muscular atrophy in both, and even a transitory loss of sensation; or the gray matter of the anterior horns may be involved throughout the cord on both sides, as in poliomyelitis anterior, with similar results. Finally, we may have involvement of the cerebral (pyramidal) motor tracts in the lateral columns of the cord at any height, cutting off voluntary innervation to all parts supplied below the lesion, but without producing trophic disturbance.

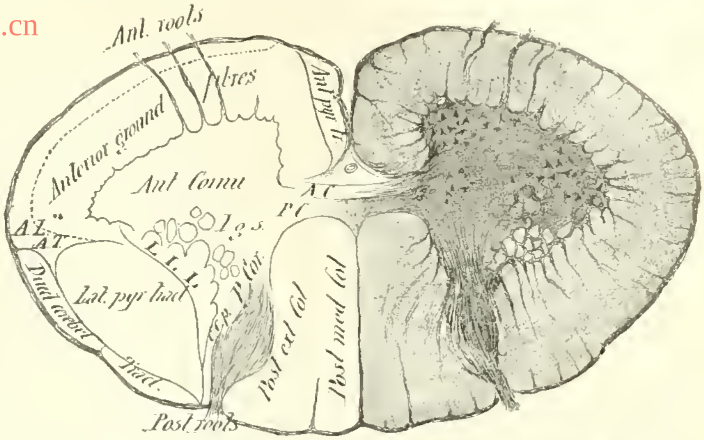

FIG. 3740.—Diagram of a Section of the Spinal Cord in the Cervical Region. *A.C.*, Anterior commissure; *P.C.*, posterior commissure; *I.g.s.*, intermediate gray substance; *P.cor.*, posterior cornu; *c.c.p.*, caput cornu posterioris; *L. L. L.*, lateral limiting layer; *A.-L. A. T.*, antero-lateral ascending tract, which extends along the periphery of the cord. (From Gowers.)

These examples show the necessity of keeping before us a mental picture of the topographical anatomy of the nervous system, and a recollection of the functions of the different tracts to the extent known, in all our attempts to localize a lesion from the symptoms found. The disturbances which accompany the bilateral paralysis constituting paraplegia will vary (1) *according to the level of the lesion* through interference with the visceral, vaso-motor, sensory, and reflex functions of the segment involved; (2) *according to the extent of the lesion transversely in the cord*, through involvement of different functional tracts and centres; and (3) *according to the predominance of an irritative, or of a destructive pathological process* constituting the lesion, producing increase, diminution, or perversion of function. The first and second factors concern the localization of the lesion, the third its nature and course. To aid in the consideration of the former, diagrams and tables are given, and a brief résumé of certain anatomical and physiological data.

The spinal canal is longer than the cord, the latter terminating in man at the upper border of the second lumbar vertebra. The exits of the several spinal nerves do not, therefore, correspond to their levels of origin in the cord, nor do the bodies of the vertebræ correspond to their spines. Gowers' diagram (Fig. 3739), showing the relations of the segments, nerves, and bodies of the vertebræ to the spinous processes, together with the table (Fig. 3741) showing the functions of the different segments, are valuable aids to diagnosis. The cervical enlargement corresponds to the lower five cervical spines; the lumbar enlargement to the tenth, eleventh, and twelfth dorsal, and first lumbar spines.

The ascending tracts of the spinal cord are (1) the antero-lateral ascending tract of Gowers, supposed by him to conduct painful sensations; (2) the direct cerebellar tract, whose function is unknown; and (3) the posterior columns, which conduct tactile and muscular sensations. Fibres serving the latter function, it is thought, occupy part of the median division of the posterior columns (columns of Goll), and do not decussate, while other sensory fibres do. The external columns (columns of Burdach) include the posterior root zones and fibres having a short course up and down the cord, probably decussating at higher levels, or connecting different levels of the cord. The ascending tracts degenerate upward from the

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level of a destructive lesion. The descending tracts are the direct and crossed pyramidal tracts, concerned in the transmission of cerebral impressions downward to the motor centres in the anterior horns. They diminish in size downward, going chiefly to the cervical and lumbar enlargement; the direct tract mostly to the former. The remaining portions of the lateral column and the lateral limiting tract are supposed to contain commissural conductors of motor impulses between different levels of the cord on the same side. The anterior roots originate in the gray matter of the anterior cornua as already described, traverse the anterior columns (anterior root zones), and go to the muscles. In connection with the sensory roots through the gray matter, they constitute the "reflex arcs," interruption of either the motor or sensory division of which abolishes reflex action in that segment. Destruction of any portion of the motor division from the muscles to the cells of the anterior cornua, including the latter, besides producing paralysis and abolition of reflex action, also causes atrophy in the muscles and the corresponding motor tracts up to the point of lesion, which is characterized by the electrical reaction of degeneration. This does not follow a lesion of any other part. Destruction of the pyramidal tracts causes a degeneration of the column downward from the point of lesion, but this does not usually go beyond the connections of these tracts with the cells of the anterior horns. Atrophy, and the reaction of degeneration are absent. The reflex arc is not only preserved, but reflex excitability is increased. Impairment of voluntary power, and exaggerated motor reflexes frequently amounting to clonic or tonic spasm, characterize lesions of these tracts. Lesions of the cervical region may be accompanied by disturbances of respiration, of the cardiac functions, of the cilio-spinal centre (radiating fibres of iris), and by vaso-motor phenomena, showing either increased or diminished functional activity, as the lesion is irritative or destructive. Lesions in the lower segments of the cord interfere with certain functions of the bladder, the rectum, the sexual, and the vaso-motor apparatus in a similar manner, serving as aids to localization.

As disturbances of the bladder and rectum are usually important features in the paraplegic state, their complex functions should be referred to. Each of these organs has two sets of muscles, which are opposed to each other in action—the detrusors, which expel the excretions, and the sphincters, which oppose expulsion. Besides the local nervous apparatus which are found in the walls of all hollow muscular organs, and which probably constitute a reflex apparatus between the mucous membrane and the subjacent muscular, vascular, and glandular apparatuses, in a manner not fully known, these organs have their opposed muscular movements represented in the cord by motor centres situated somewhere between the origins of the second and fifth sacral nerves, and a reflex arc is established through sensory fibres from their mucous membrane and muscles. In addition to this there are sensory connections (posterior columns) with the brain, and voluntary paths from the brain (pyramidal tracts), by which a certain amount of control is obtained over the sphincters and detrusors, the mechanism of which is but imperfectly understood. The important facts for pathology are that, as in the involvement of other motor organs, lesions above the motor centres in the cord simply cut off the sensory impressions from these organs to the brain when the ascending tracts are destroyed, and interrupt voluntary impressions to them when the pyramidal tracts are destroyed. In the former case, there is no consciousness of the necessity of micturition or evacuation, and therefore no attempt to restrain it. In the latter, there is consciousness of the necessity, but inability to resist the expulsion. When both paths are cut off there is neither desire nor power to expel the excretions—involuntary and unconscious evacuations take place through the reflex mechanism in the cord; but when the lesion destroys the motor centres of the bladder and rectum, expulsive power and the power of the sphincters are lost, and the retention of excretions results, except evacuation due to the mechanical expulsion of liquid fæces and the dribbling of urine.

In most of the examples given to illustrate the question of localization of the lesion, destructive lesions have been assumed—that is to say, abolition or diminution of function, rather than the intensified activity of an irritative lesion. It should be borne in mind, however, that in most cases, before a pathological process becomes destructive, an irritative stage has existed; and that the irritative and destructive stages may so vary in their course and duration that both processes go on at the same time in different areas involved by the lesion. Thus paralysis may be preceded by clonic or tonic spasm; anæsthesia, by pain and by paræsthesia; abolition of reflex action, by an exaltation of the reflexes; vaso-motor paresis and failure in nutritive processes, by functional exaltation. Or, as instanced in paraplegia from transverse myelitis, between the focus of disease, in which function is lost, and the healthy portion, there is usually a region of increased activity—an irritated zone. The balance between these opposite conditions, which shade into each other, and the degree and extent of each, will vary with the nature and rapidity of the pathological process producing it.

MOTOR (NERVES).		MOTOR.		SENSORY.		REFLEX.
	C 1	Small rotators of head	1	Scalp	1	
St. mastoid, Upper neck muscles, Upper part of Trapezius	2		2		2	
	3	Lev. ang. scapulæ	3	Neck and upper part of chest	3	
	4	Diaphragm } Shoulder muscles	4		4	
	5	Serratus, Flex. of elbow, Supinators	5	Shoulder	5	
	6	Ext. wrist & fingers.	6	Arm	6	
Lower neck muscles, Middle part of Trapezius	7	Ext. elbow, Flex. wrist & fingers, Pronators	7		7	Scapular
	8	Muscles of hand	8	Hand (ulnar n. lowest)	8	
	D 1		1		1	
	2		2		2	
	3		3		3	
	4		4		4	
	5		5	Front of thorax	5	
Lower part of Trapezius and Dorsal muscles	6	Intercostals	6	Ensiform area	6	Epigastric
	7		7		7	
	8		8		8	
	9		9	Abdomen (Umbilicus 10th)	9	
	10	Abdominal muscles	10		10	Abdominal
	11		11		11	
	12		12	Buttock, upper part	12	
	L 1		1		1	
	2	Cremaster, Flexors of hip	2	Groin and scrotum (front)	2	Cremasteric
Lumbar muscles	3		3	Thigh: outer side, front, inner side	3	Knee-jerk
	4	Extensors of knee, Adductors of hip	4		4	
Peroneus l. Flex. of ankle, Ext. of ankle	5	Ext. & abduct. of hip	5	Leg, inner side	5	Gluteal; Foot clonus
	S 1	Flexors of knee	1	Buttock, lower part	1	
	2	Intrinsic muscles of foot	2	Back of thigh; Leg & foot except inner part	2	Plantar
	3		3		3	
	4	Perineal and anal muscles	4	Perineum and anus	4	
	5		5	Skin from coccyx to anus	5	
	Co.		Co.		Co.	

FIG. 3741.—Table Showing the Approximate Relation of the Various Motor, Sensory, and Reflex Functions of the Spinal Cord to the Spinal Nerves.

Concerning the nature of the pathological process, the common division into structural and functional will serve our purpose; meaning, by the latter, that in which no perceptible change exists—abnormal variations in those molecular movements which constitute functional activity, and which are, therefore, dynamic rather than static in character. This class comprises many of the defects due to unstable molecular conditions, partly

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Paraplegia.

inherited, partly acquired, and frequently dependent upon imperfect nutritive processes in the neural tissues, either assimilative or excretory. From this extreme, we have a gradation into coarser forms of molecular derangement, and, finally, into those in which the microscope, or the eye alone, distinguishes derangement in structure. Taking the latter first, as being more tangible, we find that nearly all structural neural disease begins in non-neural tissues. True, we may have direct traumatisms, as cutting, crushing, and compression of neural tissues; and there may be degenerative processes originating primarily in nerve fibres and cells, and direct toxic effects from organic or inorganic poisons conveyed by the nutrient fluids; but there is a larger group of disorders which are secondary to inflammation, acute or chronic, in the connective-tissue structure which forms the framework or support of the neural elements, or to vascular disease, such as hemorrhages, thrombosis, embolism, or proliferative occlusion.

Leaving the consideration of these elementary propositions, we pass on to consider the actual clinical forms of disease which result in producing paraplegia.

Taking the disease which most frequently produces paraplegia, myelitis, as a type, let us study its most common form—namely, transverse dorsal myelitis. This name implies that the entire transverse area of the section is more or less involved in the inflammatory process, and does not include the more limited centres of myelitis, termed *focal* lesions, which may be located in one-half of the cord, and rarely produce paraplegia; though this may result when independent foci involve motor tracts of the anterior horns or root zones, at the same level, or the pyramidal tracts even at different levels. Where several myelitic foci exist, the term *disseminated focal myelitis* is used. While the term "transverse" implies that the longitudinal extent of the lesion is limited, this is not construed in a narrow sense, and may be properly applied when the lesion invades both the lumbar enlargement and the dorsal segments. When the entire length of the cord is involved, the term *diffuse myelitis* is applied; this may be general—*i.e.*, involving both white and gray matter—or may be limited to the latter, when the term *diffuse poliomyelitis* (myelitis of gray matter) is used. The term poliomyelitis anterior indicates that the anterior cornua alone are invaded; while the term *central myelitis*, or *diffuse central myelitis* (according as it is local or general), is applied to poliomyelitis originating about the central canal and invading any portion of the remaining gray matter. Other adjectives are in use—such as *hemorrhagic myelitis*, when secondary to a hemorrhage within the cord; *compression myelitis*, when secondary to compression of the cord, as from tumors, inflammatory exudations, and fractures or dislocations of the vertebræ; *meningomyelitis*, when the inflammatory process invades the membranes and cord. The terms acute, subacute, and chronic prefixed to these various terms, specify whether the onset has been sudden, gradual, or slow.

1. Acute Transverse Dorsal Myelitis (involvement of any segment of the cord between the cervical and lumbar enlargements).

Symptoms.—Paraplegia resulting from this disease is usually characterized by the rapid onset of motor weakness of the lower extremities, preceded by numbness and painful tingling in the extremities; formication and other paræsthesiæ, moderate or severe; pain in the back and limbs, of a boring, tearing character; irregular twitching of muscular fasciculi; painful tonic spasm (cramps), and tremor of some of the muscles of the extremities; besides, in many cases, general febrile symptoms, usually of a moderate grade, and in rare cases eclampsia, particularly in young subjects. The motor weakness may be hours or days in reaching its highest degree, and this may be gradual, or by a succession of sudden accessions with intervals of partial recovery. Before it becomes complete the gait is similar to that of double hemiplegia of cerebral origin, for it is due to involvement of the pyramidal tracts. The superficial (skin) and deep (tendon) reflexes of the extremities are preserved, and the paralyzed muscles respond to such reflex excitation and also to electrical stimulation; the reaction of degeneration is absent, and the muscles of the extremities do not undergo atrophy except from disuse. Later, the reflexes become increased, often to a high degree. Spastic conditions and contractures may follow, and frequently become permanent. The lower trunk muscles may be involved and flaccid, showing diminished response to faradic excitation; there is retention of urine at first, followed by incontinence from reflex action. The sphincter ani is also cut off from cerebral control.

The pulse is usually rapid. Sensation is rapidly lost; anæsthesia takes the places of the painful paræsthesia, though frequently a condition of hyperæsthesia exists, particularly in the distribution of the nerve coming from the limit of the lesion, where it may form a zone producing the sensation of constriction about the trunk. The dorsal spines may also be sensitive to pressure at this level, but the pain and hyperæsthesia are not increased by active or passive movement. All sensation in the parts supplied from below the upper margin of the lesion may be cut off. If recovery takes place, sensation is usually regained before motion. Death may result from general exhaustion, though myelitis limited to the dorsal region is the most favorable form for recovery. If it extends to the cervical region, respiratory failure may follow; or if it invades the lumbar enlargement, bedsores, cystitis, and nephritis may hasten death. The course and duration, as well the acuteness of onset, are very variable. Months may elapse before recovery takes place; or sensation may be partially recovered, and there may be some return of power, but with spastic conditions which may persist for years. But some patients recover so completely and rapidly that after a few months no trace remains, except an increased patellar tendon reflex.

When the myelitic process involves the lumbar enlargement, either primarily or by the extension from the dorsal region, we have—

2. Acute Transverse Dorso-Lumbar Myelitis.—Here additional phenomena are present, due to the destruction of the motor and reflex connections for the muscles of the lower extremities, and for the bladder, rectum, and sexual apparatus. In place of increased reflexes we have both skin and tendon reflexes abolished. The reflex functions of the bladder and rectum are lost, as already described. Alkalinity of the urine, cystitis, and suppurative nephritis may follow. The muscles of the extremities are flaccid, undergo atrophy, and after a time the reaction of degeneration is found (frequently not before a week or two after paralysis).

Trophic disturbances in the skin and subcutaneous tissues, in the form of bedsores, frequently occur over the sacrum and the buttocks, and sometimes suppuration in the pelvic cellular tissue. The skin of the extremities is often œdematous, livid, and, in late stages, subnormal in temperature, although at the onset it may be supernormal—it may be dry or moist.

3. Acute Transverse Cervical Myelitis.—In this form the lower extremities and pelvic viscera are affected as in the dorsal variety; and, in addition, changes occur in the upper extremities similar to those described in the dorso-lumbar variety for the lower extremities—namely, trophic changes in the muscles and nerves, and in the electrical reaction and the reflexes; besides, vaso-motor, pupillary, cardiac, and respiratory disturbances occur; painful rigidity of the cervical muscles, pallor or flushing of the face and neck, contraction or dilatation of the pupils, and slowness or rapidity of the pulse, according to whether the irritative or destructive stage prevails. Optic neuritis has been found associated. Priapism is a more frequent condition in this than in the dorso-lumbar variety. The upper extremities are paralyzed first. If the process remains strictly a central myelitis, the lateral column will not be invaded and the lower extremities will not be involved. Should the section involved lie

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above the cervical enlargement, the upper extremities would be affected like the lower ones—namely, preserved and exalted reflexes, and absence of trophic changes in the muscles. Respiration, deglutition, articulation, and the diaphragmatic functions (origin of phrenic nerve) may exhibit great disturbance, death usually resulting from respiratory failure.

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The morbid anatomical changes which constitute the basis of these symptoms are the result of irritative and destructive inflammatory processes in the cord; the irritative stage being represented by hyperæmia, exudation from the vessels, proliferation of lymphoid elements, minute capillary extravasation, and frequently by hemorrhage from small arteries. Later, the myelin of the medullated fibres undergoes swelling, granular degeneration, and disorganization. The axis cylinders and nerve cells may become swollen, opaque, or granular, some undergoing complete disorganization—this representing the stage of destruction. The latter process may continue until complete softening occurs, showing, on section, a softened or liquefied state, and, under the microscope, the débris of nerve cells, broken cell processes, myelin drops, lymphoid bodies, red blood cells, and the so-called granule cells—bodies many times the size of lymphoid elements, filled with highly refractive granules. When the process stops short of complete disorganization and a more chronic stage is reached, and also in the earlier stages of chronic myelitis, the neuroglia proliferates, forming more numerous and thicker bands, the walls of the vessels are thickened; lymph spaces may be obliterated or choked with lymphoid cells; so-called spider cells (Deiter's cells), larger connective-tissue cells, with larger and numerous processes, are scattered through the tissues, and the so called corpora amylacea are numerous.

This condition is known as sclerosis. It presents a grayer appearance in unstained sections; deeper red with carmine, and a paler color with the Weigert process, than the normal tissue. The naked-eye appearance, where the cord has undergone softening, has been divided into red, yellow, and white softening, representing successive stages during which the extravasated red blood cells are being absorbed. The more vascular parts of the cord are usually the first to undergo softening. These are on either side of the central canal in the gray matter, the process usually extending outward to the white columns, frequently along blood-vessels or connective-tissue trabeculæ. The appearances of softening or sclerosis on section are often quite irregular, particularly in the white matter.

Simple Softening of the Cord is met with, probably due to occlusion of the vessels from arteritis, embolism, or thrombosis. There are fewer signs of an active inflammatory process, white or yellow softening being found. It is characterized by the absence of marked irritative symptoms, which precede the destructive stage of the inflammatory variety.

Hemorrhagic Myelitis is characterized by a more sudden onset of the paraplegia than occurs in the inflammatory form, frequently becoming complete in a few minutes. The occurrence of traumatic conditions, as concussion, injuries to the vertebræ, etc., will frequently lend support to this diagnosis. The later changes are similar to the forms already described. A hemorrhage may be so small and so located as to produce only unilateral paralysis at first, as in the anterior cornua, paraplegia recurring later from a more general myelitis, secondary to the hemorrhage.

Compression Myelitis presents the usual features of a transverse myelitis, except that paraplegia may be preceded for a longer time by irritative symptoms than in the common inflammatory form, as compression is usually slow, being due to tumors in the membranes, or to vertebral disease. In its common form it is known as *the paraplegia of Pott's disease*. The paraplegic symptoms are those due to irritation of the sensory and motor nerves at their exit from the membranes, which may present pachymeningitis, or from the vertebral foramina, giving rise, chiefly, to bilateral pains in the trunk or upper extremities, in the course of the sensory nerves involved, and being frequently accompanied by hyperæsthetic or anæsthetic areas. Herpes zoster sometimes occurs. The reflexes and the functions of the sympathetic may be disturbed (pupillary, vaso-motor, sweating), and even muscular paresis and atrophy of the upper extremities follow, from this cause. The chief diagnostic features are evidence of localized bone disease, curvature, spinal tenderness on movement, and reflex muscular spasm at the region involved on flexure of the spinal column. Paraplegia, when it does develop, may appear suddenly. The distribution of the paralysis is usually that of the dorsal or cervical varieties, and presents the variations in localization of lesion described for these conditions.

It is considered one of the most favorable forms of myelitis as regards a partial recovery.

In Compression by Tumors pain is such a prominent feature that Cruveilhier was led to characterize the paralysis which it produces as *paraplegia dolorosa*. The pain is lancinating, at first intermittent, but finally becoming constant, and increased by movement. It is of a more severe character than the pain of vertebral caries. All varieties of localization may be presented, and all possible variations in mode of onset, and in slowness or rapidity of course, depending on the location, size, and rapidity of growth of the neoplasm, various symptoms becoming prominent according as different functional tracts are chiefly involved. Sarcomata (including gliomata) are the most frequent; gummata and tubercle are about equally common, while carcinomata and hydatids are among the neoplasms occasionally found.

Meningo-myelitis may result from an extension of the myelitic process outward to the membranes, or of a meningitic process into the cord.

Meningitis, both acute and chronic, may produce paraplegia by involving the anterior roots. When the entire circumference of the cord is involved, the sensory roots being also affected, we have a condition similar to involvement of a mixed peripheral nerve.

The lancinating pains, constrictive bands, muscular rigidity, and convulsive twitching are greater than in simple myelitis, and usually serve to distinguish one from the other. In cervical meningitis the paraplegia will be confined to the upper extremities, as the pyramidal tracts will be free unless there develop a meningo-myelitis, when these tracts may be involved.

As numerous examples have already been given, it will be unnecessary to review all the possibilities that may follow, or to consider all the varieties of meningitis. With a clear appreciation of the anatomical relations and functions, the extent and location of the lesion may be concluded from the symptoms, or *vice versa*. *Traumatisms* may also be left out of consideration, after what has been said on compression myelitis.

Poliomyelitis Anterior (infantile and adult spinal paralysis) may produce a paraplegia; usually, however, the lesion in this case being limited to the anterior cornua and their neighborhood in the anterior columns, certain cell groups succumb, while others survive, leaving an irregular distribution, not symmetrically bilateral, and therefore not paraplegic. The anterior group of one leg is most frequently involved. Nearly one-half the cases are monoplegic, and when bilateral the paralysis is frequently not symmetrical. It should be stated, however, that often during the first hours, and sometimes days, of this sudden paralysis, there is complete paraplegia, the trunk and all four extremities being involved; but it is distinguished from transverse myelitis by the absence of marked sensory or vesical symptoms, and by abolished reflexes. The statement concerning the unsymmetrical distribution of the paralysis also applies to the subacute form of this disease, and in fact to chronic degeneration of the anterior cornual cells, which produces progressive muscular atrophy.

The condition known as Landry's acute ascending paralysis, and also the lateral amyotrophic paralysis of Charcot, which may produce paraplegia, are so rare as to warrant no more than their mention.

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The paraplegiform affection due to the ataxia of tabes dorsalis may give place to a true paraplegia by an extension of the degenerative process to the anterior cornua, producing muscular atrophy, or, in the form combined with sclerosis, by involving the pyramidal tracts, it may develop spastic and ataxic paraplegia.

Spastic Paraplegia results, as we have seen, from the symmetrical involvement of the pyramidal tracts in any part of their course, and is usually secondary to a transverse myelitis, or to a transverse lesion of the pyramidal tracts in their intracranial portion, or, particularly in infants, to arrested development of the cortical motor areas, in both hemispheres. It is sometimes termed double hemiplegia. It may affect chiefly the arms, or the legs, and has the usual characteristics, namely, spastic movements, exaggerated reflexes, and absence of sensory and trophic changes. Primary sclerosis of the pyramidal tracts in the cord is a rare condition, if it occurs at all.

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Intracranial tumors, by pressure upon the crura and pyramidal tracts in the pons and medulla, or in the cerebellum, may produce paraplegia or paraplegiform symptoms, in some cases being ataxic rather than paretic, or a combination of both.

Paraplegia from Multiple Neuritis is characterized by both motor and sensory impairment involving all the extremities, and ascending the members from periphery to trunk, also by pain, hyperæsthesia, tenderness of the nerve trunks to pressure, trophic changes in the muscles, the reaction of degeneration, œdema of the extremities, the absence of visceral disturbances (bladder and rectum), and the absence of a constriction band. It is most common in those addicted to alcohol, but is also a manifestation of certain endemic diseases, such as beriberi or kakki.

Pseudo-hypertrophic Paralysis produces a form of paraplegia somewhat similar to poliomyelitis anterior, and is considered by some to be a form of that affection, by others to be a connective-tissue disease of the muscles. The increase in size of the muscle (usually the calves) and its hardness, serve to distinguish it from ordinary poliomyelitis anterior.

There are several forms of paraplegia usually classified under functional disorders of the nervous system, namely, hysterical paraplegia, paraplegia depending upon idea, reflex paraplegia, malarial paraplegia, anæmic paraplegia, alcoholic paraplegia, and toxic paraplegia.

Hysterical Paraplegia is a less frequent form of hysterical paralysis than that of hemiplegic or monoplegic distribution. It is less apt to be confounded with paralysis of organic origin than the other varieties, for the reason that hysterical paralysis resembles in its symptoms a lesion of cerebral motor tracts in the brain and cord, rather than one in the remaining portion of the motor tract in the cord and peripheral nerves. The reaction of degeneration is absent in hysterical paralysis. Atrophy may be present, but it is that form which is dependent upon disuse. The volume of the muscles may be reduced in such cases, and may give a feeble reaction to electrical excitation; but, what is of the utmost importance, *faradic excitability is preserved, and the contractions are quick.* The skin and muscles may be cold, livid, and flabby, resembling paralysis from peripheral or cornual disease, and contractures may form as in degeneration of the pyramidal tracts, though in many cases the muscles and skin appear normal, except that voluntary control is lost. The tendon reflexes are rarely lost; usually they are increased, sometimes excessively so. The bladder and rectum are not usually affected, though voluntary control over these organs may be lost. Thus, paraplegia from transverse myelitis of the lumbar enlargement would not be confounded with hysterical paraplegia on account of the absence in the latter of trophic and electrical changes in the muscles and nerves, bedsores, and atrophic changes in the bladder; but the latter might closely resemble paraplegia from transverse dorsal myelitis in which these signs are absent. The presence of a constriction band at the level of the segment involved, and the sensory, motor, or reflex disturbances in this zone would exclude hysterical paraplegia. Hysterical paralysis of all the extremities might simulate cervical paraplegia of myelitic origin, but would be differentiated from it by the presence of trophic changes in the muscles of the upper extremities, and by the vaso-motor and visceral symptoms which accompany organic lesions of this region. Again, the onset and course of the two classes of disease are usually sufficient to distinguish one from the other. The irritative stage of most acute or subacute organic diseases of the cord, in which pain, hyperæsthesia, and slight motor irritation precede the paretic and anæsthetic period, is not usually present in hysterical paraplegia. In the latter, sudden development of the paraplegia, and sudden variations in its distribution and intensity, often serve to indicate it. Anæsthesia and analgesia may have a distribution inconsistent with the lesions producing paraplegia of structural origin.

It must not be forgotten that hysteria may accompany organic lesions, and should not, therefore, be taken as proof of the hysterical nature of the paralysis, unless organic lesions can be excluded.

Paraplegia Dependent upon Idea is a form described by Dr. J. Russell Reynolds. Though closely allied to hysterical paralysis, it may be independent of hysteria, hypochondriasis, and simulation, though frequently associated with functional debility, anxiety, and a morbid imagination. "Many cases of paraplegia following railroad accidents," says Reynolds, "may be classed under this head; the attention of the victim being influenced in the most unfortunate manner by the stories of friends, inquiries of his physician, the talk of his attorney, and the sober face of the company's physician." Pain, distributed in a manner inconsistent with the anatomical relations, on the supposition of an organic lesion; spasm, which, however, is sometimes relaxed in a remarkable way when the patient's attention is directed elsewhere; and paralysis, which is rarely complete, and almost identical with a voluntary attempt not to move the parts, or to move them with care, as in simulation, are the chief features of the affection. The removal of the morbid idea, *i.e.*, that the patient is paralyzed, or has a severe disease, results in improvement or cure. An award for damages has also frequently proven a valuable therapeutic agent in such cases.

Reflex Paraplegia, termed by older writers urinary paraplegia, was shown by Brown-Séquard to follow irritation not only of the genito-urinary tract, but also of the intestines and other viscera in animals. He attributed it to an anæmia of the cord, due to contraction of the blood-vessels, while Charcot considered the motor weakness due to inhibitory action of the sensory irritation. While we must admit the possibility of this form of paraplegia, it should not be forgotten that organic lesions may have been lost sight of, or might be sufficiently slight to be transitory. The positive evidence of some form of peripheral irritation, the removal of which has been followed by recovery, is the only basis on which it should be admitted, and then only in the absence of indications of organic disease.

Malarial or Intermittent Paraplegia is a curious form of poliomyelitis anterior, which recurs with the periodicity of intermittent fever. Alcoholic paraplegia, when not due to multiple neuritis, is a temporary affair, following an alcoholic debauch.

Anæmic Paraplegia follows ischæmia of the cord, from pressure on the abdominal aorta, and from pressure or occlusion of the iliac arteries within the pelvis, or ischæmia of muscles; rare conditions.

The indications for *treatment*, where paraplegia exists, are those adapted to the correction of the various pathological processes concerned in the diseases which we have considered. More than a brief résumé would carry us beyond the proper limits of this work. In the irritative stage of acute meningitic and myelitic processes, rest is the first essential. The reduction of hyperæmia, by means of agents supposed to cause vaso-motor contraction, such as ergot and belladonna, and the relief of pain by means of cutaneous irritation (the actual cautery, blis-

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ters, sinapisms, cupping, etc.), and also by morphine, may be attempted. The use of cold to reduce inflammation in spinal-cord disease is an uncertain procedure, concerning the real effects of which we know but little.

In the destructive stage of these conditions, when paralytic and anæsthetic phenomena are present, rest may still be an important factor. The use of mercury, and of potassium iodide, may be of service in this period to promote the absorption of exudations.

In later stages and in chronic cases the use of tonics, of iron, strychnine, arsenic, etc., is called for. Nitrate of silver may be indicated. Electricity is usually to be avoided in the irritative stage of an acute affection; or, if used, as for the relief of pain, it should be in the form of a gradually increased galvanic current, avoiding interruption. For the paralysis, the interrupted galvanic and the faradic currents, to produce muscular contractions, and spinal applications of the uninterrupted galvanic current, are of value, as are also massage and passive movements. For anæsthesia, the faradic brush is often serviceable.

Extreme care and cleanliness are essential in all cases of paraplegia, and the avoidance of pressure and irritation over the buttocks and sacrum, on account of the danger and frequency of bedsores. Attention must be paid to the bladder and rectum. Catheterization, conducted with extreme cleanliness, may be necessary, and also antiseptic irrigation of the bladder. Constipation must be prevented by cathartics, enemas, etc. Compression myelitis from caries, dislocations, fractures, and other traumatisms requires appropriate surgical treatment.

W. R. Birdsall.

PARASITES.—A parasite is an organism which lives, temporarily or permanently, within the body or on the surface of some other living thing upon which it feeds. Evidently, then, not only may there be both phytoparasites and zoöparasites, but also that form which is parasitized upon and is known as the host may be equally either plant or animal. Among forms which find in man at some time or in some region a subject for attack, the phytoparasites include the prominent group of bacteria which have received attention elsewhere, and a few fungi of etiological importance, in dermal affections chiefly, which have also been discussed. Here will be given a brief discussion of the animal parasites of man, with especial reference to their biological and etiological relations.

It is important to notice first the wide range in degree of parasitism exhibited and the manner in which the various grades merge into one another, producing a scale of dependence in which almost every stage is represented. Most independent of all are the temporary parasites, like the mosquito, bedbug, or leech, which stay by the individual host only long enough to secure a single meal, and which present clearly the structure and habits of free living organisms. Some leeches suggest most plainly the close relation between the carnivorous and the parasitic habit since they often devour bodily small aquatic forms, but when favored by opportunity extract the blood of larger animals. More dependent are such forms as the fleas which can change their host and often do so, and yet their structure has been highly modified in the loss of wings which are generally characteristic of insects and by the development of powerful leaping and grasping organs. Somewhat further modified in the direction of parasitism are the lice, which, moreover, lack special means for effecting a change of host, and may be included among the list of stationary parasites—*i.e.*, those that remain with a single host constantly, or at least for considerable periods of time.

All of the forms thus far noted are parasitic upon the exterior of the host, and consequently are denominated Epizoa or ectoparasites. All human ectoparasites belong to the group of Arthropoda, and include both mites (*cf. Arachnida*) and true insects (*cf. Insects*). Among the water-living animals, however, soft bodied forms such as flat worms (Trematoda) and unicellular animals (Protozoa) occur as Epizoa. With the gradual assumption of an aërial or terrestrial existence on the part of the host such parasites were necessitated, if they had not already sought more sheltered regions, now at least to abandon the external surface and to colonize internal organs where thin mucous membranes afforded facilities for extracting nourishment similar to those which existed on the thin outer skin of the aquicolous animal. The choanæ, pharynx, gills, lungs, alimentary canal, and even the bladder were thus invaded by forms whose kinship to the ectoparasitic species on these lower animals is too plain to fail of recognition.

The Entozoa or endoparasites of man, however, do not even belong to the same branch of the animal kingdom as the forms ectoparasitic upon him, with the single exception of the rare and aberrant Linguatulids, now usually regarded as highly degenerate arachnids (*q.v.*), though formerly classed with the Cestoda. The human Entozoa include Protozoa, Trematoda, Cestoda, and Nematoda, and many of them are highly modified in adaptation to the parasitic mode of existence, as compared to the related free living forms which, however, are entirely wanting in the second and third groups listed.

The term helminthology has been used as synonymous with animal parasitology, and yet this is a considerable extension of its original meaning. The Helminthes or intestinal worms included the pre-eminently parasitic groups, such as Trematoda, Cestoda, and Nematoda, while the Protozoa, Arthropoda, and even the few parasitic Turbellaria, which are in fact closely related to Trematoda, were omitted. The term became thus one of convenience rather than of scientific accuracy.

It is necessary to emphasize the fact that neither Helminthes nor parasites constitute a group of systematic value. At most the forms are related in a biologic sense and not structurally, for they are comprehended in several distinct branches of the animal kingdom, and a given form is often more closely related to free living species than to other parasitic forms. Even the narrower term Helminthes embraced forms of little similarity to each other and rightly to be distributed with their related free living species into several distinct groups, namely, the Linguatulida to the Arachnida, the Trematoda and Cestoda to the Plathelminthes, and the Nematoda to the Nemathelminthes.

Location.—While the majority of endoparasites inhabit the alimentary canal and its adnexa, there is no organ which is immune to them. The following list of human parasites arranged according to the organ inhabited will serve to indicate the extent of the parasitic habit, and will assist in the identification of a given form. The records given apply only to the human host. Parasites are entered under the normal location of the species, and in the most frequent erratic location only; a few forms of doubtful standing, as human parasites or of uncertain location in this host, are omitted.

Parasite.	Stage.	Type of parasitism.	Normal habitat.	Recorded in U. S. A.
Skin and subdermal tissue.				
Leptodera Niellyi........	Larva..	Accidental.	Europe....	No.
Gnathostoma siamense..	Adult..	Occasional.	Siam......	No.
Filaria medinensis......	Adult..	Normal....	Africa.....	Yes.
Uncinaria duodenale...	Larva..	(?)........	Cosmopolitan.	Yes.
Eye.				
Filaria loa..............	Adult..	Normal....	Africa.....	Yes.
Filaria lentis............	Adult..	(?)........	(?)........	No.
Filaria conjunctivæ.....	Adult..	Occasional.	Europe....	No.
Cysticercus cellulosæ....	Larva..	Erratic....	Europe....	No.
Echinococcus polymorphus.	Larva..	Erratic....	Europe....	Yes.
Brain and membranes.				
Cysticercus racemosus—cellulosæ.	Larva..	Erratic....	Europe....	Yes.
Cysticercus acanthotrias	Larva..	Erratic (?).	U. S. A....	Yes.
Echinococcus polymorphus.	Larva..	Erratic....	Europe....	Yes.

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Parasite.	Stage.	Type of parasitism.	Normal habitat.	Recorded in U.S.A.
Brain and membranes.				
Paragonimus Westermanni.	Adult..	Erratic	Asia	*
Connective tissue.				
Fasciola hepatica........	Adult..	Erratic	Europe	*
Bothriocephalus Mansoni	Larva ..	Occasional.	China	No.
Cysticercus cellulosæ....	Larva ..	Normal....	Europe	Yes.
Cysticercus acanthotrias..	Larva ..	Normal....	U. S. A	Yes.
Echinococcus polymorphus.	Larva ..	Normal....	Europe	Yes.
Filaria loa...............	Adult..	Normal....	Africa	Yes.
Paragonimus Westermanni.	Adult..	Erratic	Asia.......	*
Muscles.				
Cysticercus cellulosæ....	Larva ..	Normal....	Europe	No.
Cysticercus acanthotrias..	Larva ..	Normal....	U. S. A	Yes.
Trichinella spiralis	Larva ..	Normal....	Cosmopolitan.	Yes.
Heart.				
Filaria Magalhaesi.......	Adult..	(?).........	So. Amer..	No.
Cysticercus cellulosæ....	Larva ..	Erratic	Europe	No.
Echinococcus polymorphus.	Larva ..	Erratic	Europe	Yes.
Blood-vessels.				
Fasciola hepatica........	Adult..	Erratic	Europe	*
Schistosoma hæmatobium.	Adult..	Normal....	Africa	Yes.
Echinococcus polymorphus.	Larva ..	Normal....	Europe	Yes.
Filaria immitis (?).......	Adult..	Occasional.	Europe	*
Filaria embryos (see key under Nematoda).	....	Normal....	....	Yes.
Lymph vessels.				
Filaria Bancrofti	Adult..	Normal....	Tropics....	Yes.
Filaria volvulus..........	Adult..	Normal....	Africa	No.
Filaria lymphatica.......	Adult..	Occasional.	Europe	No.
Lungs.				
Fasciola angusta.........	Adult..	Erratic	Africa......	No.
Paragonimus Westermanni.	Adult..	Normal....	Asia.......	*
Cysticercus cellulosæ....	Larva ..	Normal....	Europe	No.
Echinococcus polymorphus.	Larva ..	Normal....	Europe	Yes.
Strongylus apri	Adult..	Occasional.	Europe	No.
Liver.				
Fasciola hepatica	Adult..	Occasional.	Europe	*
Opisthorchis felineus	Adult..	Normal....	Russia	No.
Opisthorchis sinensis	Adult..	Normal....	Asia.......	Yes.
Opisthorchis noverca	Adult..	Normal....	Asia.......	No.
Distoma Rathouisi.......	Adult..	Occasional?	Asia.......	No.
Dicrocœlium lanceatum.	Adult..	Normal....	Europe	*
Cysticercus cellulosæ	Larva ..	Normal....	Europe	No.
Echinococcus polymorphus.	Larva ..	Normal....	Europe	Yes.
Paragonimus Westermanni.	Adult..	Erratic	Asia.......	*
Small intestines.				
Fasciolopsis Buski.......	Adult..	Normal....	Asia.......	No.
Opisthorchis felineus	Adult..	Erratic ...	Russia	No.
Opisthorchis sinensis	Adult..	Erratic	Asia.......	No.
Heterophyes heterophyes	Adult..	Normal....	Africa	No.
Dibothriocephalus latus..	Adult..	Normal....	Europe	Yes.
Dibothriocephalus cordatus.	Adult..	Occasional.	Greenland.	No.
Diplogonoporus grandis .	Adult..	Occasional.	Japan	No.
Dipylidium caninum.....	Adult..	Occasional.	Europe	Yes.
Hymenolepis nana........	Adult..	Normal (?).	Europe	Yes.
Hymenolepis diminuta ..	Adult..	Occasional.	Europe	Yes.
Hymenolepis lanceolata .	Adult..	Occasional.	Europe	No.
Davainea madagascariensis.	Adult..	Occasional (?).	Africa	No.
Tænia solium	Adult..	Normal....	Cosmopolitan.	Yes.
Tænia saginata.........	Adult..	Normal....	Cosmopolitan.	Yes.
Tænia africana..........	Adult..	Normal....	Africa	No.
Tænia confusa	Adult..	Normal (?).	U. S. A	Yes.
Strongyloides stercoralis.	Adult..	Normal....	Asia.......	Yes.
Trichinella spiralis	Adult..	Normal....	Cosmopolitan.	Yes.
Strongylus subtilis.......	Adult..	Normal....	Africa.....	No.
Uncinaria duodenalis ...	Adult..	Normal....	Cosmopolitan.	Yes.
Uncinaria americana	Adult..	Normal....	America ..	Yes.
Physaloptera caucasica..	Adult..	(?).........	Caucasus...	No.
Ascaris lumbricoides	Adult..	Normal....	Cosmopolitan.	Yes.
Ascaris canis	Adult..	Occasional.	Europe	*
Ascaris maritima........	Adult..	Occasional.	Greenland.	No.
Oxyuris vermicularis	Adult..	Normal....	Cosmopolitan.	Yes.
Gigantorhynchus gigas..	Adult..	Occasional.	Cosmopolitan.	No.
Gigantorhynchus moniliformis.	Adult..	Occasional.	Cosmopolitan.	No.

* Present in the United States of America in some other host, hence easily possible in man, although no record of its occurrence in the human host was found.

Parasite.	Stage.	Type of parasitism.	Normal habitat.	Recorded in U.S.A.
Large intestine.				
Gastrodiscus hominis....	Adult..	Occasional (?).	India......	Yes.
Trichocephalus trichiurus	Adult..	Normal....	Cosmopolitan.	No.
Oxyuris vermicularis	Female.	Normal....	Cosmopolitan.	Yes.
Kidney.				
Echinococcus polymorphus.	Larva ..	Normal....	Europe	Yes.
Dioctophyme renale.....	Adult..	Occasional.	Europe	*
Bladder.				
Leptodera pellio.........	Adult..	Accidental.	Europe	No.
Anguillula aceti.........	Adult..	Accidental.	U. S. A	Yes.

SPUTUM—EGGS.

Parasite.	Frequence.	Size in microns.	Plate E.
Fasciola angusta	Recorded once.	143–151 × 82–88.	
Fasciola hepatica.......	Not observed, but possible.	Given below under Fæces.	
Fasciola magna, etc.....			
Paragonimus Westermanni.	Frequent	88–103 × 53–68.	Fig. *a*.
Strongylus apri	Few cases	50–100 × 39–72.	

SPUTUM—EMBRYOS.

Filaria, many species possible (see key under *Nematoda*).

URINE—EGGS.

Parasite.	Frequence.	Size in microns.	Plate E.
Fasciola hepatica.......	Not observed, but possible.	Given below under Fæces.	
Fasciola magna, etc.....			
Schistosoma hæmatobium	Frequent	135–160 × 55–66.	Fig. *c*.
Filaria Bancrofti.........	Recorded once.	25–28 × 15 (or 35 ?).	
Dioctophyme renale......	Few cases	64–68 × 40–49.	Fig. *b*, *b'*.
Oxyuris vermicularis†....	Common	50–54 × 20–27.	Fig. *d*, *d'* *d''*, *d'''*.

URINE—EMBRYOS.

Filaria, many species possible (see key under *Nematoda*).

The eggs of the other kidney parasites will not hatch as long as kept in urine.

Adult forms, like accidental parasites of the Nematode type, are so small as to be easily taken for embryos (see Anguillula aceti, etc., under *Nematoda*).

FÆCES—EGGS.

Parasite.	Frequence.	Size in microns.	Plate E
Gastrodiscus hominis	Recorded once.	150 × 72.	
Fasciola hepatica.........	Several cases ..	130–172 × 72–80.	Fig. *c*.
Fasciola magna	Not recorded ..	109–168 × 75–96.	Fig. *aa*.
Fasciola angusta	Recorded once.	143–151 × 82–88.	
Distoma Rathouisi	Recorded once.	150 × 80.	
Fasciolopsis Buski........	Several cases ..	120–126 × 77.	
Opisthorchis felineus.....	Several cases ..	26–30 × 11–15.	Fig. *f*.
Opisthorchis noverca	Recorded once.	34 × 21.	Fig. *ff*.
Opisthorchis sinensis.....	Several cases ..	27–30 × 15–17.	Fig. *g*.
Dicrocœlium lanceatum..	Several cases ..	40–45 × 22–30.	Figs. *h*, *h'*.
Heterophyes heterophyes.	Frequent	26–30 × 15–17.	Fig. *i*.
Paragonimus Westermanni.	Frequent	88–103 × 53–68.	Fig. *a*.
Dibothriocephalus latus..	Frequent	68–71 × 45	Figs. *k*, *k'*.
Dibothriocephalus cordatus.	Reported once.	75–80 × 50.	
Diplogonoporus grandis ..	Few cases	63 × 48–50.	Fig. *l*.
Dipylidium caninum	Few cases	43–50, embryo 32–36.	Fig. *m*.
Hymenolepis nana	Frequent	39, or 43 × 31.	Fig. *n*.
Hymenolepis diminuta ...	Several cases ..	70–86, embryo 36 × 28.	Figs. *o*, *o'*.
Hymenolepis lanceolata..	Recorded once.	50 × 35.	
Tænia solium............	Frequent......	30–35, embryo 20	Figs. *p*, *p'*.
Tænia saginata	Common	(Yolk membrane 70) 30–40 × 20–33.	Figs. *q*, *q'*.
Tænia africana	Recorded once.	31–34 round, or 34 × 39.	Fig. *r*.
Tænia confusa	Two cases	30 × 39.	Fig. *s*.
Strongyloides stercoralis..	Frequent	67 × 37.	Fig. *t*.
Trichocephalus trichiurus.	Common	50–54 × 21–23.	Figs. *u*, *u'*.

* Present in the United States of America in some other host, hence easily possible in man, although no record of its occurrence in the human host was found.

† Only in female through infection of vagina from rectum.

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FÆCES—EGGS.—*Continued.*

Parasite.	Frequence.	Size in microns.	Plate E.
Strongylus subtilis	Several cases	63-80 × 35-41.	Fig. *v*.
Strongylus apri	Few cases	50-100 × 39-72.	
Uncinaria duodenalis	Frequent	[illegible] × 32-45.	Fig. *w*.
Uncinaria americana	Frequent	61-72 × 36-40.	Figs. *x*, *x'*, *x''*, *x'''*.
Physaloptera caucasica	Reported once.	57 × 39.	
Ascaris lumbricoides	Common	50-75 × 40-50, fertilized.	Fig. *y y''*.
		63-98 × 31-77 unfertilized.	Fig. *y'*.
Ascaris canis	Few cases	72-68, spherical.	Fig. *z*.
Oxyuris vermicularis	Common.	50 × 16-20.	Figs. *d*, *d'*, *d''*, *d'''*.
Gigantorhynchus gigas	Few cases.	80-100 long, oval	Fig. *dd*.
Gigantorhynchus moniliformis.	Few cases.	85 × 40.	

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FÆCES—EMBRYOS.

Parasite.	Frequence.	Size in microns.	Plate.
Filaria.*			
Strongyloides stercoralis	Common	200-400 long	
Trichinella spiralis	Rare	90-100 × 6.	

* Many species possible (see key under *Nematoda*).

One may recognize among these parasites those which occur in their normal host but in an unusual location, like the brain cysticerci or a liver fluke in a subcutaneous cyst; there are also many of the species listed which cannot be regarded in any way as characteristic of the human host. Such are the occasional parasites which are species of true parasitic habit and can attain normal development in the human host, but ordinarily do not find conditions favorable for their introduction. As an instance of such species may be mentioned *Fasciola hepatica*, the common liver fluke of the sheep, which in many regions of the world is extraordinarily abundant. That it can thrive in the human system is demonstrated by the score or more of cases of its occurrence there definitely recorded; but its infrequence is equal evidence of a general immunity on the part of man, lacking in these particular cases, or of special features in its life history which make the infection of the human host difficult. That the latter is the probable explanation may be inferred from the fact that the cercaria larva, liberated from the intermediate host, encysts on grass, and hence could reach the human alimentary canal only under unusual circumstances. Similar examples may be taken from other groups of parasitic forms, such as the rare occurrence in man of *Strongylus apri*, one of the commonest parasites of the pig in Europe, or of *Dipylidium caninum*, the cosmopolitan tapeworm of both dog and cat, which has been reported only rarely from man.

Such occasional parasites often occur under abnormal conditions; thus a fish nematode, *Ascaris clavata*, was discovered once in the hollow tooth of a man. Here the position was probably accidental, but in other cases it is the result of the action of the parasite itself. So the "red spiders," or "jigger" mites of the Central States bury themselves in the skin of man, although such a position is so clearly abnormal that in fact it destroys the chance of further development and costs the parasite its life. A small leech, *Limnotis nilotica*, common in the Circummediterranean area, is often drawn into the throat of men and other animals drinking at wayside pools. It usually retains its position, causing serious difficulty, until removed by operative interference; hence it has become an occasional parasite of man rather than, as in the case of most leeches, a temporary parasite; or one may regard it as falling in the next following group of accidental parasites. This example shows most clearly the narrow and somewhat artificial limits which separate these groups of parasites from one another. Of the mites also, which have been reported a few times as obtained living from stomach, bladder, and rectum, it is difficult to say whether they are occasional or accidental parasites of man.

There are also rarely forms which commonly occur free living, but which by chance are introduced into some organ in which conditions are such that they can thrive. They become thus accidental parasites, a group difficult practically to distinguish from the last, the occasional parasites, and yet presenting somewhat different biological conditions. The recent discovery by Stiles and Frankland, as well as others, of the vinegar eel, *Anguillula aceti*, as an apparently successful colonizer of the bladder in a female patient illustrates the type under consideration. There is little doubt that this parasite was introduced through the use of vinegar in vaginal douches and effected a successful colonization, possibly by virtue of the trace of albumin present in the urine which furnished it with nourishment. Equally striking is the case of Scheiber, who discovered *Leptodera pellio* in the urine of a female patient in Hungary. This typical slime-inhabiting nematode gained entrance, no doubt, through the application of mud poultices, which are commonly employed by peasants in that region. It should be noticed that such accidental parasites are necessarily confined to those groups of animals which have free-living forms. Such are Protozoa, Nematoda, and perhaps Insecta in the larval condition, while Cestoda and Trematoda, which live only as parasitic forms in some host, would become rather occasional parasites of man should they stray into the human system in some chance manner and find favorable conditions for existence.

Quite distinct from the types just considered are pseudo-parasites, which rank high in clinical importance. Among them one may recognize several very distinct classes. First, those which are actually free-living animals, introduced by accident, usually in food or drink, into the human alimentary canal, exciting there abnormal conditions which induce their more or less immediate and forcible expulsion. Thus Botkin found in the vomit of a Russian numbers of a small nematode which he wrongly believed to be a human parasite. In fact it lives normally in the onion, and its introduction into the stomach with this food excited the untoward symptoms noted. Similarly Blanchard records a case in which coleopterous larvæ were found in the vomit of a child.

That such may be the result of introducing a true parasite from some other host is indicated by several cases, like that of *Ascaris maritima*, which Leuckart described from a single specimen vomited by a child in Greenland, and which this author noted was very similar to *A. transfuga* of the brown bear. In all probability it was ingested with the viscera of some animal (seal?), though it may have been a species which had strayed into this unusual host, only to make its appearance under the circumstances noted.

Of similar import are the cases of *Gordius*, the hair snake, which have been reported from man. In the adult condition this is normally a free-living species, but about a dozen specimens have been taken from man after a supposed sojourn of from a few hours to fourteen days. Some of these have been vomited and others passed per anum. This form has often been passed off upon the physician as a true parasite, and in one celebrated case at least as the Guinea-worm.

In the same way one may find the explanation for other isolated cases of parasitism, even when the parasite is reported to have been passed from the alimentary canal. Thus Cobbold reported that larvæ of *Blaps mortisaga*, the English churchyard beetle, were found in fecal discharges, and many authors have recorded the presence of dipterous larvæ in the alimentary canal.

The majority of such observers have inclined to regard these larvæ as temporary endoparasites, and to consider that they have accommodated themselves to the conditions present in the human host. The cases seem to show that these larvæ live for some time in the canal, and they often appear to evoke serious or even fatal disturbances; and yet the conclusions are open to grave doubt, for Calandruccio experimented extensively on two families of flies to which many of the supposed accidental parasites

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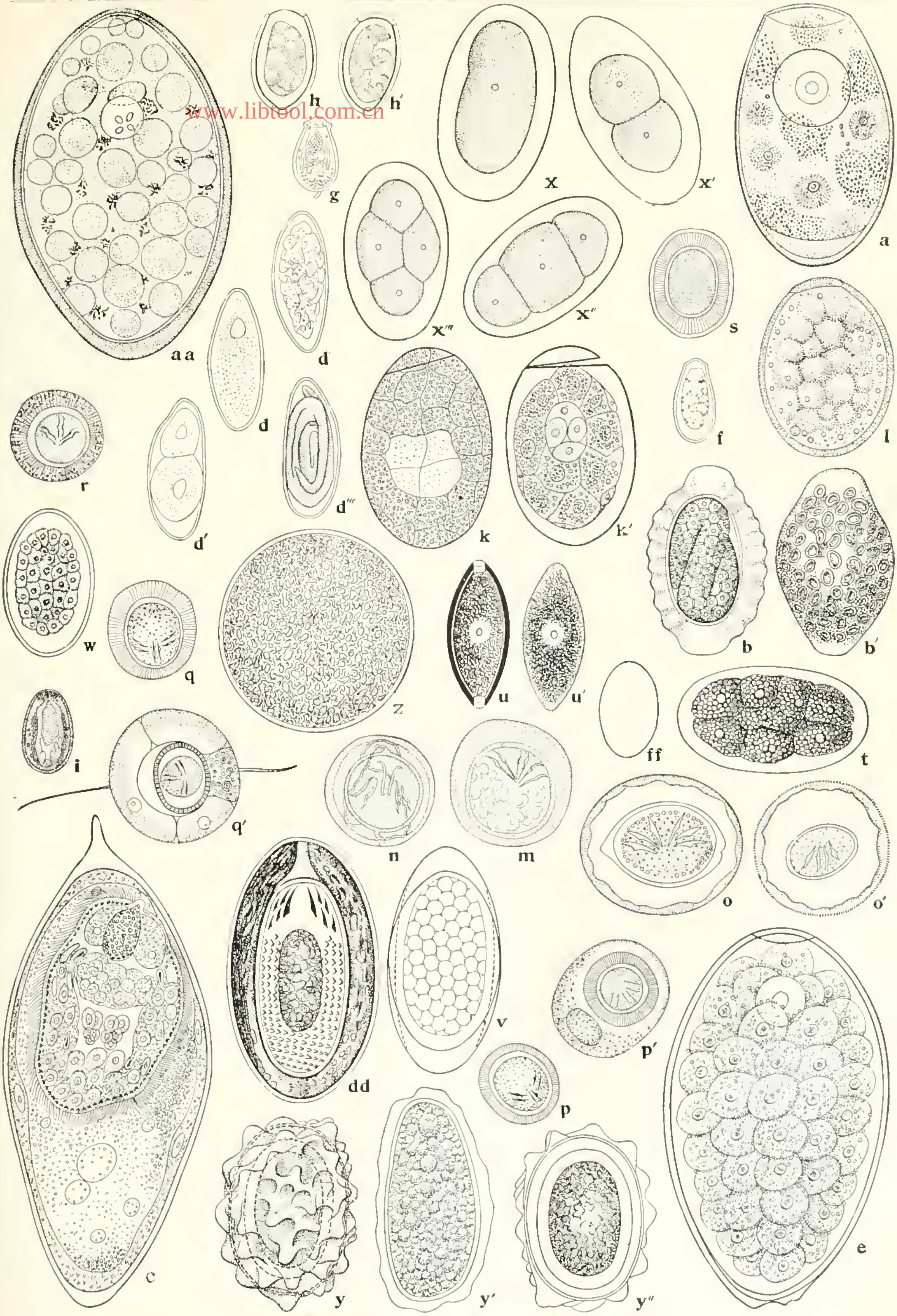

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EGGS OF HUMAN PARASITES
(MAGNIFIED FIVE HUNDRED DIAMETERS)

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belong, and found that the ingested larvæ were regularly and promptly evacuated, dead or dying, and in no case did they secure a footing in the canal.

Among the myriapods about forty recorded cases of pseudoparasitism have been brought together and discussed by Blanchard. In the large majority the animal was taken from the nasal fossæ, though in a smaller number it was actually obtained living from the alimentary canal, where it undoubtedly can exist for a brief time in spite of the untoward environment. The ingestion of such forms is purely accidental, the symptoms are those of helminthiasis in general, and their stay at most is very limited. They never show any evidence of adaptation to the new environment.

In some such accidental fashion other forms are sometimes introduced into various organs not connected with the alimentary system. Thus Trouessart reported the occurrence of a species of detricolous Sarcoptids in the human testicle where the mites formed an old colony in a painless cystic tumor.

In contrast with the living animals of the types noted, the second class of pseudoparasites includes a large number of other structures which have been described as parasites. These may be considered conveniently in a few groups, the first of which includes bodies which are parts of the so-called host animal itself. Thus fragments of the arteria hyaloidea have been described as eye worms (*Filaria lentis, F. oculi humani*, etc.), the organisms of whooping-cough are nothing more nor less than ciliated tracheal cells torn from the wall and found in the sputum in distorted form, while groups of small axillary and inguinal glands, hydatid moles, and Pacchionian bodies from the arachnoid have been frequently put on record as hydatid cysts.

Parts of substances used as food, both of plant and of animal origin, which have not been destroyed by the action of digestive juices are also among the pseudoparasites of man. The radulæ of the common limpet have been reported several times from stools; the seeds of the mulberry were duly baptized as parasitic worms; and plant vessels and other similar undigested structures of peculiar appearance appear periodically as new helminthes. That a differentiation of such structures is not simple appears from the account given by Stiles of the partially digested banana fibres which closely simulate minute tapeworms. Some years ago Leuckart entrapped a group of research students in helminthology with the pulp vesicles of an orange which were found in a fecal examination.

In all of the cases considered above it should be kept in mind that the animals or these other structures actually came from within the human body. There is, however, another class of objects of which this cannot be said.

In determining the nature of unusual forms reported from man it should always be kept in mind that in the absence of positive personal evidence, suspicion in case of neurasthenia at least favors the deceitful introduction of doubtful bodies. In many cases on record such things as earthworms, chicken entrails, etc., have been forcibly introduced into the rectum or vagina, and have been subsequently reported by the attending physician as undoubted human entozoa of a remarkable character! Here as elsewhere the appearance of unusual structures should at once arouse the suspicion of the physician and call forth a most searching examination of the case in all its factors, that any deceit be disclosed, or that in the event of the discovery of some rare parasite all conditions connected with its appearance be put on record for future use. The large number of parasites in other animals which some unusual combination of circumstances may bring into the human system makes it imperative also that any supposedly new species be submitted to the judgment of a specialist before it is described as such. Only in this way can the discoverer avoid adding to the long list of synonyms, which already burden the literature of this subject, and render it so difficult for the investigator not a specialist in this particular line to find his way aright. Furthermore, it is important to preserve the fullest data in regard to any substances associated with the supposed parasite, as well as the food of the patient, whether usual or unusual, since in this way some hint as to its introduction may be found.

Effect upon the Host.—In the belief of the medical profession two hundred years ago there was no disease, real or imaginary, which was not due to the presence and effect of some kind of parasite. Each ailment had its particular "worm" in its characteristic location. This was a direct result of the endeavor to reduce every malady to some definite cause, and of the joining of the unknown sickness with the parasites of which they knew as little. Under the influence of study and of increasing knowledge regarding the parasites such a theory was seen to be untenable, and the movement in the opposite direction began, a tendency which may be said by this time to have passed its height.

It is true that internal parasites are very widely distributed, and that scarcely any individual is entirely free from them. They are, however, usually present in limited numbers, and are believed to be harmless if infrequent or of small size. This does not seem to be strictly correct, for while it is doubtless true that the effect of a single parasite, or even of a considerable number of minute size, is small and difficult to measure or estimate, it is equally clear that even this is a certain drain on the host. Furthermore, the tax on the host is in proportion not only to the number and size, but also to the habits of the parasites present. Thus there is a great difference whether the parasite is active and growing in the alimentary canal or some other cavity in the body of the host, or passively resting in the midst of the tissue of some organ.

While encysted parasites exercise a continued and sometimes serious pressure on adjacent tissue, yet the draft on the host by free parasites is much the greatest, and manifests itself in three ways. The parasite requires a certain amount of food for its support; this it takes directly from the host, either from that which the latter has digested for its own use, if the parasite be in the alimentary canal, or from material which the host has formed to perform certain work, as in the case of blood parasites, or from the tissue of the host, as in the case of some intestinal worms which feed on the cells composing the wall of the intestine. In any case the host expends at least the extra energy necessary to procure and digest the food taken by the parasite, and this extra labor will be directly in proportion to the amount of food taken, or in general to the size of the parasite and to its fertility.

In the second place the parasite occupies a certain amount of space, and correspondingly reduces the calibre of the tube in which it lives. Unless a considerable number are present this is hardly a practical stoppage for the alimentary canal, although in several recorded cases death has followed occlusion of the canal by a mass of ascarids, and in the case of the blood system a vessel may be closed or a clot formed by the presence of even a very few parasites.

In the third place active parasites will, by their movements, give rise to a certain amount of irritation and inflammation of the membranes over which they move. This is in some ways, perhaps, the most serious trouble which a few parasites can cause, and it is much increased if in the special case the parasite obtains its food at the expense of the tissues of the host, that is, if it tears or consumes the walls of the cavity in which it lives. A secondary, though possible, result of this manner of living is the liability of rupturing some blood-vessel, with consequent serious results, as in the case of certain lung flukes which may chance upon some large blood-vessel and in this way produce even fatal hemorrhage. In the alimentary canal a single ascaris may perforate the wall and induce fatal peritonitis, as has been observed several times in recent years. It is evident, then, that no more than a single active parasite may be dangerous, and that it is always some tax on the domestic economy of its host. Of course, the effect of a microscopic worm in the alimentary canal of an elephant will be so small that it

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could hardly be calculated in any way; but this reasoning should not be extended too far. The disturbance produced in the human system by a single tapeworm is sufficient to call for prompt measures to remove it.

Recent studies have demonstrated the presence of hæmoglobin in the alimentary canal of many nematode parasites, the pathological effects of whose activities must be counted much more important than heretofore estimated by reason of this blood-sucking habit. Thus in cases of uncinariasis the amount of blood lost from myriads of minute hemorrhages imparts a characteristic reddish-brown color to the fæces, the intestinal wall becomes seriously affected and affords places of easy attack for any pathogenic germs which may be present. This indirect damage may be very serious in the individual instance, and may include primarily or secondarily undesirable retrogressive or progressive histological changes, inflammatory processes, and disturbances in the circulation.

Another source of danger from parasites is one which has long been surmised but only recently demonstrated. A number of investigators have shown that various Cestoda, Acanthocephala, and Eunematoda contain definite poisons (toxins) which when extracted and employed experimentally affect particularly the nervous system and the formation of blood. The continued formation and giving off of such a substance would explain the apparently excessive results of parasitism in some instances, results which are shown prominently in reflex nervous symptoms such as have been noted under Argas (*Arachnida*), and Tænia (*Cestoda*). In a certain proportion of cases pernicious anæmia is the result of this toxic effect, and is accompanied by a mortality of seventeen per cent., according to one report regarding Bothriocephalus. Whether the poison is elaborated by the parasite or is produced by pathological processes in the worm or by its death, as well as the ground for the variability in the toxic action of different specimens, are questions as yet undecided. It has been shown, however, that extracts from different species of helminthes vary considerably in toxic power. Vaullegrard has isolated two toxic principles, one of which acts upon nerve centres and the other upon muscles, and many symptoms produced experimentally by the injection of these substances are analogous to those manifested in parasitic disease. According to this chemical theory, the troubles caused by parasites are due to the formation of toxic substances more rapidly than their elimination by the host, and their consequent accumulation in the system.

It is noteworthy that eosinophilia has been recorded as a frequent if not universal symptom in parasitic infections. From 15 to 50 per cent. of eosinophiles in trichinosis, 10 per cent. in uncinariasis, 15 per cent. in oxyuris infection, and 20 per cent. in ascarid infection are average figures. The percentage varies greatly and does not appear to be constant, while it is present in other pathological conditions as well.

Life History.—Normal parasitism is related to the life history of the parasite with peculiar intimacy. Among accidental parasites the animal seems to continue the usual method of multiplication under the changed conditions. Thus Oerley was able to colonize *Leptodera pellio* in the vagina of mice where they reproduced normally. But in case of the well-known *Rhabdonema nigrovenosum* of the frog the parasitic generation alternates with a free living generation, and the two are distinguished only slightly in structure but radically in method of reproduction, since the one is diœcious and the other hermaphroditic. In the case of the parasite of Cochin China dysentery also, *Strongyloides stercoralis*, there is a hermaphroditic parasitic generation and a diœcious free-living generation, in which the individuals differ noticeably from the first. Alternation of generation is not infrequent among true parasites, but it usually bears a different relation to the life history, and one which will be clear after the examination of the simpler cases.

In the simplest case which is exemplified by many of the Nematoda parasitic in the alimentary canal the eggs reach the exterior with the fæces of the host, and in them or in water undergo development until after a brief period of growth, either still enclosed in the protecting egg membranes, as is the case in *Ascaris lumbricoides*, the common stomach worm, or as a free-living form in the water, the larva is ready to be reintroduced into the human alimentary canal. Then it undergoes its transformation into the adult, which is usually only growth, and the formation of the reproductive organs which are present in the larva in the form of a single cell or group of cells near the centre of the body, often so insignificant in the undeveloped condition as to escape observation. This type of development may be somewhat complicated by the sojourn of the parasite in one region of the canal, where it passes through the earlier stages of development and becomes sexually mature before seeking its definitive location. Such is the case in the pinworm, *Oxyuris vermicularis*, which grows to sexual maturity in the ileum, while the pregnant females migrate to the rectum in order to make periodic excursions to the perineum for oviposition.

A more complicated development is illustrated by the Guinea-worm, *Filaria medinensis*, in which the embryos set free into the water seek out a new host and enter its body in order to pass through the early stages of development there. After having attained a certain stage of growth in this host the larval parasite is ready for introduction into the final host, in which it reaches sexual maturity, and this change is effected probably by chance. The host in which the sexually mature parasite occurs is known as the primary, while the secondary is that in which the larva is found.

In the extreme case the life history is so modified that the parasite never reaches the external world, but passes from one host to another directly. Here the ultimate extreme of the parasitic habit has been attained. As illustrations of this several species of *Filaria* and *Trichinella* may be instanced. In *Filaria Bancrofti* the adult is parasitic in lymph glands and the embryos are set free in the blood stream. From this they are sucked out into the body of a mosquito and there undergo early development, only to be reintroduced at a later stage into the body of a new host where the mosquito is biting. In *Trichinella spiralis* the encysted larvæ in flesh are set free in the stomach by processes of digestion. They wander into the duodenum, and after attaining sexual maturity the female penetrates a villus and sets free the embryos which, reaching the muscle tissue through the agency of the blood current, encyst there and await transference to a new host. Thus in both cases no part of the life history takes place in the external world, and the transfer of the parasite is dependent upon the carnivorous or blood-sucking habit of the animal which functions in the one case as secondary host and in the other alternately as primary and secondary host, but in different organs.

A still more complicated relation is found in the majority of Trematoda and in some Cestoda when the change of host is associated also with an alternation of a sexual with an asexual generation. In most Cestoda the eggs develop into an embryo which in the secondary host gives rise by metamorphosis to a peculiar larva, the bladder worm; and this after its transfer to the primary host develops into the adult tapeworm. The relation between primary and secondary host here is generally that of food and feeder. Thus the bladder worms of the two most common human cestodes are found in the flesh of cattle and hogs respectively and develop when introduced into the alimentary canal of man into the adult tapeworm. Though somewhat complicated by radical changes in form, the process is generally regarded merely as a metamorphosis. The case is somewhat different in those forms, as, for instance, *Tænia echinococcus*, in which the bladder worm proliferates, forming not a single head merely, but several or many, from each of which when introduced into the proper host there may develop an adult cestode. Here the larva in the secondary host multiples asexually, while the adult in the primary host

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reproduces sexually. The change of hosts is accompanied by an alternation of generations or metagenesis.

In the Trematoda one finds the same alternation of generations coupled with change of hosts, only that the asexual generation may be repeated and the life history further complicated by the introduction of a new host, the tertiary, in which a stage of the development is passed. Among those forms of which the life history has been ascertained great difference obtains in detail; of the species parasitic in man the development is as yet known only in part so that the general statement may suffice and reference be made for details to the special account of the group given elsewhere.

Mode of Introduction.—The life history often gives a clew to the means by which the parasite gains introduction into the human host. Thus the discovery of bladder worms or of larval *Trichinellæ* in pork suggested at once the manner of infection, namely, by eating the flesh containing these larval stages without the flesh having been subjected during preparation to conditions such as to kill the larvæ. This method of infection, namely, the introduction of encysted larvæ, is characteristic for the Cestoda. Those species most common as adults in man among civilized nations are obtained directly from articles of food, as *Tænia saginata* from beef, *Dibothriocephalus latus* from fish; other less frequent species as *Hymenolepis diminuta*, *Davainea madagascarensis*, and others of which the larval stages are found in insects (cockroach, beetle, meal worm) owe their introduction perhaps to the chance inclusion of such infected insects in bread, puddings, or other similar articles of food.

Disregard of personal cleanliness on the part of the individual, the habit of biting the finger-nails, and among children the practice of sucking fingers or toes serve to infect such with the eggs or embryos of many parasites or to increase an infection already acquired. In this way there is introduced the larva of *Dipylidium caninum* which lives in the dog and cat fleas, the eggs of *Ascaris canis*, the dog and cat round worm, eggs of *Oxyuris vermicularis* which are deposited upon the perineum of the host, eggs of *Cysticercus cellulosæ* when the adult is present in the same host, and many other species. Contamination of hands with eggs from dirt and consequent infection of the individual is common in children and field laborers, and may introduce any form of which the eggs are capable of causing the direct infection; these forms are *Ascaris lumbricoides*, *Trichocephalus trichiuris*, and other Nematoda.

The introduction of eggs and embryos takes place in the majority of cases, no doubt, through the contamination of the water supply. Almost all the eggs of the helminthes develop in standing water, and primitive methods of obtaining drinking-water from pools afford the best means of disseminating the species. Salads and other foods eaten uncooked serve as further means of infection, especially in those regions where it is customary to use human excrement to enrich the soil, or where the water supply of the village is dependent upon infected sources.

Among the important parasites which reach the human system as eggs in water or on uncooked vegetable food are of the Cestoda: *Cysticercus cellulosæ*, the larva of *Tænia solium*, *Echinococcus polymorphus*, the larva of *Tænia echinococcus*; of the Nematoda: *Ascaris lumbricoides*, *A. canis*, *Oxyuris vermicularis*, *Trichocephalus trichiuris*; of the Linguatulida: *Pentastoma denticulatum*, *Porocephalus constrictus*.

Of those which as larvæ attain the human host in the same manner one may list all the Trematoda parasitic in man, and of Nematoda *Strongyloides stercoralis* and possibly *Uncinaria duodenalis*, though according to the studies of Looss the latter seems to bore its own way actively into the body of the host.

The part played by chance in the introduction of parasites is very large. Grubs, hairworms, maggots, and even tapeworms have been taken from wells and from running water. The same forms occur frequently in various kinds of fruit; others in old or carelessly handled meat, also mites in cheese and fruit; and any or all of these may at times reach the human alimentary canal, where according to their adaptability they become occasional, accidental, or pseudoparasites. Their presence may be made known at once by adverse conditions, or they may remain long undetected so that their source is fully unknown. They may reach peculiar locations, as is shown by the flesh fly maggot taken from an abscess in the middle ear, which it had in all probability reached by active migration through the Eustachian tube, having been introduced into the throat with a piece of meat.

Factors Controlling the Abundance of Parasites.—The life of man in communities led at first to a large increase in the number of parasites and to frequent epidemics; and both of these results were due to conditions resulting from the communal life. Of primary importance is the impure water supply which semicivilized communities are wont to draw from the nearest pool. The minute, well-protected eggs of parasites distributed in fecal matter everywhere (for such communities are not exacting in their demands for the disposition of waste) are carried by rain water and distributed over large areas contiguous to the settlements and contaminate generally the surface water of the district. In case the parasite develops directly, the human host becomes infected by the use of this surface water; and if it is a form requiring a secondary host, the same conditions give it easy access to the forms which serve as such, since these are largely domestic animals. The close relation of the abundance of parasites to the water supply is well illustrated by the case of *Bothriocephalus latus*. This form is very common in a few regions in Europe, all of which are proximate to bodies of water. The intermediate host is a fish, and the very means adopted by civilized communities for removing danger of contamination from waste, namely, the sewage system, became the medium through which the eggs and embryos were carried into the lake. There they found suitable secondary hosts in the fish which subsequently reached the city markets further to infect the populace. The life cycle was complete within narrow geographical limits, and the element of chance which plays a large part in limiting the numbers of parasitic animals was reduced to lowest terms.

The dangers of parasitic infection in communal life, which pays little attention to the amount and character of surrounding surface water, is also illustrated by the spread of malaria, elephantiasis, and yellow fever, which depend upon the abundance of mosquitoes bred in this casual water. It has been abundantly shown that criminal carelessness on the part both of individual and community has multiplied breeding places and contributed materially to the spread of these diseases. Even the invention of protective screens has not been able to cope with these aggravating carriers of disease.

The habit of the isolated individual is also that of the community, even such as may be well advanced in the social scale, namely, to deposit human excrement indiscriminately. This method, which even to-day is practised in some parts of the United States, is well calculated to give to eggs of parasites a maximum opportunity for development. The same opportunity is afforded when the Chinese gardener employs for the enrichment of his garden patch human excrement from the neighboring village.

The same massing of individuals which has made the community more liable to parasitic infection plays its part in the infection of the secondary hosts, especially those which are domesticated animals. If the ground on which cattle are grazing becomes infected by tapeworm eggs, the entire herd may receive bladder worms. The infection of a single hog with trichinæ means the contamination of the entire group if the pernicious habit is followed of feeding to others the remnants of a slaughtered animal. Just here is the chief reason for the strong condemnation which has been visited upon local slaughter-houses. They regularly feed the offal to hogs, and by so doing further the spread of such parasites. In the large packing establishments the requirements of modern

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industrial success are met by regulations which cure the evils referred to. All remnants are used and are subjected to processes which destroy whatever parasites may be included. Under these conditions one may safely predict the gradual disappearance of parasites, especially with the co-operation of certain factors not yet mentioned.

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In addition to municipal features as noted, personal habits play an important part. Cleanliness of person and hands, coupled with careful ablution not only of the person but also of the various articles of food, reduces the percentage of parasitic infection. A simple infection of *Trichocephalus* becomes manyfold greater by the accidental transfer of eggs from the skin near the anus, where they are deposited, to the mouth. The reality of such supposed auto-infection is proved by the high degree of infection among insane and defective classes which are known to exercise little care over personal cleanliness. No doubt many eggs of parasites are introduced on salads and other uncooked foods which are eaten without sufficiently careful cleansing previously.

The employment of footgear and hand coverings is influential also, because it reduces directly the likelihood of infection from eggs of parasites contained in earth, etc., which with uncovered hands become temporarily imprisoned beneath the finger nails of the field laborer. These coverings may also play a considerable part in preventing infection with *Uncinaria* if the observations of Looss are confirmed that the larvæ enter the body by an active migration through the skin, chiefly of the hands and feet, with which they come in contact in the case of field laborers.

Another factor which has tended to reduce the percentage of parasitic infection is the less intimate association of the more highly civilized individuals with domestic animals, especially dogs. The parasites of these animals, and in particular one species, *Tænia echinococcus*, possess great clinical importance for man. Not only is it apparently less frequent than previously, but also its frequence is certainly greatest now in those regions in which the inhabitants live most familiarly with their dogs. It should be noted also that the initial infection of the dog is prevented by keeping from it the offal from slaughtered cattle and sheep.

Probably more influential than any other factor in determining the reduction in degree of parasitism is the use of cooked food. A large part of the flesh food of semicivilized man is eaten raw or only partially cooked, in which condition the larval parasites are capable of development to the adult on reaching the alimentary canal of the new host. Were all animal food eaten only when thoroughly cooked, the common tapeworms and the dreaded *Trichinella* would cease to have clinical importance. The abundance of *Tænia saginata*, the beef tapeworm, where beef is eaten raw, of *T. solium*, the pork tapeworm, where raw ham is a delicacy, and of *Dibothriocephalus latus*, the broad tapeworm, where partly cured fish is eaten uncooked, furnishes the demonstration of the proposition advanced. And so long as pork is eaten uncooked cases of trichinosis will occur, whatever means may be taken to reduce the danger by meat inspection.

That factor which is about to be considered is destined to play the greatest rôle in the limitation of parasitism; it is the intellectual, and by it is brought about the determination of a rational hygiene and its application by the individual. National prejudice or established custom can oppose its introduction only temporarily, and it must ultimately succeed in reducing to lowest terms the parasitic infections of man and the important food animals.

Henry B. Ward.

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References to the important works consulted may be found under *Arachnida, Cestoda, Hirudinea, Mosquitoes in their Relation to Human Pathology, Nematoda, Protozoa*, and *Trematoda*.

PARATHYROIDS. (NORMAL AND PATHOLOGICAL ANATOMY.)—In 1880 Sandström discovered the presence of small glandular organs on the posterior surfaces of the lateral lobes of the thyroid. He found these to be of constant occurrence, and from their structure regarded them as embryonic thyroid tissue; he accordingly named them *glandulæ parathyroideæ*. A year later, the same organs were independently discovered by Stieda in embryos of the pig, and by Baber in different animals. The former regarded them as carotid glands, the latter as embryonic thyroid tissue. But little attention was paid to these glands until 1891, when Gley asserted their importance. In the few years immediately following, his statements were supported by numerous observers. In 1895 the first careful study of the minute anatomy of the parathyroid was given by Schaper. Numerous experimental investigations followed, both in normal and thyroidectomized animals, showing the physiological importance of these structures. Various names have been proposed for them: "*epithelial bodies*," "*accessory glands*," "*accessory thyroids*," "*glandules thymiques*," etc.; the original designation *parathyroid* has the advantage, however, that the organs are not thereby confused with the accessory glands having the true thyroid structure.

As to the physiology of the parathyroids and their function no absolute knowledge has yet been obtained. It was first believed that they had a direct connection with the thyroid, and could compensate for it. Later experimental investigations in transplantation and extirpation, as well as in feeding with gland substance, have shown that the parathyroids have a function distinct from that of the thyroid. The loss of the thyroid leads to a chronic disease, that of the parathyroids to an acutely fatal disease. Feeding with gland substance is effective only in case of the administration of the same gland substance as that of the organ affected; thus thyroid feeding is of value only in case of the loss of the thyroid, and parathyroid feeding only in case of loss of the parathyroids. In transplantation, both thyroid and parathyroid preserve their characteristic structure.

The various investigators are not yet agreed as to the embryology of these glands, but it may be regarded as proved that the parathyroid bodies lying outside of the thyroid have an independent *Anlage* in the fourth gill pouch. In some animals there occurs constantly an epithelial body included in thyroid tissue, which probably arises from the third gill pouch. This internal epithelial body occurs so rarely in man that its presence may be regarded as a probable anomaly of development. Further, the parathyroids arise from single symmetrical *Anlagen*, and their occasional multiplicity is to be ascribed to a secondary snaring off.

The parathyroids occur usually in pairs; sometimes one on each side, or two on one side and one on the other. The writer has also found three upon one side. The total number observed has never been greater than four.

In size they vary greatly, but they are usually very small; the average, as found by the writer, being about 7 mm. long, 2–3 mm. broad, and 1.5 mm. thick. The average weight is about 0.2–0.3 gm. They are often almond-shaped, having one end recurved; but the shape not infrequently suggests the spleen. At other times they may be flat, cylindrical, or round. Their color is usually pale brown, but may be brownish-red or bluish, so that they are easily mistaken for hæmolymph glands. They usually lie behind the lower poles of the lateral lobes of the thyroid, separated from the thyroid tissue by connective tissue, their convex surfaces lying in slight depressions on the under surface of the lobes. Not infrequently they are found below the thyroid, even as low as the level of the clavicle. It is often very difficult to recognize the parathyroids at the autopsy; therefore all of the glandular structures in this region should be removed for microscopical examination. It is of advantage, in case the organs are not easily found, to take out the neck organs *in toto* and fix them in formalin. After fixation the dissection of the region behind and below the thyroids usually results in the determination of the exact location and relations of the parathyroids, their brown color becoming more prominent in contrast to the white adipose tissue about them. By following up the branches given off from

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the inferior thyroid artery, just before the vessel passes into the thyroid, the parathyroids are usually easily discovered. They derive their blood supply from these branches. Their veins empty into the veins on the surface of the thyroid, or directly into the inferior thyroid vein. But little is known of the nerve supply. Sacerdotti and Anderson have traced nerve fibres along the vessels and between the epithelial cells.

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The microscopical appearances are those of a gland having a delicate capsule, from which thin connective-tissue septa pass in, supporting the larger blood-vessels, and separating the imperfectly developed lobules. The general appearance of the gland may vary greatly. Often it appears as a single mass of closely placed cells, between which run numerous delicate capillaries, forming a network in the meshes of which lie the cell groups or alveoli. No connective tissue accompanies the capillaries. In other cases the lobular arrangement is much more marked, the cells showing a more decided cord-like or alveolar arrangement. The anastomosing columns may consist of a single row or of several rows of cells, arranged upon the capillaries. In other specimens the cells may be grouped into round follicles. Not infrequently all three types are found in one gland.

The cells vary in appearance, so that three chief varieties may be distinguished. The majority are somewhat larger than those of the thyroid; the nucleus stains deeply, the protoplasm but slightly. The boundaries of these cells are visible as fine lines. Besides these, there are large polygonal cells with deeply staining nucleus, very granular protoplasm which stains deeply, and with sharp cell outlines. The third type of cell is low, columnar, and is arranged upon a basement membrane in such a way that the cells radiate toward the centre of the group, giving it the appearance of a follicle. In the centre of this a definite lumen may often be made out. It usually contains a finely granular substance, but may contain a colloid-like material. Occasionally the follicles are cystic. Between these three types of cells there are all possible transition forms.

Many of the large polygonal cells stain heavily with eosin, resembling closely the acidophile cells of the hypophysis. In others fine fat droplets are often present. The follicular arrangement of the cells is always more marked when the lumen-like opening, containing granules or colloid-like material, is present. The different appearances presented by the cell indicate most probably different stages of functional activity.

The circulation of the gland is sinusoidal in character, the epithelial cells being separated from the blood by endothelium only, connective tissue as a rule not accompanying the capillaries. The secretion of the gland, as clearly shown in a hypertrophic parathyroid obtained by the writer in a case of acromegaly, is into the lymph vessels.

According to Benjamins colloid is constantly present. The writer has not found this to be the case, but has found constantly in the open follicles a finely granular substance. He agrees with Benjamins that the parathyroids are individual and constant organs, differing in structure and function from both the fœtal and the mature thyroid; and that the differences in size, form, and staining reactions represent different stages of functional activity.

Pathology.—Variations in size, shape, and number of the glands occur. Cysts lined with columnar or flattened epithelium may be found near or in connection with the parathyroids, as congenital "rests" of the gill pouch or of a diverticulum of the same. Benjamins suggests that this is an analogue of the *ductus thyreoglossus*, and should be designated as the *ductus parathyroideus*. The writer has observed in one case in man a blind duct, lined with low columnar cells, passing into the parathyroid, its epithelium being directly continuous with that of the gland. Near the entrance of the duct into the parathyroid there were several large cystic follicles containing colloid-like material.

Circulatory Disturbances.—In general venous congestion the capillaries of the parathyroids are dilated; in general anæmic conditions they are collapsed and contain but little blood. Local anæmia may be caused by pressure of strumous thyroids. Hemorrhage, œdema, and inflammation may also be caused by struma.

Retrogressive Changes.—*Pressure atrophy* may be caused by struma of the thyroid. *Fatty atrophy* occurs in old age and in cachexias. Benjamins has observed *hydropic degeneration* in groups of cells, occurring in two cases in which the organ was hyperæmic. The writer has obtained a reaction for *mucin* in the cysts found in one case. He further regards the presence of *colloid material* in such cysts as being of the nature of a degeneration.

Hypertrophy.—In a case of acromegaly with adenomatous tumor of the hypophysis the writer found great enlargement of the parathyroids, the right parathyroid weighing 1.5 gm., the left 1.7 gm.; the right one being nearly 2 cm. long. Both were deep bluish-red. The microscopical examination showed the follicles to be for the greater part cystic, and containing finely granular material staining deeply with eosin. No colloid was found. All transition stages could be observed, from the closed follicle to the cystic ones. The dilated cystic follicles could be seen to possess direct communication with the lymph vessels. The thyroid in this case showed interstitial increase of connective tissue.

Benjamins has seen an interstitial hyperplasia of the connective tissue of the parathyroids in a case of Basedow's disease associated with cirrhosis of the liver.

In struma of the thyroid, according to Benjamins, there is no increase of size in the parathyroids; on the contrary, they are often smaller, and are either normal or show retrogressive changes rather than progressive. These changes are to be referred to the pressure of the enlarged thyroid.

With the exception of the one case mentioned above, Benjamins found no changes in the parathyroids in Basedow's disease.

Benjamins describes a tumor attached to the right lobe of the thyroid, which in structure he regards as closely resembling that of the parathyroid, and regards its origin from the latter as possible.

Functional Relation between Thyroid and Parathyroid.—The evidence at present is against the existence of any close functional relationship between these organs. In conditions of extensive thyroid disease the parathyroids are normal or only secondarily affected. In a case of cretinism with total defect of the thyroid, reported by Maresh and Peucker, the parathyroids were normal. Other disturbances of development of the thyroid occur, in which cases the parathyroids are found to be normally developed. In a case of pigment atrophy of the thyroid Benjamins found the parathyroids normal. According to Vassali and Generali, if the parathyroids be removed at the same time with the thyroid tetany results. If the parathyroid on one side alone be removed, the tetany is transitory. If the parathyroids are not removed, cachexia strumipriva or myxœdema follows.

Whether the case of hypertrophy of the parathyroids in acromegaly is to be regarded as a compensatory hypertrophy on the part of these organs for the hypophysis, or is to be explained as a part of the general hypertrophy occurring in the disease, the writer is not able to decide. The evidences of excessive secretory activity would favor the former view. (See Benjamins, "Ueber die Glandulæ parathyroidæ," *Beiträge zur pathologischen Anatomie*, 31, 1902.)

Aldred Scott Warthin.

PARATYPHOID FEVER.—Up to the time when the Gruber-Durham-Widal reaction came to be used as a routine method in the diagnosis of typhoid fever no hesitation was felt in classing all the cases presenting certain symptoms as typhoid fever; but with the use of this method it has been recently discovered that in some cases the characteristic serum reaction fails. In these it has been found possible to isolate from fæces, urine, blood, and various other situations, organisms which have been carefully described by a number of workers, and which

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agree in morphological and cultural characteristics closely enough to be at least classed in one group, if not actually identified with one another. Such organisms have been spoken of as "typhoid-like bacilli" or "paratyphoid bacilli," and the clinical phenomena in such infections may perhaps, from their resemblance to typhoid fever, be suitably spoken of as paratyphoid fever.

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The disease has occurred, sometimes in small epidemics, in several places in Europe, notably in Paris, Bremen, etc., and has also been observed in American cities. It seems to attack persons of any age, but the average in a number of cases was about twenty-seven years. The symptoms resemble very closely those of typhoid fever—indeed, one cannot point out any symptom of pathognomonic importance, so far as our knowledge yet extends. The onset is, as a rule, with headache and general malaise, with some stupor. There is a continuous, if irregular, high temperature lasting throughout the illness and terminating gradually by lysis, after a duration generally of about four weeks. The spleen is, as a rule, not markedly swollen, and often is not at all palpable. Intestinal symptoms are not characteristic—there may be diarrhœa, or constipation may persist throughout the course of the illness; in some cases there has been intestinal hemorrhage. The blood shows no typical changes—the leucocytes are, as a rule, not increased. Rose spots are very often—indeed generally—present. Various complications, such as bronchitis, abscesses in various localities, slight hemorrhages, etc., have occurred, and in one case (that of Cushing) there was a costo-chondral osteomyelitis from which the organism was isolated.

The prognosis on the whole seems very good, as of twenty-six or more reported cases only a small number were fatal and two or three autopsy records only are at our command. Most of the cases have terminated by lysis—convalescence progressing much as after typhoid fever, while in one or two described by Kurth a sort of crisis occurred.

At autopsy it is found in these cases that there is no intestinal lesion whatever; the Peyer's patches and solitary follicles are not swollen and show microscopically no lesion. The spleen is somewhat enlarged and soft, and on section has a dull, opaque, grayish-pink color. Microscopically there is no great proliferation of the endothelial cells, and no red-corpuscle-carrying cells are seen, although the lymphoid cells of the splenic pulp are more abundant than normal. In one case focal necroses have been described in the liver.

Little characteristic as the symptoms and pathological lesions are, the bacteriological findings are fairly definite and serve well to outline this group of cases. There have been isolated by various workers (Gwyn,[1] Cushing,[2] Schottmüller,[3] Kurth,[4] Johnston,[5] Hewlett,[6] Longcope,[7] and others) bacilli designated under various names and still closely enough related to be classed, with some approach to unanimity, as a group standing half-way in its properties between the Bacillus typhosus and the B. coli, and very closely related indeed to the so-called group of Gärtner, the type of which is the B. enteritidis, a form associated with the epidemics following meat poisoning. Morphologically these paratyphoid bacilli cannot be distinguished from the typhoid. On the ordinary culture media, such as agar, gelatin, bouillon, etc., their growth is practically identical with that of typhoid. In litmus milk they produce, as a rule, acid at first with terminal alkalinity if exposed to the air and they do not clot the milk. Unlike the B. typhosus they ferment glucose with the production of acid and gas, while with lactose media they produce no gas. In these latter respects they most closely resemble the group of B. enteritidis. The production of indol is very slight and even somewhat doubtful.

Far more definite, however, than the results of these cultural methods of differentiation are the serum reactions. It is found that the serum of such a patient will never agglutinate the typhoid bacilli; it will, however, in great dilutions, agglutinate the bacilli isolated from the patient's blood, and sometimes even the bacilli from other cases. Some of the organisms described, however, such as those of Gwyn and Cushing, practically identical as they are culturally, refuse to be agglutinated by one another's sera. Similarly, while it is possible to immunize laboratory animals from each of these bacilli, so that their serum in the greatest dilution will agglutinate the bacilli used, it is often found that the bacilli from another epidemic or from another case will not be agglutinated by this serum. Nevertheless, it seems justifiable to consider these organisms extremely closely related, if not quite identical, and even if, as has been suggested, they are merely the results of altered environment on typhoid or colon bacilli, they have acquired such characters as to secure them a specific value.

To resume, therefore, we have in this recently described group of cases a disease clinically in every respect resembling a mild typhoid fever, but in which the general septicæmia is not as in typhoid associated, so far as we know, with such definite, localized pathological lesions. The serum reaction fails with the typhoid bacilli, but is positive in great dilution with the characteristic bacilli which can generally be isolated from the blood and fæces, and which morphologically and culturally are closely related to the group of B. enteritidis and to the B. typhosus, and from this relation are designated paratyphoid bacilli.

William G. MacCallum.

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[4] Kurth: Deutsch. med. Wochenschrift, 1901, Nos. 30 and 31.
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PAREIRA BRAVA.—*Pareira*, U. S. P.; *Pareiræ radix*, B. P. The root of *Chondrodendron tomentosum* Ruiz et Pavon (fam. *Menispermaceæ*).

This drug is derived from a tall woody twiner of Brazil and adjacent parts of tropical South America. It was first introduced to the notice of physicians in Europe about two hundred years ago, and after a period of neglect was again brought forward in the early part of this century. It is very little used at present—at least in this country. During this period several other closely related products from allied genera have been imported as pareira brava, adding much to the botanical confusion in regard to its source. The "false pareiras" appear to have about the same slight degree of usefulness as the genuine.

Pareira occurs in subcylindrical, knotty, and somewhat tortuous, hard, heavy, and tough pieces, of indefinite length and 1–6 cm. (½ to 2½ in.) thick; externally dark brown or blackish, longitudinally wrinkled and bearing transversely elongated protuberances or incomplete annular ridges, as well as constrictions, or occasionally fine fissures; the dried transverse surfaces exhibit several equilaterally concentric circles of interrupted, porous wood wedges, projecting beyond the markedly retracted intervening tissue of the rather large medullary rays; internally pale brown or yellowish-brown, when freshly cut having a waxy lustre; inodorous and bitter.

Of the several spurious pareiras, all have a gray or grayish-brown surface instead of the blackish color of the genuine, and are less, or not at all, knotty and roughened. None cuts with its waxy lustre, and all are lighter in weight and less solid.

Pareira contains from three-fourths to one per cent. of an alkaloid which is probably pelosine, similar to, if not identical with, buxine of box, and biberine of greenheart bark. A little tannin also exists, together with starch, gum, and about eight per cent. of ether-soluble fat.

Action and Uses.—What we know of the constituents of pareira and their actions does not support the therapeutical ideas upon which its use is based. It is known to be a fairly good bitter tonic, and slight anti-periodic properties may be reasonably assumed. Its use, however, is chiefly as a diuretic, and in inflammatory diseases

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of the genito-urinary organs, more especially in orchitis. While it does appear to have a slight diuretic action, the idea of its use in this way probably depends upon administering it in decoction well diluted with water. Certainly, the idea of its having the great diuretic value once ascribed to it has been completely abandoned. There is good clinical evidence of a moderate degree of usefulness in the other directions named, although such action is by no means certain or uniform.

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The Pharmacopœia provides a fluid extract made with ten per cent. of glycerin, of which the dose is a fluidrachm. For its diuretic effects, the five-per-cent. decoction is best employed.

Allied Drug.—The drug which is, in the United States and England, regarded as the principal adulterant or substitute of pareira is that wholly or partly specified in some pharmacopœias, namely, the root of *Cissampelos Pareira* L., a plant of similar habit and growing in the same region, though much more widely distributed, and believed also to grow in India. The root is generally smaller than pareira and is of a brown or gray-brown color; longitudinally much grooved and transversely fissured, and readily losing its bark when kept in stock.

The alkaloid of this drug has been proven to be pelosine. Cissampelos is believed to act much like pareira, though it is more generally used as a tonic.

A number of other tropical American drugs are locally known as "pareira," but they bear no resemblance to the genuine article. *Henry H. Rusby.*

PARIS CHALYBEATE SPRINGS.—Lawrence County, Missouri. Post-Office.—Paris Springs. Hotel and cottages.

Access.—Viâ Kansas City, Fort Scott, and Gulf Railroad to Ash Grove, thence two miles by stage to springs.

The springs are delightfully located in the Ozark Mountains, the surrounding country being interspersed with beautiful glens, green meadows, dense forests, and orchards. The elevation (1,500 feet above the sea level) is sufficient to assure freedom from depressing heat in the summer time. The spring yields about one hundred and twenty gallons of water per hour, having a temperature of 52° F. A qualitative examination showed the presence of oxide of iron in solution, besides the carbonates of lime and magnesia, the chlorides of sodium, potassium, and iodine. A complete qualitative analysis is desirable. Patients suffering from disorders of liver, kidneys, stomach, skin, and nervous system have found great benefit from a sojourn at the springs. The tonic properties of the water have been well shown in the debility of anæmia and in various disorders of the female sexual system. *James K. Crook.*

PARIS, PARISETTE.—A European plant, *Paris quadrifolia* Linn., belonging to the order *Liliaceæ*, and closely allied to the *Trillium*, which is so common as an American wild flower. Experiments with an extract prepared from the entire plant show that it exercises a direct action upon the medullary centres. It at first produces a short period of excitation which is followed by a diminution of sensibility and reflex action, and a slowing and weakening of the respiration and heart beats.

It was suggested that it might prove of value as a substitute for aconite, but it has failed to obtain any recognition as a therapeutic agent. *Beaumont Small.*

PARKER MINERAL SPRING.—McKean County, Pennsylvania. Post-Office.—Gardeau. Hotel and sanitarium.

Access.—Gardeau is a station on the Western New York and Pennsylvania Railroad, four passenger trains daily stopping at this point.

This resort is located in the Alleghany Mountains, on the headwaters of a branch of the Susquehanna River. The elevation here is about 2,000 feet above the sea level. The country in this part of Pennsylvania is still wild and sparsely settled. Dense forests of hemlocks are frequent, and bear and deer may yet be found to reward the hunter's pursuit. Mountain trout streams abound. It is scarcely necessary to add that the climate in this wild and rugged region is bracing and salutary. In 1865 the present mineral well was drilled on the site of an oil spring. At 650 feet a vein of water was struck that flows from the top of the well in an unvarying current of about seventy gallons per hour. After some delay a bathhouse, sanitarium and hotel were built, and the place has developed into a very comfortable and attractive resort. An analysis of the water by Henry Trimble, analytical chemist of Philadelphia, resulted as follows: One United States gallon contains: Magnesium chloride, gr. 109.84; calcium carbonate, gr. 11.95; calcium chloride, gr. 221.92; sodium chloride, gr. 282.55; potassium chloride, traces; silica, gr. 1.33. Total, 627.59 grains. Temperature of water at spring, 50° F.

This is a richly impregnated saline water of the magnesic-sodic-calcic variety. When used under proper medical supervision it ought to exert a very beneficial influence in a variety of disordered states of the physical economy. It should always be taken at first in small quantities. The water has been found to possess active cathartic and diuretic properties. It is also a stimulant to the gastric mucous membrane, promoting the flow of gastric juice and aiding the process of digestion. The best effects of the water will be observed in atonic dyspepsia, torpor of the liver, abdominal venosity, constipation, in nephritis with scanty, highly colored urine, and in irritable states of the bladder. At the resort it is also used in the form of baths in a variety of conditions. The water is bottled and shipped to any desired point. *James K. Crook.*

PARK'S SPRINGS.—Caswell County, North Carolina. Post-Office.—Pelham.

These springs are located six miles east of Pelham, but they do not seem to be used much as a resort. The waters, however, are used commercially, and are highly recommended by physicians of North Carolina and the neighboring States in chronic constipation, dyspepsia, and portal congestion. The following analysis was made not long ago by Prof. Albert R. Ledoux, Ph.D., of the State Agricultural Experiment Station at Chapel Hill: One United States gallon contains Magnesium sulphate, gr. 1.50; sodium sulphate, gr. 1.48; iron oxide, gr. 3.50; alumina, gr. 3.50; uncombined sulphur, gr. 0.15; calcium carbonate, gr. 4.80; silica, a trace; sodium chloride, a trace. Total, 14.93 grains.

In its chemical constitution the water bears some slight resemblance to the well-known Hunyadi-Janos water of Hungary. It is a valuable chalybeate, but must be taken in considerable quantities to secure a purgative action. *James K. Crook.*

PARONYCHIA. See *Hands and Fingers, etc.*

PAROTID GLAND, DISEASES AND INJURIES OF.—I. Injuries.—The parotid gland may be injured from the outside through the cheek or from the inside through the mouth or pharynx. The more common injuries in the reported cases have been the result of blows and sword thrusts and have proved of little importance. However, occasionally hemorrhage, venous or arterial, may be alarming, and if it cannot be controlled by pressure one or more vessels will have to be ligated. The internal and external carotid and the vertebral arteries have been severed in such wounds; when this occurs, if it is found impossible to ligate the arteries in the wound, the common carotid should be at once exposed and tied. Hemorrhage may always be temporarily controlled by pressure. Associated injury to the facial nerve may cause a more or less complete unilateral facial paralysis with areas of anaesthesia, and in such a case an attempt should at once be made to suture the ends of the divided nerve.

An injury to the gland substance is usually demonstrated by the flow of saliva from the wound after the hemorrhage has been controlled. The escape of the fluid

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secreted is usually augmented, in such a case, by the movements of the jaws in mastication and by the reflex stimulation caused by the ingestion of food.

Injuries to *Stenson's duct* are important on account of the conditions to which they give rise and of the difficulties which stand in the way of successful treatment. The duct is more often divided or lacerated on the masseter, where it is more fixed, than on the buccinator, where it is moderately movable. The fact of its having been divided is made evident by the flow of saliva from the wound. Occasionally spontaneous healing occurs, but the results to be feared are either the formation of a fistula, the common termination, or the obliteration of the duct, a sequel of more rare occurrence. Stenosis of the duct may lead to the formation of a cyst and eventually, as stated by some authorities, to complete atrophy of the gland.

The *treatment* of injuries to the parotid and its duct demands first of all the control of hemorrhage. Ligation of a vessel in the wound is difficult if it is large, and, if it is not possible to ligate the internal and external carotids singly, the common carotid should be tied. The vertebral artery has been ligated in its first part and also in the vertebral canal after removal of a transverse process. If hemorrhage from collaterals persists, pressure and cold applications will be found sufficient to control it. The possibility of the formation of a fistula and the danger of secondary infection of the gland afford us two special reasons for seeking primary union in wounds of this locality.

Immobility of the head and jaw should be secured with starch or plaster splints, and for a few days fluid food only should be administered through a tube. Talking should be forbidden.

II. Parotid Fistula.—Parotid fistula is a condition in which the normal secretions of the gland escape through an abnormal opening on the side of the face or into the mouth, in the latter case the lesion is of no pathological importance. Among the causes may be mentioned wounds involving the gland or Stenson's duct, either accidental or made during the removal of diseased lymphatic glands or tumors, abscess formation and ulceration following calculus or necrosis of the jaw, and involvement of the gland or duct in a tuberculous or syphilitic process.

In a case of fistula there are usually, on the outside of the cheek, a small opening surrounded by a few granulations and a circumscribed area of reddened and irritated skin. If there is no obstruction in the duct the fistula often heals spontaneously; but at times the fistulous condition is very persistent and obstinately resists treatment.

Slight weeping of the gland from injury to the glandular substance heals spontaneously in a few days.

Treatment.—This consists primarily in removal of the cause of the abscess or ulceration by local and constitutional measures, and the reduction of the lesion to a simple fistula. If the patient is seen soon after the injury has been inflicted a small silver probe may be passed through the orifice of the duct in the mouth and into the proximal portion of the severed duct, and an attempt be then made to suture the ends of the duct with fine catgut sutures, this material being more easily absorbed and less liable to become infected than silk. The sutures should not enter the lumen of the duct. The external wound should then be carefully closed.

If the fistula has existed for some time the edges of the artificial opening may be freshened and closed, in the hope of forcing the saliva into its normal channel.

Another method is to pass a stout thread soaked in balsam of Peru through the fistula into the mouth bringing it out at the angle of the mouth and tying the ends on the cheek. After the lumen is by this means well reëstablished, the duct and external wound may be closed as above. Homer's method is to make a hole with a punch through the cheek into the mouth, this hole including the orifice of the fistula. After this the external wound is closed.

III. New Growths.—There are a certain number of growths which, while they do not involve the substance of the parotid gland, lie in close proximity to it, and should not therefore be passed unnoticed in a consideration of tumors of this region. These, as a rule, lie without the capsular limits of the gland; but at times, particularly when they are of vascular origin, they penetrate the gland substance. These penetrating tumors are sebaceous cysts, dermoids, enlarged lymph nodes, lipomata, nævi, angiomata, and lymphangiomata. They do not differ from similar growths in other regions. The writer has recently seen, in a case of multiple venous angiomata, an angioma occupying the site of the right parotid gland. When the patient was in the recumbent position the tumor was the size of a goose egg and of a deep purplish hue; but with the patient in the erect position the contents were discharged, the tumor entirely disappearing and the skin regaining its normal hue. The left parotid was not similarly affected. These vascular tumors may be removed by pressure, by ligation of the vessels, or by extirpation, the others by extirpation.

Neoplasms of the parotid are very rarely of a single type. Mixed tumors are more common here than in any other part of the body excepting the ovary. "It is not unusual," says Sutton, "in sections from parotid sarcoma to meet with spindle cells, cartilage, myxomatous tissue, and glandular acini in an area two centimetres square." It will be convenient, however, to group these growths according to the tissue which is predominant in each variety and to outline the general characters of each. The neoplasms vary greatly as to their malignancy, but in general it may be stated that the mixed tumors grow rapidly, attain a large size, and tend to infiltrate the adjacent tissues, involving both blood-vessels and lymphatics, thus producing secondary deposits in other parts, and more particularly in the lungs. The growths when small are usually painless; they become painful only when in consequence of their size the pressure on the nerves is considerable, or when the nerve sheath is involved in the process of infiltration. Involvement of the skin with ulceration is characteristic of the later stages of the more malignant varieties. Pressure may cause a facial palsy, occlusion of Stenson's duct, interference with the blood supply of the parts dependent on the carotids, and, when growing deep into the neck, obstruction of the œsophagus and difficulty of deglutition. Facial palsy is more often the result of infiltration than of pressure, and is accordingly more common in malignant growths.

Enchondromata.—Cartilage enters into the formation of nearly all parotid neoplasms. Enchondromata are encountered in two forms: those composed of pure hyaline cartilage, and those in which the cartilage is associated with other tissues. Enchondromata of the first variety are of slow growth, attaining the size of a walnut in the course of several years. It is only in rare cases that they exceed an egg in size. The tumor is firm in consistence with a surface smooth or nodular, at times adherent to surrounding tissues. It is benign, and does not return when removed. Extirpation is usually not difficult. The other variety consists of small masses of cartilage associated with connective, mucous, adenomatous, or carcinomatous tissues. It assumes the character of a mixed tumor, is more malignant than the first variety, grows more rapidly, and tends to recurrence after removal.

Adenomata of the parotid are rare; they are encountered during the period from fifteen to thirty years of age. They have a distinct capsule, and may appear in any part of the gland. They are usually small, painless tumors, easily shelled out. If large they are movable and loosely connected with the parotid tissue. The surface is irregular and nodular, hard in places, but often elastic or fluctuating on account of the presence of associated cysts.

Sarcomata found in this region may be spindle-celled, solid, or cystic. They are rarely pure, and are mixed with cartilaginous, myxomatous, or fibrous growths. They are more common than the carcinomata, and come next to these in malignancy. The soft varieties occur

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more commonly in youth, the harder types in middle life. They infiltrate all the surrounding structures, growing deep into the neck, inward behind the pharynx, and backward behind the ear, and involving the sheaths of the blood-vessels. The rapidly advancing ones involve the skin which subsequently ulcerates. A fatal issue follows dysphagia, implication of the pharynx, ulceration into some large vessel, or secondary growths (due to emboli) in more distant organs. They are removed with considerable difficulty and tend to rapid recurrence.

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Melanosarcomata occur very rarely. They are rapidly growing neoplasms, early involving the entire parotid gland, and invading the neighboring lymphatics and overlying skin, which latter is prone to ulcerate.

Myxomata, when they occur in the parotid, are usually associated with sarcomatous tissue and cartilage. They contain a thick transparent fluid, and may be definitely circumscribed or they may merge gradually into the surrounding structures. They are soft, gelatinous, and fluctuating.

Carcinomata of this region are rare. They belong to the period of advancing years. Their growth is at first slow, but later very rapid. Usually they have no capsule and infiltrate surrounding structures in very much the same manner as do the rapidly growing sarcomata. Secondary infection usually occurs by way of the lymphatics. Carcinomata are the most malignant tumors found in the gland, and they almost invariably recur after extirpation.

Endotheliomata are also rare. They are derived from a multiplication of the endothelial cells lining the lymphatics and blood-vessels. Some of these endothelial overgrowths are succeeded by fibrous tissue, while in others mucoid degeneration takes place.

Fibromata are usually associated with other neoplastic tissues, but have been met with as pure fibrous growths. Many of them contain cysts. They are hard resistant tumors, usually nodular. They should be excised, and when purely fibrous they do not tend to recur.

Lipomata rarely occur as pure growths in this region, but areas of lipomatous tissue are not infrequently found in the mixed tumors.

Rhabdomyomata.—Prudden has reported a case of rhabdomyoma of the parotid. The tumor was composed of muscle fibres, without sarcolemma, irregularly arranged. In this same tumor there were lobules of small spheroidal or polyhedral cells in a well-marked reticulum of an unusual character.

Treatment.—Excision constitutes the proper treatment of parotid neoplasms. The gravity and difficulty of the operation vary with the size and mobility of the growth, the extent of infiltration of the surrounding tissues, the age and general condition of the patient. Removal of the whole gland is a formidable operation. It was first performed by Warren of Boston in 1798. The removal of a tumor should be undertaken at the earliest possible moment, as this offers the greatest hope of a permanent cure. It should not be forgotten, however, that some tumors, especially the melanosarcomata, are often disseminated by operative procedure. In the case of a tumor which is already advanced in growth the possibility of temporary relief from the dangers and discomforts of ulceration and pressure may justify a partial or total removal of the growth. The production of a salivary fistula and the occurrence of facial palsy are complications which may attend the least of these operations, and of this possibility the patient should be warned in advance.

Cysts.—Cysts of the parotid usually occur in association with other tumors, and, according to their extent in relation to the other tissues, they modify the consistence of the tumor.

Less rarely single salivary cysts are met with. These grow slowly, at times attaining the size of a hen's egg, fluctuating, elastic, slightly movable, and not adherent to the skin. They result from the obstruction of Stenson's duct by a calculus or by a stenosis, and they usually represent a dilatation of one of the branches of this duct. They are lined with cylindrical epithelium which in time becomes tessellated. The salivary cysts are filled with clear, amber-colored, slightly viscid saliva; the contents of the simple cysts are more watery. The diagnosis, if doubtful, may be settled by means of an aspirating needle.

Treatment consists in opening the tumor and destroying the lining membrane with zinc chloride (forty grains to the ounce) or with pure carbolic acid. Cysts may be dissected out, but there is danger of injuring the facial nerve. The calculus or other obstruction to the duct should of course be removed.

Cysts due to the dilatation of Stenson's duct have been met with in glass-blowers. These are best left untreated.

Echinococcus of the parotid is exceedingly rare. Schuh reports a case in a woman eighty-three years of age. The tumor increased to the size of a hen's egg, attaining these dimensions in about one year. The tumor is cystic, and the diagnosis from other cysts can be made only by a microscopical examination of the contents of the tumor. Treatment consists in opening the tumor and destroying the walls of the cysts with the curette.

IV. Calculi.—A few cases of calculi of the parotid have been reported. They are less common than concretions in the submaxillary glands. They are the result of a change in the constitution of the salivary secretion which tends to precipitate the carbonates ordinarily held in solution. The calculi vary greatly in size; they may be as small as a grape seed, while one case has been reported in which the concretion weighed 18.6 gm. The chief constituent is calcium carbonate associated with organic substances, variable in amount, which remain after treating the concretions with hydrochloric acid. The calculus may be located in the gland proper or in the duct where it may be felt with a probe passed up the lumen. It occurs as a nodule of variable size and exceedingly hard. Sometimes it obstructs the flow of saliva from the affected side, and may thus produce a cyst, or it may, by the irritation which its presence causes, set up a chronic parotitis. Calculi of this kind should be removed by an incision, to be made from the inside of the mouth whenever this is practicable.

V. Parotitis.—Mumps, or acute infectious parotitis, has been discussed in another portion of this work. (See article on *Mumps.*) Other inflammatory conditions of the parotid gland include chronic idiopathic parotitis, toxic parotitis, and secondary parotitis.

Chronic Idiopathic Parotitis, or sialodochitis fibrinosa, is an affection of unknown cause. It is sometimes associated with xerostomia, and rarely it complicates gout. It usually commences with a catarrhal inflammation of Stenson's duct, which becomes plugged with mucus, and later develops into a chronic interstitial productive inflammation of the gland, the connective tissue replacing to a greater or lesser degree the secretory cells. The lesion is bilateral. The glands of both sides are swollen, firm, slightly elastic, painless, and not tender. The course is very chronic. The supply of saliva is much diminished so that the mouth may become dry and parched, and as a result swallowing and chewing may become difficult.

Treatment is very unsatisfactory, but the ducts should be kept open by frequent expression of the mucous plugs, and every effort should be made to stimulate the secretory function of the glands by the use of galvanism and the administration of pilocarpine and similar drugs.

Raymond Johnson has described five cases of induration and swelling of the parotids, coming on during a meal, due to a collection of saliva and obstruction of Stenson's duct. There was considerable pain during mastication. In one case there were several relapses, in another suppuration ensued. Massage sometimes caused evacuation of the plug.

Toxic Parotitis.—Hypertrophy and inflammation of the parotid have been reported in a number of toxic conditions such as lead, copper, and mercury poisoning, and in uræmic states. Comby reports the occurrence, in a case of lead poisoning, of a symmetrical enlargement of the parotids, soft, painless, and persistent, and running

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a very chronic course. In mercurial poisoning the parotids and submaxillary glands become enlarged and tender and the flow of saliva is excessive. Bilateral enlargement of the parotids following the administration of potassium iodide has been reported by Comby, Miss Bradley, Requier, and Villar. In these cases there were also œdema of the eyelids, coryza, inflammation, and salivation.

After the withdrawal of the poison the affected glands usually recover their natural size and function.

Secondary Parotitis.—Next to mumps this is the most common form of inflammation of the parotid. It is associated with many local and general infections, such as maxillary osteitis, inflammation of the temporo-maxillary joint, abscesses, erysipelas, typhoid fever, typhus fever, cholera, diphtheria, smallpox, bubonic plague, yellow fever, cerebrospinal fever, relapsing fever, pneumonia, syphilis, influenza, and gout. Paget has collected 101 cases of parotitis complicating various infectious and functional disturbances of the peritoneal and pelvic organs. Of these, 50 occurred in cases of injury, disease, or temporary derangement of the generative organs, without suppuration. In this list were included cases of pregnancy, childbirth, abortion, pelvic cellulitis, hæmatocele, and operations on the vagina and uterus. In 10 instances the disease developed after the introduction of catheters and sounds in male patients and after blows on the testicle; in 18 the disease was associated with injury or disease of the alimentary tract, involving the stomach, pancreas, etc.; and, finally, in 23 there was disease or injury of the abdominal wall. In these cases the course was, as a rule, rapid and suppuration occurred on the fourth or fifth day. Donkin has reported three cases of unilateral parotitis complicating gastric ulcer, and Pepper has also reported a similar case. Debout d'Estrées has collected the reports of twelve cases of parotitis in gouty subjects.

The route of infection is in many cases obscure, but it is probable that in some cases, as in typhoid fever, it is through Stenson's duct, while in others the metastasis takes place through the blood-vessels and lymphatics. Hanau studied the genesis of five cases of suppurative parotitis which occurred as a secondary process in septic infections. In all these instances the organisms present were staphylococci; they were always found in the abscesses and ducts, while the blood vessels and lymphatics were free. In one fatal case Dietrich found the staphylococcus pyogenes aureus in the ducts, but not in the blood-vessels. The mouth is, without doubt, frequently the direct source of the infection, for in many diseases it offers conditions peculiarly favorable to bacterial multiplication.

In *typhoid* fever parotitis occurs in a variable percentage of cases. Osler reports the complication as occurring 45 times in 2,000 cases in Munich; of 2,000 patients with typhoid fever in the London Fever Hospital, 13 had parotitis; at Basle, of 1,600 cases of typhoid fever there were 16 complicated by suppurative parotitis. Infection is usually through Stenson's duct, and when arising in this manner it is probably not so serious a form as when it occurs as a metastatic process (Osler). Keen has reported two cases in which Eberth's bacillus was recovered from the pus in the glands; in one case there was a mixture of staphylococci. This complication generally begins during the third or fourth week; one case is reported as appearing on the tenth day. It is usually unilateral, but sometimes both glands become infected, coincidently or successively. Suppuration almost invariably ensues.

As a rule, parotitis is seen only in severe cases of typhoid fever; it is in itself a serious complication, the mortality being placed at about thirty per cent. Seven of the Basle cases ended fatally. The complication is said to be less common since the introduction of antipyretic treatment, but it seems to the writer that the attention which has been paid to the care of the mouth in recent years may be the more important prophylactic measure.

In *typhus* fever parotitis occurs in many epidemics to the extent of even twenty per cent. of the cases, being a more frequent and more dangerous complication in this disease than in typhoid fever. Both glands may be affected, but the disease is more commonly unilateral. Suppuration is usual, and the gland breaks down and is discharged in small necrosed fragments. Extensive infiltration and burrowing have caused fatal exhaustion. Pepper has seen death from parotitis after all danger from the original attack of fever seemed over.

Finkler reports 12 cases of parotitis in 55,263 cases of *influenza*. He thinks that in these cases there is probably mixed infection.

Pneumonia is occasionally complicated by parotitis, which is then usually suppurative. Pneumococci have been found in the resulting exudate by Testi and by Fitz. It is a dangerous complication, and the prognosis in these cases is bad.

Parotitis is a rare sequel of *relapsing fever*, *cholera*, *bubonic plague*, *yellow fever*, and *epidemic cerebrospinal meningitis*.

The *symptoms* of secondary parotitis are often masked by those of the primary disease. The parotid region at first becomes hard and swollen; associated with this there is pain on moving the jaw and in swallowing. The area then becomes œdematous, later softening somewhat, and the surface becomes red. At the end of three or four days there is an elastic non-fluctuating tumor. At this point the swelling may begin to subside, but more often it goes on to suppuration. The inflammation may be limited to the gland or it may spread to the surrounding tissues, involving the muscles and the periosteum. The pus burrows beneath the strong fascia for some distance before it points at the skin. The pus may pass downward into the chest, backward along the pharyngeal wall, upward along the sheath of the blood-vessels to the meninges, to the articulation of the jaw, or backward into the middle ear. The blood-vessels may be injured by ulceration, and the facial and jugular veins or the cavernous sinus may become thrombosed. There may be a neuritis with or without destruction of the facial nerve. Rarely the process terminates in gangrene. The pus may discharge spontaneously through the cheek, mouth, or external auditory meatus, more rarely into the œsophagus or anterior mediastinum.

The *prognosis* depends largely upon the condition of the patient at the onset of the complication. In cases in which the patient is much reduced, as in the third week of typhoid fever, a superimposed parotitis is an exceedingly grave matter; in a series of collected cases of this nature the mortality was thirty per cent. If the disease develops after convalescence has been well established, the prognosis is much less grave. Early recognition and evacuation of pus may obviate extensive infiltration and burrowing and distinctly lessen the gravity of the situation. Common sequelæ are induration and enlargement of the glands; less frequently there remains a facial palsy. Death results from general exhaustion, septicæmia, meningitis, or cerebral thrombosis.

The *prophylactic treatment* of secondary parotitis consists in diminishing the danger of infection through Stenson's duct. In typhus, typhoid, and other infectious diseases care should be taken in keeping the mouth clean and as free as possible from bacterial growths. When infection of the gland has occurred, an attempt should be made to obtain resolution or prevent suppuration by the application of ice, leeches, iodine, or mercurial ointment. One should be on the outlook for the formation of pus at all times, and as soon as its presence is recognized it should be evacuated. The gland should be drawn forward and an incision made parallel with the main branches of the facial nerve; the incision should be made well forward so as to avoid injury to the carotid vessels. An efficient drain should be kept in place so that the abscess may heal from the bottom.

VI. XEROSTOMIA, or dryness of the mouth, is caused by a deficient secretion of saliva. It may be physiological in infancy. It occurs in neurotic individuals, partic-

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ularly in women suffering from hysteria or hypochondriasis. Sometimes a fright may appear to be the main etiological factor, and frequently the cause is entirely unknown. Excessive loss of water by the kidneys, as in diabetes and chronic nephritis, rapid evaporation in mouth-breathers, and febrile diseases often cause a similar condition. It is not infrequent in the aged. Chronic inflammation of the salivary glands and obstruction of their ducts may result in an insufficient supply of saliva and consequent xerostomia. The mouth becomes dry and glazed, and it presents the color of raw beef. The tongue may be parched and deeply fissured, and speaking, mastication, and deglutition become difficult.

In cases due to obstruction of the ducts, relief may be obtained by expressing the tenacious plugs of mucus. In the neurotic cases pilocarpine and the galvanic current have been found helpful; in these cases also general tonic treatment is always of importance, and any causes of reflex nervous irritation should be looked for and removed. Temporary relief may be obtained by moistening the mouth with hot water or with a solution of albolene. Cabot has found that the eating of small pieces of oatmeal cracker gives considerable temporary relief in some cases of xerostomia complicating diabetes.

VII. Ptyalism.—(Synonyms: Salivation, Sialorrhœa.) Ptyalism may be defined as a pathological increase in the secretion of saliva.

In the adult the normal amount of saliva secreted in twenty-four hours is from two to three pints. Pathologically the amount may be increased to ten pints in the twenty-four hours. Such saliva is viscid and glairy; its specific gravity varies from 1.000 to 1.059; it contains little sulphocyanide of potassium and less ptyalin than normally.

Physiologically, the secretion of saliva is increased by the reflex stimulation caused by the taking of food and, in children, during dentition.

Ptyalism is caused by a pathological reflex stimulation of the secretory fibres of the nerves supplying the salivary glands. It is met with in women during pregnancy and at the menstrual period; in psychic disturbances such as hysteria and insanity; in infectious diseases, particularly in rabies and smallpox; in lesions of the medulla and pons. It follows the ingestion of certain drugs, such as mercury, gold, silver, copper, arsenic, lead, pilocarpine, jaborandi, muscarine, potassium iodide, and tobacco. Bohn describes instances, in children, in which the excessive flow of saliva occurred only in the daytime and ceased at night; the cause was unknown, but he believed the ptyalism to be a form of neurosis. Sialorrhœa has been met with in affections of the liver, spleen, pancreas, and genital organs; it is believed to be due to reflex irritation from these parts.

The excessive secretion of saliva necessitates constant swallowing and may interfere with speech, or the fluid may flow from the mouth. In pregnancy it may persist until delivery has occurred. In mercurial poisoning the patient becomes emaciated, the bowels are constipated, and the amount of urine is diminished; the parotid and salivary glands are enlarged and tender. The ptyalism may persist for from one to three weeks after the removal of the drug.

Diagnosis is difficult only when a paralysis exists which interferes with swallowing and thus simulates ptyalism; actual measurement of the amount of saliva will definitely settle the question.

The *prognosis* depends upon the cause and the possibility of its removal.

Treatment consists in the removal of the underlying cause, the use of an astringent mouth wash containing alum, gallic acid, or tincture of myrrh, and the administration of atropine, one-sixtieth of a grain every four hours until there is a sensation of dryness of the throat. In cases of nephritis, the administration of mercurials is especially liable to cause sialorrhœa. During the administration of mercury salivation can be prevented in many cases by keeping the mouth and teeth carefully cleansed; if soreness and tenderness of the gums, tenderness of the teeth on striking, or the "mercurial fœtor" of the breath arises, the administration of mercury should be stopped at once.

T. Stuart Hart.

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PAROVARIUM. (ANATOMICAL.) See *Sexual Organs, Female.*

PAROVARIUM, DISEASES OF.—The term parovarium is applied to a series of from six to eight closed tubules which lie between the two layers of the broad ligament. They radiate out from the ovary toward the Fallopian tube, terminating in a large tubule which runs parallel to and beneath the Fallopian tube.

The pathological changes to which it is liable consist practically of only two varieties, viz.: cystic disease and carcinoma, the latter being secondary to similar disease elsewhere, and so rare as not to merit consideration in so short an article as this.

Parovarian Cysts.—These arise from dilatation of one of the tubules of the parovarium, and are therefore intraligamentous. Frequently they remain so, in which case their removal is an exceedingly grave proceeding, but at times they stretch the ligament to such an extent that they become abdominal with a well-formed pedicle. In the latter case they are freely movable and ovoid in shape, while in the former they are fixed in the pelvis and have often an irregular outline. When pedunculated these cysts have a complete covering of peritoneum; while at the point where they split the layers of the broad ligament only the upper surface is covered by this membrane. This peritoneum is smooth and glistening, and the blood-vessels may be seen beneath it. These cysts are nearly always unilocular and contain, as a general thing, a very thin and limpid fluid; but in the case of older cysts this fluid may be thicker and turbid, especially if any hemorrhage has taken place into the cyst.

The inner surface of the cyst is lined by ciliated columnar epithelium which may be accompanied by some cells of the cylindrical variety. Next comes a layer of connective tissue and unstriped muscular fibres, and lastly comes the peritoneal coat.

Symptoms may be absent in the pedunculated variety until the cysts become sufficiently large to interfere with the heart and respiration, when dyspnœa and palpitation, as well as the swelling of the abdomen, will be complained of. When the cyst is sessile, however, one early gets pelvic discomfort or even pain, and the action of both bladder and bowels will be interfered with.

An abdomino-pelvic examination of the patient, in a case in which the tumor is pedunculated, will give the signs of an ordinary unilocular ovarian tumor, except that the fluidity of the contents will not be so evident in the latter. When the tumor is sessile, however, a fixed and fluctuating mass is felt to one side of the uterus, which is displaced to the opposite side of the pelvis. No hard nodules are to be felt in this mass.

The tumor may rupture, and this may be followed by refilling and repeated rupture, by cure, by hemorrhage, or by sepsis and death.

The *treatment* is removal. In the case of the cyst with a pedicle this is very simple, but when the broad ligament has been split up and the tumor has reached the pelvic floor, the treatment is a difficult matter. Here there is such risk of hemorrhage when one tries to remove the tumor by itself that a clean sweep of the pelvis is advocated by most operators. Hall taps the cyst after hav-

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ing opened the abdominal cavity; he then ligates the ovarian arteries—that of the affected side to the outer side of the tumor, and that of the opposite side on the uterine side of the ovary if that is to be left, to its outer side if it is to be removed. The peritoneum is divided across the top of the bladder, which is separated from the uterus. The uterine artery of the healthy side is tied and divided, after which the cervix is divided across. The other uterine artery is then clamped, ligated, and cut. The tumor capsule is incised in front and behind, and the tumor is then shelled out and removed with the uterus. The peritoneal flaps are united by a continuous catgut suture. *F. A. L. Lockhart.*

PAROVARIUM, TUMORS OF. See *Ovaries, Diseases of.*

PARTHENOGENESIS.—(Gr. παρθένος, a virgin, and γένεσις, production.) Parthenogenesis is reproduction by means of unfertilized eggs.

Occurrence.—This means of perpetuating the species occurs normally in several widely separated groups of animals and in a few plants. It was really discovered first in the plant lice, aphids, by Bonnet through a series of experiments begun in 1740; although Albrecht had recorded a single case of parthenogenesis in the silk-moth as early as 1701. In the Aphidæ the eggs which have lasted through the winter hatch in the spring, giving rise to parthenogenic females, which in many species are winged, and in others are without wings. These are viviparous, the eggs developing within the oviduct. After a number of parthenogenic generations sexual individuals are produced, the males being winged, the females always without wings. After copulation the females lay fertilized eggs, which remain dormant during the winter and hatch into asexual individuals in the spring. In this group parthenogenesis is thus combined with an alternation of generations. But sometimes some of the parthenogenic individuals live through the winter, thus producing two parallel cycles of development. In some of the aphids the life history is complicated by the fact that the sexual and asexual generations inhabit different host plants.

Parthenogenesis occurs normally also among the worms—in the liver flukes, larvæ of *Distomum hepaticum*, and in the rotifers. In the Crustacea it is found in certain genera of the Entomostraca, namely, Cypris, Daphnia, Polyphemus, Artemia, Apus, Lepidurus, and Limnadia. The phenomenon is widely distributed among the insects, being especially characteristic of the Hymenoptera—saw-flies, gall-flies, ants, bees, and wasps; the Thysanoptera; and the Aphidæ and Coccidæ,—plant lice and scale bugs. It is found rarely among the moths, as in the genera Apteronia, Psilura, and Solenobia; and in one genus of gnats, Chironomus.

Among plants parthenogenesis is described as occurring in *Chara nitida*, *Thalictrum fendleri* and *purpurascens*, and some fungi, as Saprolegnia.

Classification. The forms of parthenogenesis have been classified by Geddes and Thompson, and later by Delage according to their mode of occurrence into several groups. Of these the most important are: (1) *Occasional* parthenogenesis, of which the only authentic example appears to be the silk-moth. It has been known for a long time that once in a while a female silk-moth may be found capable of laying eggs, some of which will develop without fertilization. Geddes and Thompson include in this group a form of parthenogenesis that they also call *partial* and that Delage distinguishes as (2) *facultative*. This form is characteristic of the bees, ants, and wasps. The queen bee, for example, as was first shown by Dzierzon, appears to be able at will either to fertilize the eggs as they are laid by means of spermatozoa stored in the sperm sac or else to withhold fertilization. The eggs develop equally well in either case, but fertilized eggs always develop into workers or queens, while the unfertilized eggs invariably give rise to drones. This is proved partially by the fact, noted by Hensen, that when a queen bee has been impregnated by a drone of another variety, the female offspring, workers and queens, will all be hybrids, while the young drones will show purely the characters of the maternal race. Moreover, queens that have been prevented from receiving the male, old queens whose sperm sacs have become exhausted, and the workers that occasionally can produce eggs but have no copulatory organs, all produce male offspring only. Finally, von Siebold was unable to find any spermatozoa in eggs from drone cells.

(3) *Seasonal* parthenogensis accompanied by an alternation of generations is common with the Entomostraca and Aphidæ. In the Aphidæ the parthenogenic young are born alive as already described. That this process is dependent upon seasonal conditions is shown by the experiment of Réaumur and Kyber, who, by maintaining artificially summer conditions in a glass case, were able to obtain fifty continuous parthenogenic generations extending through four years. In the Entomostraca the summer eggs which develop parthenogenetically are smaller, have less yolk, and thinner shells than the fertilized winter eggs, which are well provided with food yolk and covering to withstand drying and cold. This form of parthenogenesis is also characteristic of the gall flies, but in most of these there is but a single parthenogenetic generation between two sexual ones.

(4) *Juvenile* parthenogenesis has been taken to include the summer reproduction of the aphids. But that view no longer prevails, for the parthenogenetic females appear to differ from the perfect forms chiefly in the absence of certain accessory reproductive organs. So the only real case seems to be that of a species of the gnat, Chironomus, in which the pupa produces parthenogenetic eggs. In a closely related group, the gall-midges, Cicidomya, there is a form of pædogenesis that appears to be distinct from parthenogenesis. While the larvæ may contain rudimentary ovaries or testes, the offspring are produced from clumps of cells formed in connection with the fat body. This appears to be a sort of internal budding.

Finally, we have (5) total, or *exclusive*, parthenogenesis. That is, in many rotifers, some of the Entomostraca, and a few insects, no males have ever been found, and it is inferred that in these cases there is perpetual reproduction by unfertilized eggs only.

(6) *Artificial* parthenogenesis, which may be quite a different thing from the normal process, will be discussed in another paragraph below.

Another classification of the phenomena of parthenogenesis is that of Taschenberg, who distinguishes three divisions: (1) *Thelyotoky*, when the unfertilized eggs give rise to females only, as in the summer generations of the aphids; (2) *Arrhenotoky*, when males only are produced, as in the case of the queen bee; and (3) *Deuterotoky*, when the offspring are of both sexes, as with the gall-flies.

Cytology.—It was first suggested in 1877 by Minot on theoretical grounds that parthenogenesis might be due to a failure of the egg to produce polar bodies (see articles *Ovum* and *Reduction Division*). Balfour in 1880 and later Van Beneden maintained that the extrusion of the polar bodies in eggs destined for fertilization is a special provision to prevent parthenogenesis. Theory also led Weismann to investigate the question of parthenogenesis, and he observed in 1885 that in the parthenogenetic eggs of Polyphemus, one of the Daphnidæ, but one polar body is formed. In 1888 Blochmann made the important discovery that in the plant-lice, aphids, parthenogenetic eggs produce but one polar body, while the fertilized eggs produce two. Weismann subsequently found this to be true of the eggs of ostracodes and rotifers, and was led to infer that the differences observed in these forms is one that distinguishes all parthenogenetic eggs from those destined for fertilization. But doubt was thrown upon this view by the observations of Blochmann (1888–89) and Platner (1889), who discovered that in the honey-bee and in the moth Psilura (Liparis) the parthenogenetic eggs produce two polar bodies. The difficulty has been met by Brauer's brilliant research, in which he discovered that there are two types of parthenogenesis. Both

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types occur in the eggs of Artemia. In each case the first maturation spindle contains eighty-four chromosomes in the form of typical tetrads (Fig. 3742), which divide so that eighty-four dyads are removed in the first polar body and eighty-four remain in the egg (Fig. 3743). There are indications of an attempt to form a second polar spindle, but no division takes place, and the eighty-four dyads give rise to a reticular cleavage nucleus (Fig. 3744).

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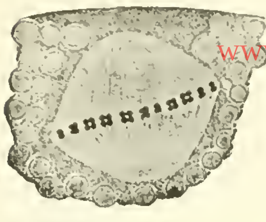

FIG. 3742.—First Maturation Spindle in Parthenogenetic Egg of *Artemia salina*. × 1060. (After Brauer.)

In the second type, which is less frequent, a second polar spindle is formed and the eighty-four dyads divide, producing two groups each containing eighty-four single chromosomes (Fig. 3747). Ordinarily these remain in the egg, producing two small reticular nuclei (Fig. 3748). Preparatory to division two centrosomes appear, whether by the division of a single one or not is not known. But, at any rate, they form a single spindle in which the one hundred and sixty-eight chromosomes arrange themselves in two distinct equatorial plates (Figs. 3749 and 3750). In rare cases, however, Brauer observed that the second polar body is actually extruded, and then its nucleus returns into the egg and presumably undergoes the changes just described. This furnishes an explanation of the appearances observed in the bee and Psilura, suggesting that further investigation will show that the nucleus of the second polar body reunites with the egg nucleus to form the cleavage nucleus in a manner similar to the union of the sperm nucleus with the egg nucleus (see *Impregnation*). If this be true, it will be established as a general fact that the parthenogenetic egg contains the same amount of chromatin as the ordinary egg does after union with the spermatozoon. The formation of the second polar body appears to reduce the amount of chromatin to a point where under ordinary conditions the egg is unable to undergo further division. But if the amount of chromatin be restored by the entrance of the spermatozoon or by the return of the second polar nucleus, then the egg may start upon its new cycle of development.

FIG. 3743.—Extrusion of the First Polar Body of the Same. × 1060. (After Brauer.)

FIG. 3744.—Egg Nucleus Derived from Half of the First Spindle Remaining in the Egg. The centrosome has divided. × 490. (After Brauer.)

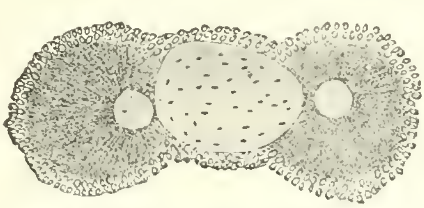

FIG. 3745.—Egg Nucleus of the First Type at the Beginning of the Formation of the Cleavage Spindle. × 490. (After Brauer.)

Brauer made the further observation, which is of considerable importance for the theory of the individuality of the chromosomes (see *Chromosomes*), that so far as he was able to trace them through the first few cleavages, the chromosomes reappear in subsequent cell divisions in the same number that was present in the first cleavage nucleus. That is, he found eighty-four when no second polar nucleus had been formed and one hundred and sixty-eight of half size when a second polar nucleus had been formed (*cf.* Figs. 3745 and 3749).

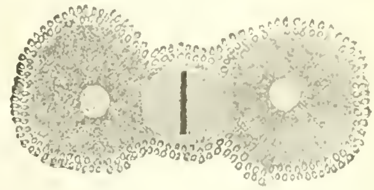

FIG. 3746.—Cleavage Spindle of the First Type. × 490. (After Brauer.)

Very recently (1902) Petrunkewitsch has studied the maturation of the winter eggs of Artemia, and he failed to find Brauer's second type, but further investigation is necessary to throw serious doubt on the positive results of Brauer's very careful work.

Heredity.—We are indebted to Dr. Ernest Warren for the only observations made so far upon heredity in parthenogenesis. The forms that he studied are Daphnia (1900) and an aphid, *Hyalopterus trirhodus* (1902). From 23 individuals of Daphnia he obtained 96 young, and from 60 aphids he reared 455 offspring. Measurements were made of parents and offspring of both species, and the coefficients of heredity were calculated by the methods described in another place (see article *Heredity*).

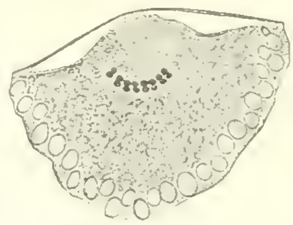

FIG. 3747.—Second Maturation Spindle of the Same. × 1060. (After Brauer.)

The results of direct inheritance were found not to differ very much from those obtained in sexual reproduction; taking the mean of Daphnia and the aphid, the coefficient for parental inheritance was found to be 0.41, and for grand-parental 0.24. But in collateral inheritance there seems to be considerable difference. The mean fraternal correlation for the two species is 0.66, considerably higher than the average for sexual reproduction, which Pearson places at 0.49 or 0.50. It is generally supposed that sexual reproduction tends to increase the variability of the race, but Warren found no significant difference in that particular between these species and sexual forms. But the whole subject of heredity and variation of asexual forms needs much more investigation before generalizations of importance can be made in regard to the different effects of sexual and asexual reproduction.

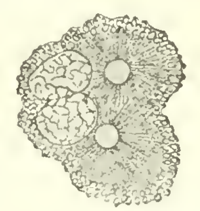

FIG. 3748.—Two Egg Nuclei Derived from Halves of the First and Second Spindles. × 490. (After Brauer.)

Artificial Parthenogenesis.—It has been known for a long time that the ova of animals that reproduce by the sexual method only will sometimes undergo an irregular segmentation. R. Bomet (1900) has given an exhaustive review of these phenomena as observed in vertebrates, and concludes they are pathological in character. The seg-

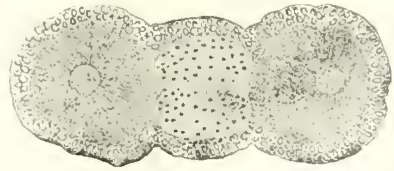

FIG. 3749.—Egg Nucleus of the Second Type at the Beginning of the Formation of the Cleavage Spindle. × 490. (After Brauer.)

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mentation observed is a fragmentation of the cell leading to dissolution. He places in this category the early experiments of Dewitz (1887), who found that frogs' eggs treated with corrosive sublimate would undergo segmentation. Similarly Tichomiroff (1886) was able to induce the development of unfertilized eggs of the silk-moth by treating them for a few minutes with sulphuric acid, but this is a species in which occasional parthenogenesis is known to occur.

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Fig. 3750.—Cleavage Spindle of the Second Type. × 490. (After Brauer.)

In 1899, however, Loeb made the remarkable discovery that by the use of a solution of magnesium chloride of a certain strength (a mixture of $\frac{20}{8}$n $MgCl_2$ and sea-water in equal parts for two hours) he could induce development in the unfertilized eggs of a sea-urchin (Arbacea), a group in which normal parthenogenesis is unknown, so that the egg not only divided but continued through the blastula and gastrula stages, and eventually formed normal pluteus larvæ (Fig. 3751). At first he attributed this result to the specific effect of the magnesium ions. But later researches showed (1900) that other salts and such organic substances as urea and cane-sugar could produce the same result. Loeb then concluded that the cause of development was not the specific effect of certain ions, but that it was due to an increase of osmotic pressure. Especially he noted that the reagents used seemed to cause a liquefaction of the nuclear membrane, and he regarded that as a prerequisite for cell division.

This idea was taken up by Mathews (1900), and he found that various agents that caused the liquefaction of protoplasm, such as lack of oxygen, slight increase of temperature (from 32° to 33° C. for two to four minutes), ether, chloroform, and alcohol would all induce segmentation in sea-urchin eggs. Later Mathews (1901) found that the eggs of a starfish, *Asterias forbesii*, could be caused to develop by shaking or by simple removal from one dish to another by means of a pipette, provided the eggs are taken at the right time, namely, from two to four hours after they have been shed, when "both polar globules have been extruded and the female pronucleus has re-formed and reached a considerable size." From eggs treated in this way he was able to rear some larvæ to the late gastrula and early bipinnarian stages. Loeb (1901) has been able to obtain artificial parthenogenesis also in an annelid, Chætopterus. By treating the unfertilized eggs with solutions of sodium, magnesium, and calcium chlorides and with cane sugar he obtained development into swimming trochophore larvæ. Fischer (1902) has obtained swimming larvæ from unfertilized eggs of two other annelids, Amphitrite and Nereis. From the former by treatment with calcium nitrate, and from the latter by using solutions of potassium chloride having considerably higher osmotic pressure than the sea-water.

By extracting the spermatozoa of sea-urchins Gies (1901) tried to obtain an enzyme that would cause the eggs to develop. But his results were negative. And he was led to criticise the positive results previously obtained by Piéri, which he attributes to carelessness in the non-removal of spermatozoa; and the results of Winkler, which he regards as due to osmosis.

After all, the physiologists have done little more than to establish the fact of artificial parthenogenesis. So far they have been unable to formulate any clear general statement as to the cause of the phenomenon, and they have told us next to nothing in regard to the internal conditions of the egg during this process.

The first one to approach this problem from the inside, as it were, was R. Hertwig (1896), who found that in unfertilized eggs of sea-urchins, Echinus and Sphærechinus, treated with dilute solutions of strychnine, the nucleus might give rise to a bipolar mitotic figure. Sometimes the chromosomes would divide, and sometimes two complete nuclei would be formed, and in a few cases irregular or incomplete cleavage stages were observed. Using mainly unfertilized eggs of Arbacea, T. H. Morgan has made a series of studies (1896, 1899, 1900) upon the effects of solutions of sodium and magnesium chlorides and also dilute strychnine upon the cytoplasm, his "principal discovery being that the eggs become filled with 'artificial astrospheres' (asters) containing deeply staining centrosome-like bodies, which may become connected with the nucleus and 'seem to act as anchors for the chromosomes and move out into the egg with the chromosomes attached to them.'"

Our principal knowledge of the internal phenomena of artificial parthenogenesis is due to the beautiful work of E. B. Wilson (1901), begun soon after the publication of Loeb's first paper. He completely confirmed Loeb's general result, finding that "unfertilized eggs of Toxopneustes (a sea-urchin), when treated with a mixture of equal volumes of sea-water and twelve per cent. $MgCl_2$ and then replaced in pure sea-water, may segment, give rise to actively swimming blastulæ and gastrulæ, and in many cases to plutei." The different stages, however, showed a large number of abnormalities and monstrous forms, and even the most perfect specimens were not exactly like those produced from fertilized eggs.

As to the internal changes observed in these eggs, we have space here for only the briefest possible summary of the most important results. The first change noticed in the eggs was the appearance of a vague primary radiation centring in the nucleus. In many eggs a varying number of secondary centres of radiation (cytasters) were formed at various points in the cytoplasm. Then after a reduction of the rays almost to the vanishing point and their reappearance nuclear division proceeds as in fertilized eggs; but the division of the cytoplasm may be delayed until several nuclei are formed. Serial sections showed that no sperm nuclei were present. The internal changes, while showing an interesting parallel to those occurring in fertilized eggs, were unmistakably different from the latter. During cleavage many of these eggs show but *one-half* the normal number of chromosomes, namely, eighteen instead of thirty-six, and most of the

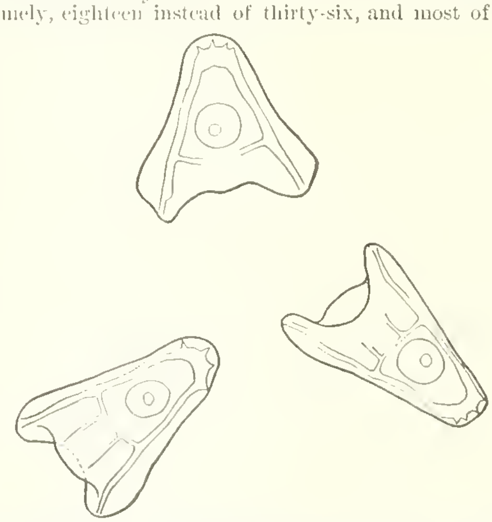

Fig. 3751.—Normal Plutei Reared from Unfertilized Eggs; treated with equal parts of a $\frac{20}{8}$n $MgCl_2$ solution and sea water. Magnified. (After Loeb.)

eggs failed to form any trace of a vitelline membrane, which in fertilized eggs is formed after the entrance of the spermatozoon. Both the primary and secondary asters are formed *de novo* and subsequently multiply by division; and both may act as centres of cytoplasmic division. But, as a rule, complete division does not take

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place except when the asters are connected with chromosomes. Even in enucleated fragments of eggs, produced by shaking, asters may be formed in the magnesium solution, and these, like the others, may contain at their centres deeply staining bodies resembling centrosomes.

Delage (1901) has also investigated the internal phenomena of artificial parthenogenesis, using eggs of species of sea-urchins and starfish. He obtained development in the former after both polar bodies had been formed, and in the latter after only one polar body had been formed as is the case in normal parthenogenesis. He claims also that the number of chromosomes present is the same as in fertilized eggs. But Boveri (1902) has shown this to be an error, the number of chromosomes found by Delage in the sea-urchin being really half the normal number, thus confirming Wilson.

Robert Payne Bigelow.

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PARTURITION. See *Labor and Gestation.*

PASSION FLOWER.—*Passsiflora.* The rhizome of *Passiflora incarnata* L. or of *P. lutea* L. (fam. *Passifloraceæ*).

The herbage is also sometimes employed.

These are soft woody vines, climbing high over shrubbery and trees in the Southeastern United States, where the edible fruit of the first-named is considerably used under the name May-pop.

The elongated rhizome, usually known commercially as "Passion flower root," quite closely resembles menispermum in appearance, being elongated and cylindrical. It rarely reaches a fourth of an inch in thickness and the nodes are rather obscure. It is yellowish or light brown, often with a greenish tinge, and finely striated. It has a small hollow centre surrounded by a greenish or yellowish, finely radiated wood zone, and a moderately thick, purplish bark section. Both odor and taste are slight and indefinite, the latter somewhat fatty and disagreeable. The constituents have not been examined with any care. A trace of alkaloid has been reported.

Passion flower has been exploited by commercial interests, and most of its literature has been compiled with a view of creating a demand for it. *P. incarnata* has been considerably employed in eclectic and homœopathic practice. These authorities attribute to it mild sedative and even hypnotic powers, while larger doses are said to be emetic. Its use by these practitioners in numerous grave conditions, as well as their minute doses, involve obvious absurdities. Whatever benefit may be derived from its use may result from the administration of from 2 to 4 c.c. (fl. ʒ ss.–i.) of the fluid extract. *Henry H. Rusby.*

PATCHOULI, OIL OF.—*Oleum Foliorum Patchouli.*—A volatile oil distilled from either the fresh or the dried leaves of *Pogostemon Heyneanus* Benth. (*P. Patchouli* Pell.; *P. suavis* Tenore. Fam. *Labiatæ*).

The Patchouli plant is native and cultivated in the East Indies, especially in the Straits Settlements, and the drug or the oil distilled from it is mostly exported from Singapore. The oil ranges from pale yellow to brownish, usually with a greenish tinge, and is occasionally of a deep brown color. Its specific gravity varies from 0.97 to 0.99, even when pure. With ninety-per-cent. alcohol, it yields a clear solution which usually remains clear upon the addition of more alcohol (Gildemeister and Hoffman). The oil has a characteristic and very intense and persistent odor. Its composition is not well known, though it yields a peculiar camphor known as Patchouli camphor. This oil is little, if at all, used medicinally, though it has the ordinary aromatic stimulant properties of its class. It has very important uses in perfumery.

Henry H. Rusby.

PATELLA, AFFECTIONS AND INJURIES OF.—The patella is a sesamoid bone developed in the quadriceps tendon, and is therefore a part of the extensor apparatus of the knee. Some anatomists have considered the patella homologous with the olecranon process of the ulna; but there are serious objections to this view, and it is not indorsed by Poirier and Charpy in their recent work.

The first rudiments of the patella appear about the tenth week of fœtal life, and ossification usually begins from one centre about three years after birth; but the *x*-ray often fails to cast a shadow until the sixth year. The principal functions of the patella are to increase the leverage of the quadriceps muscle and to protect the knee-joint anteriorly. It seems to be, however, a luxury rather than a necessity, since its congenital absence may produce little or no disturbance of function. The kangaroo, which has no bony patella, is noted for its powerful posterior limbs.

Fractures and traumatic dislocations of the patella, and prepatellar bursitis are discussed in other sections of this work; there remain the congenital and developmental anomalies, and certain diseases, deformities, and painful affections which follow.

Absence and Retarded Development of the Patella is a not unfrequent accompaniment of congenital deformities involving the knee, especially of absence or imperfect development of one or more bones of the leg, and of congenital flexion, hyperextension, and ankylosis of the knee. Of these conditions the one which has attracted most attention is the so-called congenital dislocation of the knee, where the child is born with one or both knees in hyperextension, and the tibia luxated forward. In a large proportion of these cases no patella is discoverable in infancy; but in many, if not most, it develops later, and may reach normal proportions. Such a case, observed by the writer,[1] had no patellæ at seven months of age; but they could be felt as very small nodules six months later, and at three years of age were well developed. At thirteen years this boy was active, and had good functional use of the knees and perfectly developed patellæ.

Many of the cases in the literature are reported too young to determine the fact of permanent absence. Rectification of the deformity and orthopedic treatment seem to exert a favorable effect on the development of the patella in these young cases. Potel[2] has collected 78 cases of congenital knee luxation, of which about half were bilateral; in 50 of these cases the condition of the

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patella is noted, of which 18 were normal; in 16 the patella was absent, in 10 atrophied, and in 2 anomalous. Potel reports in addition 20 cases of absent or rudimentary patella accompanying other deformities of the knee. Little[3] reports 42 cases of absent or rudimentary patella, not including a remarkable group of 18 cases in four generations of one family who had no patellæ and no thumb nails. Other family groups have been reported by Wirth[4] and Wolf. Many of Little's cases are on Potel's list and on the later list of Thorndike.[5] Some of the individuals in whom the patella never develops are nevertheless active and even athletic, and unconscious of any defect. While extremely rare, cases of complete absence of the patellæ, due to developmental defect, and uncomplicated by other anomalies, do exist. Joachimsthal[6] proved by *x*-ray examination that Wirth's case was indisputable. As absence of the patella is usually a syndrome rather than a pathological entity, the treatment is that of the primary affection, and in the case of congenital luxation and some other deformities it is usually effectual. The following advice, given in a recent work of reference,[7] is erroneous: "When the patella is absent it is usually necessary to produce an artificial ankylosis between the femur and tibia." On the contrary, it is rarely if ever necessary to have recourse to this operation for this reason.

Split Patella.—Very rare are the cases of congenital split patella. Grüber[8] reports a case in which both patellæ were divided into a small superior external and a large inferior internal segment separated by a groove. Joachimsthal[5] reports a case of horizontal and another of vertical fissure in which fracture was excluded.

Congenital Dislocations of the Patella.—While this condition is uncommon there is a considerable literature on the subject. Steindler[9] reports sixty-one cases of outward and two of upward dislocation. This deformity is frequently combined with genu valgum, but such combinations are not always congenital; moreover, there are many cases of congenital dislocation in which no genu valgum is present. The affection seems to be usually due to imperfect development of the anterior part of the external condyle. Alsberg[10] reports three cases in one family, father, son, and daughter, in which the displacement was outward and bilateral. In two of these cases there was practically no disability.

Cases of congenital dislocation are also reported by Potel,[2] Bergmann,[11] Elliott,[12] Drehmann,[13] Gallet,[14] Cayre,[15] and McLaren.[16] The so-called congenital dislocation upward is rather an elevation than a luxation of the patella, as has been pointed out by Blencke.[17]

Pathological Displacements of the Patella.—The commonest of these is displacement upward from elongation of the ligamentum patellæ; this is rarely congenital, though a certain congenital laxity of the ligaments may predispose to this affection. Shaffer[18] has pointed out that elongation of the patellar ligament and displacement of the patella upward may be an important factor in the production of certain knee disabilities, and has recently[19] indicated its connection with slipping patella and displacement of the semilunar cartilages. Shaffer states that with the knee flexed at ninety degrees and the quadriceps tense, the distance from the apex of the tibial tubercle to the lower edge of the patella in an adult is normally not over two inches, and is often less. In his cases of upward displacement the patellar ligament was often three inches or more long.

In rupture of the ligament the patella is drawn upward by the quadriceps, and in rupture of the quadriceps at its insertion the patella drops downward. Schulthess[20] has shown that in congenital spastic paraplegia the ligamentum patellæ is elongated, and the patella displaced upward, probably from the continued traction of the spastic quadriceps. With the knee flexed at ninety degrees, the inferior border of the patella makes a sharp projection in front of the knee in these cases.

According to a recent investigation of Peltesohn[21] the patella was elevated in eleven out of fourteen congenital spastic cases.

The posterior surface of the patella is concave owing to its abnormal relation to the end of the femur.

Slipping Patella; Intermittent Dislocation of the Patella.—In this affection, either from congenital defect, laxity of the ligaments, trauma or genu valgum, the patella becomes displaced outward, and the malposition tends to recur more and more frequently in spite of reduction; it finally may become permanent. Shaffer believes that this condition is often associated with elongation of the ligamentum patellæ, and that this is an important factor in the affection. In several cases he found an exostosis in the intercondylar groove, due, as he supposes, to the absence of the patella from its normal position. Wiemuth[22] reports 66 cases, of which 32 were of congenital origin, 14 traumatic, and 20 pathological. Schanz,[23] Friedländer,[24] and others report cases.

In the milder cases various knee-caps and appliances may be used to hold the patella in place, or to prevent abnormal movement at the knee, but in inveterate cases one or more of the following operative procedures may be necessary:

1. Genu valgum, if present, should be corrected, though this will not always prevent the displacement.
2. The tibial tubercle with the ligamentum patellæ may be detached with a chisel, and sutured or nailed at a point farther inward on the tibia.
3. The intercondylar groove may be deepened, and an exostosis, if present, removed.
4. The capsular ligament on the inner side of the patella may be folded and sutured (Le Dentu).
5. Artificial bow leg may be produced after a supracondylar osteotomy (Chiene).
6. The patella may be excised (R. Fowler).

Ankylosis of the Patella.—After inflammation of the knee-joint involving the contiguous articular surfaces of the patella and femur, the patella may become adherent. This of course prevents voluntary motion at the knee. Where the joint surfaces between the femur and tibia are good, or where it is necessary to do so in order to correct the position of the knee, the patella may be separated by the fingers, mallet, or chisel (see papers by Hübscher[25] and Cramer[26]).

Atrophy of the Patella.—The patella follows the usual law of bone growth, increasing in size and density according to the work put upon it; active muscular individuals have large and strong patellæ. The patella also adjusts itself to the shape and pressure of adjacent structures; hence its size and shape are altered in various pathological conditions. If the function of the leg is interfered with, the development of the patella is retarded or checked, and later atrophy may set in. Individuals with clubfoot, congenital dislocation of the hip, and other affections which limit the use of the limb, show less development of bone as well as of muscle on the affected side. In infantile paralysis the effect on function and on bone growth is much more marked, and has been thought to be largely due to interference with trophic centres in the cord. It is well known that chronic joint disease has a profound effect on bone growth. In osteitis of the knee and hip all the bones of the affected limb are shortened, thinned, and narrowed, and this is due to atrophy as well as to retardation of growth. In a series of hip and knee cases measured by the writer,[27, 28] the patella was found to be from one-eighth to one-half inch narrower on the affected side within two years of the onset of the affection. The bone was markedly diminished in bulk, in many instances being less than half the size of its mate.

Riders' Painful Patella.—Rosenberger[29] has recently described a painful affection of the patella observed in cavalry and mounted officers, who have worn tight, stiff breeches and have been continuously in the saddle. The inner border of the patella, which has little adipose padding, and which is most exposed to pressure in riding, is the most painful part. There is at first more or less disability, which together with the pain soon passes off on rest and relief of the pressure. No other symptoms were observed by him, but according to Düms[30] there

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may be inflammatory swelling of the quadriceps tendon with crepitus.

Diseases of the Patella: Primary Tuberculosis.—Fibrous, fatty, sarcomatous, and other tumors of the patella or of parts adjacent to it have been reported, and syphilitic and staphylococcic infections may occur, but the most common and important disease of the patella is tuberculosis. Secondary infections, especially of the articular surface proceeding from tuberculous or other inflammation of the knee-joint, are not infrequent, and are a common cause of adherent or ankylosed patella. Infection may also occur from disease of the prepatellar bursa. Primary tuberculosis of the patella has been described by Volkmann and others, and has lately attracted considerable attention. Gross[31] in an excellent paper reports 36 cases, including 4 of his own. In 33 the age was known, of which 13 were under and 20 over the age of twenty. There is spontaneous pain in the patella in the daytime and often at night, with extreme tenderness on pressure; the subcutaneous surface of the patella may be uneven to the touch; during the early stages the functions of the knee are but little interfered with. The knee is usually held in extension or nearly so. The most significant symptom is cold, prepatellar abscess of slow formation. Such an abscess is much less movable than a bursal swelling, and puncture or exploration should clear up doubtful cases. Later on, sinuses may form, leading to cavities in the cancellous tissue. Volkmann[32] depicts (Fig. 3752) such a case in section. If it is overlooked or neglected extensive disease of the knee-joint usually results. The treatment consists in the removal of diseased tissue, by *évidement* of the focus, and when necessary by excision of diseased synovial membrane. In the late cases, in which the joint is seriously infected, the latter will require appropriate treatment.

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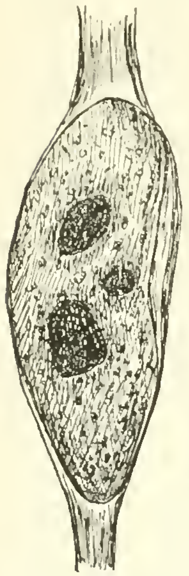

FIG. 3752.—Tuberculous Cavities in Patella. (From Volkmann.)

Gross' conclusions are that primary tuberculosis of the patella is more frequent than is usually supposed; that treatment is usually too long postponed; that it is a serious affection rapidly perforating into the joint; that with an early diagnosis a relatively simple operation will cure it; the procedures ordinarily employed are *évidement* of the focus, and in the later cases subperiosteal or total ablation of the patella, with synovectomy or arthrectomy when necessary. Absence of the patella interferes but little with function, and it may be reproduced after total subperiosteal ablation. He remarks that: "If one bears the possibility of tuberculosis of the patella in mind many knees will be saved."

Other papers on primary tuberculosis of the patella by François,[33] Forget,[34] Ménard,[35] Ribas,[36] Schlüter,[37] Kummer,[38] and Kocher[39] may be consulted.

Henry Ling Taylor.

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PAU.—The city of Pau, chief town of the Department of the Basses-Pyrénées, France, stands upon the north or right bank of the river called the Gave de Pau, at the height of 130 feet above the river-bed, and 620 feet above sea level. The latitude of Pau is 43° 17' N.; its longitude is 0° 23' W. The population of the town is about thirty-three thousand. Its situation, on the edge of a plateau immediately above the river-bed, and the location, at the brink, as it were, of this plateau, of the old castle with its terrace, of the Place Royale, the Boulevard du Midi, and the Parc (containing thirty acres of ground and beautifully planted with shade trees) render the town a decidedly picturesque place in appearance, while the view of the Pyrenees Mountains, which may be had from all the points just mentioned, is remarkably fine, and is said by Murray to be similar to, although inferior to, the famous distant view of the Alps which is obtained from the platform at Berne.

The reputation of Pau as a winter health resort is notoriously great, and its hotels are excellent, especially such as lie in that part of the city which is nearest the edge of the plateau, and from which the view just mentioned is obtained. This portion of the city, at least, is well drained; of the rest I cannot speak positively. The soil at Pau is sandy.

The mean temperature of each of the five months, November to March, is given by Dr. Julius Hann as follows: November, 47.84° F.; December, 43.34° F.; January, 42.26° F.; February, 44.42° F.; March, 48.20° F. I have no data at hand to illustrate either the extreme or the average daily maximum and minimum temperatures; but the average monthly range during the season in question is 36.5° F. (Hann's "Handbuch der Klimatologie.")

Dr. Yeo tells us that "frost and snow and cold nights are not uncommon in winter"; and it is evident that the climate of Pau at this season cannot be pronounced a very warm one. In "Murray's Guide-book" we read that "though the climate is mild the variations in temperature are often sudden." On the other hand, Dr. A. Rotureau (in the "Dictionnaire Encyclopédique des Sciences Médicales"), although giving for the monthly means of November, December, and January figures which are lower than those of Dr. Hann, and although admitting that the temperature quite frequently falls below the freezing point, nevertheless appears to regard the winter climate of Pau as one characterized rather by equability than by variability of temperature, and Dr. Weber tells us that the nycthemeral range of temperature seldom exceeds 16° F.

The mean annual rainfall is 42.7 inches, of which 11.3 inches falls in winter (Rotureau), and during the six months from November to April the average number of

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days on which rain falls is between eighty and ninety (Weber). As to the manner in which rain habitually falls, we are told by Dr. Rotureau that, although falls of rain are frequent, they are not usually of long duration, and commonly occur in the early part or toward the close of the day. The relative humidity of the atmosphere at Pau is considerable; according to Dr. Weber, it is on the average from 80 to 85 per cent. Dr. Hann's figures for the five months, November to March, derived from observations taken only twice a day (viz., at 7 A.M. and at 2 P.M.), are as follows: November, 75 per cent.; December, 76 per cent.; January, 74 per cent.; February, 72 per cent.; March, 70 per cent.

The leading characteristic in the climate of Pau, and the feature to which it largely, and no doubt deservedly, owes its popularity as a winter resort, is the prevailing stillness of the atmosphere. The great chain of the Pyrenees Mountains, distant only fifteen or twenty miles, acts as a barrier to protect the region about Pau against southerly winds; while we are told by Dr. Yeo that "a series of plateaux rising behind the town" afford a good degree of protection from northerly winds. The west and the east are the quarters in which least protection against wind is afforded; but Dr. Rotureau claims that the hills known as the Coteaux de Jurançon and the trees of the Parc serve in some degree to break the force of the westerly winds, and that the easterly winds are modified in character by being obliged to pass over a district of relatively considerable elevation before reaching the town (sont mitigés par les hauteurs du terrain sur lesquelles ils doivent passer avant d'atteindre la ville). He also tells us that the east wind at Pau is a fair-weather wind and a dry one. The "mistral" of Provence and the Riviera does not exist at Pau, although the northwest wind is a bringer of cold and dry weather. The westerly wind is damp and warm. In Dr. Rotureau's article will be found other interesting facts concerning the winds of Pau, and concerning the comparative windlessness of its climate. Suffice it to say, in this place, that, while occasional wind-storms of considerable severity are there experienced, the climate is nevertheless one properly to be regarded as exceptionally free from winds.

Huntington Richards.

[The diseases for which the climate of Pau is regarded as beneficial are the various catarrhal conditions of the respiratory passages: dry bronchitis with irritable cough, emphysema, and nervous complaints of an erethistic nature. Formerly Pau enjoyed a wide reputation as a winter resort for cases of pulmonary tuberculosis, but at the present time it is considered too moist for the successful climatic treatment of this disease. There is, however, in the neighborhood of Pau a small sanatorium (The Trespoey Sanatorium) six hundred and ninety-five feet high, for the treatment of pulmonary tuberculosis; it is open from the middle of October to the middle of May. One can find at Pau good facilities for golf, polo, tennis, and cross-country racing. There are four English churches and a Scotch one. There has recently been opened a winter palace of much magnificence, where operas, etc., are given. English physicians are also to be found here.—*E. O. O.*]

PAVILION SPRING.—Berks County, Pennsylvania.
POST-OFFICE.—Wernersville. Sanatorium.

ACCESS.—Via Bound Brook route, Central Railroad of New Jersey, Lebanon Valley Railroad, or Philadelphia and Reading Railroad to Wernersville; thence one and three-quarter miles by private conveyance to spring.

The Pavilion Spring is not itself a resort, but its waters are used commercially, and locally it is used to supply the Grand View Sanatorium. It is located on the grounds of the sanatorium, near Wernersville, and nine miles from the city of Reading. The situation of the sanatorium is on the South Mountains, about one thousand feet above tide water, in the midst of charming and picturesque surroundings. This institution is an old and well known health resort, having been established in 1847. The buildings have been greatly enlarged and improved recently, and the resort is now fitted up with all kinds of appliances and conveniences for combating morbid conditions. The Pavilion Spring was analyzed in 1885 by Prof. Otto Luthy, analytical chemist, of Philadelphia, with the following results:

Reaction neutral. One United States gallon contains: Potassium sulphate, gr. 0.18; sodium sulphate, gr. 0.02; sodium chloride, gr. 0.06; sodium carbonate, gr. 0.33; calcium carbonate, gr. 0.23; magnesium carbonate, gr. 0.12; iron oxide and alumina, a trace; silica, gr. 0.94; organic and volatile matter, gr. 0.10. Total, gr. 1.98.

This water is very lightly mineralized, containing, indeed, fewer solid ingredients than that supplied to many of our larger cities. It is remarkably pure, however, and well adapted for table purposes. The water contains a considerable amount of carbonic acid gas and atmospheric air.

James K. Crook.

PEDICULOSIS. See *Insects, Parasitic.*

PELIOSIS RHEUMATICA. See *Morbus Maculosus Werlhofii*, and *Purpura.*

PELLAGRA.—(Synonyms: Lombardian leprosy; erythema endemicum; Maidismus; *Mal de misère* [French]; *Mailändische Rose* [German]; *Mal roxo* [Spanish]; *Mal rosso; Scorbuto Alpino* [Italian]).

DEFINITION.—An affection, limited to certain countries of the temperate zone, which has been most prevalent where maize or Indian corn is the principal article of diet. It is thought to be a trophoneurotic disease of toxic origin, affecting mainly the digestive tract, cerebrospinal centres, and the skin.

The disease was first observed in Spain in 1735, and it still exists to a limited extent in that country, although it is mainly encountered in Northern Italy, in the country about Rome, in Southern Austria, in the Tyrol, and in Roumania, while Manson reports the disease as prevalent in Egypt. No cases have appeared in this country, although it is sometimes imported with immigrants coming from countries where the disease prevails.[1]

SYMPTOMS.—The disease occurs in both men and women, and it has usually been observed in adults, although children are by no means exempt. It first makes its appearance in the spring or early summer; continues during the summer months, and then subsides as winter approaches. The first symptoms refer to the digestive tract and consist mainly of loss of appetite, thirst, vomiting, together with intestinal disturbances which give rise to diarrhœa; or, more rarely, constipation may be at first complained of, but this is usually followed by obstinate diarrhœa. As might be expected in this condition the tongue is furred, and epigastric pain is not infrequently complained of. In addition, there are lassitude, sometimes dizziness, noises in the ears, headache, and sleeplessness. These symptoms are soon followed by anæmia, palpitation on slight exertion, and sometimes œdema. Pains occurring either in the joints or in the lower part of the spine may likewise be complained of. In the course of a few months, or it may be not until the summer following, the skin shows signs of being implicated in the disease. At first there may be a general pallor, or even jaundice, which is soon followed by an erythema. The erythema often develops somewhat suddenly, although less abruptly than is usually the case with simple erythema, and its duration is more prolonged. The parts exposed to the sun's rays are at first, and throughout the whole course of the disease, the regions mainly involved. The changes consist of an erythematous blush which may be uniformly distributed over the area involved, or the eruption may appear in the form of patches of various shapes and sizes. These are generally first noticed on the backs of the hands, the face, neck, and forearms in laborers who are accustomed to go in the sun bare-armed. The same may be observed on the feet and legs of children who are wont to go barefooted; and it has been observed by Raymond[2] to recur in parts once af-

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fected, although subsequently protected from the direct rays of the sun. The eruption at first bears some resemblance to an ordinary sunburn. In unusually severe cases the cutaneous eruption is often of a livid red color which disappears on pressure, and in some instances hemorrhagic petechiæ are encountered; bullæ have likewise been observed, and marked œdema of the parts affected is not an uncommon symptom. The subjective symptoms complained of in the skin are slight burning or itching, although the latter symptom is usually described by the patient as merely prickling or tingling, rather than the well-defined itching experienced in eczema. These constitute what may be called the first stage in the cutaneous manifestations.

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Toward the last of the summer, however, the skin assumes a dark, sometimes muddy, color; it becomes rough, the epidermis being thickened and slightly scaly, and not infrequently excoriated patches are encountered. These are occasioned by the rubbing and scratching indulged in by the patient. The duration of the eruption is variable.

Usually the active cutaneous symptoms begin to subside within a few weeks, or soon after midsummer, when the patient apparently recovers, and as cold weather approaches no vestige of the disease may be apparent. In this case the patient remains free from the disease until the following spring when the symptoms return usually with greater severity than characterized those of the preceding year. More frequently, however, the symptoms do not wholly subside upon the approach of winter. With the recurrence in the severity of the eruption the skin soon becomes thickened and fissures occur about the small joints; this is accompanied by marked exfoliation and constitutes the second stage of the eruption. The severity of the disease varies in different seasons and in different individuals, but it is usually commensurate with the privations to which the patient is exposed. Year after year the erythema returns and finally there takes place marked atrophy of the derma, the skin becomes shrivelled, and the fingers assume a semiflexed position, constituting the third stage of the cutaneous lesions.

During the second year the nervous system shows more unmistakable signs of implication. At this time changes in the reflexes are seldom wholly absent. In 165 cases examined by Sandwith,[3] the knee jerk was found to be normal in only 3, in 45 it was slightly exaggerated, in 70 very brisk, in 15 feeble, and absent in 23. In addition to this the patient complains of pain and tenderness in the dorsal region, the pain sometimes radiating to the extremities. According to Crocker[4] the third nerve is frequently paralyzed, and changes have been observed in the fundus oculi. These symptoms are followed by delirium, and after many years by melancholia, mania, and a tendency to suicide, while insanity is not infrequently the final sequence. It is estimated that about ten per cent. of the patients finally drift into the lunatic asylums of Italy (Billod). In young people bodily defects are sometimes attributed to this disease, especially defective development of the organs of generation, while it is said that the mental powers may be unnaturally precocious. Other symptoms noted late in the course of the disease are paralyses of various parts of the body, those most frequently reported involving the legs and arms; while atrophy of various internal organs is often observed post mortem.

Pathology.—According to Lombroso[5] the principal factor in the causation of pellagra is undoubtedly some toxic effect on the sympathetic system and the vagus nerve. The first change observed in the skin is hyperæmia, which goes on to exudation and consequent hypertrophy. Similar changes have been best observed in the meninges of the brain, as well as in the liver, spleen, kidneys, and lungs. When, as is usually the case, death occurs late in the course of the disease, atrophic changes have been for the most part observed. The most constant post-mortem changes are, therefore, general emaciation, atrophy of the skin, which presents a shrivelled, sometimes furrowed appearance, together with marked atrophy of the liver and spleen. In some instances these changes have been noted in the kidneys. Symmetrical sclerosis has been observed by Tuczek in the posterior columns of the cord and in the pyramidal tract; while in some cases fatty degeneration of various internal viscera is the most conspicuous feature. In one hundred and thirteen autopsies Lombroso found exudation into the liver, kidneys, spleen, and the meninges of the cord. He likewise found atrophy of viscera supplied by the vagus, fatty degeneration of the liver and kidneys, and pigment changes in the cells of the brain and cord.

Etiology.—It was formerly supposed that the exclusive use of unwholesome maize as an article of diet was the cause of pellagra. There can be no question, however, that bad hygienic surroundings together with exposure to the sun are the most important factors in the etiology of the disease. According to Lombroso (*loc. cit.*), the immediate cause of pellagra is a toxic influence analogous to ergotism, and further that maize when decomposed gives rise to a fatty oil or extractive which has been denominated pellagrozein. In experiments made with this oil on both men and animals it has been shown that symptoms somewhat analogous to pellagra have followed its administration. On the other hand, many cases of pellagra are reported in which the ingestion of maize has played no part. Thus Hardy,[6] Schreiber,[7] and others have reported cases of pellagra in which maize had not entered into the dietary. Alcohol and syphilis have likewise been looked upon as etiological factors. While it must be acknowledged that they may be contributory in producing the debilitated state essential in its causation, there is no positive ground for believing that they ever give rise to the disease *per se*. It is well known that maize as an article of diet is perfectly wholesome when sound and properly cured; but, like rye, maize may become affected, giving rise to a potent toxic poison analogous to ergot. Dr. Zampa,[8] medical officer of health in the province of Rome, claims to have traced a direct connection between the disease and certain topographical conditions, although malaria seems to have no part in its causation. The disease is most commonly met with among the agricultural class, although in rural districts it does not spare the artisan or those engaged in other pursuits. According to Zampa, damp, dirty, ill-ventilated habitations, scarcity of pure drinking-water, and a large consumption of "polenta" (a porridge made of maize seasoned with a little salt) as the chief article of diet, are the chief causes of pellagra. Crocker very aptly summarizes the cause of pellagra into "peasant life, poverty, and polenta." The disease is not contagious nor is it inherited. The age at which the disease is most commonly met with ranges between thirty and fifty years.

Diagnosis.—Like many infectious diseases the diagnosis of pellagra is not difficult when it is encountered in connection with other cases of the same nature, in communities where pellagra is known to be endemic, or in those known to have suffered from previous attacks of the disease. On the other hand, in sporadic cases or in countries where the disease is seldom encountered, its recognition may be somewhat difficult. The first point to be considered is the nutrition of the patient, for malnutrition is essential to the development of the affection. Gastro-intestinal disturbances, together with erythema appearing on the backs of the hands, on the face, more rarely on the forearms and dorsal surfaces of the feet as warm weather comes on, might be mistaken for ordinary sunburn. The association of gastro-intestinal disturbances, however, should put one on guard, while the persistence of the eruption would soon lead to a more thorough investigation, when the association of other symptoms or the history of previous attacks would enable the physician to make a positive diagnosis. Later in the course of the disease the occurrence of nervous symptoms would be conclusive to one familiar with the salient features of pellagra. Finally, with the continuation of the eruption year after year, together with great debility,

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despondency, an inclination to melancholia, and aberration of reflexes, an error in diagnosis need not occur.

Prognosis.—The prognosis will depend upon the severity of the disease and the extent to which it has advanced. During the first attack the prognosis may be said to be favorable, provided the patient can obtain suitable nourishment, and provided the impairment of the digestive functions be not sufficiently grave to interfere with normal nutrition. On the other hand, after the disease has existed one or more years and general impairment of nutrition becomes more marked, together with involvement of the nerve centres, the prognosis is always extremely grave. When the disease goes unchecked the final fatal termination may be expected in from three to twelve years, the average being about five. In all cases the prognosis will depend upon the ability of the patient to place himself under the most favorable conditions for recovery.

Treatment.—There are no drug specifics in the treatment of pellagra, and regulation of the diet should be the first consideration. In conjunction with this, proper attention should be paid to the digestive tract, which may require sedatives or soothing medicines, such as olive oil or albolene, together with opium, bismuth, etc. The food selected should be light and easy of digestion, and it should be given in small quantities at frequent intervals according to the strength and general condition of the patient. Milk, eggs, and meat broth are usually indicated in severe cases, and as the strength increases a meat diet with vegetables and bread obtained from well-ripened grain should be given. Next in importance to the diet are the hygienic surroundings of the patient. As has been shown, most cases occur among those who have been subjected to the vilest hygienic conditions; therefore it should be seen that the room occupied by the patient be sufficiently large to insure pure air together with free ventilation; dampness should be avoided by selecting a room to which the sun gains access at least during some portion of the day. Massage and rubbing with salt may be of benefit. By way of further medication, after the more pressing symptoms have been allayed, tonics and vegetable bitters, such as quinine and iron, together with cod-liver oil, should be prescribed. In some cases the administration of arsenic is followed by marked improvement. The cases in which this remedy is most liable to prove beneficial are those which have extended over several years and in which the disease has assumed a chronic stage. To quiet the apprehension of the patient, especially when the nervous manifestations assume a serious aspect, opium may be given.

William Thomas Corlett.

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PELLITORY.—*Pyrethrum*, U. S. P.; *Pyrethri radix*, Br. P.; *Spanish Pellitory; Spanish Chamomile.* The dried root of *Anacyclus Pyrethrum* (L.) DC. (*Anthemis P.* [L.] fam. *Compositæ.*)

The pellitory plant is a pretty little perennial herb, which somewhat resembles the chamomile, whence one of its common names. It is a native of the Mediterranean basin, where it is cultivated not only as a drug, but also as a garden flower.

From 5 to 12 cm. (2 to 5 in.) long and 1 to 2 cm. ($\frac{2}{5}$–$\frac{4}{5}$ in.) thick, nearly straight and unbranched, cylindraceous, tapering or slightly fusiform, bearing a few tough, hair-like, yellowish rootlets and in the centre of the crown usually a tuft of cottony or silky, whitish, fibrous tissue; externally deep brown, or slightly grayish brown, inconspicuously annular near the crown, very roughly wrinkled and pitted, harsh to the touch; fracture short and sharp; bark thick, the inner layer brown, containing about three circles of dark red resin cells, the outer layer dark brown; wood yellow-brown, finely radiate, containing four or more circles of resin cells; inodorous, pungent, and acrid, producing a prompt and strong sialagogue effect.

The acridity of pellitory is due to a number of constituents, or possibly to some one which is carried in the former. These are a resin and two fixed oils, all present in large amount, as well as the alkaloid *pyrethrine*. The latter is readily decomposed into a derivative alkaloid, believed to be piperidine, and piperic acid. The resin contains a small amount of the alcohol-soluble body, *pellitorin*. The substance which has been sold as "pyrethrin" is merely a fatty and resinous extract. Tannin and volatile oil are present in small, and inulin in large amount.

Action and Use.—These have been but little investigated, notwithstanding that the powerfully active properties of the drug warrant a thorough experimental study. It is one of the most powerful of sialagogues, a property which we have not yet learned to utilize, in spite of the important digestive functions of the saliva. It is at least possible that so powerful an action upon the salivary glands is associated with a similar action upon the pancreas, but no observations are recorded upon this point. The most general application of the drug is as a dental anæsthetic and counter-irritant, and it enters into numerous "toothache drops" which have themselves largely gone out of use. There is a twenty-per-cent. official tincture, made with alcohol, the dose of which is a fluidrachm.

Allied Drug.—*German pellitory* or *pyrethrum* is the root of *A. officinarum* Hayne, the nativity of which is not certainly known, but which is a product of cultivation. The root is very much more slender and elongated than the other, and usually comes to market with long portions of the stem attached. It has a circle of large resin cells in the bark, but there are none in the medullary rays. Its constituents and action are practically identical with those of the official variety.

Henry H. Rusby.

PELVES, DEFORMED.—Any marked deviation in size or symmetry from the normal pelvis may be regarded as constituting a deformity of the pelvis, whether the effect on the course of labor be serious or not.

A deformed pelvis may be due to an error in development, to local disease, injury, or new growth, or indirectly to injury, disease, or maldevelopment of the adjoining skeleton. Thus from errors in development there are the abnormally large pelves, called justo-major; the justo-minor, or disproportionally small, sometimes of a persisting infantile type; and the pelves of the masculine type, large and thick-boned, but with a narrowed pubic arch and pelvic outlet.

From local errors in development there are the rare varieties, where one or both of the sacral alæ are lacking, giving the Naegele (oblique) or Robert (transversely contracted) pelves. The split pelvis is one in which there is failure of meeting of the pubic bones at the symphysis.

From constitutional disease or errors of nutrition causing softening of the bones, there result the pelves deformed by rachitis and osteomalacia. From local disease there may be caries of some of the pelvic joints, with arrest of development and later ankylosis. The sacro-iliac joints, if diseased in early life, may cause extreme deformity. Following injuries there may be pelvic fracture with formation of callus. New growths may limit or obliterate the pelvic cavity—a primary sarcoma or secondary carcinoma, or some form of enchondroma or exostosis.

Any injury or maldevelopment of parts of the skeleton adjoining the pelvis, especially during early life, may have an important bearing upon the subsequent developments of the pelvis, and leave indirectly its stamp on the general contour of the latter. Thus, for example, poliomyelitis, causing a paralysis and subsequent atrophy of one limb, leaves the pelvis on that side comparatively

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undeveloped. As a further result of the shortening of the limb there must be compensatory scoliosis, with its effect upon pelvic growth.

Other forms of paralysis of the lower extremities, or joint diseases of hip, knee, or ankle, may affect the pelvis in the same way. A congenital hip-joint dislocation may seriously affect the normal growth of the pelvis. Other results of skeletal deformity upon the pelvis are not infrequently seen from defects in the spinal column, such as simple, compensatory, or rachitic scoliosis, caries of the vertebræ, and, rarely, the anterior dislocation of the bodies of the lumbar vertebræ, known as spondylolisthesis. Senile changes in the pelvis before the end of the child-bearing period sometimes cause obstruction by ankylosis of the coccyx with the sacrum.

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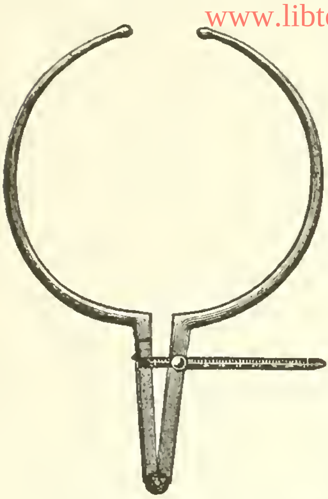

FIG. 3753.—Baudelocque's Pelvimeter.

Habits of living must always be counted upon as etiological factors. The poorly nourished and poorly housed are the ones who present pelves deformed from rachitis and tuberculosis. For this reason the percentage of deformities is small among our native country classes, large among the dwellers in cities, especially of the slums, and greatest among the immigrant population. Abroad, where the sanitary conditions of life are worse, still higher proportions of deformity are found, and osteomalacia is occasionally met with.

There are racial peculiarities in the shapes of the pelvic brim. The Caucasian normal type is one which is wide transversely; the outline of the Australian pelvic brim is almost circular; while the African pelvic brim is one which is relatively constricted transversely, and has a long antero-posterior diameter. This type of pelvis, if affected by the unsanitary conditions in which the negroes commonly live in this country in cities, supplies a large proportion of bad pelvic deformities. Thus one author has reported seven per cent. of deformed pelves in whites in a city hospital service, as against twenty-one per cent. in blacks.

The recognition of the deformity is important. One "must learn pelvimetry if he is to do intelligent obstetrics." Much can be ascertained by inspection of the patient. The facial appearance, form, carriage, height, gait, or obvious deformities of spine or lower extremities may lead to suspicions and put one on the track of a pelvic defect. A careful questioning may elicit a history of diseases such as rachitis or tuberculous bone disease, or bring out information concerning previous difficult labors.

But the history may be lacking, and all external appearance of deformity absent. Moreover, in all cases, no matter how obvious the deformity, its true extent and its obstetric significance can be ascertained only by careful pelvimetry, through palpation, vaginal examination, and instrumental pelvic measurements. External measurements, except in some cases of great obesity, are of a certain value in determining the types of deviation from the normal. Of greater importance is the exploration by vaginal examination of the pelvic cavity.

For external measurements there have been chosen certain easily recognized bony landmarks. The distance between these points is taken by a form of caliper called the pelvimeter. Of the commoner types perhaps those of Baudelocque and Breisky are best known. The essentials of a good pelvimeter are compact size and an accurate and legible scale, preferably in centimetres.

The first measurement usually taken is the distance between the anterior superior spines. For this measurement the patient should be flat on the back, with all but the thinnest clothing removed from about the hips and lower abdomen. The thumb and forefinger should steady each tip of the pelvimeter. The thumb should now be allowed to rest in the notch below the spines and the tips of the pelvimeter be lightly pressed against their outer side and the reading made. Taken in this way the measurements will be fairly constant when made by different individuals. The average interspinal diameter is 24 cm.

The next measurement should be the distance between the crests of the ilia, this measurement being made between the points which are most widely separated. The patient lying in the same position, the tips of the pelvimeter are slipped back along the outside edge of the crests, and the widest points of divergence noted and measured. This is called the intercristal measurement. It should average about 28 cm. These two distances furnish an indication of the transverse diameter of the pelvic brim, especially if taken in consideration with the so-called external oblique measurements.

The ratio of the interspinal measurements to the intercristal has a distinct value in the study of certain types of deformity, especially the rachitic.

The external oblique measurements are those taken from one posterior superior spine to the opposite anterior superior spine. To take the left oblique measurement the doctor stands on the right of the patient, who lies on her left side. The distance from the left posterior superior spine to the tip of the right anterior superior spine is measured. The posterior spines are not very prominent, but are usually indicated by the presence of a dimple on either side of the sacrum from one and one-half to two inches from the median line. The patient now lies on the right side, and the right oblique measurement is taken. The average length of these measurements is 22 cm. The right oblique is commonly 0.5 cm. larger than the left. The obliques furnish a fair idea of the oblique diameters of the pelvic brim. Any marked deviation of their normal relation to each other is a good index to oblique pelvic contraction.

For estimation of the antero-posterior diameter, or so-called conjugate of the pelvic brim, a measurement is taken which is called the external conjugate. This is the distance from the tip of the last lumbar spine to a point about one-quarter of an inch below the upper edge of the pubic symphysis in the median line. Some authorities give the depression just below the last lumbar spine as the posterior landmark, but this gives less constant and exact measurements. The last lumbar spine is usually the most prominent spine in that region. It is found about 2 cm. above the level of a line drawn through the two posterior superior spines. This measurement calls attention to contractions in the antero-posterior diameter of the pelvis. In the normal pelvis it measures from 20 to 21 cm. Any pelvis measuring less than 18 cm., even if justo minor, should be regarded as flat. There are, however, possibilities of error in this measurement. Occasionally a

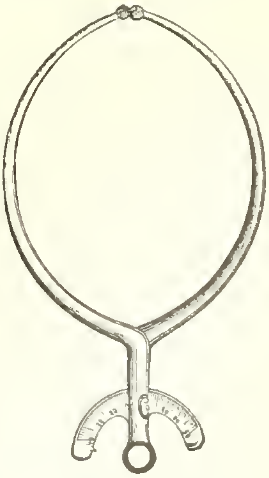

FIG. 3754.—Breisky's Pelvimeter.

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pelvis which has an external conjugate of large size will show flattening upon internal pelvimetry.

One other external measurement is sometimes of importance; that is, in the type of pelvis where there is obstruction at the pelvic outlet due to a narrowing of the pubic arch and an approximation of the tuberosities of the ischia. This is called the bi-ischial diameter. It is easily taken, while the patient is in the lithotomy position. The tuberosities may be readily felt, and the distance between them taken by tape measure or pelvimeter. If the distance be below 9 cm. the narrowing is dangerous.

The most valuable information is furnished the physician by vaginal examination. After he has acquired some experience he will be able to make out variations in the size of the cavity of the pelvis. If he can readily with the finger touch the sacral promontory, flattening is certain. Fairly accurately to estimate the internal conjugate, the first and second fingers of the right hand are introduced until the middle finger rests against the promontory. At the point where the index finger intersects the symphysis a mark is made by the finger nail of the left forefinger. The internal oblique conjugate is the distance between this mark and the tip of the middle finger. Subject to slight variations the true internal conjugate may be estimated by the subtraction of 1.5 cm. from these figures. The normal internal conjugate is 11 cm. Any conjugate below 10 cm. indicates a dangerously flattened pelvis.

Of the various types of deformities which are perhaps most commonly seen are the pelves of normal symmetry but of extremes of size. The justo-major pelves are those of exaggerated size. They occur usually in women of robust type, who have an otherwise large frame. These women are often tall, but they may be of normal stature. The effect of such a pelvis upon labor is slight. Certain authors suggest that from the lack of bony resistance there is a tendency to precipitate labors and resulting lacerations. There may be an increased proportion of uterine displacements from lack of bony support. The practical obstetrician may disregard this deformity. The diagnosis of this condition may be made in those cases in which the oblique diameters measure 24 cm. or more.

The justo-minor or equally contracted pelvis is of more serious moment. It is usually found in smaller women, but may occur in women of otherwise normal development. It may be classified as one of symmetrical shape, but with external obliques measuring 20 cm. or less. The etiology of this condition cannot always be explained. It is of great frequency in the African race. In this class, however, the deeper conjugate acts somewhat in compensation. In some cases the justo-minor pelvis is only a part of a dwarfed general system. In some cases it seems to go with under-developed pelvic organs, a retention of the juvenile type. Unfavorable surroundings in childhood or during intra-uterine life may have affected development unfavorably. The effect upon labor depends necessarily upon the degree of the deformity and the size of the child's head. In those patients who are naturally small the child will be in proportion, except where the father is of large size or where pregnancy has been prolonged beyond the normal time. In these cases the only safety for the child depends on strong uterine contractions and a capacity for extreme moulding of the fœtal head. In the African race, as the fœtal cranial bones are notably soft, and the uterine pains usually very effective, the head moulds extremely well. The justo-minor pelvis, therefore, in the negress has little significance except in those cases in which some other kind of deformity is added to the general contraction. In the Caucasian the larger and firmer head of the fœtus causes trouble, and may necessitate very active interference.

The mechanism of the labor in the justo-minor pelves is as follows: The head, unable to engage by moderate flexion, becomes more and more flexed until the occipital bone presents. The external occipital protuberance may be felt. Engaging in one oblique the head gradually descends, under the influence of strong pains. The overlapping of bone at the lambdoidal sutures is an index of the amount of moulding accomplished. If the obstruction is so moderate that the pains can accomplish the delivery, after a rather protracted second stage the head reaches the pelvic outlet. Obstruction occurs until the head is well past the mid-pelvis. During this time the suffering from the pressure against the pelvic bones may be very severe. At the time of the uterine contraction the patient cries out as if suffering intensely. Between the pains there is aching discomfort from the continued pressure of the impacted head. Rarely, after the head has safely passed the pelvic brim, the shoulders may furnish some obstruction.

If the pains are not effectual in advancing the head, and artificial assistance be not forthcoming, the muscular force may diminish. Weaker and infrequent contractions may cause labor to linger along until the patient suffers from extreme prostration; or the pains may be so severe as soon to develop a tonic uterus, with retraction and migration of the muscular fibres to the fundus and a thinning of the lower uterine segment. The end result of such a case may be spontaneous rupture of the uterus. Should the breech present in a patient with a justo-minor pelvis, the complication for the child is apt to be fatal; for while the body moulds easily into the pelvis, the descent of the head can be accomplished only by moulding, which is impossible in the short space of time that safety permits for the extraction of the after-coming head. There are cases on record in which the force necessary to deliver the head through a justo-minor pelvis has caused a diastasis of one or more of the pelvic joints.

The *masculine type of pelvis* is most often found in women with large muscular frames. The external measurements may be even justo-major. The bones are unusually thick. The peculiar deformity in this type of case is in the narrowing of the pubic arch. The pelvis may be shallow or deep. In the latter case it is best described as funnel-shaped. The true funnel pelves, however, are more extreme cases than those of the masculine type, and usually occur in connection with some spinal deformity, especially kyphosis.

The diagnosis is an easy one to be overlooked, because of the otherwise large development of the patient. Indeed, in many instances the case is allowed to go on until the obstruction during the second stage of labor calls attention to the deformity. It is upon the vaginal examination that the diagnosis must be based. The pelvic walls are felt to be drawing nearer together as the outlet is approached. At the outlet the approximation of the ischial spines and tuberosities to each other should be recognized, and also the sharper angle of the pubic arch.

In the masculine pelvis labor progresses normally, even to the time of the appearance of the caput in some cases. And then as the head encounters the bony obstruction all progress ceases, or very slowly and by increased expulsive effort the head is moulded past the outlet. The narrowed arch forces the head posteriorly, and, thus increasing the tension upon the perineum, causes a liability to extensive lacerations. These lacerations may involve not only the perineum, but sometimes run up on either side of the vulva, along the line of the pubic rami. Where they extend into the venous plexuses of the vestibule, hemorrhage may be very persistent. From the prolonged pressure various necroses of the vagina or the cervix, or a trauma to the bladder, may be caused.

The pelvic narrowing sometimes causes faulty flexion of the head. The occiput may be forced to rotate posteriorly. Sometimes rotation is so interfered with that the head is born obliquely or even transversely.

The treatment is usually by assistance with low forceps. If this is not sufficient, symphyseotomy may be of especial value in this deformity. But the fact that the prolonged pressure in the second stage may have injured the child beyond hope of recovery must be taken into consideration before any major surgical operation on the mother is undertaken.

The *simple flat pelvis* is a fairly common type of de-

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formity, and one which may have a serious effect on labor. It occurs usually in pelves with measurements otherwise normal. If this deformity be engrafted on a justo-minor pelvis, the consequences are most serious. The cause of this condition is not always plain. A slight degree of rachitis, the carrying of heavy burdens, excessive standing on the feet, prolonged illness in bed in early life may all have some effect. This flattening is most often met with in the lower classes and the foreign born.

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The deformity may be anything from a simple jutting forward of the promontory to a marked approximation of sacrum to symphysis, changing the cordiform outline of the brim to a shape more reniform. There is a compensatory slight widening of the pelvic brim transversely.

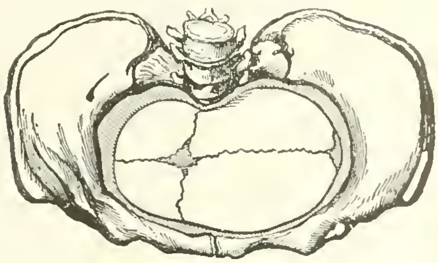

FIG. 3755.—Position Assumed by the Head in a Flat Pelvis. (After Simpson.)

Nothing about the general appearance of the individual in most cases would lead one to suspect the difficulty. The external conjugate in some cases shows no shortening. The internal measurement is therefore of greatest importance. The flattening, if of much significance, will allow the promontory to be easily reached by the examining finger. The extent of the deformity may be readily ascertained by the method suggested above.

If the narrowing be of slight extent, normal spontaneous delivery is possible, but there is a tendency to dry labors and a slight modification of the mechanism. The head engages transversely, poorly flexed, but slightly inclined laterally, so that the anterior parietal bone presents. Occupying the direction of least resistance the occiput slips to one side, thereby causing the bitemporal diameter to engage the conjugate rather than the biparietal. During the time of moulding the woman suffers severely from the pressure of the head against the sacrum.

As soon as the widest part of the head has passed the constriction advance may be rapid. Because of the poor flexion of the head rotation of the occiput to the front occurs late if at all. The head is often born obliquely, sometimes even transversely, or with the occiput still posterior. The shoulders and hips are apt to be born transversely. If much moulding has been necessary, the posterior parietal bone may show a grooving parallel with the coronal suture, caused by the pressure of the head against the promontory. The posterior parietal bone is overlapped by the anterior.

The effects of the flat pelvis upon labor may be only those mentioned above. If the child be small, attention may not be drawn to the deformity. The well-known tendency of women to have larger children in succeeding pregnancies, however, often brings the first manifestation of a flat pelvis in a later pregnancy in a woman who has already had several normal deliveries.

If the deformity be more serious the head engages, but cannot mould sufficiently to pass the brim. After a reasonable length of time artificial assistance must be employed. In the cases of greater flattening no engagement occurs and exhaustion soon supervenes from the futile efforts of the uterus at expulsion. The head rides high above the pelvic brim. The uterus tends to fall forward, causing a pendulous abdomen, which makes the efforts at engagement of the head still more ineffectual.

The flattening, preventing the fitting of the head in the pelvic basin, may cause malpresentations. The lack of adjustment between head and pelvic brim may cause a prolapse of the cord. In the earlier months of pregnancy the projecting promontory may force the uterus into retroflexion and ultimate incarceration in the hollow of the sacrum. Where the head cannot engage or descend into the pelvis the dilatation of the cervix is incomplete because the presenting part does not reach it to cause pressure against it. Instead of the usual meniscus-shaped bag of membranes a cylindrical-shaped bag forms which is ineffectual as a dilator and very prone to early rupture.

The flat pelvis may be the cause of a breech presentation, and when this condition occurs in a pelvis which by measurements other than the conjugate is shown to be ample, the breech labor seems to be the safest. The reason for this is that the after-coming head enters the pelvic canal, with the smallest part of the wedge first. The larger part adjusts itself to the most roomy part of the pelvis. The occiput slips toward one side of the pelvis, and in so doing causes the bitemporal diameter to engage the conjugate, instead of the biparietal, as is usual in vertex cases. The bitemporal diameter has the advantage of being at least 1 cm. smaller than the biparietal. The force which must now be applied from below, by traction on the child, will complete the necessary moulding in the safest possible way.

It is for this reason that the method of delivery by version and breech extraction is often considered and safely employed in a labor case with a flat pelvis.

A kind of pelvis which always shows flattening and yet is quite distinctive in type occurs in those women who have suffered from rachitis in infancy or childhood. The rachitic pelvis shows the effect of various pulling and pressure forces upon the different bones.

The extent of the deformity varies with the severity of the disease and depends somewhat upon the position occupied by the patient during the course of the disease, *i.e.*, whether lying in bed, sitting up, or walking about. One other factor is the arrested general development which occurs at that time.

The weight of the pelvic viscera combined with muscular traction tends to flatten the ilia and to prevent the inward curvature of the crests to the anterior superior spines. In this way the spines are thrown outward. In severe cases the ilia flare to the spines. The intercristal diameter is thus smaller than, or of the same width as, the interspinal. About two-thirds of the way to the posterior spines on the crests there is frequently a sharp angle where the crests turn in toward the spines.

The brim of the pelvis is diminished in the conjugate by the pressure of the weight of the trunk transmitted along the spine to the sacrum, and forcing it down and forward on its transverse diameter. The lower half of the sacrum tends to be thrown backward, but the tip is pulled forward in compensation, in sharp flexion, by the sacro-sciatic ligaments. The sacrum is further changed, so that its anterior surface instead of presenting a concavity from side to side is convex or flat. Sometimes there is a sharp bending backward of the lower part of the sacrum at the juncture of the first and second sacral vertebræ, causing the second vertebra to form a false promontory, which in estimating the internal conjugate must be accepted as the working promontory.

There is a widening of the pubic arch from muscular traction on the ischial tuberosities. If the patient be allowed to walk during the disease, there may be some constriction of the pelvis transversely by pressure over the acetabula. In general the size of the pelvis is restricted. The flattening is the worst feature. The pelvic brim presents a reniform outline, with a slightly increased transverse diameter. The pelvic cavity is usually ample and the outlet wide. The symphysis forms a wider angle with the plane of the sacrum. All degrees of deformity are met with.

The diagnosis of the extreme cases is easy. In slighter deformities the history of the patient is of some help—

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late walking, late dentition, unhygienic surroundings. There may be evident the square forehead, rickety chest, bowlegs, or any of the rachitic skeletal changes apart from the pelvis. Locally, there is found the changed ratio of the interspinal to the intercristal measurements; the easily felt promontory, with perhaps a false promontory at the junction of the first and second lumbar vertebræ; the sacrum convex from side to side; and the wide pubic arch.

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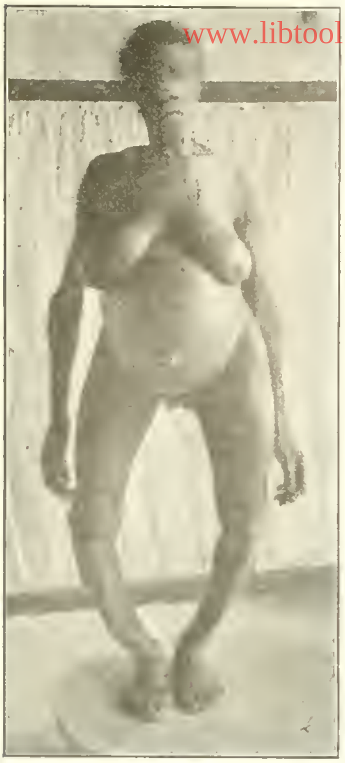

FIG. 3756.—Rachitic Negress Delivered by Cæsarean Section at the Sloane Maternity Hospital, New York City. (Service of Dr. Edwin B. Cragin.)

The effect of *rachitis* on labor depends on the extent of the deformity. Even in cases of slight deformity the effective working space of the bony passages is circumscribed. In lesser cases the mechanism may resemble that of a simple flat pelvis. In worse cases a spontaneous delivery or even engagement of the head is impossible.

Osteomalacia, or *malacosteon*, is a disease which causes a softening of the pelvic bones by the absorption of the lime salts. It develops during pregnancy or lactation; more usually the latter. The condition is rarely met with in this country. Nothing is known of its etiology other than that it is a disease of nutrition. The softening of the bones, however, is the occasion for an extreme collapse of the pelvic basin. The sacrum and the regions of the acetabula are crowded in so that the pelvic brim is triradiate in shape. This collapse leaves the symphysis projecting like a beak, giving the pelvis the name of the "rostrate pelvis." The pubic arch is much narrowed. Severe cases of rachitis show a similar deformity. For differentiation, in the cases of osteomalacia the ilia are curved like scoops and the crests are more sharply curved, while in rachitis the ilia flare and the spines are widely separated.

The history of cases of osteomalacia is characteristic. The trouble develops during the child-bearing period. There are dull aching pains in the extremities and lumbar region, with difficulty in walking and rotation of the body as one foot is advanced in front of the other. The stature is appreciably diminished during the course of the disease. There may be tenderness over the anterior pelvic wall. Examination reveals the beaked pelvis, the narrow pubic arch, and, if the finger can reach so high, the triradiate pelvic brim. Such a pelvis, unless in the earlier stages and quite soft, will not allow any form of conservative operative delivery *per vias naturales*. The Cæsarean operation with extirpation of the uterus furnishes the best solution of the difficulty.

Kyphosis developing in early life from caries of the vertebræ, possibly from rachitis, leaves its stamp upon the pelvis, producing the type known as the *kyphotic pelvis*. This was first described by Breisky in 1865. The difference in the direction of the pressure, transmitted through the spinal column on the sacrum, is dependent upon the location of the kyphos. The deformity is most marked when the kyphos is low down. In the upper dorsal region spinal deformity will affect but slightly pelvic development.

The characteristic kyphotic pelvis has a displacement of the upper end of the sacrum backward. This gives an unusually deep conjugate. The lower end of the sacrum is thrown forward. There is an approximation of the posterior superior spines and of the ischial tuberosities. There is a narrow pubic arch. The sacrum is long, narrow, and straight. This pelvis presents therefore the funnel type. The pelvic brim is deep and ample, but the outlet is much narrowed. Combined with kyphosis there is usually some scoliosis, causing some pelvic obliquity. Some of these individuals have smaller measurements in general, due to arrested development.

A kyphotic pelvis does not affect the course of the labor to the extent that would be anticipated from the examination and inspection of the patient. The successful outcome of labor in these dwarfed women is often a surprise to even the experienced.

There is always a pendulous abdomen with anteflexed uterus and a tendency to malpresentation, which is usually corrected by the onset of pains. Engagement of the head in the first stage may be delayed. As soon, however, as the head is engaged progress is normal until the outlet is reached. Here the bony obstruction may be such that prolonged moulding or assistance by forceps becomes necessary for the extraction of the head. The narrowing may prevent the forward rotation of an occiput posterior, or even cause an anterior position of the occiput to turn into a posterior. Four per cent. of cases are reported to present by the face. In this deformity the bi-ischiatic measurement is of importance in prognosis. If it is below 8.5 cm. there is probability of serious difficulty.

FIG. 3757.—Side View of Same Showing Pendulous Abdomen.

Oblique deformities of the pelvis of the extreme type are due to failure of growth of one of the sacral alæ. To this deformity the name of Naegele, who first described it, has been given. The oblique measurements vary widely. The short oblique is that of the normal side. The sacrum, which is narrowed, faces from the small side. The pubic arch is asymmetrical. The sacrum is narrowed. Vaginal examination shows the front of the sacrum and promontory facing toward the diseased side. The ischial tuberosity is higher on that side and the corresponding posterior superior spine is higher, lying closer to the sacrum. The subpubic angle is asymmetrical and looks toward the diseased side.

The failure in growth may be due to a congenital developmental defect or to disease. If it is due to a con-

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genital defect, the deformity is not evident until after walking has occurred. Pressure then causes the crowding up, in, and back of the innominate bone on the diseased side, and the rest of the asymmetry noted above. If it is due to disease of the sacro-iliac joint, tuberculosis, or some acute arthritis secondary to the general disease, must in early life have been sufficiently extensive to destroy the bony nuclei of the ala of the sacrum on that side. Ankylosis of that joint is the usual accompaniment of the deformity, but is not the absolute rule.

FIG. 3758.—High Dorsal Kyphosis. (Service of Dr. Edwin B. Cragin, Sloane Maternity Hospital.)

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The diagnosis is easily made by means of the pelvimeter and the vaginal examination. If disease be an etiological factor the presence of a scar or sinus over the affected iliac joint aids in the diagnosis.

The effect produced by this deformity upon labor in the less extreme cases may not be serious. But usually the distortion is so extreme that the natural delivery is impossible. The delivery, if possible, is accomplished by extreme flexion and moulding of the head, as in the generally contracted pelvis. Abnormalities of rotation and flexion are apt to occur in the lower pelvis.

The forceps may be tried, and if these fail craniotomy or the Cæsarean section may be performed. Symphyseotomy is contraindicated on account of the probable ankylosis of the sacro-iliac synchondrosis on the affected side.

Where both sacral alæ have failed of development that rare deformity, the *double obliquely contracted pelvis*, is found. In 1842 this type of pelvis was described by Robert, and has since been known as the Robert type. Very few cases of this type have been reported. From the same causes as in the Naegele pelvis, the sacral alæ are both absent or only partly developed. There results the extreme type of transversely contracted pelvis. The pelvic brim presents the outline of a long narrow ellipse. The conjugate is of normal or only slightly lessened size, the obliques are much shortened, and the transverse diameter excessively narrow. The sacrum is long, narrow, and oblong rather than triangular. Both sacro-iliac joints are usually ankylosed. The posterior superior spines are very close to each other. The pubic arch is narrowed. Unequal development, due to partial growth of one ala, may cause a slight degree of obliquity.

The effect of such extreme contraction must be complete obstruction to the passage of a viable child.

Another rare type of developmental deformity is that in which the pubic rami have not developed sufficiently to meet at the symphysis. This is called the *split pelvis*. It furnishes no obstruction to delivery.

The lesser degrees of obliquity, which rarely have much effect on the mechanism of labor, are due to scoliosis; to injuries or disease of hip, knee, or ankle-joint; to failure in development of one limb from some kind of paralysis, usually poliomyelitis; or to club-foot.

In cases of *scoliosis* extra pressure is transmitted through the lower acetabulum and there is consequent shortening of that oblique. Simple scoliosis is common, but it often accompanies rachitis or vertebral caries. If there is rachitis, there are the other rachitic effects on the pelvis and a greater obliquity. If scoliosis is combined with Pott's disease, there is merely slight obliquity added to the typical kyphotic pelvis. This is the so-called *kyphoscoliotic pelvis*. The slight obliquity caused by such simple scoliosis is of no significance, but the shortening of the spinal column may cause a pendulous abdomen, which will give trouble in the engagement of the head at term.

Any cause which acts so as to limit or do away with the use, in early life, of one of the lower extremities, reacts upon the pelvis by throwing greater pressure upon the well side. Tuberculous disease of the hip, knee, or ankle-joint is the most common disease affecting the lower extremities. Local deformity of the pelvis has been encountered from erosion of the acetabulum and displacement of the head of the femur through into the pelvic cavity. Ankylosis of one or both femora in adduction may cause an obstruction to delivery.

A congenital hip dislocation causes the pelvis to develop with one short oblique from pressure on the healthy side. An anterior displacement of the femur may drive in the anterior wall of the pelvis. The head of the femur may project over the ramus into the pelvic outlet. If both femora are dorsally displaced there is a shallow pelvis with wide outlet.

A rare deformity, but a most serious one from an obstetrical standpoint, is that known as *spondylolisthesis* of the lumbar vertebræ. It was described by Rokitansky in 1859, and later by Neugebauer. The bodies of the vertebræ are dislocated forward. There is some lumbosacral dislocation permitting a slipping of the body of the last lumbar vertebra in front of the sacrum. Here it becomes ankylosed. Then exaggerated lordosis occurs, and possibly there is a descent of the fourth and third lumbar vertebræ, so that they project over the pelvic brim. The sacrum is pushed down and back. In compensation the symphysis rises, lessening the inclination of the brim. There is narrowing of the brim, with antero-posterior limitation, which will prevent the passage of the head.

FIG. 3759.—Low Dorsal Kyphosis. (Service of Dr. Edwin B. Cragin, Sloane Maternity Hospital.)

This deformity may be started by disease, especially lumbar caries, or by injuries, or perhaps it may date from intra-uterine life. For diagnosis we must depend upon the history of the case—the

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story of injury from a fall or accident, or of spinal disease; perhaps the fact of carrying heavy weights.

There are extreme shortening and a pendulous abdomen. Examination shows the ribs lying close to the ilia. The shoulders are carried well back, as the patient stands in lordosis. There may be lumbar crepitus, felt while walking. The vulva, owing to the change in pelvic inclination, presents anteriorly as the patient is standing or sitting. By vaginal examination the bodies of the projecting vertebræ may be easily felt and the contracted outlet also noted. The limitation at the pelvic brim precludes any possibility of a normal fœtal head engaging.

Tumors of the pelvis may be of large size and may almost obliterate the pelvic cavity, or they may be merely bony excrescences springing from the region of the pelvic brim. They may grow from the inner surface of the symphysis, from the sacro-iliac joints, or from the ileo-pectineal line. If sharp they form what is known as the pelvis spinosa. The projecting bits of bone may cause dangerous circumscribed pressure on the child's head. The larger tumors may be enchondromata, sarcomata, or carcinomata. They necessitate embryotomy or Cæsarean section. Fractures of the pelvis rarely may cause deformity from the growth of callus.

Ankylosis of the sacro-coccygeal joint, which normally occurs after the menopause, may happen prematurely and furnish some resistance to the passage of the child's head. The uterine contractions are usually of sufficient force to fracture the bone. Sometimes the head is held by this deformity until the bone is artificially fractured or the forceps is applied. With the fracture a snap is sometimes plainly heard and the head thereafter advances readily. The fracture of the bone should be accomplished under chloroform, the thumb and forefinger of the accoucheur grasping the coccyx.

FIG. 3760.—Lumbar Kyphosis. (Service of Dr. Edwin B. Cragin, Sloane Maternity Hospital.)

The consideration of pelvic deformities is incomplete without a word concerning *prophylaxis*. The possibility of the results of rachitis upon the pelvis should make the mother careful about the feeding of the infant, its general hygiene, and especially about its allowance of fresh air. Early attempts at walking should be forbidden, especially if the infant is heavy. The effect of disease or deformity of the skeleton of the female child upon the pelvis is an argument for early consultation with the orthopedic surgeon and the early correction, if possible, of existing deformities.

When the deformity exists in the child-bearing woman the obstetrician must be able to recognize the deformity, and by trained judgment determine its probable effect on labor. The question may arise whether the patient is warranted in entertaining the hope of having children at all, or, if she be in earlier pregnancy, whether the deformity calls for an induction of premature labor. Should the patient be in labor, other conditions must be taken into account. These are: the extent of obstruction presented by the soft parts, the relative size of the child's head and its capacity for moulding, the force of the labor pains, and lastly, the ability of both mother and child to withstand the strain of delivery. The history of previous labors is of value, but it must be remembered that the size of the child tends to increase up to the fifth or sixth pregnancy.

FIG. 3761.—Kyphosis so Extreme as to Necessitate Cæsarean Section. (Service of Dr. Edwin B. Cragin, Sloane Maternity Hospital.)

If the child is small or premature, slight pelvic deformity may have no significance; and yet with a child above normal size this defect may constitute a serious obstruction. Such cases of overgrowth of the child are occasionally met with, and are the result of a large father, overnutrition of the fœtus from the mother, and sometimes of the prolongation of pregnancy one or more weeks beyond normal.

Those cases of slight obstruction, in which delay occurs in the second stage, justify a waiting policy. Nature with time will accomplish sufficient moulding in a safer way than if forceps were used. Good judgment requires that one know how long it is safe to allow this moulding to continue. Too long compression of the head gives danger of intracranial hemorrhage. Too long-continued pains expose the mother to exhaustion and shock, and ultimately to a tonic uterus with possible rupture, or an exhausted uterus with resulting post-partum hemorrhages. On the other hand, early interference before the head has had time to mould will expose both mother and child to needless trauma. Account must be taken of the force and frequency of the pains; the maternal pulse, and evident amount of suffering caused by the pains; the rate and force of the fœtal heart; and the amount of moulding, as shown by the caput and overlapping suture, and by the advance of the child's head.

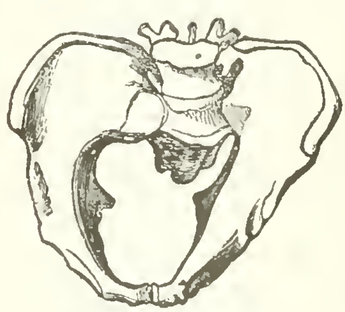

FIG. 3762.—Obliquely Contracted Pelvis. (After Duncan.)

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In some cases the severity of the pains or the poor condition of mother or child may necessitate operative delivery before the patient has been in the second stage an hour. In other cases in which the uterine contractions have been of poor quality some good may be accomplished by a delay of several hours. Uterine action may be stimulated meanwhile by tonics, such as strychnine or quinine. The erect posture increases the force of the pains. In cases with a flat pelvis some increase in the conjugate, from 0.5 to 1 cm., may be accomplished by the Walcher position. The patient lies in the dorsal position with the thighs extended over the end of the table, and the feet barely touching the floor. If there is some advance of the head, pressure on the fundus, during the pains, may be tried.

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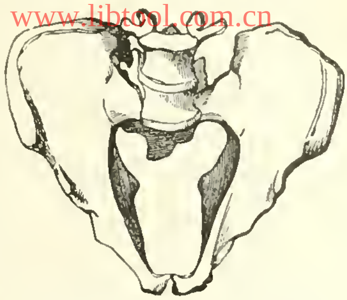

FIG. 3763.—Robert's or Double-Obliquely Contracted Pelvis. (After Duncan.)

For the more extreme degrees of dystocia, due to deformity, there may be used the forceps, podalic version, usually combined with breech extraction, the induction of premature labor, symphyseotomy with forceps, the Cæsarean section, craniotomy, or, in the cases of extreme contraction, craniotomy with evisceration.

The low forceps operation for deformities of the pelvis is usually necessary in those cases of limitation of the pelvic outlet, as in the kyphotic cases or those of the masculine type. In the worst kyphotic cases symphyseotomy may be necessary. The medium forceps operation is more common in the generally contracted pelvis. For the flat and generally contracted pelves high forceps may be needed. In justo-minor pelves, the only possibility of safe delivery by the natural route lies in extreme moulding of a well-flexed vertex.

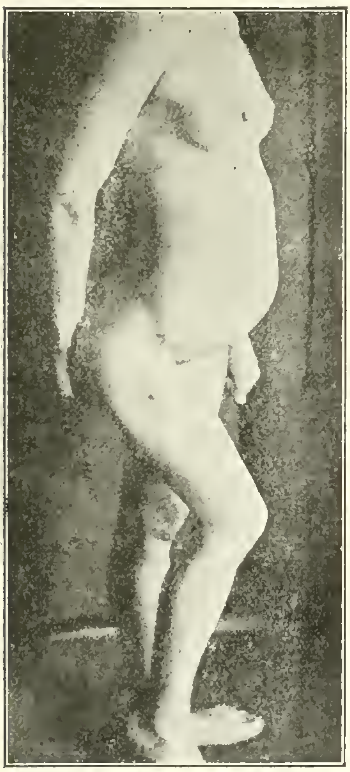

FIG. 3765.—Obliquely Contracted Pelvis, Following Coxitis. (Service of Dr. Edwin B. Cragin, Sloane Maternity Hospital.)

In the flat pelvis the indication for high forceps is not always so plain. The head in these cases coming down in the transverse diameter must often be grasped by the forceps with one blade applied to the occiput and one blade to the face. The effect of traction then is partly to mould the head so that the biparietal diameter tends to widen. As has been described above, the after-coming head in a breech extraction accommodates itself in such a way that the bitemporal diameter engages the narrowed conjugate. For this reason version and breech extraction are frequently resorted to, in cases of flattening, with good result.

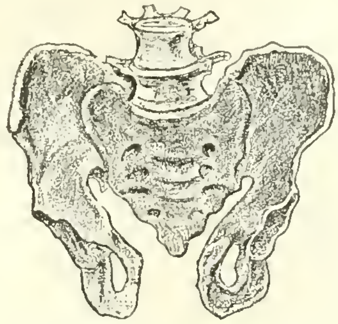

FIG. 3764.—Pelvis in which the Pubic Rami Fail to Meet at the Symphysis. (Schauta.)

If the head, in case of a flat pelvis, is engaging well, forceps may be tried gently. If the head persists in not engaging, version is preferable provided there is a reasonable possibility of bringing the head through. If in the case with the head engaged the forceps fail to accomplish advance, the head may be disengaged and version tried. It must be remembered that the version is of value only in the simple flat pelvis which is ample in other measurements. In a flat justo-minor pelvis version is worse than useless.

Where the conjugate is quite short, the head may be prevented by the deformity from descending far enough to dilate the cervix. In such a case, before any operative delivery is attempted, the cervix should be carried to full dilatation by means of the hydraulic bags or by digital stretching.

FIG. 3766.—Simple Scoliosis. Patient delivered by low forceps. (Service of Dr. Edwin B. Cragin, Sloane Maternity Hospital.)

The *induction of premature labor* in selected cases is

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Pelvic Cellulitis.

an operation which has a most important field of usefulness. If the pelvis is small and the head seems to be riding high, or if a woman habitually has larger children than can safely be born, it is proper carefully to watch the patient during the last two months of gestation and to terminate pregnancy at any time when the child's head seems, relatively to the pelvis, a close fit. Once a week the patient should be examined, and by the bimanual method the ratio between the size of the head and the diameter of the pelvis carefully estimated. There will be a certain proportion of disappointments, but what might be otherwise fatal dystocia will be avoided, and in many cases a healthy child secured.

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FIG. 3767.—Spondylolisthesis. (Neugebauer.)

As a rule any child of over eight months' gestation will do well with proper care, and sometimes one even younger will thrive. The success depends on the judgment of the physician, who should allow to the infant every week of intra-uterine life that is possible. An error either way is bad. If the operation is delayed too long, the premature infant will resist very poorly the manipulation necessary for an operative delivery. If labor is induced too early, the child is robbed of just so much vitality.

The operation of *symphyseotomy* has lost favor in the last few years because of the risk of infecting the mother, or of leaving her permanently crippled from failure of union of the symphysis, and because of its uncertain results as compared with the good results of a properly performed Cæsarean section. It must be restricted to cases in which the possible separation of the pubic bones of 7.5 cm. will enlarge the pelvic canal sufficiently to allow the head to pass. It is of no value in those cases in which the sacro-iliac synchondroses are ankylosed. The tedious convalescence of the mother is a serious matter.

FIG. 3768.—Enchondroma of the Sacrum of such a size as to Diminish very greatly the Capacity of the Pelvic Cavity. (Behm.)

Compared with the Cæsarean section, it is the more dangerous, more uncertain of the two, and of greatly restricted range of application.

The *Cæsarean section* must be employed in those cases in which there is no other possible method of delivery of the child living or dead (the absolute indication), or it may be employed (the relative indication) in cases in which delivery of a living child is possible only by laparotomy. The indication has been extended, by some, even to those cases in which delivery of a living child is improbable except by laparotomy.

This operation in properly experienced hands seems to promise great usefulness. Every year the indications for this operation are enlarged. Whereas a few years ago, on account of the great mortality of the Cæsarean section, only the absolute indication for the operation was considered valid, now, granted good surgical facilities, the question of a conservative laparotomy in the interest of both mother and child may be decided in the affirmative in cases of obstructed labor. If the deformity is so great that a successful induction of premature labor in a later pregnancy is improbable, the uterus should be removed at the time of operation.

The mutilating operation on the child, commonly known as *craniotomy*, is indicated where the obstruction is absolute and the child dead, or where the condition of the mother, or the lack of facilities for operating, prohibits surgical interference. The crushing followed by traction on the head is usually sufficient to effect delivery without much additional shock. Rarely, if the child is of large size, evisceration or further mutilation of the child must be resorted to. *Franklin A. Dorman.*

PELVIC CELLULITIS.—DEFINITION.—Pelvic cellulitis is an inflammation of the pelvic cellular tissue which may or may not go on to abscess formation. The same condition is also described sometimes as parametritis, perimetritis, pelvic abscess, etc.

ANATOMY.—Before describing pelvic cellulitis, a few words as to the anatomy of the pelvis will be necessary. Rosthorn defines the functions of the pelvic cellular tissue as follows: 1. It serves as a material to fill in empty spaces between the organs. 2. It serves to connect the peritoneum to the underlying organs. 3. It serves as a sheath for the blood and lymphatic vessels. 4. It serves as ligaments, holding the various organs one to the other and to the surrounding bony structures. We can see, therefore, that the connective tissue is freely distributed through the pelvis and forms the loose framework in which lie the organs. The denseness of this tissue varies according to its function and position. In places there is a distinct thickening, forming, if we may call it so, a species of curtain, which divides one portion of the pelvis from another and tends to localize infection to one part of the pelvis, though when an abscess forms it may be easily imagined as breaking through the septa. These septa or curtains are difficult to demonstrate by dissection, and the most striking way of showing their relations is by the injection of material which will harden *in situ*. By this method three main regions are found to occupy each side of the pelvis. (1) The anterior region comprises the cellular tissue around the bladder and that lying anterior to the cervix, there being a connection between these regions on the two sides through the cellular tissue binding the posterior surfaces of the bladder to the anterior portion of the cervix and uterus. (2) The next region is bounded anteriorly by the above-described partition, posteriorly by a second curtain which extends from the uterus outward along the infundibulo-pelvic ligament, giving to this area a rough triangular shape with the base directed toward the pelvic wall and the apex toward the uterus, and including practically all of the connective tissue lying in the fold of the broad ligament and continuous with the cellular tissue filling the iliac fossa. (3) The third, or posterior area, surrounds the rectum and is continuous with the cellular tissue of the retroperitoneal area.

Besides these three main divisions, anatomists describe several less well-marked areas where an infection may be localized.

ETIOLOGY.—Infection of the cellular tissue is always due to the attack of one of the pathogenic bacteria, and, according to whether the bacteria gain entrance directly to the cellular tissue through a wound or by lymphatic infection, or whether the infection follows by direct ex-

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tension from inflammation of the tube or other pelvic structures, we divide the cellulitis into the primary and the secondary forms.

In the primary forms the cellular tissue is invaded directly by the disease-producing bacteria, generally through a tear or wound in the cervix or uterus, or by direct lymphatic extension.

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In the secondary form the seat of infection primarily is the tube, ovary, bladder wall, or rectum, the cellular tissue being invaded by contiguity. The primary cellulitis is the rarer of the two, and for some years its possible occurrence was denied.

Wounds of the cervix are not frequent in any condition save that of childbirth, and this is by far the most frequent etiological factor in primary cellulitis, the bacteria being introduced by the unclean finger and advancing directly into the tissues. In an occasional case the infection also results from a wound of the cervix from careless dilatation, or from the use of the uterine sound or other instrument in such a manner as to cause a puncture through the vaginal wall of the cervix or the uterine wall.

Secondary cellulitis of some part of the pelvic tissue accompanies almost every case of distinct inflammation in any of the pelvic organs. Most frequently the condition follows salpingitis or pyosalpinx, the tube being the most frequent site of inflammation in the female pelvis.

Morbid Anatomy.—The pathological picture presented in this disease varies according to the type and the degree of virulence of the infecting organism. Most of the cases of primary cellulitis are due to invasion of the tissue by the streptococcus, and naturally the picture of a virulent infection is given. If the tissues be examined early enough all that will be noticed is a brawny infiltration of the loose tissue, which on minute examination is found to be due to a rapid proliferation of round cells and to the effusion into the tissues of serum and leucocytes. Later, we find distinct small abscesses scattered through the tissues, the size of the abscesses varying from the point to the head of a pin. Still later, if the infection continues and the patient lives, we find that the numerous small abscesses have become conglomerate, and that a distinct abscess has been formed. Not infrequently, however, an abscess does not form, but, instead, the tissues appear to gain a certain amount of resistance against further breaking down, and in place of the conglomerate abscess a slow absorption of the minute abscesses present and a gradual healing take place. In the secondary infections we are less apt to find abscess formation, especially if the infection is due to a not extremely virulent species of microorganism (the gonococcus, for example). Naturally, when the tubal or ovarian disease is due to infection by the more virulent organisms, we find more frequent abscess formation, generally in the folds of the broad ligament. As already stated, in the primary forms the streptococcus, either alone or in company with one or more of the other organisms, is the cause of infection. In the secondary cellulitis the gonococcus, the staphylococcus pyogenes albus and aureus, the typhoid bacillus (rarely), the proteus and certain other rarer forms, have been isolated from the tube or ovary and evidently would be found in the focus of secondary infection.

Symptomatology.—*Primary Cellulitis.*—In this form the symptoms are usually quite well marked. Generally three or four days after a labor in which careful asepsis has not been observed, or in which there has been much handling, the patient will have a distinct chill, the temperature rising to 102° or 103° F. She will complain of general malaise, violent headache, possibly nausea, and of acute pain in the lower abdomen, generally located in one side or the other. On examining such a patient the lower abdomen will be found somewhat full, and palpation will be impossible from the amount of muscular spasm present. In making a vaginal examination a sense of resistance will be found at the base of one of the broad ligaments, the uterus will also be found to be somewhat more mobile than it should be, and the patient will complain of extreme pain when we attempt to move the uterus or make pressure upon the lateral fornices. After a day or two a distinct induration will be felt through the vagina, and on bimanual palpation a moderately-sized mass will be felt lying in the broad ligament. In some cases this indurated mass can be easily felt above Poupart's ligament as a dense hard tumor.

Secondary Cellulitis.—The symptoms of this form are commonly masked by the primary disease, and it is practically always the primary disease that we are called upon to treat, for, unless an abscess of the cellular tissue be present, the curing or the removal of the primary point of infection will be followed by a slow amelioration or disappearance of the cellular inflammation.

Diagnosis.—The diagnosis of the primary form is based partly on a study of the symptoms, but chiefly on the results of the abdominal, the vaginal, and the bimanual examinations. For if we find on abdominal examination an indurated mass extending up along the anterior abdominal wall; if on vaginal examination the lateral fornix of the same side is found to be hard, dense, and brawny, or possibly depressed toward the outlet; and if on bimanual examination we can outline a distinct mass between our hands, separate from the uterus or enclosing the uterus in its outlines, we may feel reasonably sure that whatever else is present we have an inflammation and probably an abscess in the pelvic cellular tissue.

The diagnosis of the secondary form is not of so much importance if the diagnosis of the primary focus be made, as we may be sure that with pyosalpinx, ovarian abscess, or any collection of pus in the peritoneum, there will be more or less involvement of the contiguous cellular tissue.

Treatment.—*Primary Cellulitis.*—In this affection we must be governed by the inflexible surgical rule that, if pus be present, it must be evacuated by the shortest available route, and it only remains for us to decide which would be the shortest route for its evacuation. In many cases it is difficult to be absolutely certain as to whether pus is present or whether the tissues are merely densely infiltrated, and fortunately this need not greatly bother us, as the best results are gotten by breaking down and draining such an exudation. Hence in every case of primary cellulitis, whether the exudation has broken down and pus has formed, or whether merely a dense indurated mass is present, the indication is clearly to provide effective drainage.

There are two paths by which we may get at such a mass and drain it: first, through a vaginal incision; second, through an abdominal incision. The best drainage is undoubtedly gotten through the vagina, as it is the most dependent part, and this avenue of attack is selected in those cases in which the abscess or the indurated mass is distinctly palpable through the vaginal vault, or in which the abscess is distinctly pointing in this direction. The abdominal route is selected in the cases in which it may be difficult or dangerous to make the vaginal puncture, or when the mass is distinctly pointing above Poupart's ligament. To make the vaginal puncture the patient, after being anæsthetized and after the vagina and surrounding parts have been made surgically clean, is brought to the edge of the table with the buttocks protruding slightly over it and the thighs flexed on the abdomen, where they are held by an assistant or by one of the many leg-holders. A final careful examination is then made to outline again the pelvic mass. A Simon's speculum is introduced into the vagina, the posterior lip of the cervix is grasped with the tenaculum, and the posterior vaginal fornix put on the stretch. Then with the knife or scissors a little incision is made in the vaginal vault through the vaginal mucous membrane just back of the cervix. The speculum then having been withdrawn, the forefinger of the left hand should be introduced into the rectum, and the thumb of the same hand into the vagina, the tip of the thumb resting against the incision made in the vaginal vault. Then a sharp-pointed pair of scissors should be carried into the vagina, and under the guidance of the thumb the pointed end of the closed scissors should be placed in the small incision in the vault and at the proper moment plunged boldly into the pelvic mass. The presence of the forefinger in the rectum serves not only to indicate

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the exact position of this organ, but also to guard it against possible damage. If an abscess be punctured by this manœuvre, there will be a gush of pus into the vagina and the scissors can be withdrawn. Then the opening into the abscess may be widened by careful cutting or by tearing with a pair of Goodell dilators, and after this the cavity should be explored with the finger to estimate its size and position, and to make sure that no more unopened abscesses remain behind. If no pus follows the puncture by the scissors this instrument is to be withdrawn and the finger is to be carried into the track of the puncture. By this manœuvre one may oftentimes succeed in finding an abscess which was not opened by the scissors. If no abscess be present the brawny indurated tissues are broken down with the finger so that a moderately large cavity remains where the indurated mass was before. The opening into this cavity must also be widely dilated so as to prevent undue narrowing before complete healing has taken place. Then either the abscess or the artificially made hole in the indurated tissues is to be firmly packed with iodoform or subiodide of bismuth gauze, and this gauze is allowed to remain in place for some days unless untoward symptoms appear. After the lapse of five or six days the gauze is slowly removed, a little bit being taken out each day until the whole shall have been removed. In some cases it may be necessary after this to pack again.

If the path through the abdomen is chosen, the abscess or the mass of indurated tissue must be reached and drained in precisely the same manner as would be adopted in the case of any other collection of pus in the abdominal cavity. The incision is generally made parallel to and just above Poupart's ligament, care being taken to avoid the deep epigastric artery which runs directly under the incision. When the abscess is reached the pus escapes through the opening thus established. Then either a glass or a rubber drainage tube should be carried down to the bottom and gauze packed around it. On the other hand, if simply a mass of indurated tissues is found, then this is to be broken down in the same way as through the vaginal incision.

In some cases it is desirable to combine the two methods of procedure; that is to say, we may establish drainage both through the vagina and through the abdomen. Such double drainage is usually followed by a more rapid healing of the abscess cavity, but it leaves an unsightly scar on the abdominal wall, and the sinus will sometimes remain open for some months before final healing takes place.

The treatment of the *secondary cellulitis* resolves itself into the treatment of the associated primary condition, and needs no special notice.

Prognosis.—The prognosis of pelvic cellulitis will necessarily vary according to the virulence of the infecting organism. In any event, however, the prognosis, in a case of the primary form, must always be very guarded, as the patient may linger along for weeks and finally die of exhaustion even though the abscess has been thoroughly opened and apparently good drainage obtained. At the same time, if the patient survives the formation of an abscess, we may rightly expect that the free incision and the establishment of drainage, in combination with careful general treatment, will be followed by a final recovery.

Otto G. Ramsay.

PELVIC PERITONITIS.—Definition.—Pelvic peritonitis is an inflammation of the visceral or parietal pelvic peritoneum, and either remains confined to this portion or extends upward into the general peritoneal cavity. Pelvic peritonitis should not properly be described as a separate and distinct disease, for it is due to the same causes as those which excite an inflammation of the general peritoneal cavity, and the effects which are produced are also essentially the same. Because, however, of the situation and peculiar anatomical relations, inflammation here is much more commonly localized than is inflammation in other parts of the peritoneum, and for this reason we are justified in describing it separately.

Synonyms.—(Pelveo-peritonitis; parametritis; perisalpingitis, etc.)

Varieties.—There are three varieties of pelvic peritonitis, viz., (1) acute or fresh pelvic peritonitis, (2) chronic exudative peritonitis, and (3) chronic adhesive peritonitis. Except in those cases in which there is tuberculous disease, we rarely see the chronic form except as the outcome of a preceding acute inflammation. The converse is not necessarily true, viz., that the acute form of inflammation is always followed by chronic manifestations; at the same time it is not common to have an acute pelvic peritonitis clear up entirely without leaving some few slight adhesions, or a certain amount of roughening and thickening of the pelvic peritoneum.

Etiology.—Acute pelvic peritonitis is always the result of bacterial infection, and practically always secondary to some acute inflammation elsewhere, as in the tube, the ovary, the uterus, the bladder, or the rectum; or possibly it may develop from an appendicitis.

The most frequent causative micro-organism is undoubtedly the gonococcus, which, so far as danger to life is concerned, may rightly be considered the least malignant. The streptococcus pyogenes is another organism which causes pelvic peritonitis. Owing to its greater malignancy, however, this micro-organism gives rise to an inflammation which rarely remains localized in the lesser cavity, but extends upward to the general peritoneum. Pelvic peritonitis has also sometimes been due to the presence of the staphylococci, of the colon bacilli, or of some of the micro-organisms which in exceptional cases play a part in exciting tubal inflammation. As other possible sources of infection may be mentioned an ovarian abscess, or a focus of infection located in the cellular tissue or in the network of lymphatic vessels.

Morbid Anatomy.—The reaction of the pelvic peritoneum to irritation is exactly the same as that which takes place in any serous membrane. The only features to which, in the limited amount of space at my command, I need to call attention, are the following: There is a decided tendency, in an inflammation of this character, to the throwing out of plastic lymph upon the free peritoneal surface, and, at the points where this occurs, adhesion between the contiguous parts is almost sure to follow. In a few cases, however, the exuded lymph may undergo absorption, and the affected serous surfaces may eventually return to a normal state. In the majority of instances the pelvic peritonitis, after the subsidence of the more acute manifestations, assumes the characteristics of either a chronic exudative or a chronic adhesive peritonitis. The chronic exudative form is characterized by the exudation of serous fluid, which, as a rule, is found in a sort of cul-de-sac that is walled off from the general cavity by a roof of adherent intestines. This sac, in the early stages, contains a clear serous fluid, but sooner or later this fluid becomes purulent in character, by reason of the wandering in of leucocytes. In the chronic adhesive form, instead of a serous exudation, there is thrown out, as already stated, a more plastic lymph which glues together all the pelvic structures. This is the form of the disease which is most frequently observed and in which the adhesions may be so numerous that the tube, ovaries, and uterus are bound together in one indistinguishable mass.

Symptoms.—Acute peritonitis gives rise to well-marked symptoms. The patient complains of acute pain localized in the lower abdomen, and with the pain there is a distinct rigidity of the lower portion of the abdomen and probably some abdominal distention. The temperature is found elevated, sometimes reaching 103° or 104° F.; the pulse is rapid; and there may be nausea with vomiting. On examining such a patient we are almost sure to find that acute tenderness is present over the lower abdominal zone; and a vaginal examination, although it may fail to reveal anything very distinctive, is sure to cause acute pain when pressure is made on the fornices, or when any attempt is made to move the uterus. The patient, it will also be noticed, lies perfectly quiet on her back with the legs drawn up, as any move-

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Pelvic Peritonitis.

ment causes greatly increased pain. Generally, after the lapse of three to four days, the symptoms decrease in severity, the abdominal distention and muscle spasm disappear, and the temperature falls. In those cases in which the disease assumes a chronic character it is astonishing to note in how many instances the severity of the symptoms is out of all proportion to the small extent and slight degree of chronic inflammation present. These patients, as a rule, complain of much menstrual distress; backache is very common, and pain is often complained of in one or the other ovarian region. These patients are also apt to complain of headache or of some form of nervous, gastric, or intestinal disorder.

The chronic exudative form of peritonitis is characterized by the presence of an exudate, and with this may be associated the symptoms of a pelvic abscess. In cases of the latter nature acute local pain is present in the earlier stages; there are also decided abdominal tenderness, rapid pulse, and fever, and yet it is to be noted that, in the later stages, fever is not necessarily present. We find on local examination a fluctuating mass which pushes the uterus forward and which is very tender on pressure. It will also be observed that the more dense and indurated the walls of this mass are, the more apt are we to find a collection of pus rather than one of serum.

Diagnosis.—The diagnosis of an acute pelvic peritonitis is not difficult, and is based on the acute pain, the spasm of the muscles, the rise of temperature, and the local findings. In the chronic form which is characterized by adhesive inflammation, the diagnosis rests on the lessened mobility of the organs, on their abnormal positions, and on the fact that we can actually feel the presence of more or less distinct bands of adhesions.

In the chronic form which is characterized by the presence of an exudation, the differential diagnosis may have to be made between it and a pelvic hæmatocele. This, however, is usually an easy matter, as the histories of the two affections are very different, and besides, on examination, we can satisfy ourselves, in the case of the hæmatocele, that we are handling a solid tumor, which often, under the pressure of the finger, yields a crackling sensation, owing to the breaking down of the clot.

Treatment.—In the treatment of acute pelvic peritonitis two very important objects should be kept in view: First, that life may be saved; and second, that the local changes resulting from the disease may be diminished as much as possible both as regards their extent and as regards the seriousness of their character. The therapeutic measures to be adopted must vary according to the nature of the infection. Inasmuch as most of the cases of acute pelvic peritonitis are gonorrhœal in origin, this fact will be one of the first to be thought of when the questions of etiology and prognosis are taken up for consideration. In these cases, as a rule, life is not in extreme danger, because the tendency of gonorrhœal peritonitis is to remain localized in the pelvic cavity.

A patient who is suffering with an attack of this character should be put to bed and advised to remain as quietly as possible on her back. The object of this advice is to prevent any sudden movement which might cause a breaking down of adhesions between the end of the tube and the surrounding structures, and so prevent the outflow of bacteria-containing secretion from the freshly opened end. The inflammation is also to be combated by the free use of salines such as Rochelle salts, or by frequently repeated doses of Carlsbad salts. The pain may be relieved by the use of hot moist applications, or, if the attack is seen in the very early stage, cold applications may give more relief, and may possibly abort the attack. Opiates are dangerous remedies, and are not to be used unless the pain becomes extreme, in which case good results may be obtained by the use of suppositories containing extract of opium and extract of belladonna. Hot vaginal douches are also of value, if they can be given without causing the patient great discomfort. The patient should be put upon an extremely light bland diet, and she should also be allowed the free use of liquids. Such a patient should be kept quietly in bed for at least a week after all acute symptoms have disappeared. This precaution will be found to be a great help in preventing a recurrence of inflammation.

Operative interference, during an acute attack, is indicated only when the symptoms are somewhat urgent. The abdominal cavity should then be opened from above, in the usual manner, and free drainage established, or an opening may be made into the cul-de-sac from below, by way of the vagina.

In chronic exudative pelvic peritonitis, the exudate lies in the cul-de-sac, and can be most easily reached through the posterior vaginal fornix, as it generally points most distinctly in this locality. Before the operation is begun, the vulval area and the vagina should be thoroughly scrubbed and disinfected. The patient's legs being flexed on the abdomen and held in this position by a leg-holder or by assistants, the surgeon should introduce the forefinger of the left hand into the rectum, and the thumb into the vagina, the tip of the latter being kept pressed against the fluctuating swelling in the cul-de-sac. Then the pointed end of a closed pair of sharp-pointed scissors should be plunged into the mass under the guidance of the thumb, the forefinger in the rectum acting both as a guide and as a means of preventing puncture of the rectum. The insertion of the sharp-pointed instrument into the cavity is followed by a gush of clear or purulent fluid. The blades of the scissors are separated and withdrawn from the cavity, and the opening thus established should then be made still larger by stretching and tearing its sides with the Goodell dilator. Finally, the cavity should be washed out and packed with gauze, and the latter should be allowed to remain in for five or six days or even longer unless there be symptoms indicating that it should be removed sooner.

In the treatment of chronic adhesive peritonitis the use of frequent hot douches, in conjunction with the application of the tincture of iodine to the fornices, and with the introduction of cotton or lambs' wool tampons soaked in glycerin, often proves very helpful. Besides these local measures pelvic massage, regular exercise, and a general tonic treatment will sometimes be followed by an apparent cure, though such patients are very apt to have a recurrence of the disease after any imprudence.

The question whether an operation should be advised, or whether better results may not be obtained from the employment of the palliative methods of treatment, is always difficult to answer; the proper answer will depend on circumstances. In the first place, it must be remembered that the operation is always attended with a certain amount of danger, and that this danger must be incurred not for the saving of life, but simply for the relief of symptoms. On the other hand, if the patient has to work for her living, the surgeon cannot rightly refuse to place her under the best possible conditions for successful work. For this reason he is scarcely justified in advising a patient whose family is dependent on her exertions for their support, to undergo the long-continued applications, etc., which are required under the palliative method of treatment. On the other hand, in the case of a woman who can command everything necessary, palliative measures may be followed by splendid results.

On the whole, the results of operations in the pelvic cavity have thus far been very satisfactory.

Prognosis.—The prognosis of acute pelvic peritonitis, so far as life is concerned, is generally good, but caution should always be observed in promising a complete return to normal health.

In the chronic exudative pelvic peritonitis, the prognosis, after the cavity has been opened and drained, is fairly good. In most cases the patient will regain health, and, if the tubes have not been completely destroyed, she may in course of time bear children. In the adhesive form a complete cure must not often be looked for as the result of simple palliative treatment; and even when an operation is resorted to, the degree of completeness of the cure will depend on the condition of the pelvic structures.

Oliver G. Ramsay.

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PELVIS.—(Latin, derived from the Greek πέλυς, a basin, the same root as Eng., pail; Fr., *bassin*; Ger., *Becken*; It., *bacino*. The appropriateness of the appellation will be evident on placing a human pelvis on a table in a horizontal position, when it will be seen to resemble a somewhat deep wash basin, with the rim broken away in front and behind. In a restricted sense, the bony and ligamentous skeleton of that portion of the trunk to which are attached the abdominal limbs. Topographically the term is used to designate the whole region for which the bony pelvis serves as a framework, comprising, in this sense, the whole of the pudendal, perineal, sacral, subinguinal, coxal, trochanteric, and gluteal regions, and a part of the pubic and inguinal regions.

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The importance of the skeletal framework is great and twofold. First, because it is through it that the weight of the body is supported, and from it that arise the powerful muscles that move the posterior limbs; second, because it forms a bony canal which contains an important portion of the genito-urinary apparatus, and through which the matured fœtus must pass to reach the outer world. The first of these considerations is architectural, the second obstetrical, while both have important surgical bearings.

Boundaries.—This portion of the trunk is defined on the surface of the body by certain landmarks and furrows. Above, there may be noted, in well-nourished individuals, crossing the median line in front, a shallow depression, concave upward, separating the pubic eminence (mons pubis, mons veneris) from the general superficies of the abdomen. This may be called the pubic furrow and extends from groin to groin. From either end of this the shallow but well-marked inguinal furrow (sulcus or plica inguinalis) may be followed upward and outward to the anterior superior iliac spine. The crest of the ilium may then be easily traced along the flank backward as far as the depression which marks the posterior superior iliac spine. From this a line should be drawn to the spinous process of the fifth lumbar vertebra, which for topographical purposes is usually included in the pelvic region, and is characterized by a well-marked depression. This boundary, drawn on each side, will mark the limits of the pelvis above.

Below, it is best defined behind by the well-marked gluteal fold (sulcus gluteus) that indicates the lower border of the nates or rump. An arbitrary line drawn horizontally outward from the outer end of this fold, around the thigh to the inguinal furrow, will roughly include somewhat more than may properly belong to the pelvis, as it takes in the upper part of the femur with the great trochanter, usually regarded as belonging to the crural region.

Surface Markings.—Within the area thus delimited there is in front the pubic eminence, covered with hair in the adult and resting upon the pubic bone. It is more prominent in the female. On either side of this the inguinal furrow follows the course of Poupart's ligament from the anterior superior spine of the ilium to the spine of the pubis. It is maintained by fibres passing from this ligament to the skin, resembling in this respect the axillary fossa. Shallow and broad when the subject is standing erect, it is deep when the thigh is flexed. Above, it is continuous with the iliac furrow; below, it ends in the genito-femoral furrow. In females and well-nourished persons a second furrow is usually seen, corresponding more nearly to the flexion of the thigh. This terminates before reaching the anterior superior iliac spine at a depression corresponding to the separation between the sartorius and the tensor of the fascia lata. Below, it runs into the inguinal furrow.

In muscular persons, not too fat, the outer edge of the rectus abdominis, well defined upon the abdomen, may be traced down to the inguinal furrow, which it cuts at an acute angle. It is at this point (the inguinal trigone of Henke), immediately above and external to the spine of the pubis, that is found the external or superficial abdominal ring from which the spermatic cord in the male and the round ligament in the female may be easily traced to the scrotum and the labium majus respectively. The internal or deep abdominal ring is a little more than half an inch (15 mm.) above Poupart's ligament, and midway between the anterior superior iliac spine and the symphysis pubis.

The spine of the pubis (tuberculum pubicum) lying, as it does, between the course of an inguinal and that of a femoral hernia, becomes an important point to determine. In fat persons it cannot be felt with ease except by pushing up the skin of the scrotum or labium, but may always be found by tracing up the tendon of the adductor longus muscle, made tense by adducting the thigh. The spine is nearly on a level with the top of the great trochanter, and this enables us to determine its position when it is desired to avoid external manipulation. Between the spine and the symphysis pubis the pubic crest may be made out.

Another important point is the anterior superior iliac spine, always easily felt. It is used as a point of reference in judging of deformities and injuries to the pelvis, and in measuring the relative length of the two limbs. Although situated much farther from the median line than is the spine of the pubis, it will be seen, when the pelvis is viewed laterally in its normal position, to be in the same frontal plane. A line connecting the anterior superior spines of opposite sides passes just above the level of the promontory of the sacrum. In females it is, when the pelvis is normally placed, at the same height as the middle of the third sacral vertebra, and very nearly on a level with the upper edge of the great sciatic notch. In males it is 1 or 2 cm. higher.

Below the pubic eminence appear the external organs of generation, separated from the thigh by a deep groove, the genito-femoral furrow, more fully seen on the perineal aspect. The angle of the pubis, where the two pubic bones unite at the median line, may be obscurely felt from without. In the female it is much more obtuse than in the male, and is easily accessible by vaginal examination. In the normal position of the pelvis its vertex is on a level with the lower bony edge of the obturator foramen and with the middle of the posterior surface of the tuberosity of the ischium.

If the pelvis be looked at from the side, it is seen to be limited above by the crest of the ilium, whose general situation is indicated by a slight superficial depression, the iliac furrow (sulcus coxæ). This does not, however, exactly correspond with the underlying crest, the difference depending on the varying length of the aponeurotic fibres of the external oblique muscle of the abdomen, which is inserted on the outer lip of the crest. The mid-axillary line produced passes through the highest point of the crest (punctum coxale), the most prominent part of the great trochanter and the lower part of the tuberosity of the ischium (punctum ischiadicum), and bisects a line connecting the anterior and posterior iliac spines. When the arm is extended at right angles in front, the scapula is so rotated as to bring its inferior angle into this vertical. The level of the crest of the ilium is usually a little lower than the umbilicus, corresponding to the disc between the fourth and fifth lumbar vertebræ, though it may reach as high as the body of the fourth.

On this aspect the situation of the great trochanter should be noted. Usually a distinct prominence, more in relief than the crest of the ilium, in fat persons, owing to the tendinous insertion of the gluteus maximus, it may be marked by a depression. Its top is on a level with the middle of the acetabulum, and when the thigh is at rest, with the muscles relaxed, it just touches a line drawn from the anterior superior spine of the ilium downward and backward to the tuberosity of the ischium (Nélaton's line). It may rise somewhat above this line when the thigh is fully abducted (Sheild).

The most prominent features of the pelvic region, when viewed from the rear, are the rounded masses forming the buttocks or nates. While the main body of these protuberances is formed by muscles they owe their rounded outlines to a thick layer of fat. For this reason they are

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better developed in well-nourished persons, in the young, and in women, than in athletes, and are frequently the seat of lipomatous tumors. In some African tribes the deposit of large quantities of fat in this region seems to be normal, especially among the females, and it forms a large projecting mass (steatopygy). The underlying masses that influence surface form are the gluteus maximus nearest the median line and the gluteus medius laterally. In muscular individuals in good training the separation between these two muscles is usually observable on the surface. They are especially important for keeping the trunk upright; and since man is the only animal that habitually walks erect, the prominence of the nates is peculiar to him.

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The nates are separated from each other by a well-marked cleft, the intergluteal furrow (crena ani), usually quite deep. At its bottom is found the tip of the coccyx, a little lower than the horizontal line drawn through the top of the symphysis pubis, and about a finger's breadth farther forward is the margin of the anus, hidden from sight except in emaciated persons. Here the furrow ends in the male; in the female it becomes continuous with the beginning of the genital cleft.

Below, the nates are limited by a sharp crease, the gluteal fold (fold of the nates, gluteo-femoral fold, sulcus gluteus), caused by the attachment of the integument to the deep fascia by means of fibrous bands, which prevent the fat of the buttock from sliding down into the thigh when the sitting posture is assumed, thus making of it a veritable cushion. This fold does not correspond to the edge of the gluteus maximus, which runs obliquely downward and outward to its femoral insertion, but is nearly or quite horizontal when the subject is standing erect. When he is resting on one leg only and allowing the gluteus maximus of the free member to become stretched, the fold assumes more nearly the direction of the muscle. Externally each natis is defined by a broad, shallow depression (lateral gluteal furrow), due to change from muscle fibres to aponeurosis of insertion.

The nates are bounded above by the crest of the ilium, which terminates toward the middle line in the posterior superior spine, on a level with the spine of the second sacral vertebra, and at a point corresponding to the middle of the sacro-iliac synchondrosis. Immediately above the spine is a small area of bone quite free from muscle fibres, and therefore marked externally by a depression, especially noticeable in females. Below this the converging masses of nates leave between them a flattened triangular area which extends down as far as the fourth or fifth sacral vertebra. This flattening extends upward as far as a depression just below the spine of the fifth lumbar vertebra, and taken altogether the area constitutes a rhomboidal field (sacral rhomboid, Kreuzraute of Waldeyer) of which the two upper sides are much shorter than the two lower ones. In females the upper angle is 3–4 cm. higher than the line connecting the posterior superior spines. Through the middle of this there extend from above downward on the median line the coalesced spines of the sacral vertebræ (sacral crest, crista sacralis media), the most prominent part of which is the third sacral spine.

The general direction of the gluteus maximus is indicated by a line drawn from the posterior superior iliac spine to the most prominent part of the great trochanter. The juncture of the first and second thirds of this line is at the level of the great sciatic notch, where the gluteal artery emerges from the pelvis.

The tuberosity of the ischium, on which the body rests when sitting, is readily felt beneath the gluteal fold. It is situated in the same frontal plane as the transverse process of the fifth lumbar vertebra, and its middle is nearly the same horizontal distance behind the centre of the acetabulum that the anterior superior spine of the ilium and the spine of the pubis are in front. A line drawn from the posterior superior spine of the ilium to the outer part of the tuberosity of the ischium crosses the posterior inferior spine at 4 cm. and the spine of the ischium at 10 cm. distance, and the sciatic and internal pudic arteries make their exit from the pelvis at the juncture of its middle and lower thirds. The tuberosity is well padded with fat contained in small loculi formed by fibrous bands that pass between it and the skin. Several small bursæ are frequent near it, one, under the tendon of the biceps and semitendinosus, being quite constant.

There is, besides, another aspect of the pelvis almost wholly concealed when the subject is standing erect with the thighs approximated, being then reduced to a mere furrow. This is the inferior or perineal aspect, corresponding to the outlet of the pelvis. To examine it the thighs should be flexed and abducted when there will be displayed a rhomboidal space known as the perineal region, lying between the thighs, having its angles at the angle of the pubis in front, the tip of the coccyx behind, and the ischial tuberosities on either side. Its sides are formed in front by the ischio-pubic rami, behind by the great sciatic ligaments, which may in this position be felt in thin subjects on deep pressure along the edge of the gluteus maximus.

It will be seen that the gluteal fold encircles on each side the inner aspect of the thigh and ends in the genito-femoral furrow. Frequently an accessory furrow is found running parallel to it. From the rounded protuberance of the nates a pointed process extends forward, bounded laterally by the gluteal fold on the outer side, mesially by a furrow (gluteo-perineal furrow) that separates it from the external genitals and ends in front by uniting with the genito-femoral furrow.

In both sexes the external genital organs impinge upon the anterior part of this space, the area occupied by them being known as the pudendal region. The remaining space is usually divided for topographic purposes by a line drawn arbitrarily between the anterior part of the tuberosities of the ischium (interischiadic line). It has been pointed out by Waldeyer and others that a more suitable line, from a morphological point of view, is formed by curving somewhat forward to where the urogenital trigone, or triangular ligament, meets the pelvic diaphragm (line of the perineal septum). This separates a urogenital region through which the urogenital orifices pass, from an anal (ischio-rectal) one through which the alimentary canal discharges.

In this region there may be noted, in the median line, the tip of the coccyx, often marked by a slight depression; the anus, its centre about 3–4 cm. in front of the coccyx in the male and a little farther in the female; then the median raphe of the perineum, extending in the male from the anus to the scrotum, in the female lost almost at once in the genital cleft. The point where the raphe crosses the line of the perineal septum is called the tendinous centre of the perineum (centrum perineale), where the two layers of deep fascia and the triangular ligament meet. It affords a point of origin for several muscles. A slight swelling in front of this marks in the male the underlying bulb of the urethra, situated 1–1.5 cm. from the anterior edge of the anus.

THE OSSEOUS PELVIS.—Of the bones composing the pelvis two, the sacrum and the coccyx, belong to the spinal column; and two others, the so-called ossa innominata, or hip bones, belong to the limbs and constitute the pelvic girdle, which differs remarkably from the thoracic girdle in that it is articulated firmly with the sacrum, thus affording a firm basis of support.

The Sacrum.—This bone is said to owe its name to the use made of it by nations who offered human sacrifices, it being held to be particularly sacred to the gods, because it was used as an offering representing the entire victim, it being evident that the subject must be dead if the sacrum was offered. It is reputed to be found entirely uninjured when other portions of the skeleton have decayed, and a rabbinical tradition holds that it is the essential or sacred part of man, which is to be preserved, and from which the entire body is to sprout at the judgment day. Hyrtl, whose authority on such matters is entitled to weight, considers, however, that these are mere etymological fantasies, and that in the phrase *os sacrum* the adjective is used in the sense of great or im-

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portant, because it is the largest bone of the spinal column.

The bone presents the appearance of an irregular pyramid, the axis of which has been curved so that the concavity looks downward and forward, the base presenting upward, jointing with the last lumbar vertebra, the apex downward, jointing with the coccyx. Laterally it articulates with the innominate bones. Even a superficial examination shows it to be composed of coalesced vertebræ, normally five in number, six or four being occasionally found; but this is usually accompanied by a corresponding increase or decrease of the vertebral elements of contiguous regions of the spinal column. Accordingly the main descriptive features of the sacrum depend upon its composite character. There are, on the anterior surface, transverse lines showing the original divisions; on the posterior, vestiges of the spinous and articular processes, and of the laminæ; on both surfaces

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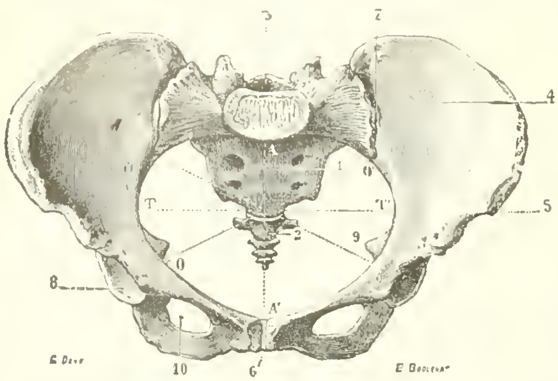

FIG. 3769.—Antero-Superior Aspect of the Pelvis. (From Testut.) 1, Sacrum; 2, coccyx; 3, sacral canal; 4, internal iliac fossa; 5, anterior superior spine of the ilium; 6, symphysis pubis; 7, sacro-iliac articulation; 8, acetabulum; 9, spine of the ischium; 10, obturator foramen.

The dotted lines indicate the diameters of the superior strait. *A*, *A'*, conjugate diameter; *T*, *T'*, transverse diameter; *O*, *O'*, oblique diameter.

foramina for the exit of nerves from an axial canal, a continuation of the spinal canal of the lumbar region. Anteriorly, obliquely cut grooves lead from the sacral foramina outward, affording, to the sacral nerves that lie in them, some protection from sliding pressure.

The non-articular vertebræ diminish rapidly in size, their characters are more obliterated, and they curve forward much more than the others. The summit of the curve formed by the sacrum is therefore in the third sacral vertebra, the spine of which projects in the median line. The prominence of the spine is not, however, a good guide to the convexity of the curve, which varies much in different individuals. The depth of the curve from a line subtending the arc averages 18.8 mm., having a maximum of 44 mm. and a minimum of 4 mm. The curve is developed during intra-uterine life, being probably due to an adaptation of the spinal column to the pelvic viscera. Cunningham found it in a fœtus 46 mm. long (about ten weeks). It is also seen in anthropoids.

Meyer calls that part of the sacrum which articulates with the ilium the pelvic portion, the remainder the perineal portion. Broca has pointed out that, in considering the question of the number of bones that form the tail of a vertebrate animal, we should not make the division at the sacro-coccygeal joint, as that is a character which may be considered merely a matter of special arrangement for each animal, but should rather begin to count at the non-articular portion of the sacrum. Viewed in this manner the articulating vertebræ would form a true sacrum, and those which follow would belong to the tail, and be divided into *true caudal*, having a spinal canal, and *false caudal*, reduced to centra only. According to this view, almost all the lower apes have three sacral vertebræ, as has man; and man has a tail formed of from six to eight pieces, resembling in this respect the anthropoid apes, they varying merely in the unimportant circumstance of having a few segments more or less.

The rectum reaches the spinal column at the third sacral vertebra and thence continues along it. Rose therefore designates the portion of the spinal column thus related as the rectal cover (*Mastdarmdeckel*). As it may be necessary to remove some of these vertebræ in operations for tumors, it becomes important to know how high it is safe to go. While the spinal cord terminates far above this, its envelopes continue down within the sacral canal, and the sac containing the cerebro-spinal fluid may reach as low as the third sacral vertebra. It is therefore allowable to remove the fourth and fifth sacral vertebræ; and, since the sac is pointed, to encroach laterally upon the third. In children the sac is lower than in adults. The width of the sacrum at the upper limit of surgical interference (between the second and third sacral vertebræ) is 8–11 cm. ($3\frac{1}{2}$–$4\frac{1}{3}$ in.). In the last two vertebræ the arch becomes deficient behind, leaving the sacral canal covered by membrane. This is, therefore, a weak point, and sloughing bedsores may here invade the canal and induce a meningitis. At the sides of the coalesced vertebræ fused costal elements form strong bars known as the lateral masses of the sacrum.

As compared with other animals the sacrum of man is broad in proportion to its length. The same holds when the sacra of Europeans are compared with those of the lower races of man. In order to express this Sir William Turner has devised the *sacral index*, obtained by multiplying the breadth of the sacrum by 100 and dividing by the length. The following are the average results of many measurements: European, female, 116; European, male, 112; negro, 106; Australian, 99; Andaman Islander, 94; Orang, 87; Gorilla, 72.

Sacra having an index above 106 are termed platyhieric; those between 100 and 106, subplatyhieric; those below 100, dolichohieric. The variations in width appear to depend mainly upon variations in the lateral masses.

The Coccyx.—This is also an assemblage of from four to five coalesced vertebræ, and corresponds to the tail of lower mammals; and in very rare instances it may, like that, be enclosed in a fold of skin. The vertebral characters of its elements are very much reduced, there being but little more than the centra or bodies, with two vestigial articular processes called the cornua, which articulate with the sacrum. It is triangular in form and continues forward the curve of the sacrum, making together with it an almost complete quadrant, so that the apex points directly forward. It may be readily felt in rectal or vaginal examination.

The number of vertebræ in the coccyx is subject to considerable variation; five is considered the normal number in the male, four or five in the female, while six are sometimes found. In vertebrate animals the number of caudal vertebræ varies greatly, from two hundred and seventy in some sharks to two in the gibbon and fruit-bat.

The Innominate Bone.—This is a complex of three originally distinct elements, the ilium, the ischium, and the pubis. When complete it resembles in shape two of the twisted blades of a propeller extending radially on opposite sides of an axial depression, the acetabulum, which receives the head of the femur. The upper expanded and somewhat longer blade is the ilium; the lower one, which has a large fenestration called the obturator or thyroid foramen, is formed by the combined ischium and pubis, the pubis forming the anterior por-

FIG. 3770.—Innominate Bone of Alligator, showing the Rod-like Character of the Separate Elements.

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tion, the ischium extending backward and downward to afford support while sitting. The narrowest part of the bone (the isthmus coxæ of Waldeyer) is just above the acetabulum, lying between the greater iliac notch of Henle (from the anterior inferior iliac spine to the symphysis pubis) and the great sciatic notch.

A study of the characters of the bone throughout the vertebrate series shows that its components were originally rod-like in form. This is shown in a striking manner in the alligator (Fig. 3770), and is also indicated by the course of ossification in the human bone, for accessory points form at the crest of the ilium, the symphysis pubis, the tuberosity of the ischium and within the acetabulum, that is to say, exactly where terminal epiphyses would form at the extremities of long bones. Even in the higher mammalia the rod-like character of the bones is still apparent (Fig. 3771). When the upright position begins to be assumed, lateral expansions becomes necessary to support the weight of the viscera. A transition form is seen in the pelvis of the gorilla (Fig. 3772).

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The thickness and strength of the different parts of the innominate bone vary according to the weight and strain to which they are subjected. While a person is standing,

FIG. 3771.—Pelvis of the Horse.

the weight of the body is supported by the upper lip of the acetabulum, whence it is transmitted to the symphysis pubis on the one side and the sacro-iliac joint on the other. Hence a strong bar of bone extends from the symphysis along the upper edge of the acetabulum and the ilio-pectineal line to the posterior superior spine of the ilium, where it ends in a protuberance called by Waldeyer the tuber glutæum posterius. This bar may be called the pubic trabeculum. While an individual is sitting, the greater portion of the weight is borne by the tuberosity of the ischium, and is transmitted through the thick strong body of the ischium (superior ramus of many authors) and the posterior edge of the acetabulum, directly upward to a thickened portion of the crest of the ilium (tuber glutæum anterius of Waldeyer). This also is a thickened bar, and may be called the ischial trabeculum. These bars cross each other at about right angles near the axis of motion of the hip-joint.

The upper edge or crest of the ilium is sinuous and thick, and gives attachment in front to the great, sheet-like muscles that form the parietes of the abdomen, and behind to the muscles of the back. Below the crest is a comparatively thin portion caused by the hollowing out of the substance of the bone within, for the attachment of the iliacus muscle, forming the internal iliac fossa, and without, for the attachment of the glutei muscles, forming what is sometimes called the external iliac fossa (ala ossis ilium). The internal iliac fossa supports the weight of the intestines laterally and forms in the articulated pelvis the lateral portion of what is known as the false pelvis, separated from the true pelvis by a ridge (ilio-pectineal line, linea terminalis) passing from the crest of the pubis backward and upward.

The acetabulum or cotyloid cavity appears a little below the middle of the external surface of the innominate bone. It is hemispherical in shape, formed by portions of the ilium, ischium, and pubis, and receives the head of the femur. It may become perforated by suppuration within the cavity, and thus inflammation of the intrapelvic structures may be induced. Below, the edge of the cavity is incomplete, giving passage to vessels that supply the joint. This notch is usually directed downward, and it therefore affords a means for establishing the normal position of the bone.

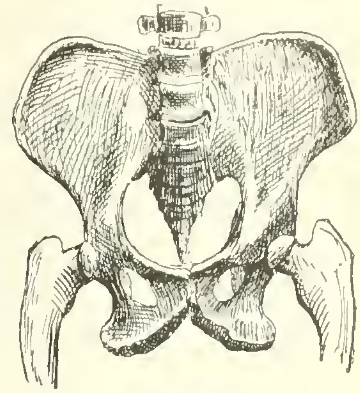

FIG. 3772.—Pelvis of a Gorilla.

The united ischium and pubis constitute the side of the true pelvis. They here form three bony bars that surround the large obturator foramen, closed in, during life, by a thick sheet of fascia called the obturator membrane. This is deficient above, affording, between it and the bone, a passage about an inch long, walled in above by the bone and below by the membrane, the obturator muscles and some masses of fat. This passage, the obturator canal, contains the obturator vessels and nerve. The membrane is reinforced near the canal by independent bands attached to small bony projections on the edge of the foramen. Three of these projections have been distinguished as fairly constant. They are named by Waldeyer according to their situation—the tuberculum obturatorium laterale superius, the tuberculum obturatorium laterale inferius, and the tuberculum obturatorium mediale. The arrangement of the fibrous bands and the shape of the canal have important effects upon obturator hernia.

The two anterior bars enclosing the foramen are known as rami, the upper one being the horizontal ramus of the pubis, the lower one being the descending ramus of the pubis above, the ascending ramus of the ischium below. It may be remarked that these terms apply rather to the artificial position of the pelvis given when it is set upon a table than to its true position in the body during life, as the "horizontal" ramus is far from being horizontal, varying from that by as much as 30° in some subjects. Along these bars are attached the muscles of the perineal

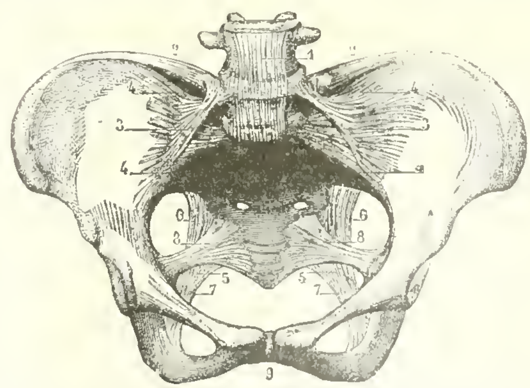

FIG. 3773.—The Articulations of the Pelvis as Seen from the Front. 1, Anterior common ligament; 2, ilio-lumbar ligament; 3, lumbosacral ligament; 4, anterior sacro-iliac ligment; 5, great sciatic ligament; 6, its external border; 7, its internal border; 8, lower sacrosciatic ligament; 9, symphysis pubis.

floor and the urogenital diaphragm, on the inner side the muscles of the abdominal wall, below the adductors and rotators of the femur.

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Behind, the ischium expands to a large tuberosity that gives origin to the great hamstring muscles (biceps, semitendinosus, semimembranosus), and affords attachment to the great sciatic ligaments. A pointed process (spine of the ischium) divides the posterior border into two notches, the greater and lesser sciatic.

Articulations.—The pelvic bones are joined together by five joints, all of which are synchondroses (Figs. 3773 and 3774). Two of these are vertebral joints, viz., the

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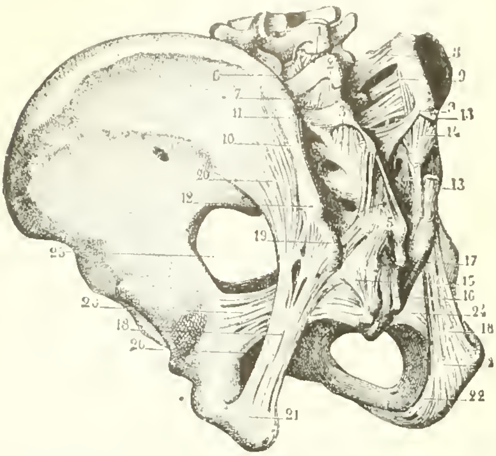

FIG. 3774.—Posterior View of the Ligaments of the Pelvis. 1, 2, 3, 4, 5, Interspinous ligaments; 6, 7, ligamenta subflava; 8, ilio-lumbar ligament; 9, posterior sacro-iliac ligament; 10, its oblique portion, continuous externally with the great sacro-sciatic ligament; 11, posterior superior spine of the ilium; 12, tubercle representing the transverse process of the fourth sacral vertebra; 13, deep layer of the posterior sacro-iliac ligament; 14, insertions of the same; 15, 16, lateral ligaments of the sacro-coccygeal articulation; 17, posterior ligament of the same; 18, great sacro-sciatic ligament; 19, its sacral insertion; 20, its iliac insertion; 21, its ischiatic insertion; 22, reflected portion; 23, lesser sacro-sciatic insertion; 24, its attachment to the sacrum and coccyx; 25, great sciatic notch converted into a foramen by the sacro-sciatic ligaments; 26, lesser sciatic notch, forming with these ligaments a triangular orifice.

lumbo-sacral and the sacro-coccygeal; there is one on either side of the sacrum where it unites with the ilia; and one in front, where the innominate bones join, called the symphysis pubis.

At the lumbo-sacral joint we have the same general features as in other spinal joints, viz., a union by means of fibro-cartilage between the bodies of the last lumbar and the first sacral vertebra, and a pair of arthrodial joints between the articular processes of the two bones. The anterior common ligament of the spine passes downward upon the sacrum in front, and within the spinal canal the posterior common ligament does the same. Besides these the anterior lamina of the lumbar fascia becomes thickened to strong bands, which, springing from the transverse processes of the fourth and fifth lumbar vertebræ, pass to the inner lip of the crest of the ilium (ilio-lumbar ligament) and to the brim of the true pelvis and the base of the sacrum (lumbo-sacral or sacro-lumbar ligament).

The joint is indicated by a well marked angle, the promontory of the sacrum, slightly greater in females than in males, being determined by Cunningham as averaging 137° 40' for females as against 133° 6' for males. This is not usually the most anterior part of the spine, for that must be sought in the forward projection of the lumbar curve, that is to say, in the fourth lumbar vertebra or even as high as the disc between the fourth and the third. Externally it may be felt on deep pressure of the relaxed abdominal wall if the subject is lean. It is one of the landmarks by which a contracted pelvis is known, and cannot, in a properly formed pelvis, be reached by the finger through the vagina, but can easily be felt in a rectal examination.

The joint between the sacrum and the coccyx is very simple, being entirely similar to that between the bodies of the vertebræ. The articulation is usually sufficiently free to permit the apex to be displaced some 2 cm. or more, and there is sometimes a midcoccygeal articulation between the first and second coccygeal vertebræ. Movement usually occurs during defecation and labor, but the bone may be so firmly ankylosed to the sacrum that it offers an obstacle to the delivery of the head of a child. In the male pelvis the joint is frequently obliterated quite early. A number of ligamentous bands have been described, but they appear to have no practical importance beyond that of an investing capsule.

The joint between the sacrum and the iliac bones on either side possesses an incomplete synovial cavity. The ear-shaped articular surfaces may be divided into two parts—an upper which is clothed with cartilage and synovial membrane, and a lower whose surfaces are interconnected by means of an interosseous ligament. The joint is a very strong one, as the entire weight of the trunk is thrown upon the articulation. Owing to the wedge-like shape of the sacrum it is often described as the keystone of the pelvic arch. It should be noted, however, that in the natural standing position the bone is somewhat narrower behind and above than below and in front, so that it would seem that the weight of the body resting upon it from above might tend to displace it. This is prevented, (1) by the sinuous character of the articular surfaces; (2) by the extremely strong sacro-iliac ligaments that bind the sacrum closely between the two iliac bones, so that any displacement forward tightens the joint; (3) by the sciatic ligaments that stretch from the sacrum and the coccyx to the tuberosity and spine of the ischium and counteract any tilting forward of the upper end of the sacrum. The interosseous ligament that closes the joint behind is very thick and strong, while the anterior ligament that closes it in front is thin. Hence it is easy to open the articulation from the abdominal cavity, but difficult to do so from behind. Injury to it is rare, but when it occurs it is of a serious nature, owing to the weight the joint carries in the standing posture.

The articulation usually affects the three upper sacral vertebræ, but variations from this frequently occur. The following are the results of 265 cases observed by Paterson and Waldeyer:

S 1 + 2	21 times.
S 1 + 2 + 3	242 "
S 1 + 2 + 3 + 4	3 "
S – 2 + 3	3 "
S – 2 + 3 + 4	3 "
L 5 + S 1 + 2	1 "
L 5 + S 1 + 2 + 3	4 "
L 6 + S 1 + 2	2 "
L 6 + S 1 + 2 + 3	1 "
Total	280 "

The total amounts to 280 instead of to 265 for the reason that in 15 cases the articulation differed on one side from that on the other. It will be noted that the second sacral vertebra is always involved in the articulation.

As already mentioned, the sacro-sciatic ligaments act as restraining bands to this articulation. (See Figs. 3773 and 3774.) The great or posterior sacro-sciatic ligament (ligamentum sacrotuberosum) appears as if a continuation of the sacro-iliac, passing to the lateral parts of the sacrum and the coccyx and then to the external surface of the tuberosity of the ischium. It is somewhat narrower in the middle than at either extremity, and in its course becomes twisted upon its axis. At its lower insertion it runs as a thin sharp band (falciform process) along the ramus of the ischium and protects the internal pudic artery. Its interlaced fibres are somewhat extensible, so that it offers no considerable resistance to the moderate movement of the coccyx during labor. It is believed to represent a former continuation of the biceps and semitendinosus muscles whose tendons pass directly into it.

The small or anterior sacro-sciatic ligament (ligamentum sacrospinosum) lies in front of the great ligament

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and is partly covered by it. Triangular in form, it passes from the side of the sacrum and coccyx to the spine of the ischium. It blends at its insertion with the coccygeus muscle and is regarded morphologically as a fibrous reduction of it.

These two ligaments convert the sciatic notches of the innominate bone into foramina, through which pass important structures. The greater sciatic foramen, above the spine of the ischium, is nearly filled by the pyri-

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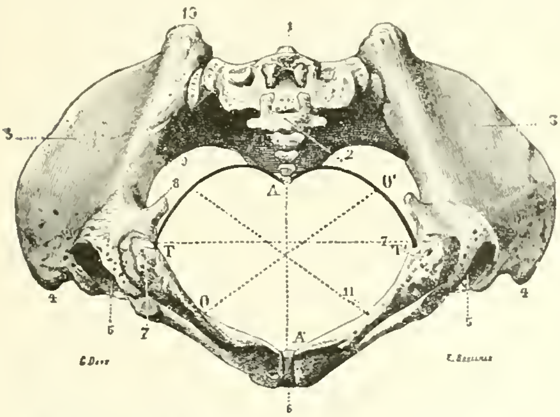

FIG. 3775.—The Inferior Strait of the Pelvis. (From Testut.) 1, Sacrum; 2, coccyx; 3, 3, external iliac fossæ; 4, 4, anterior superior spines of the ilium; 5, 5, acetabula; 6, symphysis pubis; 7, 7, tuberosities of the ischium; 8, spine of the ischium; 9, great sciatic notch; 10, posterior inferior spine of the ilium; 11, ischio-pubic rami. The dotted lines indicate the diameters of the inferior strait. *A, A,'* conjugate or coccy-pubic diameter; *T, T'*, transverse or bi-ischiatic diameter; *O, O'*, oblique diameter.

formis muscle, small intervals being left above and below—the suprapyriform and infrapyriform foramina of Waldeyer. Through the former pass the gluteal vessels and the superior gluteal nerve; through the latter the internal pudic vessels and nerve, the sciatic vessels and nerves, the inferior gluteal nerve and the muscular branches of the sacral plexus. Through the lesser sciatic foramen, below the spine of the ischium, pass the obturator internus muscle, and the internal pudic nerve and vessels re-entering the pelvis.

The two pubic bones are united in front by a fibrocartilage that forms a slight eminence on the pelvic aspect of the joint. During pregnancy this swells and relaxes, and there is thus obtained a mobility that may persist for some time after delivery. Traces of a synovial cavity are occasionally found as a small slit lying near the pelvic surface, not lined with synovial membrane and apparently being a simple lymph space. This is found in both males and females, though it is larger and more constant in the latter, and is not dependent upon pregnancy. It is not found in young children. Four peripheral ligaments are described: anterior, posterior, superior, and inferior. The investment is strengthened by fibrous expansions from the recti muscles of the abdomen and the adductors of the thigh. Malgaigne considered that the height of the symphysis increased considerably after the menopause, being 38 mm. at forty-five years, and 45 mm. at seventy and eighty years. The arrangement of the abdominal muscles in their insertion about the joint is such as to draw the ends of the bones together, so that during the bearing-down pains of labor the joint is strengthened.

The Ligamentous Pelvis.—Taking now the pelvis as a whole, we find it to be divided into two well-marked parts by a line, the linea terminalis, made up of the promontory of the sacrum, the rounded angle between the upper and the lower surfaces of the sacrum, the ilio-pectineal line, the pecten or crest of the pubis, and the upper surface of the symphsyis pubis. The part above this line which supports the abdominal contents is termed the *false* pelvis; the part below it, containing the pelvic viscera, the *true* pelvis, forming the bony ring through which the fœtus is expelled.

The superior opening of the true pelvis is termed the inlet or the superior strait (apertura pelvis superior). (See Fig. 3769.) Its shape is reniform in the female, cordiform in the male. Similarly the lower opening, by which the fœtus is expelled, is called the outlet, or the inferior strait (apertura pelvis inferior). (See Fig. 3775). It is bounded by the ischio-pubic rami in front, on the sides by the tuberosities of the ischium, behind by the sciatic ligaments and the coccyx, only about half of its circumference being bony. Its form is elliptical, slightly encroached upon by the coccyx.

That part of the pelvic canal between the inferior and superior straits is called the cavity of the pelvis. It is customary to divide this into four regions, an anterior, a posterior, and two lateral. The anterior comprises the symphysis pubis, the posterior surface of the body of the pubis, and the obturator foramen with its membrane. It is limited by a line passing from the tuberosity of the ischium to the ilio-pectineal eminence. The posterior region is formed by the anterior surfaces of the sacrum and the coccyx; the lateral regions are between the anterior and the posterior. Each is again subdivided into two portions called the anterior and posterior inclined planes. The anterior comprises the internal face of the ischium and the interior surface that corresponds to the acetabulum. Its direction is oblique, downward, and backward. The posterior inclined plane is entirely composed of soft parts, and is directed downward and forward. The planes meet at a line passing through the ischial spines.

Normal Position.—When standing erect the pelvis is tilted forward, so that the anterior superior iliac spines and the spine of the pubis lie in the same vertical plane. The promontory of the sacrum is then 9.5–9.9 cm. ($3\frac{3}{4}$–$3\frac{7}{8}$ in.) above the upper edge of the symphysis pubis and at about the same level as the posterior superior iliac spines and the interspace between the first and second sacral spines. The frontal plane tangent to it cuts the middle

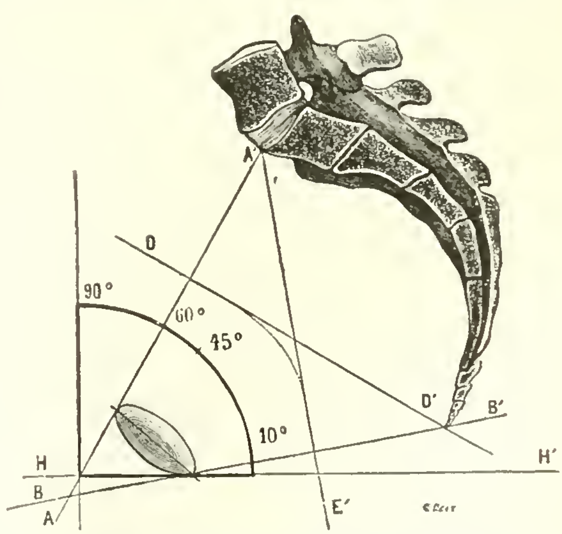

FIG. 3776.—Axes and Inclinations of the Pelvis. (From Testut.) *A, A'*, Plane of the superior strait; *B, B'*, plane of the inferior strait; *D, D'*, axis of the superior strait; *E, E'*, axis of the inferior strait; *H, H'*, the horizontal plane, with which the plane of the superior strait, *A, A'*, makes an angle of from 55° to 60°.

of the acetabulum and passes close behind the angle of the pubis.

In this position the planes of the pelvic inlet * and outlet are inclined to the horizontal plane, the first making

* Strictly speaking the limits of the superior strait do not lie in the same plane, as the promontory never coincides with the plane of the linea terminalis (ilio-pectineal line).

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an average angle of about 60° (from 55° to 65°, Naegeli), the second an angle averaging about 12°. (See Fig. 3776).

Meyer proposed to measure the inclination of the pelvis by taking that of a line drawn from the summit of the curve formed by the sacrum (at the body of the third sacral vertebra, see *ante*) to the upper border of the symphysis (normal conjugate). He thought this angle to be more constant than that made by the plane of the inlet, and estimated it as averaging 30°.

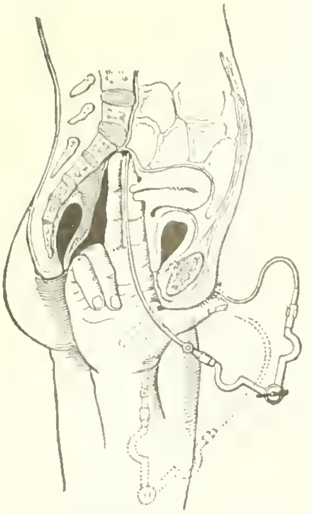

FIG. 3777.—Method of Measuring the Conjugate Diameter of the Superior Strait in the Living.

Measurements.—For obstetrical and surgical purposes it is important that the average dimensions of the pelvis should be accurately known. Of these the diameters of the inlet and the outlet are the most generally useful. The older obstetricians, considering these openings as approximately elliptical, applied to them designations derived from the diameters of an ellipse; so the antero-posterior diameter is often spoken of as the conjugate, the others as the transverse and the oblique diameters.

The conjugate of the inlet might be measured from the middle of the promontory to the top of the symphysis (anatomical conjugate), but for practical purposes the shortest line between the promontory and the symphysis is taken (true conjugate, obstetrical conjugate) which strikes the symphysis below the upper edge, usually about the junction of the upper and middle thirds. The transverse diameter is the longest transverse line that can be drawn between two symmetrical points of the brim. These points are usually situated about the juncture of the posterior and middle thirds of the circumference, immediately behind the acetabula. The oblique diameter is measured from the sacro-iliac articulation to the point on the opposite side where the linea terminalis meets the ilio-pectineal eminence. (See Fig. 3769.)

At the outlet the conjugate is measured from the tip of the coccyx to the angle of the pubis, and is increased by

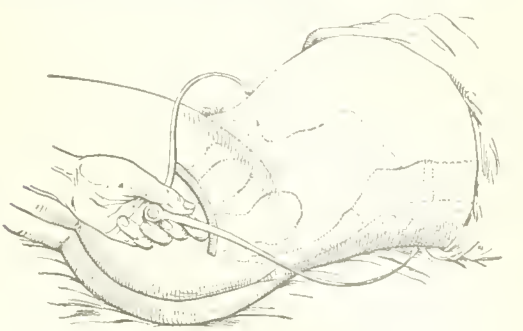

FIG. 3778.—Method of Measuring Baudelocque's Diameter in the Living.

about 2 cm. by moving the coccyx backward. The transverse diameter is measured between the middle points of the posterior borders of the ischial tuberosities. No satisfactory oblique diameter of the outlet can be measured. When stated it is considered to be the shortest distance from either ischiopubic ramus to the great sciatic ligament of the opposite side. (See Fig. 3775.)

The calibre of the cavity of the pelvis varies somewhat from that of the brim. The widest part (amplitudo pelvis) is in a plane passed through the midpoints of the acetabula, the synostosis between the second and third sacral vertebræ and the middle of the symphysis pubis. The narrowest part (angustia pelvis) is between the lower end of the sacrum behind, the summit of the pubic arch in front, and the two ischial spines on either side. The contraction here is caused by a slight elevation (angulus ischiadicus, Waldeyer) that runs on either side from the ischial spine to the lateral tubercle of the obturator foramen, separating a supraspinous from an intraspinous plane.

While these measurements are especially important as relating to normal labor, the following are commonly used for ascertaining pelvic deformities:

The External Conjugate (Baudelocque's diameter). The distance between the upper edge of the symphysis pubis and the tip of the spinous process of the fifth lumbar vertebra. This is readily measured with calipers in the living. (See Fig. 3778.) When less than 19 cm. the pelvis is too narrow for safe delivery.

The Diagonal Conjugate. Distance from the vertex of the pubic angle to the promontory of the sacrum. This may be measured by means of a pelvimeter or closely approximated by measurements made by introducing two fingers into the vagina. (See Fig. 3777.) In a normal pelvis the promontory cannot be reached by introducing a single index finger.

The distance between the anterior superior spines of the ilium.

The greatest distance between the iliac crests.

The greatest distance between the great trochanters.

The external circumference of the pelvis measured from the spine of the fifth lumbar vertebra around to the symphysis pubis on either side, passing between the iliac crest and the great trochanter.

The following table of measurements is from the determinations of Waldeyer, C. Krause, and Schröder:

	Male.	Female.
Inlet.		
True conjugate diameter	10.5 cm.	11.0 cm.
Transverse diameter	12.5	13.5
Oblique diameter	12	12.75
Outlet.		
Conjugate diameter	7.5 (9.5)	9 (11)
Transverse diameter	8	11
Amplitudo.		
Conjugate diameter	11	12.75
Transverse diameter	11	12.5
Angustia.		
Conjugate diameter	9.5	11.5
Transverse diameter	8	10.5
External conjugate	18	20
Diagonal conjugate	......	13
Distance between anterior superior spines	26	26
Distance between iliac crests	26	29
Distance between great trochanters	31.5	31.5
External circumference	.....	89
Dorsal length of sacrum	......	12.5
Ventral length of sacrum	13.5	12
Height of symphysis pubis	5.5	4.5

The *axis* of the superior strait is a line perpendicular to the plane of that strait at its central point. (See Fig. 3776.) It nearly coincides with a line drawn from the tip of the coccyx to the umbilicus. The axis of the inferior strait is similarly obtained, and when produced reaches the promontory of the sacrum. The axis or traction line of the pelvis is one that bisects all possible conjugate diameters. It is practically parallel with the curve of the sacrum and coccyx, and therefore, in the female pelvis, nearly straight above and sharply curved below. It is important to bear in mind its direction when attempting

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traction upon the fœtus and when introducing instruments.

Indices.—The method of proportional measurements or indices, first devised for the cranium, has also been applied to the pelvis. Two of these are used, first that which Topinard calls the general index of the pelvis, found by comparing the greatest width between the iliac crests with the height taken from the punctum ischiadicum or lowest point of the ischial tuberosity to the punctum coxale or highest point of the crest; second, the index of

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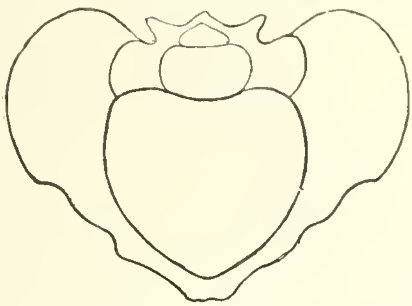

FIG. 3779.—Pelvis of an Andaman Islander. (Garson.)

the superior strait, found by comparing the anatomical conjugate diameter with the transverse diameter of the inlet.

By the first method the height is taken as 100, and the index expresses the proportionate breadth. Topinard obtained the following averages:

46 European males	126.6
17 African negroes, males	121.3
11 Natives of Oceanica, males	122.7
24 European females	136.9
10 African negresses	134.2
10 Natives of Oceanica, females	129.0
20 Anthropoids	105.6
16 Ruminants	77.2
12 Carnivores	68.1
4 Rodents	66.8
4 Kangaroos	63.0
2 Edentates	61.4

These figures appear to show that as we rise in the scale of races the pelvis broadens. It should be remembered, however, that exceedingly heavy animals, like the

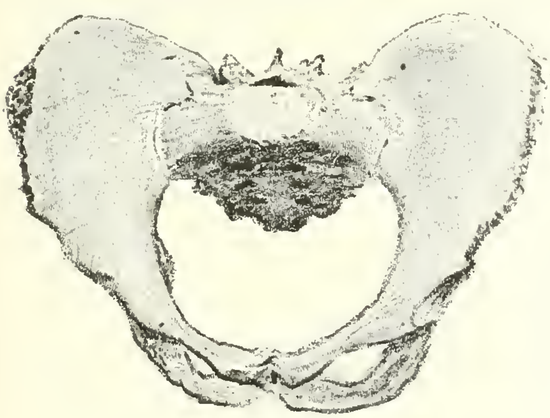

FIG. 3780.—Pelvis of an Aino. (Hennig.)

elephant and rhinoceros, have a proportionately wide pelvis to permit of the insertion of the muscles necessary for sustaining their enormous weights. Some authors use the breadth of the pelvis as the basis of comparison, which changes the figures without altering their serial relation. It will be noted that in all human races the female pelvis is broader in proportion to its height than that of the male.

By the second method the breadth of the superior strait is taken as 100, and the index expresses the proportionate value of the conjugate diameter. Sir William Turner

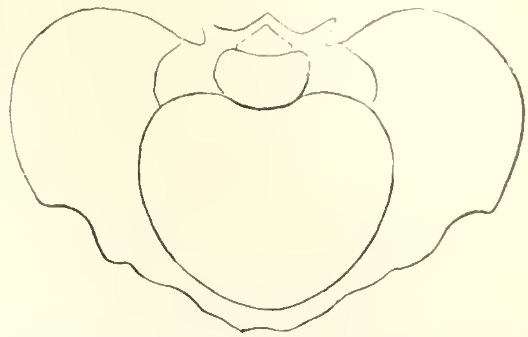

FIG. 3781.—Diagram of European Pelvis, seen from Above. (Garson.)

used this index in his investigation of the bones brought back by the *Challenger*. He devised the terms *dolichopellic* for pelves having an index above 95, *mesatipellic*

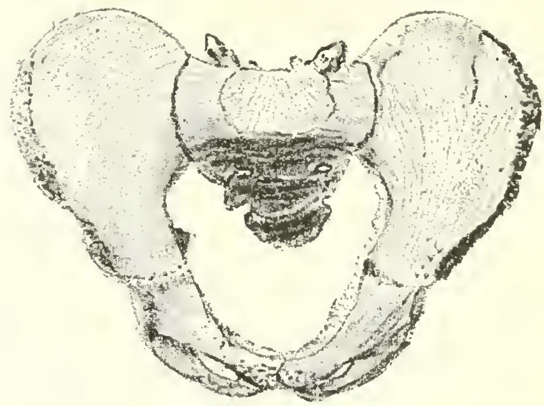

FIG. 3782.—Pelvis of a Young Maori. (Hennig.)

for those from 90 to 96, and *platypellic* for those below 90. The Andaman Islanders appear to have the inlet most nearly circular of any yet examined, Garson finding

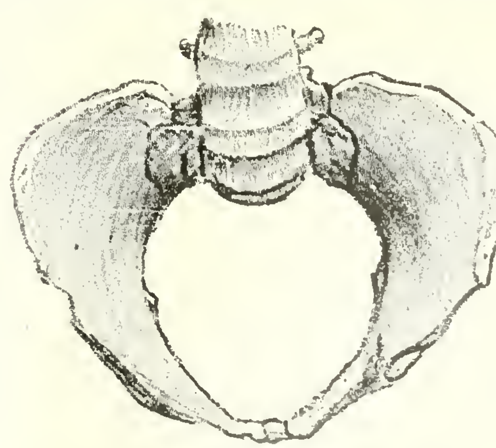

FIG. 3783. Pelvis of a Negress. (Hennig.)

the index 99 in an average of 13 cases. Figs. 3779 and 3781 show a comparison between this pelvis and that of a

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European. Other peoples hitherto investigated may be classified as follows:

Dolichopellic.—Australians, Bushmen, Hottentots, Kaffirs, many Polynesians, Malays.

Mesatipellic.—Negroes, Tasmanians, New Caledonians, many Melanesians.

Platypellic.—Europeans, Mongolians, East Indians.

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This relates to male pelves only, as nowhere do females possess dolichopellic pelves. Anthropoid apes have markedly dolichopellic pelves, much exceeding in this character any human forms. Indeed, as compared with lower animals, the pelvis of man is much broader and of greater capacity. These differences are occasioned by

FIG. 3784.—Pelvis of an Individual Belonging to the Stone Age. (Hennig.)

the erect attitude, which necessitates an effective support of the viscera. In some races of men slight peculiarities appear which may be considered to be transitional forms. (See Figs. 3780, 3782, and 3783.) The Veddahs of Ceylon, for example, have pelves in which the inlet is remarkably contracted in front, so that the inlet appears almost wedge shaped.

Sexual Differences.—From what has been said above it will be seen that the highest and best developed forms of pelvis are not found in the human male but in the female, contrasting markedly with other sexual characters which usually tend toward embryonic or undeveloped forms. This also is a natural result from the erect attitude. In the quadrupedal position comparatively little weight is hung from the pelvic arch, and a marked separation of the bones during parturition does not necessarily impair to any considerable degree the stability of the support of the body. In the erect position, however, so great a weight is thrown upon the arch that no considerable amount of separation is practicable, and there comes to be an antagonism established between the constantly increasing size of the child's head and the diameters of the pelvic straits. The female pelvis therefore becomes comparatively wider, shorter, smoother, and more capacious than that of the male. It has been described as a short segment of a long cone, that of the male being a long segment of a short cone.

The following table, mainly from Waldeyer, gives the principal sexual differences in the articulated pelvis:

Portion.	Male.	Female.
Sacrum	Relatively longer and narrower. Average index 103.5.	Relatively shorter and wider.
Curvature	Generally more marked, uniform.	Usually less; flatter above, more curved below.
Promontory	More prominent	Less prominent.
Coccyx	More frequently has five vertebræ. Co-ossification earlier, projects forward more.	More frequently has four vertebræ. Synchondroses remain later; projects forward less.
Ilium	Higher, narrower; placed more obliquely, inclination of borders to each other = 53°.	Lower, broader, less obliquely placed; inclination averages 50°.
Crests	Thicker, rougher, more sinuous.	Narrower, less rough, less sinuous.
Posterior superior spines	Average distance apart 50 mm.	Average distance apart 40 mm.
Fossæ	Deeper	Shallower.
Ischium	Stronger, thicker	Less massive.
Tuberosities	Nearer together, inflexed	Wide apart, everted.
Ischio-pubic rami.	Margins more everted.	Margins less everted.
Pubis	Arch pointed, more angular (70°–70.95°). *Angulus* pubis.	Arch rounded, arch-like (90°–100°). *Arcus* pubis.
Symphysis	Deeper. At birth its width is narrower than or equal to its height (Fehling).	Shallower. At birth its width is greater than its height (Fehling).
Joint cavity	Rare	Frequent.
Spines	Nearer together	Farther apart.
Crests	Shorter	Longer.
Insertions of graciles muscles.	Nearer together	Farther apart (Cleland).
Obturator foramen.	Higher, more oval, obturator canal narrower.	Lower, almost triangular, obturator canal wider.
Acetabula	Nearer together, show less in front.	Wider apart, show more in front.
Great sciatic notch.	Lower, more oval	Higher, more circular.
Distance from body of ischium to posterior inferior iliac spine.	Averages 40 mm	Averages 50 mm. (Cunningham).
True pelvis	Deeper, narrower, more funnel-shaped, capacity less.	Shallower, wider, not markedly funnel-shaped, capacity greater.
Superior strait	More heart-shaped and dolichopellic, transverse diameter less, plane less inclined.	More elliptical (reniform) and platypellic, transverse diameter greater, plane more inclined.
Inferior strait	Narrower	Wider.
Inclination	Less marked	More marked.

Development.—Each of the three or four upper vertebræ which form the sacrum are developed from eight centres, three of which are primary and like those of other vertebræ, namely, one for the body appearing at the fourth to the eighth month, and two for the neural arch. (See Figs. 3785 and 3786.) From these latter grow out the articular and transverse processes. There are also five secondary centres, two for the epiphyseal plates, that from the tenth to the thirteenth year form along the upper and lower surfaces of the body of each vertebra, one for the spinous process, and two situated laterally and representing costal elements. The lower vertebræ usually lack these. In addition, there are formed in the seventeenth or eighteenth year two marginal epiphyses on each side, the upper ones being connected with the auricular facets. The bone is complete from the nineteenth to the twenty-first year.

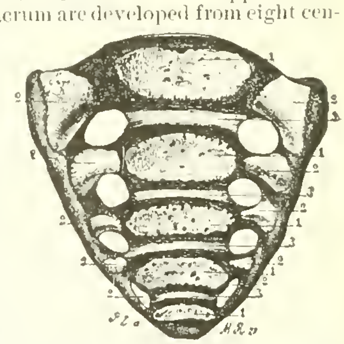

FIG. 3785.—Sacrum of a Child of Eleven Months. 1, 1, Ossific points for bodies; 2, 2, lateral points; 3, 3, intervertebral ligaments.

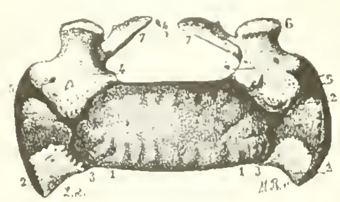

FIG. 3786.—Ossification of First Sacral Vertebra. 1, 1, Body; 2, 2, lateral points; 4, 4, centres for arch.

Each coccygeal vertebra ossifies from a single primary centre, which does not appear until from four to nine years after birth, and there appear later secondary cen-

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tres representing the upper and lower epiphyseal plates, and in the upper vertebra two additional centres for the cornua. (See Fig. 3787.)

The hip bone is formed from three cartilages that originate separately, the one for the ilium appearing latest. (See Fig. 3788.) Ossification occurs by three primary and nine secondary centres, the primary ones being first separated in the acetabulum by a Y-shaped piece, the triradiate cartilage. In rare cases an independent centre, the os acetabuli, may remain in the acetabulum ununited. Marks of the original composition remain on the developed bone: (1) at the ilio-pectineal eminence; (2) on the ischio-pubic rami, at the seat of origin of the corpora cavernosa; (3) as a thickened bar extending from the posterior border of the acetabulum to the great sciatic notch. Ossification occurs in the order shown in the following table:

FIG. 3787.—Development of the Coccyx. 1, 1, Centres for bodies; 2, 2, articular processes; 3, 5, epiphyses.

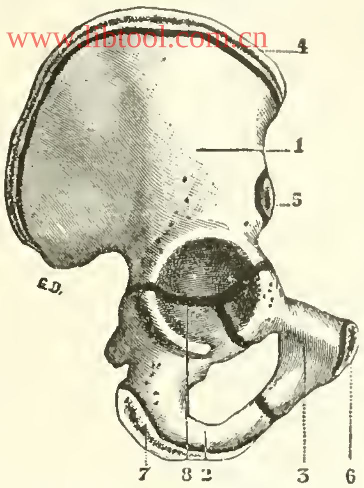

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FIG. 3788.—Development of the Hip Bone. (From Testut.) 1, Ilium; 2, ischium; 3, pubis; 4, epiphyseal point for the iliac crest; 5, epiphyseal point for the anterior inferior iliac spine; 6, epiphyseal point at the symphysis pubis; 7, epiphyseal point for the ischium; 8, Y-cartilage uniting the three primitive portions of the hip bone.

Centres.	Time of appearance.	Time of union.
Primary.		
Ilium	3d to 4th month.	17th to 18th year.
Ischium	4th to 5th month.	17th to 18th year.
Pubis	5th to 7th month.	17th to 18th year.
Secondary.		
Epiphyses acetabuli.		
Between ilium and pubis	12th year	18th year.
Between ilium and ischium	12th year	15th to 16th year.
Between ischium and pubis	12th year	15th to 16th year.
Epiphyses marginales.		
Iliac crest	15th to 16th year.	21st to 25th year.
Symphysis pubis	18th to 20th year.	20th to 21st year.
Tuberosity of ischium	15th to 16th year.	17th to 22d year, female. 21st to 24th year, male.
Anterior inferior spine of ilium	15th to 16th year.	16th to 17th year.
Spine of pubis	18th to 20th year.	20th year.
Spine of ischium	15th to 16th year.	17th to 18th year.

Frank Baker.

PEMPHIGUS.—The word pemphigus does not convey to the mind the idea of a clear-cut disease. The pemphigus diseases have been divided into a number of groups whose only common bond of union is the occurrence of bullæ at some time in their course. Any particular group of bullous affections may differ in every other respect from the other groups. Although these bullous diseases differ widely from one another, yet owing principally to the obscurity of their causes, it has been found difficult to segregate them or to remove any particular group from the conglomerate class of pemphigus diseases, and put it under a distinct heading. Duhring and Brocq have done much to simplify the study of pemphigus by removing altogether from this class the group of cases that Duhring has called dermatitis herpetiformis, and Brocq has called dermatitis polymorpha dolorosa. Brocq, under the term dermatitis polymorpha dolorosa, includes rather more cases than Duhring does under the term dermatitis herpetiformis. Some of Brocq's cases are not herpetiform at all.

PEMPHIGUS NEONATORUM.—Pemphigus neonatorum is an instance of what has been before mentioned of groups of cases being removed from the class of pemphigus diseases and classified under a different head. This disease in future will have to be described under the heading impetigo contagiosa, to which class it really belongs. It is described here for two reasons: first, its name is still a familiar one in medical literature, and, secondly, its most striking symptom, sometimes its sole symptom, is a bleb, leading the observer most naturally to look for its description under the heading pemphigus.

Pemphigus neonatorum is an acute contagious disease characterized by the occurrence, during a limited time, of crops of blebs.

Symptoms.—In otherwise apparently healthy infants of from three to eight days old, blebs suddenly arise. They vary from a pea to a hazelnut in size, or they may be even larger. They are at first tensely filled with clear yellow serum, and are scattered anywhere over the cutaneous surface, and spring from an apparently normal or a reddened skin. After a short time the bullæ become flabby and the contents grow turbid. Then shortly the delicate covering of the bleb gives way, exposing a red weeping surface upon which the epidermis has more or less perfectly formed, according to the time, whether early or late, at which it has broken. The blebs arise, become turbid, burst, and heal in a few days. The duration of the disease is from one to two weeks, in which time it produces several crops of bullæ. This constitutes the whole disease, which usually affects only the skin, and seems but rarely to have an influence on the constitution. It may, however, run a severe course, and cause death in a very short time.

Most of the recorded cases are reported as epidemics in foundling asylums. It is probable, however, that even a larger number occur scattered throughout the community, but are left unnoted. The sporadic cases are usually seen only by the obstetrician or midwife, who, seeing that the general health is not affected, adopts some indifferent treatment under which the patients generally recover.

Diagnosis.—In the hereditary bullous syphilide the bullous eruption is particularly marked on the palms and soles, situations that remain free in pemphigus neonatorum. Besides this, in syphilis the base of the bulla is infiltrated and frequently ulcerated, and the eruption is polymorphous, consisting of papules, pustules, and large erythematous infiltrations. In addition, in syphilis, there are snuffles, mucous patches, and condylomata. In varicella the lesions are vesicles rather than bullæ and are rarely large. In Ritter's disease the erythema, usually beginning near the mouth and spreading over large areas or the whole cutaneous surface, is the principal symptom. The bullæ are subsidiary to this. Besides, in Ritter's disease the connection between the horny layer of the skin and the rete Malpighii is loosened as in pemphigus foliaceus, so that the horny layer either comes away spontaneously or can be taken off in large masses or ribbons by a stroke of the finger. It must be mentioned here that Richter, in a recent and careful study, has concluded that Ritter's disease is not an independent affection at all, but an unusually malignant variety of pemphigus neonatorum.

Pathology.—The opinion is gaining ground that pemphigus neonatorum, some cases of pemphigus febrilis, impetigo contagiosa, and possibly Ritter's disease are identical affections. The pronounced contagiousness of pemphigus neonatorum, its confinement to the very surface of the skin, its frequent lack of constitutional symptoms, its self-limitation, and its duration, all correspond

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to what we know of impetigo contagiosa. We know also that impetigo contagiosa, even in adults, may be a bullous disease, and that it is particularly apt to be so in

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FIG. 3789.—Dr. H. M. Sherman's Case of Acute Pemphigus, Probably Infective, in Full Eruption.*

the tropics. In infants, who are always kept very warm and whose skin is delicate, the tendency to form bullæ, even in temperate climates, is marked. It is also urged in favor of this view that if an infant is infected from an adult who has impetigo contagiosa it gets pemphigus neonatorum, and vice versa if an adult is infected from an infant having pemphigus neonatorum he gets impetigo contagiosa (Matzenauer). Luithlen has shown that the bleb in pemphigus neonatorum is caused by separation of the horny layer from the rete Malpighii. This anatomical finding of the superficial situation of the bleb corresponds with what we know of its clinical appearance and behavior, for it will be remembered that the bleb has a thin delicate covering and heals with great rapidity, and it also corresponds with what we know of the very superficial character of the lesions in impetigo contagiosa.

Treatment.—It has been found that pemphigus neonatorum occurs with noticeable frequency in the practice of uncleanly midwives and nurses, and therefore a thorough personal disinfection of these should be required. It is with a view to getting on the track of such disease carriers that the Berlin authorities have ordered all cases of pemphigus neonatorum to be reported to the health office.

If it be true that pemphigus neonatorum and Ritter's disease are simply forms of impetigo contagiosa, then the parturient woman and the infant should be carefully shielded from this very prevalent disease. Attention is here drawn to the facts that many cases of what are commonly called barber's itch in men and impetiginous eczema in children are really impetigo contagiosa, and that impetigo contagiosa is so frequent, particularly in children, that a skin clinic is scarcely ever without examples of it.

As the infants attacked rarely suffer from constitutional symptoms, and the disease is generally short and self-limited, no internal treatment is required. If, however, constitutional symptoms do arise, such as fever and exhaustion, they must be treated on the principles obtaining in such cases, as no specific treatment is known. As the malady is contagious and is scattered over the entire cutaneous surface, a general cutaneous antiseptic treatment is indicated. The antiseptics chosen, however, must be those that will neither injure the infant's delicate skin nor by absorption cause constitutional symptoms. In regard to absorption, it must be remembered that the thin skin of the infant more readily absorbs medicaments than the stronger, thicker skin of later life. As fulfilling these indications, two antiseptics come to mind: alcohol and boracic acid. Boracic acid may be used in the infant's bath in the proportion of about four ounces to the gallon, and a lotion consisting of a saturated solution of boracic acid in dilute alcohol, may also be used as a rub-down. This solution, by the way, is one of the best to use in any case of pyogenic infection of the skin. It may be readily made by the family in the following way: A bottle is half-filled with alcohol, then nearly filled up with water, and then boracic acid is poured in until some of it remains undissolved in the bottom of the bottle after shaking. The supernatant fluid is of course a saturated solution of boracic acid. When an ointment is necessary or desirable, as on the face or in the flexures, a weak ammoniated mercury ointment is the best; it is made by adding five grains of ammoniated mercury to an ounce of vaseline. When crusting takes

* The instance of acute bullous eruption, the subject of these photographs (Figs. 3789 and 3790), occurred in the practice of Dr. H. M. Sherman of San Francisco. The patient was a boy, seven years of age, who had been operated upon for tuberculosis of the right knee-joint. Subsequently to the operation sinuses formed, discharging a bright green pus. The eruption then appeared behind the ears and on the neck, and spread rapidly over the head, trunk, and extremities, even to the fingers and toes. The eruption consisted of blebs only. The contents of these blebs were clear at the start, and remained clear throughout their entire course, and there was no evidence of any inflammatory reaction of the skin. There was no rise of temperature, nor was there any disturbance of the general health; the eruption disappeared at the end of a few days. No bacteriological examination was made. This was probably an instance of an acute infective pemphigus, the exact nature of which is not known.

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place, the crusts must be removed before either lotions or ointments may be expected to be of any use. This is best done by applying boracic acid starch poultices. These are made by adding hot water to ordinary laundry starch while constantly stirring, to make a moderately thick paste. To a large teacupful of the paste a heaping teaspoonful of boracic acid powder is added, and it is then poured into a thin muslin bag and applied.

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Acute Febrile Pemphigus.

Acute febrile pemphigus is a very rare disease of which Köbner has formulated the following requirements: After brief prodromes, and after fever has begun to show itself, blebs appear on the previously healthy skin. The fever continues with exacerbations and remissions, and at the same time there are repeated outbreaks of blebs. The blebs are not confined to any particular region of the cutaneous surface, but occur in a scattered manner. After three or four weeks the bullous eruptions subside completely and do not recur. No blebs should appear at a time when no fever is present. It will be observed that the only real point of distinction between pemphigus neonatorum and generalized bullous impetigo of the adult on the one hand and acute febrile pemphigus on the other is a rise of temperature in the latter. Richter, however, has shown that there may be even a severe constitutional disturbance with fever in pemphigus neonatorum, and it is not improbable that in some instances of generalized bullous impetigo there may be fever, so that these three diseases may be identical. There is, however, a still much more severe febrile bullous disease, which has been described by Pernet and Bulloch. Their cases were acute septicæmias; in both instances they occurred in butchers, and followed knife wounds. Probably in the same class are the bullous septicæmias occurring in inflammatory diseases of the umbilical cord, or the bullous septicæmias in the new-born, coincident with septicæmia in the mother. The affection on the skin in such cases may look like an extensive burn with scalding water. These grave bullous diseases seem in many instances to be different from what is understood in speaking of pemphigus neonatorum.

No specific internal treatment has been outlined for pemphigus febrilis. The external treatment would be that advised for pemphigus neonatorum.

Pemphigus Chronicus Vulgaris.

Definition. — Pemphigus chronicus vulgaris is characterized by the appearance of blebs on the skin and also on the mucous membranes. Pemphigus foliaceus and pemphigus vegetans are to be looked upon as varieties of pemphigus chronicus vulgaris. They are worthy, however, on account of their peculiar clinical appearance and course, of a separate description.

Etiology.—The cause of pemphigus is unknown. That it is not merely a local, but a constitutional, disease is shown by the fever that accompanies it, and also by the more or less rapid deterioration in the general health of those afflicted with it. That few blebs on the surface of the body should cause cachexia and death is not to be thought of as a possibility. The blebs are only one symptom of a general constitutional disease. Take, for example, pemphigus vegetans when at times the blebs cease to appear. This temporary cessation of the appearance of the blebs does not seem to retard in the least the general course of the disease.

The occurrence of blebs in diseases of the nervous system, in nerve injuries, and in neural leprosy has led many to think that pemphigus is a disease of the nervous system. These are the only facts, however, that favor this view. That the disease is due to some toxic substance that acts through the nervous system, in some such way as an intoxication with rotten fruit will cause urticaria, is not impossible.

Symptoms.—Pemphigus vulgaris frequently commences with general as well as with cutaneous symptoms. The general symptoms are fever, malaise, gastric disturbance, sleeplessness, and decided nervousness. With these symptoms there appears on the skin a greater or less

Fig. 3789.—Stage of Convalescence from the Attack of Acute Pemphigus. (Same case as that shown in Fig. 3790.)

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number of blebs, which may come in crops, each crop being accompanied by an exacerbation of the constitutional symptoms. The course of the disease may present great variations. In the first place the initial crop of blebs and those following may be accompanied by very little rise of temperature or none at all, or there may be much constitutional disturbance, with very little eruption, or the reverse. The outbreak of blebs and the constitutional disturbance may be continuous, reducing the patient's strength very rapidly; or the disease may begin acutely and stormily, gradually linger on for weeks or months, and finally die down altogether, possibly to

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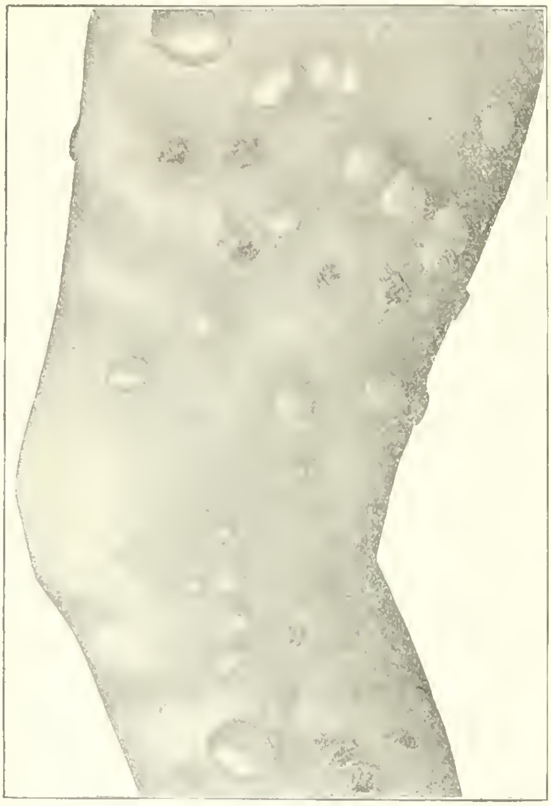

FIG. 3791. Chronic Pemphigus Vulgaris. In the picture the bullæ can be seen with great distinctness to be full, tense, hemispherical and oval, variable in size and springing from a skin, which is, to all appearances, healthy. In some places there are vestiges of old bullæ that have gone through their evolution: some are broken, others are dried down. There are no evidences of scratching. (From a plate in L. Brocq's article on Pemphigus in "La Pratique Dermatologique" par Ernest Besnier, L. Brocq, and L. Jacquet, t. iii., p. 770. This figure is a reproduction of an aquarelle in Cazenave's collection in the Museum of the Hôpital Saint Louis, and had already been published in the "Leçons sur les maladies de la peau" par Alphée Cazenave, 1856.)

start up again at some future time. The blebs arise either from what appears to be a normal surface or from a reddened spot, and are at first filled with a fluid either as clear as water or of a yellow serous appearance, or red or brown or blue from mixture with blood. In any case this fluid quickly becomes turbid then purulent. The blebs may be the size of a pea or a hen's egg, or even larger. After a time the blebs either dry down, forming a scab, under which healing takes place, or they may break spontaneously or be broken, leaving a non-infiltrated eroded surface upon which there forms a flat, yellow, brown, or black scab. In due course this scab falls off, leaving a more or less deeply tinted brown pigmented patch, but rarely a scar. At times, after healing, milium bodies, first described by von Bärensprung, are found in the epithelium.

On the mucous membranes the lesions are rarely seen as blebs, because the delicate and moist epithelial layers soon burst, leaving non-infiltrated erosions, which are either red or covered by a yellowish coating. The circular or polycyclic form of these erosions, together with the tatters of epithelium around their borders, show their origin as blebs. On either the skin or the mucous membranes any individual lesion may stop short of forming a bleb or an erosion as the case may be. On the skin such a lesion would be merely an erythematous spot, while on the mucous membranes it would show itself as a whitish-gray epithelial thickening. In pemphigus there may be no eruption whatever on the mucous membranes, or the outburst on the mucous membranes may precede, be simultaneous with, or follow the eruption of blebs on the cutaneous surface. Mosler and Köbner have seen pemphigus of the mouth exist for four years before there was an outbreak on the skin.

As has been said, it is very rare for scarring to follow pemphigus blebs on the skin. It is also rare, but not so rare, for scarring to occur on the mucous membranes. What is equivalent to scarring occurs on the conjunctiva, constituting what has been called essential shrinking, but this will be considered later on. Sometimes the erosions on the mucous membranes, especially of the mouth, ulcerate. Probably these ulcerations are not an essential part of the disease, but adventitious from the increased vulnerability of the eroded surfaces, and also from infection, usually with staphylococci or streptococci. In the same way pemphigus may be accompanied by lymphangitis and adenitis, the broken mucous membrane being the open door for the entrance of bacteria. It is said that ulceration in the cheek pouches may result in so much cicatricial tissue as to interfere with the action of the lower jaw. Pemphigus of the throat may cause hoarseness, suffocation from swelling of the glottis or of the mucous membrane of the larynx, a feeling as if a fish bone had lodged in the throat, or a disagreeable feeling of rawness. In pemphigus of the mouth or throat the interference with mastication and the difficulty or impossibility of swallowing solid food add to the misery and weakness of the patient.

As in pemphigus of the other mucous membranes blebs on the conjunctiva are very seldom seen. It may be that they very rarely form, or that if they form they quickly burst. The pemphigus lesion as seen on the conjunctiva consists of an irregular-shaped membranous exudation of grayish-white or grayish-yellow color. Pemphigus of the conjunctiva is almost always followed by cicatrization. It is not meant by this that every pemphigus lesion on the conjunctiva is followed by scar formation. In fact almost all the lesions here, as on the skin, heal without leaving a scar. It seems necessary to scar formation that a number of pemphigus lesions should occur successively at one place (Michel), and, as this often happens, scar formation frequently results.

The scars may be localized, or they may involve almost the whole of the conjunctiva. If they are thus generalized, the conjunctiva will be turned into a dirty gray or whitened, thickened, cutis-like membrane, with a dull dry surface. This is the condition that has been called "essential shrinking." With much shrinking the entire conjunctival sac may be obliterated, and one or both lids may be entropioned, or drawn tight down on the edge of the cornea. In such cases the cornea itself is diseased from exposure, and from the eyelashes of the entropioned lids sweeping over it. It is white and opaque, and its surface is dull and dry, and covered with scaling epithelial cells. Michel never has seen a bleb of the cornea itself, but he quotes Seggel as having seen one, and Mueller as having seen an ulcer covered with a membranous exudation on the upper border of the cornea and on the neighboring conjunctiva; Pergens has also seen a broken bleb of the cornea in an infant.

Pemphigus of the conjunctiva may exist alone or with pemphigus of other mucous membranes such as the mouth, pharynx, trachea, or bronchi, or with pemphigus of the skin. It is held that a diagnosis of pemphigus,

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when the mucous membranes alone are effected, cannot be made. It seems, however, that the clinical picture is clear enough, and that such lesions are pemphigus is shown by the fact that after existing for a longer or shorter time pemphigus of the skin may supervene. Just as there can be a pemphigus of the skin alone without pemphigus of the mucous membranes, so also can there be a pemphigus of the mucous membranes without pemphigus of the skin (Kaposi).

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Eosinophilia, either in the blebs or in the blood of the general circulation, seems to have very little value as a symptom.

Diagnosis.—In dermatitis herpetiformis the mucous membranes are not apt to be affected; the lesions on the skin are multiform and consist of erythematous patches, papules, wheals, vesicles, and bullæ; the itching and pain are severe and occur in distinct attacks; and the general health is undisturbed.

In epidermolysis bullosa the disease occurs in families and is hereditary; the bulla occurs when an injury has been received, even a slight pressure, as on the feet and hands, may cause it; and the general health is unimpaired. Colcott Fox has, however, reported a case in which the disease resembled epidermolysis in every particular except that it was not hereditary, and he warns against drawing too fine distinctions between it and pemphigus. In epidermolysis bullosa the nails also frequently grow to be deformed, and the disease is probably something more than a mere over-sensitiveness of the skin to pressure. Another instance showing the intimate relationship between these two diseases is the case reported by Mertens, in which there was pemphigus of the mouth, throat, and conjunctiva. Blebs appeared also on the skin, but only after trauma.

The vesicular and bullous eruptions that sometimes follow trauma and also those that sometimes follow vaccination, and that in either instance may last for years, resemble more closely the type of dermatitis herpetiformis than that of pemphigus. Just where they stand, however, in a classification, has not yet been determined.

Quinine, iodine, bromine, and copaiba may all cause bullous eruptions that have to be differentiated from pemphigus.

The blisters caused by the external application of drugs must also be considered. Sometimes such drugs are applied with the intention of deceiving. The occurrence of the blebs exclusively on the skin in an hysterical person in situations easily reached by the patient may cause suspicion. The wings of the Spanish fly have been found on the blebs.

Hardy mentions the occasional occurrence of blebs on the hands and feet in eczema. I have seen this occur in two separate attacks of eczema in the same patient. Bullæ may also occur in lichen planus (Whitfield). The differentiation would here be made by the presence of the lichen papules and by the itching.

In impetigo contagiosa the eruption, as has been previously mentioned in the section on acute pemphigus, may be bullous even in the adult. This is particularly apt to occur in the tropics. The swift course of the disease, its marked contagiousness, its non-interference with the general health, the very large yellow superficial crusts, and the occurrence of pustules should put one on one's guard.

Prognosis.—Pemphigus is one of the few diseases of the skin in which the life of the patient is threatened.

In such a capricious disease the prognosis is always uncertain. Cases that begin benignly may end malignantly, and vice versa. Nevertheless there are indications that point to a good or bad course of the malady. Luithlen, for instance, divides pemphigus, in regard to prognosis, into two classes of cases. In the first class the blebs appear on erythematous patches, and there is no rise of temperature. In these cases the blebs are situated in the epithelium, and the rete is not raised away from its bed on the papillary layer. The prognosis here is favorable. In the second class of cases the blebs arise on the perfectly sound skin, and their eruption is accompanied by fever and exhaustion. In this class the blebs arise under the rete and lift it completely away from the papillary layer. The prognosis here is always unfavorable.

When the blebs are tense and filled with a clear white or amber-colored fluid this fact is viewed as a favorable sign; while, on the other hand, when the blebs are slackly filled and pus quickly forms, collecting as an hypopyon in the dependent portion of the hanging bag, the outlook is bad.

In pemphigus of the mouth and throat the difficulty or impossibility of swallowing solid food interferes with the patient's nutrition. Independently of this, however, the occurrence of pemphigus of the mucous membranes may be looked upon as an ominous sign. In general, in those cases in which the mucous membranes are affected at the very first or early in the disease, the prognosis is the worst; but no matter at what time in the course of the malady the mucous membranes are affected the symptom is a bad one.

Pemphigus Foliaceus.

That form of pemphigus which is called pemphigus foliaceus has for its chief clinical characteristic the exfoliation of the skin. There may be very few blebs; indeed, when the disease is well under way and the exfoliation is active there may be no blebs at all.

Pemphigus foliaceus may attack either sex, at any age, even in childhood. The disease appears in all countries, and does not seem to depend in any way on climatic influences. It is neither epidemic nor contagious.

It is said that prodromal symptoms are either absent or are not at all well marked, and that when present, they consist in a feeling of general lassitude and a slight rise of temperature. The first symptoms of the disease proper may appear on any part of the skin, or on the mucous membrane of the mouth. The blebs in pemphigus foliaceus, even at first, generally differ from those in ordinary pemphigus. Instead of being large, clear, and bubble-like, they are small, slackly filled, and slushy, with a delicate covering that soon breaks. The blebs often have a reddish tint from the red color of the injected blood-vessels shining through the thin layer of fluid and the very delicate covering of the bleb. The erosion left by the first bleb that appears in a given locality enlarges by undermining of the surrounding epidermis, and, moreover, new blebs form in ever-widening circles about the site of the first, which by this time will probably have healed. But when this healing takes place it does not end the process. It is just at this point that the most prominent characteristic of the disease and the one to which it owes its distinctive title of foliaceus begins. Serous exudation continues to be poured out rather into than under the newly formed, but by no means normally formed, epidermis. This exudate and the epithelial layers into which it is poured form leaflets resembling French pastry; hence Cazenave's epithet foliaceus as applied to this form of pemphigus. The loosening of the attachment between the layers of the epidermis is also a remarkable phenomenon in pemphigus foliaceus, and may be demonstrated by drawing the finger firmly along the apparently sound skin. The top layers of the epidermis will slip off, leaving an excoriation. This slipping of the epidermis is found in other forms of pemphigus, but is particularly well marked in pemphigus foliaceus.

By the spread and coalescence of diseased patches the whole cutaneous surface tends to become involved. This generalization may take place in a few days, or may not be completed before several months have elapsed.

From the above description one can understand that the appearance of the patient will differ widely according to the stage at which the disease is seen. There may be groups of circinate patches of miserably formed bullæ, or there may be circular patches covered with yellow crusts, or the whole skin may be bluish or brownish-red and actively desquamating, with here and there raw patches, but yet with very little weeping. The skin in pemphigus foliaceus is only moderately or not at all thickened.

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Gradually other changes occur. The hair falls out. The eyelids become ectropioned and their lashes fall. The nails atrophy.

At first the general health of the patient remains unaffected, but gradually, through the uncomfortable condition of the skin, the occasional fever, the sleeplessness aggravated by severe attacks of itching, the constitution becomes undermined. The patient becomes thin and poorly nourished, then through complications, either in the lungs, or intestines, or kidneys, he is carried off.

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It is said that pemphigus foliaceus, after existing for a longer or shorter time as such, may turn to the type of pemphigus chronicus vulgaris (Kaposi).

Diagnosis.—The most important disease to differentiate from pemphigus foliaceus is dermatitis herpetiformis in its generalized exfoliative form. The two diseases are at this stage so closely alike that only a very clear history or a continued observation of a patient enables one to come to a definite conclusion. Severe attacks of itching, the occurrence of the vesicles or bullæ in groups, and only slight interference with the general health should lead one to suspect the disease in question to be dermatitis herpetiformis.

Pemphigus Vegetans.

In pemphigus vegetans the denuded areas left by the blebs, instead of healing over, sprout peculiar vegetations. This is one of the chief characteristics of this variety of pemphigus, and the one to which it owes its distinctive title of vegetans. It is, however, not the only point of difference between it and ordinary pemphigus. The individual cutaneous lesion is usually smaller and more flabby, the contents are more turbid, and the covering of the bleb is more delicate than in pemphigus vulgaris. The blebs and the subsequent erosions may, however, resemble those of pemphigus vulgaris in every respect up to the time when the vegetations sprout.

The bullæ appear suddenly on an apparently healthy surface, and are generally delicate and soon break, leaving smooth, deep, red excoriations exuding an abundant, foul-smelling serum. The border of both the bleb and its succeeding excoriation remains sharply limited, and there is no infiltration. The vegetations may be present before the bleb breaks, but more frequently they appear in the erosion, at first as a rounded, prominent, dirty white elevation, in the centre of which the vegetations sprout. This process slowly extends out over the entire excoriation and even beyond it. This growth is surrounded by a zone of dark red erosion, which in turn is bounded by a collar of loosened macerated epithelium. The vegetations are closely bunched, their free surface is necrotic, excoriated, and dirty, and they have in their substance many pinhead-sized pustules, giving them a stippled look.

Many of the vegetations are flattened across the top, and, although larger than the broad condylomata of syphilis, look strikingly like them. By individual increase in size neighboring lesions coalesce with one another, forming large patches with serpiginous boundaries of tattered, ragged epithelium. As a rule the lesions on the tongue and mucous membrane of the mouth and lips resemble those seen in pemphigus vulgaris, but they may also become vegetative, although these vegetations do not reach anything like the size or extent of those seen on the skin.

The disease may begin by the appearance of blebs on any part of the skin or mucous membranes, but it is particularly apt first to show itself in the mouth. Spiegler has recently said that of twenty-eight cases of which he had known, eighteen began with lesions in this situation.

It is only in bad cases that all the lesions on the cutaneous surface become vegetative. In certain regions, as in the naso-labial and labio-mental grooves, in the armpits, groins, and navel, and on the belly, the lesions are particularly apt to sprout vegetations.

The constitutional symptoms, such as sleeplessness, fever, and loss of strength, are present as in pemphigus vulgaris, but are usually more marked.

The *prognosis*, although commonly far worse than in pemphigus vulgaris, is by no means fixed.

In all medicine there is no disease with a more dramatic course than that of pemphigus vegetans. For instance, a man consults a physician in regard to an insignificant erosion in the axilla. A simple treatment is prescribed. He appears shortly again with some vegetations on the erosion. These may be cauterized, and the patient dismissed without any thought of the serious nature of the malady. The lesion, however, does not heal, and new excoriations and blebs appear, especially about the privates, with coincident dirty white patches in the mouth. At the same time the patient gives off a most horrible carrion-like odor. He shortly becomes a miserable, fulsome, horrible object to himself and others; and, to add to his miseries, there is often the moral degradation of being thought to have syphilis. Inanition from refusal of nourishment, fever, exhaustion, marasmus, spinal irritation, and acute œdema of the brain succeed one another rapidly, and in a few weeks or months the patient dies.

Where the lesions first appear is a matter of importance in the prognosis, for in those cases in which the lesions begin on the lips, in the mouth, on the scalp, or on the genitals the prognosis is bad.

Not all the blebs in a case of pemphigus vegetans become vegetative, and when only a few of them sprout vegetations the prognosis approaches more that of pemphigus vulgaris—that is to say, it is serious, but not necessarily fatal. On the other hand, the more blebs there are that become vegetative, the more quickly does the disease terminate in death.

Necrosis of the surface of the vegetations is the rule, and the more marked the necrosis the worse the outlook for the patient. If, however, this necrosis does not take place, and the vegetations tend to become covered with horny epithelium, the patients may recover and live for years (Neumann).

It is not an absolute rule that a pemphigus vegetans should remain as such throughout its entire course. In general, the vegetations cease appearing as a fatal termination approaches, and Kaposi has demonstrated a patient in whom pemphigus vegetans healed, but the disease returned some time afterward as a pemphigus cachecticus.

As above shown, the estimate of the course which a given case should take may be modified by a number of considerations, such as the severity of the constitutional disturbance, the localities where the lesions first appear, and the abundance and the dirty necrotic condition of the vegetations. The beneficial effects of treatment have also helped to modify the unmitigatedly bad opinion previously entertained of the course of pemphigus vegetans. Under drying disinfecting powders the prognosis has improved, and Köbner, Mueller, Kaposi, and Mraçek have reported cases showing at least temporary relief or cure.

The resemblance of pemphigus vegetans to syphilis is striking. The white patches in the mouth resemble absolutely the mucous patches of syphilis, and the vegetations, especially the button-like ones, differ in no respect, except in their larger size, from the broad condylomata that were at one time supposed to be found only in syphilis. These symptoms, together with the situation of the patches, especially those in the groins, in the folds between the thighs and the scrotum, and in the anal fold, all go to form a picture that is in the highest degree deceptive. There are differences, however, which aid in distinguishing the two diseases. For instance, the growths in pemphigus are always surrounded by the tatters of the blebs, while in the confluent condylomata of syphilis the patches are bounded by sharp infiltrated borders. Furthermore, the condylomata in syphilis always occur at an early stage of the disease and are accompanied by other symptoms of syphilis. In syphilis the growths when left to themselves tend to subside, while in pemphigus the longer the disease lasts the more

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the growths increase; and while they grow, the general condition of the patient becomes worse and worse. Furthermore, pemphigus vegetans is a disease of adult life, and the presence of blebs is unknown in the course of syphilis of adults.

Post-bullous vegetations are not absolutely pathognomonic of pemphigus vegetans, as in rare instances they occur in several other affections, such as in dermatitis herpetiformis, impetigo contagiosa, and in the iodine (Hallopeau) and bromine (Wallhauser) eruptions. Post-bullous vegetations also occur in impetigo herpetiformis, but impetigo herpetiformis is by many observers now considered a clinical variety of pemphigus vegetans.

Treatment.—The outlook for the cure of any given case of pemphigus, through either internal or external medication, is not good, yet much may be done to alleviate the symptoms and to stay the progress of the disease.

Arsenic.—So many have praised the effect of arsenic in pemphigus that it should be the first drug to receive a trial. The favorite way of giving it is as Fowler's solution, in increasing doses, beginning with six drops, and, as some advise, running up to twenty or thirty drops a day. Very high doses of arsenic are of questionable benefit as they depress. If such high doses are used it is entirely for their specific effect, and as soon as they are found valueless they should be stopped. On the other hand, small doses, on account of their tonic effect, may be continued for a long time.

Strychnine. — Neisser has recommended strychnine. Its only effect seems to be that of a powerful tonic, useful in combating the great exhaustion, which is so frequently a marked feature of the disease.

Quinine.—Mosler has reported an apparent cure after taking 40 gm. of muriate of quinine in five weeks (Jarisch). In most cases, however, it acts simply as a bitter tonic.

Acids.—Dilute sulphuric acid, acetic acid, and citric acid have been recommended, but no specific action can be attributed to them. They probably act as tonics.

Opium.—Opium besides being a soporific is said by Malcolm Morris to be one of the best curative agents we possess.

Chloral hydrate is an excellent drug for the sleeplessness which is a marked symptom in some cases of pemphigus.

Ordinarily the simplest measures may be employed to relieve the local conditions. Frequently a mild antiseptic powder, made, for instance, of equal parts of boracic acid, starch, and oxide of zinc, is all that is required. If the tension of the blebs is uncomfortable they may be opened, and the above powder may be used to soak up the secretions, and to prevent the excoriations sticking to the bedclothes. If there are much heat and inflammation, or if pus is retained under the crusts, mild antiseptic lotions or salves may be the best topical applications. Lotions will be mentioned after speaking of baths. A red oxide of mercury salve is excellent: ℞ Hydrarg. ox. rub., ʒ ss.; lanolini, vaselin. alb., āā ℥ ss. M. S.: Apply on cloths.

Carbonate of lead, employed as a salve, is also good: ℞ Plumbi carbonat., ʒ i.; lanolini, vaselin. alb., āā ℥ ss.

Baths.—The continuous bath, when it can be obtained, is of the greatest comfort in severe cases. It relieves the tension and pain, softens the crusts, mitigates the fever, and induces sleep. With its help a patient may be carried through an eruptive attack that would otherwise have killed him. Hebra's water-bed is excellent for the purpose. (Fig. 3792.) It consists of a box or bath lined with zinc, with a plug and overflow pipe at its foot, and the feed pipe with hot and cold water mixed, entering at the head of the bath near its bottom. The temperature should be maintained at about 36° or 37° C.

The patient rests on a wire netting over which are thrown woollen blankets. This wire netting may be raised and lowered as wished. After the patient is lowered into the water the bath may be covered over with blankets for the purpose of retaining the warmth.

When such a bed is not obtainable, the patient may be put in a bath for several hours a day. Soothing or antiseptic medicaments may be added to the bath, as for instance one or two drachms of permanganate of potassium, or a couple of tumblerfuls of boracic acid powder, or biborate of soda, or bicarbonate of soda, to sixty gallons of water. It must be remembered that there are people to whom baths are debilitating, and on whom, in such an asthenic disease as pemphigus, their use would be particularly disastrous. In such cases we must content ourselves with compresses either wrung out of simple water or wet with medicated lotions. These compresses may be covered in either with oil silk or with rubber tissue. Hutchinson's lotion is an excellent one for allaying inflammation, irritation, and itching. It consists of: ℞ Liq. plumb. subacetatis, ℥ ss.; liq. carbonis detergentis, ℥ iiss. M. S.: A teaspoonful in a pint of water, to be used as a lotion.

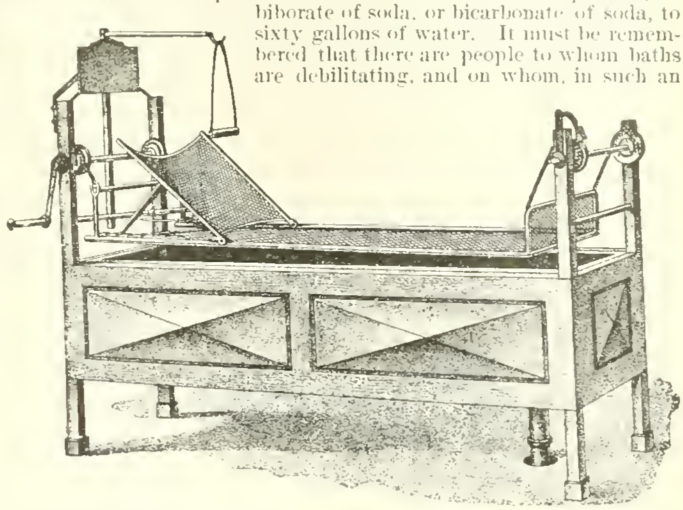

FIG. 3792.—Hebra's Contrivance for Administering a Continuous Bath. (From Jarisch's "Hautkrankheiten," in "Nothnagel's System.")

Other solutions to be used on compresses are those of acetate of aluminum, saturated solution of boracic acid, and liquor plumbi subacetatis. Carron oil, made with equal parts of lime water and olive oil, with the addition of four per cent. of boracic acid, is one of the best applications in pemphigus, and is especially useful in the dry scaly condition in pemphigus foliaceus.

Treatment of Pemphigus Vegetans.—Unna introduced a treatment of pemphigus vegetans which consisted of painting the lesions with tincture of iodine. This treatment is so painful that the patient must be anæsthetized, and on awaking must receive full injections of morphine. Köbner first curetted away the vegetations or burnt them down with the thermo-cautery; then afterward he treated any vegetations that appeared with tincture of iodine.

Jarisch said he saw the lesions in a typical case of pemphigus vegetans clear up with wonderful celerity under a paste consisting of: ℞ Sulphur. præcip., zinc. ox., amyli, āā 10.00; vaselin. flav., 30.00. M. S.: Spread on linen and apply or rub into patches, and dust with some indifferent powder, such as oxide of zinc and starch.

In pemphigus vegetans, however, these measures for controlling the vegetations, no matter how successful locally, have no effect on the course of the disease. The general symptoms of sleeplessness and exhaustion go on unchecked. In fact it is the rule for the vegetations spontaneously to cease appearing as the fatal termination approaches.

Neumann found solutions of salicylic acid applied on

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cotton an excellent deodorant for the foul odor present in pemphigus vegetans. A powder made of equal parts of talc and salicylic acid may also be used.

In looking over the literature of the drugs and applications used in pemphigus, one cannot fail to note everywhere a tone of helplessness, with perhaps a slight brightening up when the continuous bath is mentioned. The good effect [illegible] may, in almost all instances, be reduced to their tonic or sedative action, and of the external remedies to their soothing effects, their power to diminish tension and burning, or to control the evil odors and the undue activities of the pyogenic bacteria. The treatment, it is true, is still far from our ideal of what effective treatment should be. Nevertheless, we have grounds for claiming that the actual advance made in the treatment of pemphigus is by no means so small as upon first thought it would seem to be. Thanks to Neumann's discovery of the true nature of pemphigus vegetans we are now able to save many a patient from the mental worry and humiliation of being thought to have a syphilitic disease, and from the physical suffering which he would have to undergo before it could be demonstrated by treatment that this diagnosis was incorrect. *Douglass W. Montgomery.*

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PENIS, DISEASES OF. See *Sexual Organs, Male, Diseases and Injuries of.*

PENNYROYAL, AMERICAN OR MOCK.—*Hedeoma.* "The dried leaves and tops of *Hedeoma pulegioides* (L.) Pers. (*Mentha p.* L.; fam. *Labiatæ*)." U. S. P.

This is a slender annual herb very abundant in dry, especially rocky meadows and pastures throughout Eastern and Central North America. The base of the stem is frequently decumbent. The upper portion is usually much branched, the branches are slender, erect or ascending and quadrangular, the leaves opposite, slenderly petioled, blades usually less than 2.5 cm. (1 in.) long, and 1 cm. (½ in.) broad, oblong ovate, narrowed gradually into the petiole, obtuse, distantly and shallowly serrate, pale or grayish-green, thin, with few, strongly ascending secondary veins, and the lower surfaces beset with small, circular, depressed glands, which are usually golden yellow and shining under a strong lens; flowers several in a leaf axil, pedicelled, the calyx tube cylindraceous, somewhat contracted at the mouth, strongly nerved, its tube two lipped and slenderly and sharply five-toothed, corolla tubular, two lipped, pale blue, spotted; stamens four, two of them sterile, odor strong, somewhat mint like; taste aromatic and pungent.

With a little tannin and bitter extractive it contains nearly one per cent. of a volatile oil, official under the title *Oleum Hedeomæ*, which is its active portion.

American pennyroyal possesses the carminative, aromatic, and diffusive stimulant properties of the mints in general, and is similarly employed. There is no official preparation, but an infusion is probably the best form of administration. One of the important properties of this plant and of its oil is that of repelling mosquitoes, to a considerable and useful extent.

Oil of pennyroyal is thus described: A pale yellowish, limpid liquid, having a characteristic pungent, mint-like odor and taste. Specific gravity 0.930–0.940 at 15° C. (59° F.). The oil should form a perfectly clear solution with twice its volume of a mixture of three volumes of alcohol and one volume of water, this solution being neutral or slightly acid to litmus paper. It is also readily soluble in carbon disulphide, or in glacial acetic acid. It consists chiefly of pulegone. The dose is 1–5 minims. The genuine or European pennyroyal is *Mentha Pulegium* L. (*Pulegium vulgare* Mill.) in the same form. It has a similar taste and odor, and contains an almost identical volatile oil. *Henry H. Rusby.*

PENTAL (*Trimethyl-ethylene*), a purified amylene, introduced by Mering as an anæsthetic. It is a colorless liquid with a sharp penetrating odor, but not irritating to the mucous membrane. Specific gravity 0.8; boiling point, 100.4° F. It is insoluble in water, but mixes freely with alcohol, chloroform, and ether.

Pental is administered in the same manner as chloroform. Anæsthesia is produced in three or four minutes and lasts for about four minutes.

Following its introduction pental was employed by many as an anæsthetic, with very satisfactory results, but experimental work upon animals proved that it was a powerful cardiac depressant, and also produced marked renal irritation. Many instances of dangerous depression during its use and several deaths were soon reported, and it rapidly fell into disuse. *Beaumont Small.*

PENTASTOMA. See *Arachnida.*

PENTOSURIA is the term applied to the occurrence of sugars of the five-carbon series (pentoses) in the urine. The pentoses ($C_5H_{10}O_5$) include the carbohydrates arabinose, xylose, and rhamnose ($C_6H_{12}O_5$), the latter being a methyl pentose. The appearance of sugars of this type in the urine was first detected by Salkowski and Jastrowitz in the urine of a morphine habitué. Since then similar observations have been made on various individuals. In some of these instances the pentosuria has been found to persist unchanged for many months and even for several years. The pentose either occurs as the only carbohydrate present in noticeable amount, or it may accompany dextrose, the sugar of ordinary glycosuria.

Various methods of testing for pentoses in the urine have been proposed. Of these the following are most widely used.

Tollens' Reaction with Phloroglucin and HCl.—A small quantity of phloroglucin is dissolved in 7–8 c.c. of HCl (specific gravity, 1.12) with the aid of heat. After cooling, ten drops of the urine are added to one-half of the reagent, and the mixture is immersed in a boiling water-bath. In the presence of pentoses a cherry-red coloration quickly results. An immediate spectroscopic examination reveals a characteristic absorption band between the D and E lines. The remainder of the reagent is used for a control comparison with normal urine. The presence of dextrose may interfere with the reaction. (Salkowski's modification.)

Tollens' Reaction with Orcin and HCl.—The urine is mixed with an equal volume of fuming HCl containing orcin (instead of phloroglucin) and heated. After cooling it is shaken with amyl alcohol, which assumes a greenish tint. In this reaction the characteristic spectral absorption band is between C and D. Salkowski prefers the orcin test to all others.

Reaction with Aniline-acetate Paper.—The urine is treated with an equal volume of fuming HCl and heated to boiling. If a strip of filter paper, moistened with aniline acetate, is now immersed in the fluid, it is quickly colored cherry red by the furfurol formed from the pentoses present.

Liberation of Furfurol by Distillation with HCl.—The method is essentially the same as that used in the estimation of the pentosans in foods. The furfurol may be detected in the distillate by the use of aniline-acetate paper. Normal urine or urines containing dextrose or lactose do not ordinarily give any positive reaction.

Preparation of a Pentosazone.—The osazone is prepared with phenyl hydrazin and acetic acid as in the ordinary tests for sugar. (See *Urine.*) The pentosazone is characterized by: (1) Its greater solubility as compared with glucosazone; and (2) its melting point, 156°–160° C. When large quantities of dextrose are present, they may previously be removed by fermentation with yeast. The pentoses do not ferment, but they reduce alkaline copper solutions.

Preparation of the Benzoyl Ester.—The benzoyl esters are prepared from 500 c.c. of urine, then saponified with sodium ethylate and the mixture is filtered at once. The filtrate will give the orcin reaction for pentoses (see above) and glycuronic acid is said to be excluded. When dextrose is present slight modification of the method is desirable. (Von Alfthan.)

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In considering the possible origin of the pentose found in the urine, the wide distribution of the five carbon carbohydrates in the vegetable kingdom, as shown by Tollens and others, must be recalled. In the form of pentosans they may enter into the diet. Such precursors of the pentoses occur in certain fruits, like cherries and plums for example. In animal tissues precursors of the pentoses are also found, notably in the pancreas, from which the carbohydrate may be obtained, combined as a glyconucleoproteid. Neuberg has shown the pancreas pentose to be *l* xylose. When fed as such, the pentoses are apparently not well assimilated. Regarding their occurrence in the urine, it seems probable from the meagre data at present available that we must look to metabolic processes for an explanation. For there is no evidence that the diet in the cases on record was particularly rich in pentoses, and in one instance at least pentoses were excreted for a long period on an ordinary diet. Furthermore, the urine pentose is the optically inactive racemic arabinose, and is probably a synthetic product. The pentosuria seems comparable to those perversions of metabolism which are seen in severer forms of diabetes in which the sugar excreted is independent of the diet. In accord with this are the observations of Külz and Vogel on diabetic patients and on dogs suffering from experimental diabetes. They were able to detect pentoses in company with the dextrose present in the urine in several cases. Regarding the immediate precursor of the urine pentose in the body nothing definite is known at present.

Lafayette B. Mendel.

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PENZANCE AND THE SCILLY ISLANDS.—These two localities on the extreme southwestern coast of England, although possessing no great value as health resorts, are taken as representatives of the mild winter marine climate of the south of England. "Penzance appears to be warmer in the winter than any other place on the mainland of England from which we have records" (Dickinson, "Climate and Baths of Great Britain"), and the temperature of the Scilly Islands for the same season is still higher. Mildness and equability of temperature is about all that can be said in favor of such resorts as the above, as well as of others in the same county of Cornwall and in the adjoining one of Devonshire, the most noteworthy of which is Torquay. Such a climate has been resorted to by consumptives and by patients having other inflammatory respiratory affections, notably by those patients with bronchitis who require a moist air.

As will be observed from the climatic chart of Penzance, the temperature range throughout the year is comparatively small. It is neither hot in summer nor cold in winter. Frost and snow are rare. The mean temperature for the three winter months is 43° F., while the mean of the coldest is 40° F. The relative humidity for Penzance is not obtainable, but it probably does not differ much from that at Falmouth, twenty-five miles to the East, which is eighty two per cent. At the same place (Falmouth) the amount of sunshine is said to be greater than at any other place in England except Jersey, and it is therefore a fair inference that Penzance is also similarly favored, although it is said to have more mist than Falmouth. Everywhere in England there is rain enough, and Penzance, it is seen, has its share, the annual rainfall being 42.59 inches. The winds from the north and south are equally common, while those from the west are more prevalent than those from the east. Penzance has a southeastern exposure, and is sheltered from the prevalent west wind by the high country about the Land's End, and "very completely from the north by elevations of from five hundred to seven hundred feet within four miles. It is exposed, however, to the east, although some protection can be obtained by a choice of residence" (Dickinson, *loc. cit.*). With so many unfavorable climatic features—the large amount of rain, the high humidity; the wind and the relatively small number of sunny days, although large for England—such resorts as Penzance cannot compare with many other mild-winter marine ones except as regards equability, such, for example, as those on the Mediterranean coast, or the Pacific coast of Southern California, on the Gulf and Atlantic coasts of Florida, and many insular resorts. For the inhabitant of England, however, who desires for any reason a mild and equable winter climate, it offers an easily accessible retreat.

CLIMATE OF PENZANCE, ENGLAND. LATITUDE, 50° 8' NORTH. TEN YEARS.

	January to March.	April to June.	July to September.	October to December.	Year.
Temperature (degrees F.)					
Mean monthly average	43.2	52.4°	59.8°	47.7	50.7°
Mean daily range	6.0	9.7	9.5	6.1	7.8
Mean of warmest	46.3	57.4	64.6	50.6	54.7
Mean of coldest	40.2	47.5	55.0	44.5	46.8
Highest or maximum	58.0	77.0	76.0	64.0	77.0
Lowest or minimum	21.0	33.0	39.0	26.0	21.0
Precipitation					
Average in inches	10.81	6.65	9.54	15.59	42.59
Wind—					
Prevailing direction	S. W.	N. W.	S. W.	N. W.	S. W.

The situation of Penzance is very picturesque, as indeed are so many of these seaside towns in Cornwall and Devonshire. There are also numerous attractive excursions in the neighborhood and in the adjacent district of Land's End.

The vegetation of Penzance and its neighborhood is very luxuriant and rich and it seems quite extraordinary that in the latitude of 50°, that of Southern Labrador, one should find exotics flourishing in the open air, even in winter; geraniums and fuchsias attaining the dimensions of large shrubs; aloes flourishing, and hollyhocks, mignonettes, magnolias, and roses blooming, sometimes even in January. Potatoes are cultivated extensively, and sent to London and elsewhere during the winter months. A marked difference is noted between the north and south coasts, although only ten miles apart, not only in the vegetation, but also in the character of the climatic effects. On the north coast the vegetation is far less luxuriant and the climate is more bracing and exciting.

The *Scilly Islands*, although but little resorted to by invalids, represent an interesting phase of climate and present many attractions from their picturesque situation, as well as from the fact that the Bishop lighthouse, which marks the group, is the first evidence of land which greets the Transatlantic voyager as he enters the English Channel. The group, consisting of forty islands, some only tiny specks, lies about forty miles southwest of Penzance, from which it is reached in four hours. But five islands are inhabited, and but one, St. Mary's, possesses any satisfactory accommodations. This island, which is the largest of the group, contains sixteen hundred acres, and no part of it is a mile from the sea. The scenery is of a peculiar and weird grandeur; great masses of granite cliffs standing out against the sea and storms. In this country the Isles of Shoals, off the New Hampshire coast, would appear to bear a close resem-

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blance to the Scillies both in situation, in the open Atlantic, and in their granitic formation and bold rugged scenery. "The air here (Scilly) is as marine as on the deck of an Atlantic steamer. Every sight and sound tells of the sea, the influence of which is here paramount in every shape" (Dickinson, "The Climate of Cornwall," in "Climates and Baths of Great Britain"). The exposed portion of the island of St. Mary's is treeless and bare; but in the valleys, and wherever artificial protection is afforded, the vegetation is luxuriant and almost tropical. Myrtles, fuchsias, geraniums, and aloes grow in great profusion, and palms and bamboo are abundant. "In the gardens of Tresco, unprotected except by the configuration of the ground, a mass of tropical vegetation presents itself which I suppose has no equal in Europe" (Dickinson, *loc. cit.*). The cultivation of the narcissus for Covent Garden is the chief industry of these islands. The climate is relaxing and soothing, a type of a mild, moist, marine one, with great equability. From the chart the mean yearly temperature is seen to be 52.4°, the highest in England. The mean for the three months, January, February, and March is 45.3°. The relative humidity is high, and the rainfall large. The islands are fully exposed to the east and west winds. The former are especially felt in spring. Whatever value such a climate has must consist in its warmth, equability, and humidity, together with the marine influence. About the only conditions which appear to be favorably influenced by such a climatic combination are inflammatory affections of the respiratory organs other than phthisis, especially bronchitis. Chronic renal disease may also do well in such a climate, although the humidity is not a particularly favorable factor. A very charming description of the scenery of the Scilly Islands will be found in Sir Walter Besant's "Amorel of Lyonnesse."

Several other resorts in Cornwall and Devonshire, possessing somewhat similar climatic features, may be mentioned in this connection. On the south coast are Falmouth, Marazion, Torquay, Sidmouth, and other small resorts. On the north coast are St. Ives, Newquay, Tintagel, and Boscastle in Cornwall, and Ilfracombe, Lynmouth, and Lynton in Devonshire. The resorts on the north coast are frequented only in the spring, summer, and autumn.

CLIMATE OF THE SCILLY ISLANDS, ENGLAND, TEN YEARS.

	January to March.	April to June.	July to September.	October to December.	Year.
Temperature (degrees F.)—					
Mean monthly average..	45.3°	52.0°	62.9°	49.7°	52.4°
Mean daily range.......	6.4	8.0	8.0	6.3	7.1
Mean of warmest	48.7	55.9	63.4	53	55.2
Mean of coldest.........	41.8	47.9	55.4	46.7	47.9
Highest or maximum ...	57.0	73.0	75.0	65.0	75.0
Lowest or minimum	29.0	36.0	44.0	32.0	29.0
Humidity—					
Mean relative	87%	84%	85%	85%	85%
Precipitation—					
Average in inches	7.65	5.54	7.52	11.52	32.23
Wind—					
Prevailing direction	W.	N.	W.	W.	W.

Edward O. Otis.

PEPPER, or **BLACK PEPPER.**—*Piper*, U. S. P.; *Piper Nigrum*, Br. P. The dried, nearly ripe fruit of *Piper nigrum* L. (fam. *Piperaceæ*).

The pepper plant is a native of India, but commercial pepper is wholly the product of cultivated plants, and comes chiefly from the East Indies, that of Penang being preferred. The plant is a woody climber, and is trained chiefly to the betel tree. The fruits are produced in aments, somewhat resembling strings of currants. Upon ripening they turn first red, then yellow. After the latter change their properties are largely lost. They are therefore gathered and dried when they begin to change color.

DESCRIPTION.—About 4 mm. (⅙ in.) in diameter, nearly globular, blackish, very strongly reticulate-wrinkled, bearing a low style base at the summit and consisting of a thin fleshy pericarp and a crustaceous, whitish putamen containing a more or less undeveloped seed; odor characteristic, strong; taste strongly aromatic and pungent.

A transverse section of pepper shows a layer of large resin cells near the surface, and beneath this a soft parenchyma (shrivelled in the dry state) containing starch and oil drops. The inner portion of the pericarp contains large oil cells and the seed shows brownish masses of amorphous piperin.

Piper Album, or *White Pepper*, is pepper with most or all of the fleshy portion removed, either before drying or by subsequent grinding. One variety consists of the very young fruit dried entire. Its pungency varies accordingly. If nearly ripe when gathered, it is less pungent than it is when the innermost layers of the sarcocarp have been rubbed or ground away, since these are rich in the active constituent.

COMPOSITION.—The pungency of pepper is due to the presence of ten or twelve per cent. of soft, very sharp-tasting *resin*, which is contained, as indicated above, mostly in the cells just beneath the surface. An *essential oil* of clear white color, having the full fragrance of the spice without its biting taste, exists to the extent of one or more per cent. The third and most peculiar ingredient is the neutral, crystalline, tasteless, and inodorous substance *piperin*, which exists to the extent of from two to eight per cent. It was discovered by Oerstedt in 1819. Piperin is scarcely soluble in water, but dissolves moderately well in chloroform, ether, and alcohol; at 212° F. it melts to a yellow, oily liquid. Besides these, starch, mucilage, and albuminous matters are found, as in other vegetable tissues.

ACTION AND USE.—Applied to the skin, pepper is rubefacient, and finally painfully irritant. It is occasionally sprinkled over the surface of other applications for this effect. In water it is a popular but painful gargle for "sore throat." Taken internally, it is in small doses a stimulant, in large ones an irritant to the stomach—that is, it acts like most other spices. It has been given as a specific in the treatment of hemorrhoids, but is out of use for this purpose. As an antiperiodic it is also obsolete, although piperin is occasionally mentioned in this connection. Whole peppers were formerly swallowed for the cure of some cases of dyspepsia. Dangerous symptoms—"rigors, convulsions, and delirium"—have been said to follow the immoderate use of pepper (Phillips). Although a typical spice, pepper is much less employed in medicine than ginger, cardamon, and cinnamon.

ADMINISTRATION.—For dyspeptics or others needing spices, there is no better way than to eat it on the food, or if a larger quantity is indicated than is agreeable to the taste, 0.5 gm. (gr. vij.) or less may be given in pills or in a bolus, with honey, two or three times a day; or four or five drops of the *oleoresin* (*Oleoresina Piperis*, U. S. P., strength about $\frac{8}{1}$) may be taken if a more compact and stronger dose is needed. Dose of piperin, 0.5 gm. or less.

ALLIED PLANTS.—The genus is a very large one, of six hundred species, of exclusively tropical plants, mostly shrubs, and frequently, like the present one, climbers. Many of them have pungent fruits. *P. officinarum* Cas., D. C., and *P. longum* Linn., are the sources of "long pepper," which comes in compact spikes one or two inches (2–5 cm.) long, and about a sixth (0.5 cm.) in diameter. Its constituents are identical with those of the above, but its flavor and strength are inferior. Long pepper is never sold at retail in this country, yet it is a common article in wholesale houses; it is probably used as an adulterant of black pepper. *P. betle* Linn. is an East Indian vine whose leaves are chewed with areca nuts as a masticatory (or a habit) by many aboriginal tribes of the great Polynesian Islands (see also *Cubeb*, *Matico*, and *Kava*).

W. P. Bolles.

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PEPPERMINT.—*Mentha Piperita.*—"The dried leaves and tops of *Mentha Piperita* L. (fam. *Labiatæ*)," U. S. P.

Peppermint is a slender, nearly smooth, perennial herb, native of Europe, widely naturalized in temperate regions and cultivated upon a great scale for the herbage, for culinary uses, for flavoring and perfuming, for medicinal employment, and for the distillation of its oil and the preparation of menthol. It spreads by runners, producing frequently dense beds of slender stems about a yard long, ascending from a prostrate rooting base, quadrangular, frequently purplish, and bearing leaves and flowers described below. The stems and leaves are very sparingly and obscurely hairy, the hairs short and stout, usually containing menthol crystals in one or more cells; leaves opposite; exstipulate, petioled, the petioles winged toward the summit, the blades usually less than 5 cm. (2 in.) long and about half as broad, ovate, with the rounded base very abruptly produced into the petiole, acute, sharply serrate, thin, wrinkled, of a bright and usually light green; flower spikes oblong or oval, 1–2 cm. ($\frac{2}{5}$–$\frac{4}{5}$ in.) broad, with rounded summit, dense, or somewhat interrupted at the base; flowers about 6 mm. ($\frac{1}{4}$ in.) long, the calyx tubular, ten-nerved, scarcely two-lipped, five-toothed; corolla light purple, nearly equally four-lobed, or one lobe (consisting of two united) a little larger; stamens four, short, equal; fruit of four ovoid, smooth nutlets; odor strong, but not heavy, characteristic; taste characteristic, pungent, and cooling.

The leaves bear numerous globular oil glands and slender, several-celled hairs which often contain menthol crystals.

The drug contains, with a little tannin, about one per cent. of a volatile oil, which is the active constituent, is official under the title *Oleum Menthæ Piperitæ*, and is described as follows in the Pharmacopœia:

A colorless, yellowish, or greenish-yellow liquid, becoming darker and thicker by age and exposure to the air, having the characteristic, strong odor of peppermint, and a strongly aromatic, pungent taste, followed by a sensation of cold when air is drawn into the mouth.

Specific gravity, 0.900–0.920 at 15° C. (59° F.).

The oil does not fulminate with iodine.

It forms a clear solution with an equal volume of alcohol, becoming turbid when somewhat further diluted, and is soluble, in all proportions, in carbon disulphide, and in glacial acetic acid.

The alcoholic solution of the oil is neutral to litmus paper.

If five drops of the oil be added to 1 c.c. of glacial acetic acid, and the mixture gently warmed, the liquid will assume a blue color, with a red fluorescence.

If 2 c.c. of the oil be mixed with 1 c.c. of glacial acetic acid, and one drop of nitric acid added, the liquid will soon acquire a green, greenish-blue, blue, or violet tint with a copper-red fluorescence.

If 1 c.c. of the oil be dissolved in 5 c.c. of alcohol, 0.5 gm. of sugar and 1 c.c. of hydrochloric acid added, and the mixture gently heated, a deep blue or violet color will gradually be produced.

If to 5 c.c. of nitric acid one drop of the oil be added, and the mixture gently agitated, and allowed to stand for about three hours, it should have a yellowish, but not a bright red, color (absence of *oil of camphor* and of *oil of sassafras*).

If a portion of the oil, contained in a test tube, be placed in a freezing mixture of snow (or pounded ice) and salt for fifteen minutes, it should become cloudy and thick, and after the addition of a few crystals of menthol, being still exposed to cold, it should soon form a crystalline mass (distinction from *dementholized oil*).

When heated on a water-bath, in a flask provided with a well-cooled condenser, the oil should not yield a distillate having the characters of *alcohol*.

This oil contains as its active portion the peculiar substance *menthol*, considered separately under that title. A good article has been found to contain about sixty per cent. of total menthol, about one-fourth of it occurring as ester, the remainder free. However, the percentage and composition of the oil, as produced in different countries, and even in different parts of the same country, varies widely, not only as to the percentages, but even as to the nature, of the compounds.

ACTION AND USE.—Notwithstanding that menthol is the active constituent of peppermint and its oil, yet the action and uses of the latter and of that constituent require separate consideration.

Peppermint and its oil are, from their taste and agreeable action, the most generally liked of all the mints, if

FIG. 3793.—Peppermint Plant. About one-half natural size. (Baillon.)

not of all carminatives. This oil is warming and stimulating to the stomach, very seldom irritating. It is a favorite household remedy for nausea, flatulence, and colic; applied to the skin and evaporation prevented, it is a mild stimulant, useful in neuralgia and rheumatism; applied to the forehead and temples it produces a grateful, cooling feeling, with a little tingling that occasionally relieves slight headaches; this property is mostly due to the menthol it contains. The most common employment of peppermint oil by physicians, however, is as a flavor, vehicle, or adjuvant of other medicines, especially of cathartics, whose griping it undoubtedly diminishes. Like most mints, peppermint is frequently used in hot infusion in colds, etc. It is also a favorite flavor for candies.

The powdered drug is sometimes given in doses of 1–2 gm. (gr. xv.–xxx.). There is, properly speaking, no

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official preparation of it, though the official spirit contains one per cent. It is often given in the form of the infusion. The common form of administration is that of the oil (dose 1–5 m.), or of the following preparations of it: The Spirit or Essence (*Spiritus Menthæ Piperitæ*) contains ten per cent. of the oil, and there is three and a half per cent. of it in the popular mixture of rhubarb and soda. The dose of the spirit is 0.3–1 c.c. (♏ v.–xv.). Peppermint water (*Aqua Menthæ Piperitæ*) contains 0.2 per cent. of the oil and is given in doses of 15–60 c.c. (fl ℥ ss.–ij.). The official troches each contain 0.01 c.c. (about ♏ 1/6) of the oil.
Henry H. Rusby.

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PEPSIN.—*Pepsinum, U. S. P.* "A proteolytic ferment or enzyme obtained from the glandular layer of fresh stomachs from healthy pigs and capable of digesting not less than three thousand times its own weight of freshly coagulated and disintegrated egg albumen when tested by the process given below."

Our present knowledge and conception of pepsin have been arrived at by the inevitable, slow, intermittent progress in science, marked by brilliant epochs and retarded and clouded by faulty and incomplete observations and erroneous theories. The investigation of ferments and ferment action has necessarily involved the whole field of problem and inquiry in biology. The history of pepsin, therefore, is found in the voluminous recorded labors of a host of workers. In briefest possible mention it begins perhaps with the first perception by Borelli three centuries ago (1608–1679), of the existence of secreting glands in the stomach and of the value of gastric juice, then the studies of the gastric juice of regurgitating birds, which established the independence of digestion of mechanical power (an early theory) and of chemical change produced on food (Réaumur, 1752). In 1772 Hunter's observations established the fact of the post-mortem digestion of the stomach by its own juices. It was in 1783 that the first demonstration *in vitro* with pure animal gastric juice obtained by ingenious devices from living animals (Spallanzani) was made. At about this time also were made the first recorded clinical researches in regard to gastric juice as a surgical solvent and as an internal remedy—researches which were inspired by Spallanzani and made by his colleagues, Jurine, Carminati, Senebier, and others. Many interesting and singularly clear and detailed observations are recorded in relation to the gastric juice of beasts and birds, its properties, behavior with various foods, etc., and its action when used as a topical application; and it was observed to have the power "to remove all disagreeable smell from fetid ulcers, to give them a clean appearance, to change the quantity and quality of suppurative matter, and obtain a speedy cicatrization." It was employed thus successfully for tumors, ulcers, gangrene, old sores, abscesses, etc., and internally with benefit in "weakness of the stomach and all these affections produced by faults in this fluid and particularly by its diminution in point of quantity and energy for the purpose of digestion." Very remarkable effects were particularly noted in a "case of gradual emaciation with continual nausea and vomiting."

In 1824 Prout, Tiedemann and Gmelin discovered hydrochloric acid in the gastric juice. In 1834 Beaumont made his classical observations, and drew the faulty conclusion that gastric juice was the sole digestive fluid and formed gastrites with food. In the same year an impetus was given to the study of gastric juice by Eberle's suggestion and use of infusions from the stomach glands. This led to the brilliant and careful researches of Schwann (1836) upon the active principle of the gastric juice—its behavior, theory of action, method of separation, etc. He gave to this principle the name "pepsin." In 1842 Lehmann published his theories as to the peptic nature and cellular origin of pepsin, and its action in the transformation of albuminoids into absorbable substances. Wasmann also put forward at the same time the theory that pepsin is the granular matter of the cells or the substance from which it is formed. In 185[illegible] Corvisart and Beale suggested the use of pepsin itself in medicine. In 1864 Hoppe-Seyler classified the various forms of proteids according to their solubility and precipitability by various neutral alkali salts, this classification, by reason of the similarity of pepsin in these respects to other proteids, leading to the present methods by which pepsin is produced by these reagents. Scheffer's suggestion and development of sodium chloride as a pepsin precipitant were inspired by his observations of this reaction of proteins.

Pepsin is now produced from the stomach with the same facility as quinine is made from bark, for, in view of its peculiar origin and nature and susceptibilities on the one hand, it is singularly capable of extraction and utilization in a practical way as an article of commerce. During the last half of the twentieth century, with its accurate, scientific methods of research, and especially during the past thirty years in which pepsin has been increasingly utilized, it, as well as the gastric extract and gastric juice itself, has been the subject of elaborate investigation, and we have now exhaustive data concerning pepsin from a pharmaceutical standpoint.

Great therapeutic interest attaches to the very recent methods of Pawlow for obtaining pure gastric juice from the living animal (dog), to his profound studies thereof, and to the free administration, by Fremont and his colleagues, of this juice in cases of disease of the stomach. They gave it in quantities that sometimes amounted to as much as 500 c.c. per day, and the results which they obtained were at times brilliant. They also used gastric juice as a topical application, noting its solvent, healing and sedative action; this latter quality was also attributed to it when administered internally. Fremont considers this animal gastric juice to be especially adapted to all cases of hyposecretion of the stomach, whether resulting from glandular ulceration, from acute or chronic infection, or from disease of the liver, heart, lungs, and nerve centres. Under its influence dyspeptic phenomena have disappeared more or less promptly, and a remarkable gain in weight and strength has taken place. Patients who have suffered acutely from dyspepsia, and who have become extremely emaciated, have also obtained complete and permanent relief under the use of the remedy.

Pawlow especially calls attention to the fact that gastric juice is now pharmaceutically available as a clinical agent. Others have argued that with a corresponding free use of pepsin and acid similar results may be obtained.

Inasmuch as the healthy stomach of recently killed animals affords a resource for gastric juice in a very concentrated form, rendered perfectly pure by simple means of clarification and filtration, sterile, and free from objectionable odor and taste, there is good ground for the presumption that the fullest therapeutic possibilities of the gastric juice may be realized without the elaborate methods resorted to in obtaining the secretion from the living animal. These observations, which represent the last word of modern achievement in this particular field, give great interest and significance to the early discoveries of Spallanzani and his colleagues, and to the fact that they attracted no further attention and were thus barren of result.

Pepsin is found in the gastric cells of all animals, but the gastric juice of the carnivora is much more powerful in proteolytic action. Pepsin itself, however, has no particular degree of energy or peculiarity of action from any particular source; its "strength" is strictly in ratio to its degree of isolation from the associated non-peptic material of the gastric cell or juice, and from the agents used in its separation therefrom. The pepsin obtained from one creature, therefore, is not stronger than that obtained from another. In the gastric juice of the dog, it is to be noted that the pepsin is associated with a peculiarly high percentage of HCl.

Pepsin is normally associated also with another distinct ferment—the milk-curdling enzyme—which is very energetic in the suckling animal. The ultimate composition of pepsin, the method of its elaboration from the cell, the

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mode of its action, and its relation to the other constituents of the gastric juice, proteid, hydrochloric acid, and inorganic salts, have been the subject of laborious research and of speculation, and are receiving increased attention in the progress and practical interest of biological study.

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Pepsin is a soluble, unorganized ferment, an enzyme, having the property of converting native proteids into soluble, highly diffusible, non-coagulable proteids. Its action is exerted only in an acid medium, most freely in the presence of 0.2 per cent. absolute acid, slight variations from this not sensibly influencing its action; if the proportion of acid, however, be materially increased—say, to 0.3 per cent.—the enzyme is much enfeebled.

Pepsin exerts freely its characteristic action in the presence of organic acids in general—lactic, tartaric, citric, etc. Notwithstanding the fact that the ferment is so closely and characteristically related to the HCl, the mineral acids in general are not favorable to its action, phosphoric being the only one which approximates at all to the HCl in its affinity to the enzyme; nitric and nitro-muriatic acids are distinctly unfavorable.

Pepsin exhibits considerable activity at a temperature much below the physiological, converting albumen slowly even at ordinary room temperature (60°–70° F.), and its action is completely arrested only at a temperature of about 40° F., and greatly accelerated at 120°–130° F.

Pepsin does not exist preformed in the gastric cell, but is developed from the mother substance, pepsinogen, and under the influence of the acid simultaneously secreted in the gastric juice. This view has for a long time been entertained, and very recently pepsinogen has by Glaessner been prepared free from pepsin and found to be devoid of proteolytic power. This pepsinogen was found promptly to develop into pepsin under the influence of both mineral and organic acids; while oxygen and neutral salts were without effect, and alcohol, ether, and chloroform proved destructive.

"If it be desired to use a diluent for reducing pepsin of a higher digestive power to that required by the Pharmacopœia, sugar of milk should be employed for this purpose.

"A fine, white, or yellowish-white, amorphous powder, or thin, pale yellow or yellowish, transparent or translucent grains or scales, free from any offensive odor, and having a mildly acidulous or slightly alkaline taste, usually followed by a suggestion of bitterness. It slowly attracts moisture when exposed to the air.

"Soluble, or for the most part soluble, in about one hundred parts of water, with more or less opalescence; more soluble in water acidulated with hydrochloric acid; insoluble in alcohol, ether, or chloroform.

"On heating a solution of pepsin in acidulated water to 100° C. (212° F.) it becomes milky, or yields a light, flocculent precipitate, and loses all proteolytic power. In a dry state it can bear this temperature without injury.

"Pepsin usually has a slightly acid reaction. It may be neutral, but should never be alkaline."

Pepsinum Saccharatum, U. S. P.—"Pepsin triturated with milk sugar in such proportion that the resultant saccharated product shall digest three hundred times its own weight of coagulated egg albumen under the United States Pharmacopœia method of valuation for pepsin."

Pepsin of the British Pharmacopœia is of 1–2,500 strength. The United States Pharmacopœia method of valuation (that of the British Pharmacopœia is similar) in brief is this: 0.003 gm. of pepsin is required completely to digest 10 gm. of hard boiled comminuted egg albumen in 100 c.c. of a 0.2 per cent. solution of absolute HCl in distilled water, the mixture maintained at a temperature of 100°–104° F. for six hours, and the flask shaken gently every fifteen minutes. At most only a few thin, insoluble flakes should be left. Pepsin fluids must be assayed according to the United States Pharmacopœia method, the conditions prescribed being strictly adhered to, but use being made of a corresponding proportion of the fluid to represent the amount of ferment necessary to digest the 10 gm. of albumen.

Pepsin of the United States Pharmacopœia and British Pharmacopœia requirements is obtained by precipitation, with neutral salts, of the alkalies from purified infusions of the fresh, healthy stomach glands, and the precipitate purified by mechanical means—by reprecipitation and dialysis. By this means mucus is wholly, and non-peptic proteids and peptones well, separated. The *rationale* of the process will appear in the consideration of the nature and behavior of the enzyme.

No official method is given in the United States Pharmacopœia or in the British Pharmacopœia; their standards make obsolete the cruder, earlier forms. It is to be regretted that European standards are so greatly inferior, for a uniform, definite, adequate pharmacopœial standard for pepsin of commerce is absolutely essential. In the past pepsin has been too commonly of insignificant value—even inert; and variable and apparently conflicting results and theories are inevitable when pepsin still means in various countries a product of from 1 to 40 to 1 to 3,000 standard; moreover, there are offered in commerce, in the United States, pepsins of even *stated* digestive value below the obligatory pharmacopœial standard.

Both physiological and chemical data almost irresistibly lead to the conclusion that pepsin is a nucleo-proteid and sharply distinguished from all other forms of proteid by its proteolytic action, exhibited under conditions which are in themselves incapable of effecting these chemical changes without the intervention of the enzyme. The degree of isolation of pepsin is necessarily only to be judged by the energy of the product which is obtained by the exclusion of foreign substances capable of separation and identification by chemical processes and dialysis. The enzyme so far isolated exhibits the characteristic behavior of a nucleo-proteid. It is freely soluble in water, is non-dialyzable, readily precipitated by the neutral salts of the alkalies and by strong alcohol in excess, and is coagulated in solution at 160° F. both in neutral and in acid media; it is destroyed in solution at this temperature (160° F.) which, it is interesting to note, is the coagulating point of albumen and destructive to organized ferments; it is destroyed in alkaline solutions at any temperature; its action is strongly influenced by various reagents which do not in themselves effect any known change in the enzymic substance; and, finally, when once destroyed its vitality cannot be restored by any means whatever. A striking example of its physiological relations is found in its behavior with common salt; the presence of sodium chloride in so small a quantity as one per cent. of the digesting mass completely retards digestion *in vitro*, yet we have the fact that pepsin may be precipitated by means of common salt (in saturated solution), and kept in contact with it for a long time without impairment of its activity.

The most perfectly isolated pepsin yet produced is found to be a nitrogenous body with the chemical constitution of a proteid, and this pepsin proteid contains phosphorus and iron like other nuclein bodies. The fact, then, that the chemical composition of pepsin remains yet to be absolutely established is of little significance from a therapeutic standpoint, for it imposes, in the light of all the material and important facts known, no limitations upon the complete utilization of the enzyme.

The physiological test for pepsin is as conclusive and reliable as any chemical test by which we establish the presence or identity of any chemical substance. It is by the physiological test that we readily measure the strength of any specimen of pepsin; and it is by it, furthermore, that we have determined the influence of medicinal and food substances upon pepsin, and have gained accurate data as to the conditions which are favorable and unfavorable to its action or destructive to the life of the enzyme. These data clearly reveal that physiological considerations are as conclusive in relation to the enzymes as are chemical reactions, both in theory and in practice, in relation to the use of other agents of the materia medica.

Pepsin behaves as a true ferment whose peculiar form

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of energy is capable of liberating latent energy in complex labile substances—the proteids, breaking them down into simpler, more stabile bodies. We have had the statements that pepsin actually loses its activity in this process, and that it remains unaltered. There can be no doubt, however, that pepsin undergoes no change in exerting its energy, as has been demonstrated.

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A pepsin having been subjected to the usual digestive test—upon acid albumin mixture—may be made repeatedly to exhibit its action upon the addition of fresh volumes of water and albumin and when the requisite percentage of acid is maintained, thus preventing saturation of the digestive fluid with the soluble products formed. In this way the writer has found pepsin to digest several hundred thousand times its own weight of albumen without exhaustion of energy. Interesting as this may be as to the marvellous power of the enzyme, it seems, however, to be without therapeutic bearing, in view of the fact that the gastric juice is normally discharged into the intestine with the completion of the stomach digestion.

Pepsin in the dry form, if non-hygroscopic, retains its vitality for years at ordinary temperature. In solution it may be readily preserved without serious impairment; alcohol and glycerin combined form the best preservatives, from both the medicinal and the pharmaceutical standpoints; for general use, about fifteen per cent. absolute alcohol and glycerin being the amount required. The anhydrous glycerin does not readily take up the enzyme; when diluted with water, to the extent of about forty per cent., it affords a useful vehicle. Elixirs, essences, and glycerites are commonly and very conveniently made with pepsin. There is no pharmacopœial method or standard for these products; they are variable, and distinctly inferior in therapeutic utility to fluids made directly from the fresh stomach.

Chemical preservatives—salicylic acid, boric acid, etc. —are obviously objectionable. Absolute alcohol precipitates pepsin, and by long contact distinctly weakens it; but the presence of alcohol up to about fifteen per cent. exerts no sensible influence upon the ferment, the enzyme being freely extracted by such hydro-alcoholic menstruum. *In vitro* alcohol, when it constitutes ten per cent. of the medium, sensibly affects the *digestive* action of pepsin; and it checks this digestive action, not by altering the ferment, but simply for the reason that alcohol is not a competent medium for the ferment in any particular. The products of enzymic action are insoluble in alcohol and are of lessened solubility in hydro-alcoholic media in direct ratio to increased percentage of alcohol. This, however, concerns digestion *in vitro* solely, for alcohol as present in any proper peptic fluid becomes in this respect a negligible quantity by dilution with gastric content and its free absorption. The inert or feeble nature of many of the vinous and alcoholic preparations has been due to the insignificant amount of pepsin actually contained in them and not simply to their alcohol content. The intimate relation of pepsin to hydrochloric acid has naturally led to the impression that this and other mineral acids may be freely admixed with the ferment; but this is a serious error. The acid of the gastric juice is bound up in a peculiar manner with the proteids, and thus the enzyme seems to be protected from the acid, whereas pepsin in solution with pure water and the normal content of absolute HCl (0.2 per cent.) rapidly deteriorates at ordinary temperature. This constitutes a striking evidence of the fact that a solution of pepsin and water and HCl is not gastric juice; it represents the proteolytic ferment, and exhibits absolutely the proteolytic action only of the gastric juice. Other mineral acids are distinctly injurious to the ferment in any fluid form. It is not possible to mix a mineral acid in medicinal quantity with pepsin in a fluid mixture of convenient volume of dosage without distinctly injuring the ferment even for extemporaneous use; while combined in a percentage much above that of the gastric juice content, such mixtures are distinctly incompatible with the normal activity of the ferment and unsuited for pharmaceutical products. For instance, if we take five minims as a moderate dose of official dilute HCl, this in two fluidrachms would yield an acidity of 0.42 absolute HCl, which is twice the acidity of normal gastric juice and fatal to the enzyme.

Pepsin fluids should have an acid reaction; but when acids *per se* are indicated medicinally, it is the best practice to exhibit them separately by such vehicle and means as are most desirable in conjunction with the pepsin preparation. If the preparation has an alkaline reaction, this is conclusive evidence of its inertness.

Pepsin is incompatible with bismuth ammonio-citrate in solution. If the mixture has a neutral or an alkaline reaction, the ferment cannot retain its activity; on the other hand, if it is acid, it is impossible to maintain the bismuth in solution. Owing to the unstable and insoluble nature of the salt, its solution is usually effected by the addition of ammonia, which is obviously incompatible with pepsin. The therapeutic value of elixirs of pepsin, bismuth, and strychnine necessarily cannot be attributed in any degree to pepsin; devitalized pepsin cannot in any way add to the value of a medicinal compound.

Pepsin and pancreatin are incompatible in solution, for the reason that if the menstruum be of such acid nature as to preserve the pepsin, the pancreatic enzyme will be in time destroyed; while if it is neutral or feebly alkaline, the pepsin will be destroyed. Acid-pepsin fluids are unsuitable for the admixture of all ferments except the milk-curdling; the pepsin will be the only enzyme of all those originally combined which will retain its activity. Mixtures of the ferments in solution are readily subject to recognized tests for the presence of any one of the ferments. If a fresh and feebly acid infusion of the stomach, or solution of pepsin, be mixed with an aqueous infusion of the pancreas, each one of the ferments contained in this mixture may be immediately made to exert its peculiar action under the proper conditions; the mixture will exhibit the digestive action of pepsin, of trypsin, and of diastase. But upon keeping this mixed ferment solution at ordinary room temperature for a few weeks, it will be found upon systematic assay to have gradually and rapidly deteriorated in respect to one or another of its ferments.

The fact that a number of ferments are mixed in any fluid does not in the least interfere with the method of assay for testing or determining the presence of any one or of each separate ferment in the fluid mixture. When it is desired to combine gastric and pancreatic ferments in solution, they are best directed in extemporaneous mixture of preparations which have been obtained directly from the stomach and the pancreas gland, and thus they will maintain their individual action for such length of time as will ordinarily be required by the patient.

The therapeutic use of pepsin is prejudiced and complicated by the prevalence, in the past, of inefficient products and incompatible combinations, a condition which does not exist concerning any other agent or class of agents of the materia medica, owing to the fact that with the definite and standardized chemicals and galenical products there has been presented no such obstacle in establishing therapeutic action and scientific dosage. The increasing knowledge and application of physiological chemistry in therapeutics, and the accumulation of laboratory and clinical observations with regard to the action of animal gastric juice, have strongly confirmed its rational and obvious utility and promise, and have advanced its repute and use as a therapeutic agent.

Pepsin exhibited in adequate doses aids gastric digestion, with effects apparent in the relief of various dyspeptic symptoms and in the promotion of nutrition; it affords a rational remedy to which the physician may have recourse in cases of feeble and readily disturbed digestion. The beneficial effects of pepsin are not restricted alone to the improvement of gastric disorders; there is abundant evidence that each step in the chain of digestive action is of essential importance, and defective stomach digestion cannot but influence the entire digestive process.

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The pancreatic ferments attack with great facility the soft and partially converted proteids and starches in the form in which they normally reach the intestinal tract, breaking them down into their most soluble and diffusible forms, and the development of the latent pancreas enzymes waits upon the influence of constituents of normal gastric juice. Coagulated protein food in masses is but very slightly attacked by pancreas juice in contrast with peptic action, and thus the complete conversion of food is absolutely dependent upon the interaction of both gastric and intestinal digestion. Disorders even of the intestinal tract are frequently benefited by the administration of pepsin. Pepsin in doses so small as to seem a slight factor in the physiological process, and administered either just before or immediately after eating, produces results which can be attributed only to the theory advanced that it imparts an impetus to peptic secretion and action. Pepsin is used to promote the toleration of drugs which impair the appetite and disturb digestion. For all these purposes the gastric juice, extracted directly from the fresh stomach in proper pharmaceutical form, is found most generally useful. This preparation renders available at once all the properties of the gastric juice, both its enzymes (the peptic and milk-curdling) and its acid in proteid combination—the entire organic and inorganic content in natural association. These enzymes are thus less susceptible to unfavorable influence than is the precipitated ferment.

Pepsin is given in scales, powder, tablets, and capsules, ordinarily in doses of from one to five grains; the scales are readily soluble in water—plain or with acid; the glycerite, especially the glycerin extract from the stomach, is useful, and if properly prepared is far more agreeable than the scale itself taken in solution. The essence prepared from the gastric juice is the most efficient and agreeable preparation, and its grateful qualities enhance the effect of the digestive principles contained therein. The desired dose of drug, for instance sodium salicylate or iodide of potassium, is prescribed in the proportion of, say, five grains to each teaspoonful of the essence of pepsin, and this added to two or three tablespoonfuls of warm milk gives instantly a firm curd. The milk may be previously sweetened or flavored if desired, the object being to present the drug in a small bulk for convenience; even this serves well to disguise the medicine.

When pepsin is given simply to promote digestion, it should never be administered in a disagreeable form, and when given to facilitate the exhibition and therapeutic action of disagreeable drugs, the essence is not only valuable as a vehicle, but should be given immediately after the drug if it is desired to obtain its best effect.

The essence of pepsin is much used in combination with savory, soluble, and diffusible food products, the prepared peptonized foods, and it should be mixed in about equal quantities therewith; this combination proves of peculiar value in acute forms of indigestion and intolerance of food; in seasickness, for instance, it is especially useful. Essence of pepsin is also much used in combination with pure phenol, which is thus well masked and well borne, and this mixture, which is both antiseptic and sedative to an irritable gastric mucous membrane, does not in medicinal proportion unfavorably influence the gastric enzymes.

The gastric juice essence is more especially found serviceable as a drug vehicle, and in conjunction with it maximum doses of mercurials, iodides, salicylates, etc., are peculiarly well tolerated. It is also valuable for the production of junket—a jelly-like, diffusible form of pure milk—which is also a carrier of drugs which blend with it and thus lose much of their disagreeable taste and effect. Junket affords an agreeable and wholesome variety of food, and is serviceable in convalescence where liquid foods have become distasteful and are no longer required. It is made as follows:

Junket.—Into a clean saucepan put one-half pint of fresh, cool milk, heat it lukewarm (not over 100 F.); then add one teaspoonful of essence of pepsin, and stir just enough to mix; divide quickly into small cups or glasses and let stand until firmly jellied, when the junket is ready for use, just as it is, or with sugar; it may be placed on ice and taken cold.

Whey.—After preparing the junket by the above method, let it stand until firmly jellied, then beat with a fork until it is finely divided; now strain and the whey (liquid part) is ready for use; keep in a bottle near ice.

Pepsin digestion has long been observed to effect the solution of dead tissue, pus, necrosed bone, etc. The availability of the gastric juice in an active, sterile, and stable extract of great potency, has recently led to its application as a surgical solvent in the bladder, urethra, eye, ear, nose, and throat, and in pus cases in general—sores, abscesses, carbuncles, gangrene, leg ulcers, etc. Gastric juice is thus found to possess peculiar and valuable properties as a solvent, healing, antiseptic, deodorizing, and sedative agent. It is painless in its action and incapable of attacking normal tissue, and has caused a speedy cure in cases which were so aggravated as to have resisted other treatment, thus rendering surgical interference unnecessary. In genito-urinary diseases it promises, from the most conservative estimate of the clinical trial which it has already received, to afford a remedy of great importance.

Benjamin T. Fairchild.

PEPTONURIA. See *Urine, etc.*

PERFORATING ULCER OF THE FOOT.—This is a rare affection, caused by pressure or injury where there is a degenerated nerve supply. It is found in leprosy, locomotor ataxia, lues, and alcoholic and diabetic neuritis. The most common location is where there is great pressure, as over the metatarso-phalangeal articulation of the great or little toe, or over the ball of the toes. Occasionally there are several lesions existing at the same time in one or both feet. A similar condition may also occur on the hands.

The process is very slow. It begins as a thickening of the skin resembling a corn, under which suppuration occurs; and later, when the horny plug is cast off, an ulcer is left. The destructive process extends downward until it reaches the bone, which may also become affected. The condition now is more that of a sinus than of an ulcer. The skin surrounding the opening is usually much thickened, and there may be granulations at the orifice. The diseased parts are generally painless and the neighboring parts are usually anæsthetic. Distortion of the toes, as well as trophic changes in the nails, may occur later; they are usually accompanied by an increased growth of hair, pigmentation, and hyperidrosis. The patients frequently complain of cold feet and neuralgic pains.

The prognosis is unfavorable, even if the lesions should heal, on account of the liability to recurrence, which in turn is due to permanent nerve lesions.

Perforating ulcer has to be differentiated only from a suppurating corn, which latter is painful and is accompanied by abnormal sensitiveness of the surrounding skin. In the case of a suppurating corn the results of surgical treatment are always satisfactory.

Prolonged rest will occasionally lead to healing of the lesion in the early stages, but exercise will cause the sore to recur. Packing the sinus with lint wet with a saturated solution of salicylic acid in glycerin, and the employment of mechanical devices to prevent pressure will frequently produce a temporary cure. Free opening of the sinus or stretching of the nerves which supply the part has been followed by good results in some cases. In the later stages excision of the ulcer is useless and amputation of the foot is necessary. Even then the ulcer may recur in the stump, unless the limb is removed at a point far from the lesion and above the line of anæsthesia.

Howard Morrow.

PERICARDIUM, DISEASES OF THE.—HISTORY.—Anatomical alterations in the pericardium were known long before diseases of the heart proper received careful

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study. Galen was familiar with pericardial effusion in animals, and suspected it in men.

The fables about the occurrence of hairy hearts in men of remarkable strength and daring are doubtless based upon the discovery of stringy fibrin deposited upon the heart. Rondelet described pericarditis as having symptoms of fever, dyspnœa, pain under the sternum, and attacks of syncope.

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In the eighteenth century the authors of works upon diseases of the heart made numerous anatomical observations upon diseases of the pericardium.

Vieussens often met with adhesion of the heart to the pericardium at autopsies, and assigned certain functional disturbances which occur during life to the existence of this condition. In earlier times it was thought to be a congenital defect. Albertini appreciated the difficulties of a symptomatological recognition of pericardial effusion. Morgagni believed that on account of the difficulty of diagnosis, the day was yet remote when we should have recourse to the puncture of the pericardium as suggested by Riolan. Senac realized that it was impossible to make a diagnosis from the indefinite symptomatology, but thought that in hydropericardium he recognized an undulatory movement between the third and the fifth ribs. Corvisart thought that he could feel this. Both were in error. However, Corvisart first distinguished between inflammatory exudations and dropsical effusions, but could not lay down any fixed rules for differential diagnosis. Avenbrugger was the first to state any accurate physical signs; these were bulging of the præcordium and increase in the area of percussion dulness. Laënnec, however, doubted the possibility of diagnosing pericarditis with certainty.

The discovery of the pericardial friction rub by Collins in 1824 made certain the recognition of dry pericarditis. Since this time our knowledge of the physical signs of all varieties of pericarditis have increased remarkably, but none are so pathognomonic or of so much assistance in diagnosis as this peculiar friction rub.

ANATOMY.—Before launching upon a description of the diseases of the pericardium, it will be well to devote a few lines to its normal anatomy. It is a fibro-serous sac, somewhat conical in shape, surrounding the heart and the origin of the great vessels. Its base is directed downward, rests upon the diaphragm, and is firmly attached to its central tendon, and more loosely to its muscular structure by areolar tissue. Its narrower portion is directed upward, and surrounds the great vessels. The fibrous layer is continued for some distance along the coats of the great vessels, in the form of prolongations, which gradually become incorporated in their coats. The inferior vena cava passes through the floor of the pericardium to reach the heart. The serous membrane lines the fibrous sac and is reflected over the surface of the heart, thus constituting its parietal and visceral portions. They are continuous along the great vessels, about an inch to an inch and a half above the base of the heart.

Externally, the pericardium is in contact anteriorly and laterally with the pleuræ covering the lungs, with the exception of a triangular space, behind the lower sternum, which remains uncovered. It is attached by fibrous bands to the manubrium and ensiform cartilage. Behind it are the œsophagus, descending aorta, bifurcation of the trachea and left bronchus, and the other structures which form the root of the left lung. The phrenic nerves pass down, one on each side of the pericardium, on their way to the diaphragm.

In health the serous surfaces are kept moist by a secretion normal to serous membranes. The amount is always small, but varies from a few cubic centimetres to an ounce or two. It is common to find at autopsy several ounces of pericardial fluid. In most cases, however, this is a post-mortem transudate. As a result of the presence of this fluid the serous surfaces glide smoothly over each other during the various phases of the heart's action without producing audible or palpable signs.

The pericardium of an adult man with a healthy heart is capable of holding from fourteen to twenty-two ounces of fluid; that of a boy between six and nine years old, about six ounces when the sac is distended to the full by injecting water into it, by means of a syringe, through an opening made into the anterior part of the pericardium (Sibson).

The following are the important diseases of the pericardium:

1. Pericarditis: (*a*) dry or plastic (pericarditis sicca); (*b*) wet pericarditis, or pericarditis with effusion; (*c*) suppurative pericarditis; (*d*) chronic adhesive pericarditis.
2. Hydropericardium.
3. Hæmopericardium.
4. Pneumopericardium.
5. New growths in the pericardium.

MORBID ANATOMY.—I. *Abnormal Conditions of the Pericardium* not of clinical interest, and which do not furnish physical signs.

(*a*) *Absence of the Pericardium.*—This occurs in ectopia cordis. It is usually only partial, there being a slit in the pericardium through which the heart protrudes. Very rarely the heart and the left lung lie in the same serous sac. The heart is covered by the visceral layer of the pericardium; at the origin of the great vessels there are usually found rudimentary portions of the parietal layer in the form of fringe-like reduplications.

(*b*) *Diverticula.*—Hernia-like pouches are rarely found. They are due to the pressure outward of fluid. This occurs in chronic conditions in which the fibrous layer has become weakened, and either yields or separates and allows the serous layer to be pushed through by the exudate.

Such pouches are usually small, but they have been known to contain as much as from three to four ounces. The opening into the pericardium may be wide or narrow. These conditions are not recognized during life.

(*c*) *Milk Spots*, also called soldier's spots and tendinous spots.

By these terms are meant those circumscribed, whitish, slightly thickened spots which are so frequently found upon the pericardium. Some authorities look upon them as evidences of an old pericarditis, and as such they have influenced the statistics of pericarditis.

Most writers now believe them to be areas of chronic hyperplasia of connective tissue. Friedreich believed that they resulted from a continual mechanical irritation of the surface of the heart, and were found most frequently on those parts of the heart which were continually brought into contact with the more resisting portion of the chest wall. These spots are nearly always found on the visceral pericardium and on the anterior surface of the right ventricle along the coronary arteries. They are much more common in advanced age than in youth, and in men than in women. They are of no clinical importance and cannot be recognized during life.

(*d*) *Thinned Pericardium.*—The wall of the sac may be thinned as a result of distention from an enlarged heart or from the pressure of fluid.

(*e*) *Foreign Bodies.*—These have been found lying free in the sac, and have been regarded as polypi detached from the inner surface of the pericardium, or as results of fibrous or calcareous deposits about foreign substances.

(*f*) *Calcareous Deposits.*—In cases of prolonged pericarditis there may be more or less calcareous deposit in the pericardium.

II. *Acute Plastic Pericarditis.*—In this variety both layers of the pericardium are covered with a yellowish, sticky layer of inflammatory lymph of varying thickness. As a result of the constant friction of these two surfaces during the heart's action, this material is thrown into ridges, and at times presents a ragged appearance (so-called bread and butter adhesions of Laënnec), resembling the appearance of two slices of bread and butter, which have been stuck together and then drawn apart. It has also been likened to tripe. The involvement of the pericardium may be universal or only partial. If only partial it is more common at the base of the heart than elsewhere.

The various changes occurring in pericarditis are some-

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times described as following a definite order of succession: (1) Increased vascularity; (2) fibrinous exudation; (3) fluid effusion; (4) absorption; (5) adhesion. It is very seldom, however, that these stages can be recognized, as there is likely to be a mixture of two or more—as, for instance, the association of a plastic exudate with fluid effusion, or even the combination of adhesions and fluid.

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It is possible for absorption to take place, followed by resolution. Very often, however, especially in the pericarditis sicca, the plastic material becomes organized into firm adhesions which pass from parietal to visceral pericardium. In the early stages of an inflammation the adhesions may be very fine and delicate and easily broken with the fingers. Later on, however, they become exceedingly strong, and the pericardium cannot be separated from the heart without tearing the heart substance.

The presence of adhesions may be partial or universal. If universal, there will be entire obliteration of the pericardial cavity. Adhesions may also exist between the pericardium and pleura, or between the pericardium and chest wall, as a result of mediastino-pericarditis (pericarditis externa).

Effusion.—As previously stated, there is present normally in the pericardial sac enough fluid (a few cubic centimetres) to keep the surfaces well lubricated. In diseased conditions this fluid may be enormously increased in quantity and greatly altered in character. Roberts says that the average quantity of fluid in pericarditis is from eight to twelve ounces, but it may range from an ounce or two to two or three pints or more. Balfour says several pints; Broadbent says that any large amount is exceptional.

The statements of different authorities vary much as regards the size of exudates. Sibson states that the effusion is likely to be large in rheumatic pericarditis, while John Broadbent says that it is the exception to find a large effusion in this condition. The truth is, there is no definite rule. Roberts states that the quantity is likely to be small in Bright's disease. However, Dr. Herman Allyn (*American Medicine*, October 18th, 1902) reports a case of pericarditis which occurred as a terminal infection in Bright's disease, and in which he removed by paracentesis, on the day previous to death, forty-four ounces of bloody serum. At autopsy the pericardial sac was found to contain about two hundred and fifty ounces of bloody serous exudate.

It is generally stated that the exudate is large in cases secondary to scurvy. In the Russian epidemic referred to later, the quantity amounted to from four to five pints.

Character of Fluid.—This varies much, depending on the nature of the inflammation. In the typical case of pericarditis it is a clear yellow, in which shreds of fibrin and leucocytes may be present. In rheumatic pericarditis it is usually clear, but may be blood-tinged and may occasionally become purulent. In new growths and tuberculosis the fluid is likely to be blood-tinged, but not necessarily so. In scurvy the exudate is usually bloody; in fact, it may be almost clear blood.

The specific gravity of a pericardial exudate, like that of other serous cavities, is usually above 1.015, though there are rare exceptions to this rule.

Absorption.—The natural tendency in most cases of serous or sero-fibrous effusion is toward absorption sooner or later. This is especially true in rheumatic cases. In fact, after reaching the acme, in a day or so there may be a distinct diminution in amount, and in from four to six days the quantity may fall to normal. In rare cases an ordinary inflammatory exudate does not undergo absorption, but remains as a chronic collection, or may become hemorrhagic or purulent. Many authorities believe that even a fibrinous exudation may be absorbed, up to a certain amount, after undergoing a fatty change.

The fibrous patches left from pericarditis are larger, thicker, and have a more irregular distribution than the so-called milk spots, and as a rule are associated with adhesions.

A consideration of the morbid anatomy of pericarditis would not be complete without reference to the changes which are produced in the heart. Broadbent says: "The heart is usually found to be dilated to a varying degree. In the subacute or chronic cases in which the pericardium has become adherent, the dilatation is often extreme, and the heart muscle soft and flabby, showing evidence, on microscopical examination, of well-marked, inflammatory changes. Dr. Poynton has shown by a series of sections of the heart wall, in cases of rheumatic pericarditis, that the cardiac muscle, as well as the pericardium, is almost invariably attacked by the inflammatory process, and that there are foci of small round-cell infiltration between the muscle fibres throughout the thickness of the heart wall. The myocarditis which accompanies pericarditis is therefore not simply an extension of the inflammation from the pericardium to the myocardium. There is granular and fatty degeneration of the cardiac muscle due to the toxic effects of the rheumatic poison, as well as actual destruction of muscle fibres by inflammatory exudation."

Eichhorst applies the name *Zuckergussherz—frosted heart*—to cases in which the epicardium is thickened by chronic pericarditis, so that it gives the organ the appearance of being covered by a sugar icing, as in the case of a frosted cake.

Calcareous Pericarditis has been referred to above. In chronic cases the heart may be completely invested by a calcareous coat which may in places be 1–1.5 cm. thick (Osler).

ETIOLOGY.—Pericarditis is almost always a secondary infection. Its etiology resembles very closely that of endocarditis. The more careful our examinations and the greater our bacteriological knowledge, the fewer will be the cases of idiopathic pericarditis discovered.

Rheumatism is by far the most common cause of pericarditis. Roberts, in "Allbutt's System," states that pericardial inflammation is to be looked upon not as a mere complication of rheumatism, but as an essential part of the disease.

Sibson noted that in the large majority of cases of rheumatic pericarditis endocarditis was also present. Broadbent states that pericarditis must not be regarded as a separate entity, but as part of a general inflammation of the heart, the myocardium being almost invariably and the endocardium frequently affected.

There is no definite relation, when a large number of cases is considered, between the severity of the joint affection and the severity of the pericarditis. It may develop at any time during the attack, even preceding the joint affection, or late in the disease.

Pneumonia, pleurisy, the various acute infectious diseases, especially scarlet fever—during the stage of desquamation or that of nephritis,—chorea, pyæmia, purpura, scurvy, are all causes of pericarditis. Especially interesting is its association with Bright's disease. Taylor found that pericarditis occurred in about ten per cent. of his cases of Bright's disease. Sibson, in an analysis of 1,691 cases of Bright's disease collected from various sources, found that pericarditis existed in 8.17 per cent. Tuberculosis, carcinoma, extension from contiguous tissues, traumatism, are also causes of pericarditis.

Aneurism of the aorta causes 2.6 per cent. of all cases, a very high figure when one recalls the comparative infrequency of aneurism (Preble).

Scurvy is frequently accompanied by hemorrhagic pericarditis. Seidlitz and Kyber report an epidemic occurring in Russia in 1840, in which 30 out of 60 fatal cases showed hemorrhagic pericarditis. The fluid was dark, and amounted to four or five pints.

Sears, in a study of 100 cases at the Boston City Hospital, assigns rheumatism as a cause in 54 cases, pneumonia or infection with the pneumococcus in 18; in 7 chronic nephritis, and in 5 pleurisy was the primary disease.

It is now generally accepted that the pericarditis of Bright's disease is usually an infection, often a terminal infection. (Banti believes in the uræmic theory.) Chronic disease lessens the resisting power of the tissues and invasion by micro-organisms becomes easier.

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Bacteriology.—In acute pericarditis Flexner, in a limited number of cases, found bacteria present in the following order of frequency: M. lanceolatus, 11; streptococcus, 4; staphylococcus, 1; B. pyocyaneus, 1; B. influenzæ, 1; M. lanceolatus and B. coli communis, streptococcus, staphylococcus aureus and B. coli communis, 1; staphylococcus and B. coli communis, 2; unidentified, 1.

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Infection Atrium.—Pneumonia, 8; bronchitis, 2; erysipelas, 1; leg ulcer, 1; tonsils, 1; peritoneum, 1; cancer of stomach, 1; sloughing myoma, 1; doubtful, 7.

Tubercle bacilli have rarely been found in cases of tuberculous pericarditis.

Symptomatology.—It was early recognized that the symptomatology of this condition was so indefinite, obscure, and inconstant, and resembled so closely that of other cardiac conditions, that a diagnosis could not be based upon it. This is only partly because the disease comes on secondarily to other conditions. The symptoms are often so indefinite that pericarditis is entirely overlooked, and may alter almost not at all the symptomatology of the primary disease. Even in the so-called idiopathic cases the subjective phenomena are very indefinite.

The following important symptoms may be mentioned:

Pain is present in many cases of pericarditis, especially early in their course, when friction sounds are heard, but it is not pathognomonic, and bears no special relation to the severity of the attack. It may be extremely severe in localized pericarditis and entirely absent in large effusions or extensive adhesions. When present it is usually in the precordial region. It varies much in its character, from a dull ache to a stabbing or tearing pain. It usually disappears with the advent of the effusion. There may be pain or tenderness in the epigastric region, especially when upward pressure is made at one or other of the costal angles. This pain usually comes on later than the precordial pain. The patient may complain of only a sensation of distress, a pressure or tightness about the heart, especially if a large effusion is present. There may be dyspnœa and palpitation.

The *pulse* has no special characteristics. The heart action in the early stages is rapid and energetic. Subsequently, as a result of the mechanical embarrassment superimposed by the presence of a large amount of fluid, and the involvement of the myocardium and its nerves, the heart action becomes weak and rapid, possibly irregular. In the early stages it may vary from 90 to 120; later, in rare cases it may reach 160. In some cases there is very little alteration from the normal, and rarely the pulse rate is below normal. Dr. Ewart says that in many cases of effusion the pulse is quick, resembling the Corrigan type. Pulsus paradoxus is said to be more marked in adherent pericardium than in any other known condition.

Friedreich's sign of collapse of the cervical veins during diastole is not considered important.

The respiratory symptoms vary much. Respirations are usually somewhat increased in frequency. If the effusion becomes large, dyspnœa and even orthopnœa may supervene. The patient usually prefers to lie on his back or on the left side. In large effusions there is often a short irritative cough, and in rare cases distressing hiccough due to involvement of the phrenic nerve.

There may be pain or difficulty in swallowing as a result of pressure of an effusion upon the œsophagus, or due to nerve irritation.

Inasmuch as pericarditis is a secondary affection, there is usually present the fever of the primary disease. The pericarditis may cause a slight extra elevation of temperature. It may be practically normal throughout, or only slightly elevated, to 100° or 101°; rarely to 103° F.

It must be remembered that the symptomatology of pericarditis may be altered by the associated primary disease. Thus, a case secondary to Bright's disease would differ from a case secondary to rheumatism.

Enormous effusion, by interfering with the action of the heart and aëration of the blood, may produce the most grave symptoms of dyspnœa, cyanosis, very rapid and weak heart action, which if not relieved may eventuate in death.

The rapid heart action, the pulsus paradoxus, and the asymmetry in the size of the pulse of the radials, the irregular type of temperature, the paralysis of the recurrent laryngeal nerve, the unequal pupils, the disturbed mental state, may all be important signs, if present (Billings).

Physical Signs.—*Acute Plastic or Dry Pericarditis.*—Fortunately the signs of this condition are very distinct; the danger is that they may disappear before the physician's attention is directed to the precordium. In some cases they are very evanescent, disappearing in a few hours; in others they persist for days.

Pericardial Friction Rub.—This is the pathognomonic sign of dry pericarditis. It is a superficial, dry, scraping or rubbing sound, distinctly dependent upon the heart movements. Frequently it is a to-and-fro friction corresponding to systole and diastole. It does not correspond exactly with the first and second sounds of the heart, but may occupy a place between them. At times it is only systolic. It is said to be first heard in most cases over the base of the heart, but may be heard first as a single systolic scratch at the apex. It is usually heard best just to the left of the sternum, between the third and fifth ribs. As the inflammation progresses it may be present over most of the precordium, even to the right of the sternum, in children. It is due to the rubbing of the inflamed pericardial surfaces over each other.

Palpation.—In well-marked cases a friction fremitus can be felt.

Clinical experience has proven that the most common cause of the disappearance of the friction sound is the advent of an effusion which separates the pericardial surfaces. Another fairly common cause is the development of adhesions, uniting the pericardial surfaces. Again, there may be absorption with resolution. The friction sound may reappear after the absorption of the fluid.

Differential Diagnosis.—A pericardial friction rub is usually so characteristic that little difficulty is experienced in its detection. It must be distinguished from organic and functional murmurs and from pleuritic friction sounds. Cardiac murmurs almost never have this superficial scraping, to-and-fro sound; they are likely to be more distinctly systolic or diastolic, and have special lines of transmission. They are not so much altered by changes in the patient's position and are more permanent.

Pleuritic friction sounds are very similar in their character, but are dependent on respiratory movements, and can be eliminated by causing the breath to be held.

Pleuro-pericardial Friction.—A friction sound resembling very closely the true pericardial friction is heard when there is inflammation of that part of the pleura which overlaps the pericardium. With each contraction of the heart the external surface of the pericardium is forced along the under surface of the inflamed pleura, and a friction sound is produced. Forced expiration might tend to eliminate this sound.

Signs of Effusion.—The fact that a friction sound has been heard is of great assistance in diagnosing an effusion. It is fair to suppose that an increased area of cardiac dulness, which develops subsequently to the detection of a pericardial friction rub, is due to an effusion. But one always keeps in mind the fact that a cardiac dilatation must be reckoned with.

Percussion.—It is usually stated that less than 100 c.c. of fluid cannot be recognized by percussion.

In an effusion of moderate degree the outline of dulness is quite characteristic, being of an irregular pear shape, or that of a triangle with rounded angles, whose base faces the diaphragm, and whose apex is above, to the left of the sternum. (Cabot states that he has not been able to make out this characteristically shaped area.)

More important is the fact that the dulness extends much farther to the left, beyond the apex beat, than it does in hypertrophy or dilatation.

Rotch has drawn special attention to the blunting of

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the cardio-hepatic angle in the right fifth intercostal space in pericardial effusion. In health this cardio-hepatic angle is approximately a right angle. In pericardial effusion it is more obtuse. Rotch lays great stress upon the presence of absolute dulness in the fifth intercostal space, extending one and one-eighth to one and a half inches to the right of the sternum. However, this is found in dilatation of the right heart; for instance, in a case of advanced mitral insufficiency it is a common experience to obtain dulness in this area, and a consequent blunting of the cardio-hepatic angle. In fact, Broadbent speaks of two cases of dilated heart in which paracentesis was resorted to, because the signs seemed to point conclusively to pericardial effusion.

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It is also a difficult matter to decide where liver dulness ends and heart dulness begins.

The explanation of the difference of opinion in regard to the value of Rotch's sign in the differential diagnosis between pericardial effusion and dilatation of the heart is due, I think, to the fact that one authority has in mind absolute heart dulness, the other only relative dulness.

With a large effusion, signs of compression of the left lung develop. Above the line of dulness is an area of tympany or hyper-resonance, with increased vesicular or broncho-vesicular breathing. Ewart has called attention to the presence, in large effusions, of a circumscribed patch of dulness or impaired resonance just below the angle of the left scapula, over which there are increased vocal fremitus, bronchophony, and bronchial breathing. Broadbent, I believe, is correct in saying that these signs might also be present in any case of enormously enlarged heart.

Position of the Apex.—It has been held by some of the authorities (Sibson) that the apex is pushed upward and outward by the fluid. Others state that it is tilted upward and inward, that is, is floated by the effusion. Rotch believes from his investigation that this is an erroneous view. It seems impossible for a fluid of a lighter specific gravity than the heart to float it upward.

Ludwig and Bowditch have observed that the impulse of the heart, as seen normally in the fifth left interspace, need not be caused by the heart's apex, but may be caused by a portion of the heart above the apex striking against the chest wall. This fact I have observed many times. It should also be remembered that in children the apex beat is normally in the fourth interspace. The presence of a high pulsation could be accounted for by the tumultuous action of that portion of the right ventricle.

A very important sign is the gradual weakening of the apex beat with the increase of fluid. It may be entirely obliterated. In pericardial effusions the pulse may be strong and the apex beat weak; in heart lesions the apex beat may be heaving and the pulse weak. The effusions may become enormous and thus hinder the heart's action.

The presence of adhesions may prevent a pericardial effusion from assuming the typical shape. Rotch speaks of a case in which dulness failed to appear in the fifth intercostal space (right side), because of the presence of adhesions binding the lung tightly to the right edge of the sternum.

Purulent Pericarditis.—This disease furnishes the same physical signs as the serous effusion. It might be suspected from the etiology, *i.e.*, if secondary to suppuration in the other parts of the body, especially of the lungs or pleura. The leucocyte count would very likely be higher than in the simple serous pericarditis. Paracentesis is the only positive means of determining the nature of the fluid. The temperature curve is of the septic type, resembling that of empyema. The process may come on insidiously. It is usually purulent from the outset, though a serous effusion occasionally becomes purulent.

Adherent Pericardium.—The *symptoms* are not at all characteristic, and cannot be distinguished from those of organic heart lesions.

The *physical signs* in marked cases may be quite distinctive. They depend upon whether the adhesions exist between only the parietal and visceral layers of the pericardium, or whether they include also adhesions between the external pericardium and the chest wall or pleura. The following are the most important: (1) Fixation of the apex beat. Under normal conditions the apex beat moves a considerable distance with change of position of the patient and forced inspiration. (2) Systolic retraction of one or more interspaces. This sign, however, is unreliable, especially if the retraction is present in only one interspace, and at the apex; for it is occasionally seen in greatly hypertrophied hearts, and it may also be due to atmospheric pressure.

If there be distinct dragging in of the costal cartilages at the lower end of the sternum, one can be almost certain of adhesions.

Broadbent's Sign.—"Systolic retraction of the posterior or lateral walls of the thorax may indicate the presence of a universally adherent pericardium. Such retraction may, however, be seen even when the pericardium is not adherent to the heart, but only to a larger extent than normal to the central tendon of the diaphragm, to the muscular substance on either side, and to the chest wall as well. In such cases the heart is usually greatly enlarged and hypertrophied from old valvular disease. The explanation seems to be that the portion of the diaphragm to which the pericardium is adherent is dragged upward at each systole of the heart, so that the points of attachment of the digitations of the diaphragm to the lower ribs and costal cartilages are dragged inward and retracted."

If pericardial adhesions are present between the heart and the diaphragm and the chest wall, the descent of the diaphragm would be much diminished. Fluoroscopic examination would be very useful in demonstrating this point. Litten's phenomenon would be diminished or absent.

Enlargement of the heart is common in adherent pericardium. There are both hypertrophy and dilatation. The hypertrophy results from the obstruction offered to the regular contraction of the heart.

Broadbent states that the heart becomes dilated during the acute pericarditis, and before it regains its original size, becomes anchored in this position by adhesions.

Friedreich's sign of diastolic collapse of the cervical veins is not considered useful by the majority of modern writers.

The pulsus paradoxus has generally been held to be a sign of pericarditis. It is characterized by the disappearance of the radial pulse during inspiration. Kussmaul believes that it is of diagnostic importance in indurated mediastino-pericarditis; it is due to the fibrous cord dragging on the aorta during inspiration.

Most of these signs are dependent upon the presence of adhesions between the pericardium and the chest wall. When such adhesions are absent signs are very indefinite.

Signs and symptoms of incompensation may come on which cannot be distinguished from those of incompensated organic lesions.

An important condition is that of *pseudo-cirrhosis* of the liver due to obliterative pericarditis. In this condition there is an enlarged liver, associated with ascites, but without œdema or enlarged spleen. Autopsies have shown, according to Becker, in all recorded cases, that ascites is due to a passive congestion of the liver, causing a connective-tissue formation with subsequent contraction and obstruction of the portal circulation, the result of obliterative pericarditis.

Differential Diagnosis.—The chief difficulty lies in distinguishing between dilatation of the heart and pericardial effusion, when, as occasionally happens, neither friction sound nor murmur can be heard. This may be better appreciated when it is remembered that on several occasions the right ventricle has been punctured by the paracentesis needle with fatal results, the diagnosis of effusion having been made. In many cases in which the effusion is only of moderate degree it is difficult to be absolutely certain of a diagnosis.

Massive pericardial effusions, amounting to one and a

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half or two litres, have been mistaken for pleuritic effusions.

The following excellent table is taken from Rotch's "Pediatrics," p. 761:

DIFFERENTIAL DIAGNOSIS BETWEEN A DILATED HEART AND A PERICARDIAL EFFUSION.

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Case I.—Endocarditis; dilated heart.	Case II. Pericarditis; effusion.	Case III. Endocarditis; enlarged heart; pericardial effusion.
Girl, eleven years. Attack followed acute articular rheumatism.	Boy, six years. Attack followed acute articular rheumatism.	Girl, eight years, August 3d. Attack followed acute articular rheumatism.
Orthopnœa; precordial pain; heart's impulse feeble, but perceptible a little to left and below left nipple, fifth interspace.	Orthopnœa; precordial pain; heart's impulse feeble but perceptible a little to left and below left nipple, fifth interspace.	Orthopnœa; precordial pain; heart's impulse feeble, but perceptible all over cardiac area, with apex beat a little below and to left of left nipple, fifth interspace.
Vertical absolute dulness not increased.	Vertical absolute dulness not increased.	Vertical absolute dulness not increased.
Absolute dulness under the sternum, and to left of sternum; identical with cases II. and III.	Absolute dulness under the sternum and to left of sternum; identical with cases I. and III	Absolute dulness under the sternum and to left of sternum; identical with cases I. and II.
Absolute dulness did not extend to right of sternum.	Absolute dulness in fifth right interspace 2 or 3 cm. from edge of sternum.	Absolute dulness in fifth right interspace 3 or 4 cm. from edges of sternum.
Systolic murmur at apex.	Pericardial friction rub at base.	Soft systolic murmur at apex, transmitted to axilla; pericardial friction rub at base.
Recovery.	Recovery.	August 6th. Less dulness in fifth right interspace; apex murmur much louder and harsh.
		August 11th. Dulness only to right edge of sternum.
		August 18th. Dulness only to middle of sternum; friction rub ceased.
		December 1st. Physical examination the same as on August 18th, showing enlarged heart and mitral systolic murmur.

The following points, mentioned by Osler, may assist one in differentiating between dilatation of the heart and pericardial effusion:

In dilatation the impulse in thin-chested people is usually visible and undulatory; the shock of the cardiac sound is more distinctly palpable in dilatation; the peculiar area of dulness in effusion, especially if the upper limit shifts with change of position of the patient.

In dilatation the heart sounds are clearer, often sharp, valvular or fœtal in character; gallop rhythm is common, whereas in effusion the sounds are distant and muffled.

Rarely, in dilatation, is the distention sufficient to compress the lung and produce the tympanitic note in the axillary region.

Fluoroscopic examination is extremely useful for differential diagnosis. The opaque area does not pulsate as it does in enlarged heart or aneurism. The upper level can be seen to move with changes of position.

Diseases of the Pericardium in Children.—Only a few special observations need be mentioned under this heading, as the signs of pericardial disease are practically the same at all ages. Rotch states that so far as he could determine by the dissection of sixteen infants of different ages the relation of the infant's pericardium does not differ from that of the adult. The amount of fluid normally present is of variable quantity, but is probably under 5 c.c. When pericardial friction sounds are absent, the diagnosis of pericarditis in a young child is attended with great difficulties. Some writers (Warthin) state that an accentuated pulmonary second sound is characteristic of pericarditis. In infancy, however, the pulmonary second sound is normally much accentuated. Owing to the greater flexibility of its thorax the child is much more likely than the adult to manifest a bulging of the precordium as a result of the pressure of the fluid. It must be kept in mind that on account of the smallness of the child's thorax the heart and pericardium are both brought nearer the surface than in the adult; and as a result the heart's impulse can be felt, and the heart sounds heard, in much larger effusions than would be possible in adults.

Pericarditis sicca is uncommon in childhood. Exudation takes place more frequently than in the adult, and with greater rapidity, and is more likely to be purulent (Rotch). Exudation tinged with blood is not uncommon in early life, and is not so significant of tuberculosis as is a pronounced hemorrhagic exudation.

Holt states that pericarditis is rare in infancy and early childhood, only two cases having been seen in seven hundred and twenty-six consecutive autopsies at the New York Infant Asylum. In later childhood the disease is more frequent. According to Jacobi, Holt, and other authorities diseases of the lung and pleura, especially of the left side, take first rank as etiological factors in infancy and early childhood. After the fourth year rheumatism takes precedence and the pericarditis is then usually associated with endocarditis. Pericarditis may develop in the new-born as a result of infection of the cord. In children pericarditis may develop and become very pronounced, while the articular complaint is mild.

In young children pain seems to be generally absent.

Prognosis.—Pericarditis should always be looked upon as a serious disease, chiefly because of the myocardial degeneration which accompanies it. Death may take place in a few days in the acute cases associated with rheumatism and pneumonia, but this sequel is very uncommon. The immediate prognosis in these cases is generally good. The probability of repeated attacks, the likelihood that adhesions will form, and the presence of myocarditis render the prognosis for a long life unfavorable. When associated with Bright's disease the prognosis is bad.

Patients occasionally die from syncope as a result of embarrassment to the action of the heart from pressure, by very large collections of fluid.

Suppurative pericarditis is nearly always fatal if associated with a general septicæmia; if it is secondary to an empyema or other localized collection of pus, there may occasionally be recovery, with the adoption of early and proper surgical treatment. Of thirty-five cases of suppurative pericarditis treated by incision, fifteen recovered and twenty died (Roberts, *Am. Jour. Med. Sc.*, December, 1897).

In adherent pericardium the prognosis is serious if there are adhesions to the chest wall, or if the heart is enlarged, or especially if these adhesions are associated with valvular lesions. Universal adhesion of the pericardium to the heart, provided the heart is not enlarged, does not necessarily tend to shorten life.

Treatment.—Pericarditis must always be considered a serious disease, even if the symptoms are slight. The patient should be put to bed. The diet should be chiefly liquid, milk forming the major part. The stomach should not be overloaded. In the milder cases soft articles of food may be given. Pain should be relieved chiefly by the application of the ice-bag. In children hot applications may be more satisfactory. Morphine may be required in some cases. Restlessness and sleeplessness should be controlled by suitable doses of bromide or trional. The heart action, pulse, respirations, and color of the patient should be closely watched, and heart tonics, such as strychnine and digitalis and ammonia, given when indicated. The time may come when the heart is overwhelmed by the obstacles presented by the enormous effusion; the pulse becomes extremely weak and rapid, marked dyspnœa and cyanosis develop; then heart tonics are useless, and one must resort to paracentesis to save the patient.

Unless the symptoms are moderately urgent a serous effusion should not be evacuated, because many times the absorption is very rapid. If the effusion is large and has existed for many days, and shows no signs of resorption, it should then be evacuated without hesitation.

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Paracentesis Pericardii.—The pericardium is tapped with a Potain aspirating set in the same way as is the pleura. The only difference is in the selection of the points of puncture. An excellent method is first to freeze the part with an ethyl chloride spray, make a very small incision through the skin with a bistoury, then insert the needle at right angles to the chest wall for a distance of from one and a half to two inches. After consulting a large number of authorities upon the correct site for puncture, and finding that each writer advises a different location, I have come to the conclusion that if a fairly large effusion is present it is safe to puncture anywhere from an inch to the right of the sternum to an inch or so beyond the left nipple line, between the fourth and sixth ribs. One is cautioned to avoid wounding the internal mammary artery. Little attention need be paid to the intercostal arteries.

Rotch very strongly recommends the fifth right interspace 4 cm. (1½ in.) outside the right border of the sternum. He states that an effusion of even as little as 100 c.c. can be found at this point, and that there is no danger here of wounding the heart, or the right internal mammary artery, or the pleura. Osler recommends the fourth left interspace, either at the sternal margin or 2.5 cm. (1 in.) from it. He also speaks of the fifth left interspace an inch and a half from the left sternal margin, and close to the costal margin in the left costo-xyphoid angle, as the point where the needle may be thrust upward and backward.

Purulent effusions should be treated like any other abscess, by early free incision and drainage. Irrigation of the sac is not advisable except in selected cases.

The treatment of adherent pericardium is practically that of organic heart lesions (myocardial and valvular). It is necessary to keep up bodily nutrition by proper exercise and diet, and at the same time guard against overtaxing the weak heart. If symptoms of incompensation develop they should be treated by rest, diet, and cardiac medicines, as indicated elsewhere.

Hæmopericardium and Hydropericardium have been considered in detail in Vol. IV.

Pneumopericardium, because of its extreme rarity and hopeless prognosis, is of very little practical importance. By it is meant the presence of gas or air in the pericardial sac. As a matter of fact, gas is never present alone, but is in combination with fluid, usually pus, *i.e.*, pyopneumopericardium. The fluid may be ichorous. It is always secondary to some very serious destructive disease in which a communication is established between the pericardium and a cavity or tube containing air—as, for instance, perforation from the œsophagus, especially in connection with cancer; rupture into the pericardium of a lung cavity, or pneumothorax, or perforation of a gastric ulcer. It may occur as a result of penetrating wounds, such as fractured ribs, concussion or crushing of the chest, or injury from the side of the œsophagus. The gas in pneumopericardium varies in amount and in composition, and is generally offensive. It may be under so great pressure that when the pericardium is punctured the gas escapes with a hissing noise.

Symptoms.—These are very indefinite, and difficult to dissociate from the primary disease. If the gas is present in abundance there will be dyspnœa, cyanosis, attacks of syncope, collapse, a feeble and irregular pulse, and occasionally dysphagia and precordial distress.

Physical Signs.—There may be bulging of the precordial region. The apex beat is weak or absent. The heart movements may produce a very peculiar crackling sensation due to the bursting of bubbles.

Percussion signs are very striking. A metallic tympanitic note is heard over the distended pericardium. Because of the presence of fluid and air a freely movable area of dulness is detected in the dependent part, upon change of position. The quality of the tympanitic note may also vary with the change of position.

Auscultation.—The heart sounds are unusually loud and may have a metallic ring. If murmurs are present they take on the same quality. The cardiac movements and deep breathing agitate the fluid and gas present in such a way as to produce unusual adventitious sounds. They have a metallic ringing quality, and have been likened to the sound of a water wheel.

Treatment is expectant and supportive. It may at times be wise to allow the gas to escape through a fine trocar, or even to incise and treat surgically. Little can be done in a medical way.

New Growths and Parasites.—Under this heading are included tuberculosis, carcinoma, and hydatids. Tuberculosis is much more common than the latter two. It is very unusual to find the tubercles of acute miliary tuberculosis on the pericardium. In most cases tuberculosis of the pericardium is chronic and secondary to tuberculosis in other parts of the body, especially of the lungs and mediastinal lymph glands. In many cases of pulmonary tuberculosis the complicating pericarditis is of the simple serous type. The exudate in tuberculosis and carcinoma of the pericardium is likely to be blood-tinged, and may be purulent or ichorous.

Carcinoma of the pericardium is extremely rare and is always secondary, the sac being involved by extension from neighboring organs.

Hydatids of the pericardium are extremely rare. Clinically we have no means of recognizing the presence of a new growth in the pericardium, except as we infer its presence from the detection of similar disease in neighboring tissues.

James Rae Arneill.

PERINEORRHAPHY. See *Obstetric Operations.*

PERINEUM, SURGICAL ANATOMY OF THE.—I. The Male Perineum.—In the skeleton the perineum corresponds to the outlet of the pelvis. It is a diamond or lozenge-shaped space bounded in front by the pubis and subpubic ligament, behind by the coccyx, and on each side, from before backward, by the rami of the pubis and ischium, the great tuberosity of the ischium, and the great sacro-sciatic ligament.

The whole space measures about three inches and a half from side to side, and four inches antero-posteriorly. At the posterior part it is from two to three inches deep; anteriorly it only reaches the depth of one inch. The perineal space is separated from the pelvic cavity above by the recto-fascia and levatores ani muscles. A line drawn across from one ischial tuberosity to the other, and passing immediately in front of the anus, would divide the space into two parts (see Fig. 3794), the anterior of which is called the *urethral* triangle or true perineum, and the posterior the *anal* or rectal triangle. The anterior triangle contains the bulb and urethra, with the muscles of the perineum proper; the posterior triangle has in it the rectum and the two ischio-rectal fossæ.

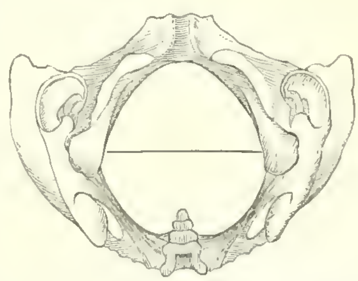

Fig. 3794.—Outlet of the Pelvis. Line dividing outlet into anterior or urethral triangle, and posterior or rectal triangle.

Surface Anatomy.—In the undissected subject the superficial area of the perineum is very limited, especially when the thighs are brought together; it then consists of a narrow space or groove reaching from the coccyx behind to the symphysis pubis in front. In the centre of this groove is an elevation of the skin, called the median raphé, which runs from the front of the anus, over the scrotum, to the under surface of the penis. No vessels cross this line, and in this situation incisions may be made without any fear of hemorrhage. The osseous boundaries of the perineum may be easily made out through the skin; the great sacro-sciatic ligaments, however, being covered by the gluteal muscles, can be felt

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only by pressing in a line drawn from the coccyx to the ischial tuberosity. In thin subjects they can be more easily felt. The anus is situated at the midpoint between the tuberosities, and its centre is about one inch and a half from the end of the coccyx. The central point of the perineum is a little more than an inch in front of the anus; this point corresponds to the middle of the free border of the triangular ligament. A knife introduced here, and given a slightly upward direction, would reach the membranous urethra. Immediately in front of the central point may be felt, in all but very fat persons and children, the bulb of the urethra and the corpus spongiosum. Abscesses point, and urethral fistulæ are often seen, in this region.

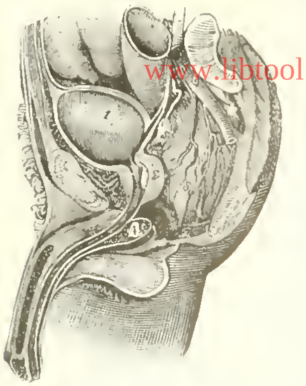

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FIG. 3795.—1, Bladder; 2, prostate; 4, bulb; 5-6, seminal vesicles and vas deferens; 7, ureter; 8, rectum; 9, sphincter ani. (Roser.)

The membranous portion of the urethra perforates the triangular ligament one inch below the symphysis pubis, and one inch and a half in front of the anus. The skin of the perineum is thin and covered with hairs; about the anus it is of a brownish color and thrown into radiating wrinkles by the contraction of the external sphincter; these folds are much enlarged when the hemorrhoidal veins are swollen and inflamed. If the skin of the anus be everted, a fine white line is seen which marks the junction of the skin and mucous membrane, and corresponds exactly to the lower margin of the internal sphincter. There are a number of follicles about the margin of the anus, and small subcutaneous abscesses frequently occur in this situation. These must not be confounded with fistulæ. The usual incision in lateral lithotomy passes between the anus and ischial tuberosity, a third nearer the tuberosity than the anus.

If the finger be introduced through the anus into the rectum, many important landmarks may be felt. The finger for the first inch is grasped by the sphincter muscles, principally the internal. Here the internal openings of fistulæ may be felt, these openings are rarely much above the upper border of the sphincter ani. One can easily feel ulcers and fissures in this situation, when they are present. In the front wall of the bowel the membranous portion of the urethra can be made out in the middle line, and when a catheter is introduced into the bladder it can be easily felt as it passes through the membranous portion; with the finger in the rectum a catheter can be guided into the bladder in cases of enlarged prostate, and if the instrument enters a false passage it can be detected and directed into the proper channel. The prostate gland can be felt one inch and a half from the anus, and its condition ascertained if it be enlarged or inflamed. Passing beyond the prostate the finger comes on the trigone of the bladder. When the bladder is distended it may be made out through the rectum as a soft fluctuating tumor. It is more easily felt when the other hand, placed above the pubis, presses the apex downward. The bladder, when distended, may be tapped through the trigone with a curved trocar, without there being any danger of wounding the peritoneum, which generally reaches only to within four inches of the anus. In rare cases the peritoneum passes down between the gut and the trigone. In such cases, of course, in this operation, it would inevitably be wounded.

The vesiculæ seminales can rarely be felt, unless affected by disease.

Stone in the bladder in children can often be diagnosed through the rectum. Above the trigone of the bladder transverse folds of mucous membrane in the rectum can be felt; these are soft and velvety when healthy, but when ulcerated or inflamed they feel thick and cause great pain on defecation. Many diseases are diagnosed by the finger in the rectum, viz., ulcers, polypi, hemorrhoids, stricture of the gut, diseases of the prostate, deep-seated abscess of the ischio-rectal fossa, pelvic tumors, etc.

With the whole hand introduced into the rectum the entire pelvis may be explored, as well as the lower part of the abdomen.

ISCHIO-RECTAL FOSSA.—The ischio-rectal fossa is the space which exists on each side between the rectum and ischial tuberosity. It is of a pyramidal shape, with the apex pointing upward to the pelvic cavity, and is from two to three inches in depth.

Boundaries.—Internally, the levator ani covered by the anal fascia; externally, the obturator internus muscle covered by the parietal layer of pelvic fascia; in front, the triangular ligament and transversus perinei muscle; behind, the lower edge of the gluteus maximus, the great sacro-sciatic ligament, and the coccygeus muscle.

The space is filled with fat, and crossing the fossa obliquely are the inferior hemorrhoidal vessels and nerves. The anterior portion is crossed by the perineal vessels and nerves, and entering the fossa at its posterior part is the perineal branch of the fourth sacral nerve.

The tuberosities of the ischia have also a cushion of fat over them, and when this is removed several bursæ are seen. The apex of the space corresponds to the division of the pelvic fascia into parietal and visceral layers, or rather to the junction of the anal with the obturator fascia. When the anal fascia is removed the levator ani muscle is exposed, and internal to the levator ani is the visceral layer of pelvic fascia.

The lower end of the rectum is placed between the two fossæ, slung, as it were, by the meeting of the two levatores ani muscles, and held in place by the external sphincter and recto-vesical fascia. The fibres of the levatores ani muscles at the lower end of the rectum are separated from one another, and in this situation the anal fascia is also very thin, so that little resistance is offered to the entrance of pus.

Ischio-rectal Abscess and Fistula in Ano.—Abscess in the ischio-rectal fossa is not an uncommon affection, and is often caused by the ulceration of foreign bodies, such as fish-bones, through the bowel into the fossa, and there setting up inflammation. Sitting on cold, damp seats after exercise is another, and perhaps the most common, cause of ischio-rectal abscess.

When pus forms in the fossa it presents at the points of least resistance, viz., the internal wall of the fossa and the skin at the base. When the abscess breaks through the skin it will be found that after a time a sinus remains, which generally communicates with the bowel; this sinus is called a *fistula in ano*. The internal opening of the fistula is usually within half an inch of the margin of the anus, as at this point pus can more easily penetrate the rectum, because of the thinness of the fascia and the scantiness of the muscular fibres. The external opening may be anywhere in the region of the posterior part of the perineum. To prevent the formation of a fistula, the ischio-rectal abscess should be opened early and freely.

PERINEAL FASCIÆ.—The superficial fascia of the perineum consists of two layers, between which, in the rectal triangle, is a large amount of fat; in the urethral triangle there is less, and as the fascia reaches the scrotum the fat is replaced by the muscle or dartous tissue of that structure. The deep layer of fascia (fascia of Colles) is limited to the urethral triangle; it is attached to the base of the triangular ligament, to the anterior lips of the rami of the pubes and ischia laterally, and anteriorly it is continuous with the fascia of the scrotum. By its junction with the triangular ligament posteriorly it forms a pouch, which is divided into two portions by a median septum.

This pouch has an important influence on the direction which urine takes when extravasated, or pus when it

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forms, in this region. Owing to the attachment of the superficial fascia to the base of the triangular ligament and to the rami of the pubes and ischia, fluid cannot go back toward the anus or down the thighs, but, as the fascia is continuous anteriorly with the dartos of the scrotum, no resistance is offered to its progress forward and upward over the scrotum to the abdomen.

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This is the course taken by urine when extravasated in front of the triangular ligament. When an abscess forms in the perineum, owing to the median septum, it is usually confined to one side of this pouch, and the swelling is triangular in shape. The pus, as it passes forward, on account of the deficiency of the septum in front, fills both sides of the pouch.

The anterior perineal pouch contains the superficial perineal muscles, vessels, nerves, and the root of the penis, which latter is made up of the two crura of the cavernous portions and the bulb of the spongy portion.

Muscles.—The muscles of the perineum bound the perineal triangle, in which the knife is entered in the operation of lateral lithotomy. The base of the triangle is formed by the tranversus perinei muscle, the outer side by the ischio-cavernosus (erector penis) muscle, and the inner side by the bulbo-cavernosus (accelerator urinæ); the triangular ligament forms the floor of the triangle.

The point of meeting of the two transverse perineal muscles, the sphincter ani, and bulbo-cavernosus muscles is called the tendinous or central point of the perineum. Along the lower border of the transverse muscles is seen the transverse artery, a branch of the internal pudic.

*Triangular Ligament.**—This ligament divides the perineum into two portions—a deep and a superficial. It has very definite attachments to the subpubic ligament, the rami of the pubis and ischia, and the superficial fascia. It also blends with the central tendinous point

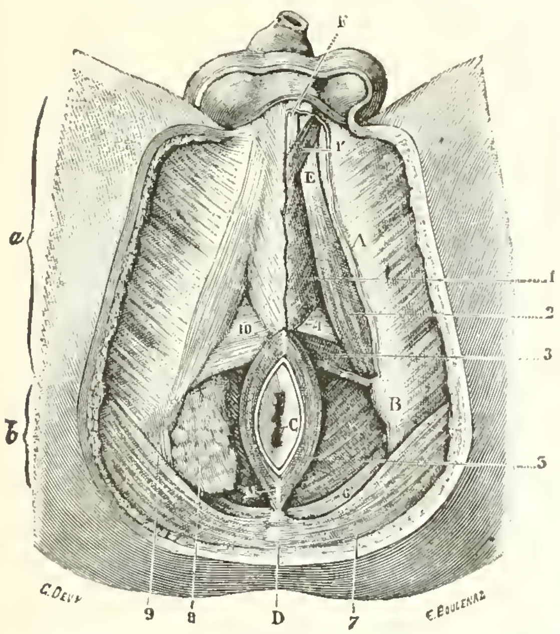

FIG. 3796.—Superficial Dissection of the Muscles of the Perineum. 1, Bulbo-cavernosus muscle; 2, ischio-cavernosus; 3, transversus perinæi; 4, triangular ligament; 5, sphincter ani; 6, coccygeus; 7, great gluteus muscle; 8, cellular fatty tissue of the ischio-rectal fossa; 9, sacro-sciatic ligament; *A*, ischio-pubic ramus; *B*, ischium; *C*, anus; *D*, coccyx; *E*, cavernous body.

of the perineum. As suggested by Prof. D. J. Cunningham, of Dublin, it is better to regard this ligament as a distinct membrane, and to class it in the same category as the obturator membrane; for "it lies in the same morphological plane as the bony and ligamentous wall of the

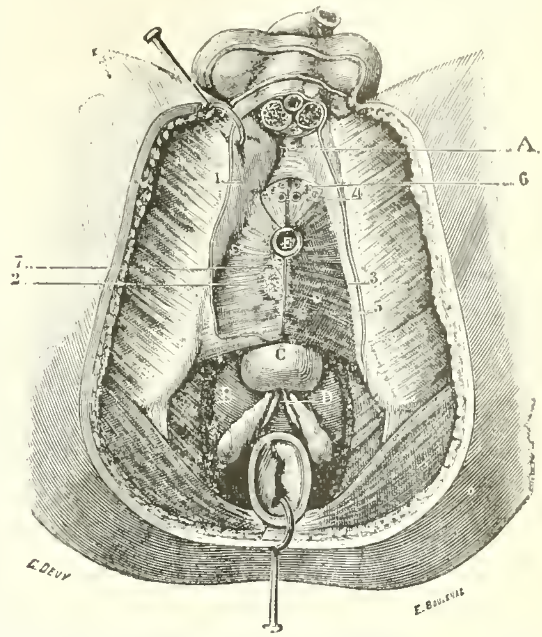

FIG. 3797.—The Muscles of the Perineum, Deep Dissection. *A*, Symphysis pubis; *B*, bladder; *C*, prostate; *D*, seminal vesicle; *E*, urethra cut transversely; 1, triangular ligament; 3, deep transverse perinei muscle; 5, Cowper's glands; 6, subpubic plexus of veins.

pelvis," and it completes the pelvic wall in front in the same manner as the thyroid membrane closes the thyroid foramen.

When the body is erect the lower surface of the triangular ligament looks downward and forward, and the deep surface upward and backward.

Structures in Relation with the Triangular Ligament.—In front are the structures named above as being contained in the perineal pouch.

The ligament is pierced by the urethra, and also by the dorsal vein and nerves of the penis and the internal pudic arteries. The urethra pierces the ligament one inch below the symphysis pubis, in the middle line. The parietal layer of pelvic fascia (posterior layer of the triangular ligament) is above and behind, and is attached to the ligament below, but as it proceeds upward the space between them widens. Between these two structures are the membranous portion of the urethra, the pudic vessels and nerves, with the artery of the bulb, the dorsal vein of the penis, the compressor urethræ muscle, which surrounds the membranous urethra, and Cowper's glands. These latter empty their secretion into the bulbous portion of the urethra; in inflammatory conditions of the urethra they may become inflamed and suppurate; they are the homologues of Bartholin's glands in the female.

The membranous portion is the least dilatable portion of the urethra, and is frequently the seat of *traumatic* strictures; it measures three-fourths of an inch in length.

Behind and above the pelvic fascia (posterior layer of the triangular ligament) is the apex of the prostate gland, covered by the levator ani muscle and by its own capsule. From this description it will be seen that the triangular ligament divides the perineum into two compartments, a superficial and a deep; the superficial contains the perineal muscles and root of the penis; the deep the membranous portion of the urethra, the pudic artery and nerves, the dorsal vein of the penis, the compressor urethræ muscle, and Cowper's glands. The base of the triangular ligament is the meeting-point of three fasciæ,

* This structure is sometimes named the anterior layer of the triangular ligament, the posterior layer being the parietal layer of pelvic fascia. It is also called the deep layer of the deep perineal fascia and the subpubic fascia.

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viz.: (1) perineal fascia; (2) triangular ligament; and (3) the parietal layer of the pelvic fascia (posterior layer of the triangular ligament).

The triangular ligament sometimes offers an obstacle to the introduction of a catheter; for if the instrument be

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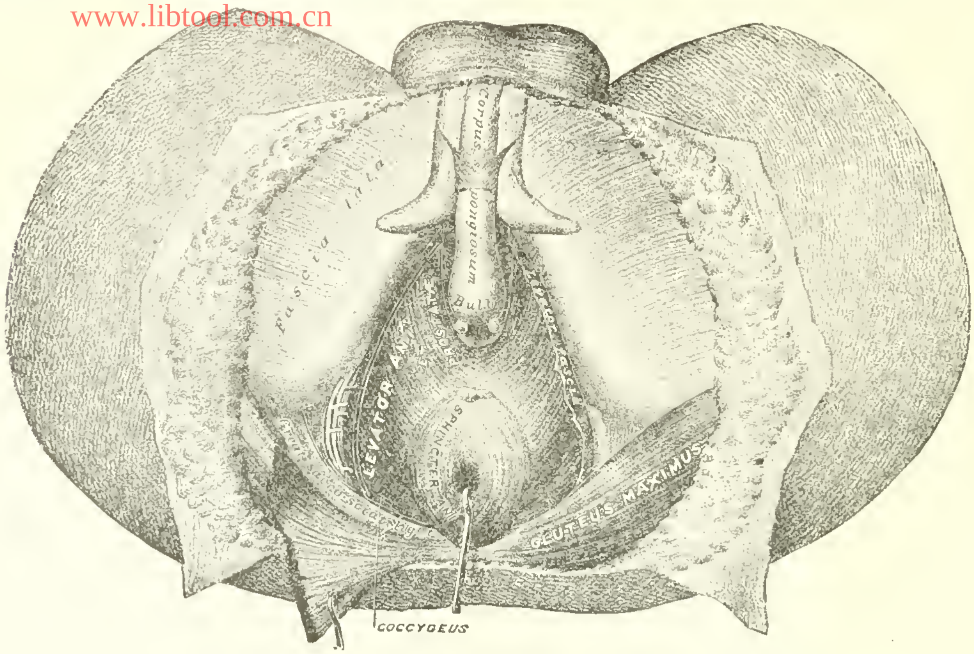

FIG. 3798.

not kept against the upper wall of the urethra, it is apt to sag in the lower wall, which is very distensible, and reach the triangular ligament below the opening of the membranous urethra. After the triangular ligament has been successfully passed, the point of the instrument may be arrested in the membranous urethra by the spasmodic contraction of the compressor urethræ muscle which encircles it; this obstruction may be overcome, without exercising any force, by merely keeping the end of the instrument pressed gently against the obstructing point; after a short time the muscle relaxes and the instrument slips into the bladder.

Kicks in the perineum, or injuries from falling astraddle of anything, may rupture the membranous portion of the urethra, and in these cases blood and urine will be extravasated between the triangular ligament and the parietal layer of the pelvic fascia (posterior layer of the triangular ligament). Should the injury tear the triangular ligament, then the extravasated fluid would take the ordinary course upward over the scrotum and abdomen. When extravasation has occurred, free incisions should be made in the perineum, and if the urethra be completely torn across, the perineum should be opened in the middle line and an instrument introduced into the bladder.

Professor Cunningham, of Dublin, has pointed out, in his "Dissector's Guide," that in removing the various structures from the surface to the prostate gland, alternate layers of fascia and muscle are met with viz.: (1) Superficial fascia; (2) *superficial perineal muscles*; (3) triangular ligament; (4) *compressor urethræ muscle*; (5) parietal layer of pelvic fascia, or posterior layer of the triangular ligament; (6) *levator ani muscle*; (7) capsule of the prostate and pubo prostatic ligament.

Internal Pudic Artery.—The pudic artery is seen in the rectal triangle enclosed within a sheath of pelvic fascia formed by the splitting of the obturator fascia. It lies about one and a half inches above the level of the ischial tuberosity and is accompanied by the pudic nerve and the two pudic veins; proceeding forward, it passes between the triangular ligament and the parietal layer of pelvic fascia (posterior layer of the triangular ligament), and then, running under cover of the rami of the pubis and ischium, pierces the triangular ligament from behind, half an inch below the symphysis and a little to one side of the middle line. It then divides into its two terminal branches, the artery to the corpus cavernosum, and the artery to the dorsum of the penis. The pudic artery, while in the ischio-rectal fossa, gives off the hemorrhoidal, and a little further forward the superficial and transverse perineal, arteries. While passing behind the triangular ligament, it gives off the artery of the bulb, the wounding of which was formerly so much dreaded by surgeons. The pudic artery itself is said to be in danger of being wounded in lateral lithotomy, but this accident could occur only to the most careless operators, when withdrawing the knife and sweeping it outward. It is possible to wound it only after it has left the protection of the pubic arch.

EXPLORATION OF THE BLADDER THROUGH THE PERINEUM.—This operation is little more than a perineal section. According to Sir Henry Thompson, after introducing a grooved staff an incision should be made in the median line, commencing three-fourths of an inch in front of the anus, and the parts should be divided till the staff is reached in the membranous portion of the urethra; the finger is introduced into the bladder through this incision, the prostatic urethra dilating easily; the staff is now removed and the exploration of the bladder is made. Through this median incision tumors and stones of moderate size can be removed. There is little hemorrhage, even should the bulb be wounded, for this latter structure is not very vascular in the median line.

Parts Divided in Lateral Lithotomy.—The incision is commenced one inch and a half in front of the anus, and is carried downward and outward to a point between the anus and great tuberosity, a little nearer the tuberosity than the anus.* In order to reach the staff in the membranous urethra the following structures must be cut:

In the first incision: Skin and superficial fascia; trans-

* The incision employed in lateral lithotomy falls about in a line parallel with the ascending ramus of the pubis and the ischio-cavernosus muscle. (Roser.)

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verse perineal muscle and artery; base of the triangular ligament; the hemorrhoidal vessels and nerves.

Second incision: The knife is now guided by the forefinger, passed up behind the triangular ligament, its point placed in the groove of the staff, and the blade is lateralized and pushed along the groove into the bladder. In this incision the following parts are divided, viz.: Membranous portion of the urethra and compressor urethræ muscle; parietal layer of pelvic fascia (posterior layer of the triangular ligament); anterior fibres of the levator ani and left lobe of the prostate.

Parts to be Avoided.—(1) Artery of the bulb, (2) rectum, (3) pudic artery.

(1) The danger from a wound of the artery of the bulb is not great, and is somewhat traditional; with the modern methods of arresting hemorrhages no one need fear wounding the artery of the bulb. Very frequently it is abnormal in its distribution, and its division cannot be avoided.

(2) The rectum may be cut, especially in children, if the bowel is not emptied previous to operation, or if the incision be carried down too vertically.

(3) The pudic artery need never be wounded in a properly performed operation. It can be cut only by lateralizing the knife too much in withdrawing it. If wounded, it may be secured with the modern artery forceps without great difficulty.

In the withdrawal of the knife a too vertical incision may cut through the prostate, and so divide the visceral layer of pelvic fascia. Should this accident happen, no ill results will follow if the wound be kept sweet and be thoroughly drained. Wounding of the visceral layer of the pelvic fascia is a danger much dwelt on by the older lithotomists, and surgeons of the present day still have a traditional fear of this accident happening. In children, lateral lithotomy can scarcely be performed without cutting through the prostate gland, and at the same time the visceral layer of pelvic fascia; yet no ill results follow; on the contrary, the operation is safer in children than in adults. The real danger in adults is not from wounding the pelvic fascia, but from wounding the prostatic plexus of veins and the ejaculatory ducts. The prostate gland when enlarged can be removed through a perineal incision either transverse or vertical. Also the seminal vesicles can be reached through the same route. When affected with tuberculous disease it is sometimes necessary to remove them. The ureter as it enters the bladder can be reached through the perineum, and stones which have become lodged there successfully extracted.

Testicle in Perineum.—During the descent of the testicle, and after it has passed through the external abdominal ring, it may, instead of entering the scrotum, pass down into the perineum (ectopia perinealis). In these cases it may be felt slightly movable under the skin, about an inch and a half in front of the anus. The scrotum of the side in which the testicle is lodged in the perineum is deficient it the affection be congenital; if the case is of traumatic origin the scrotum of that side is present. The displacement has no evil effect on the testicle, which is always of a good size. The abnormal position of the testicle renders it liable to injury, and patients apply to the surgeon for relief. An operation has been devised for restoring the misplaced testicle to its proper position in the scrotum, but its success has been only moderate. Excision is sometimes demanded to rid the patient of his trouble.

II. The Female Perineum.—The space occupied by the female perineum, owing to the wider pubic arch, is somewhat larger than that of the male. It differs from the male perineum in being perforated in the median line by the vulvo-vaginal opening. This opening occupies the place in the female which in the male is the situation of the bulb. In the female this bulb is, as it were, divided into two halves, as is also the muscle covering it. The space between the divided bulb is the opening of the vagina. The *vagina* extends upward and backward between the bladder and rectum, its upper part being covered by peritoneum, and thus it is in close relation with the peritoneal cavity.

The *triangular ligament* is also divided into two halves, and on this divided ligament rests the divided bulb, the vagina passing between. So we have a bulb which is called the "vestibular bulb" on each side of the vagina, and these bulbs are joined above by a small plexus of

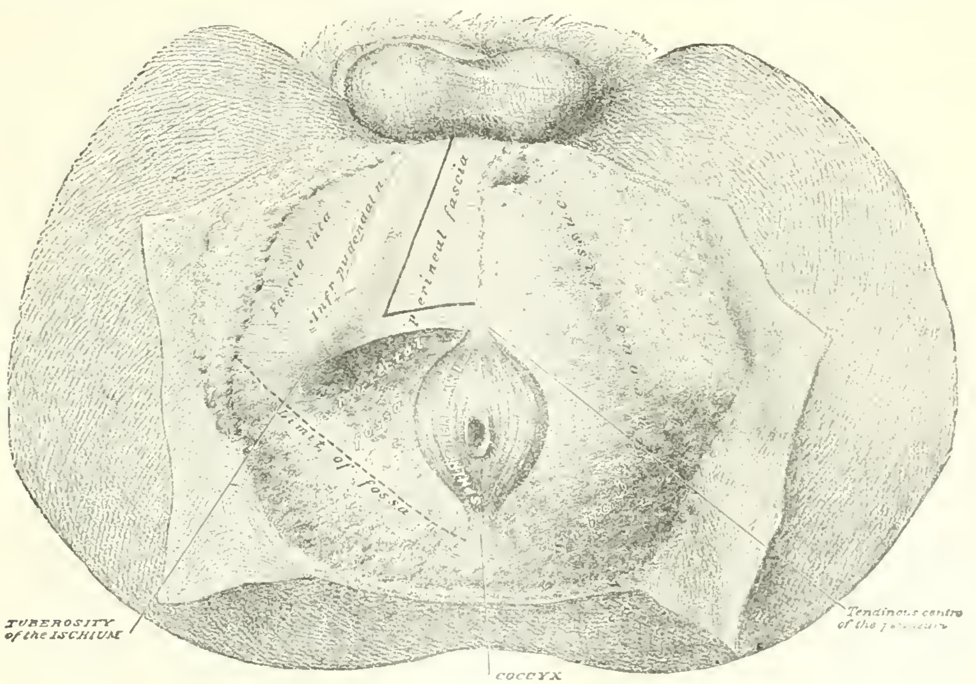

Fig. 3799.

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vessels called the "pars intermedia." The bulbs are covered by the sphincter vaginæ muscle (bulbo-cavernosus). This is the homologue of the fused *bulbo-cavernosus* muscle in the male. We also see the anterior fibres of the

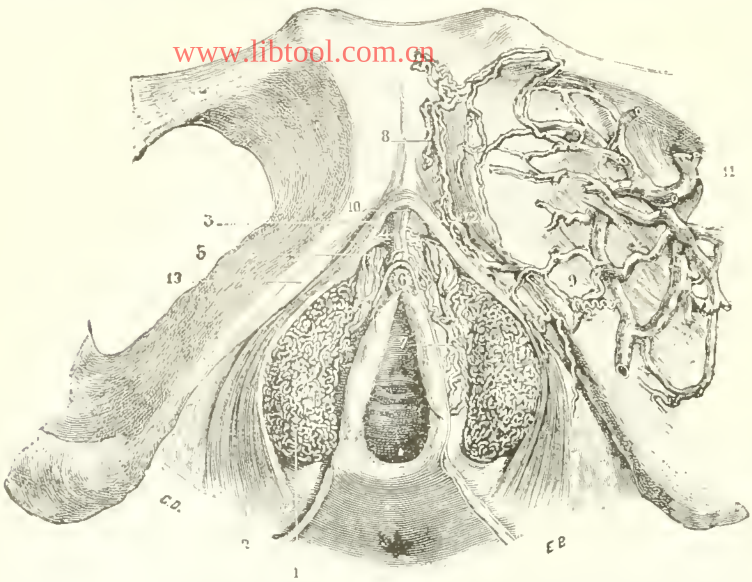

FIG. 3800.—The Bulb of the Vagina with the Venous System of the Clitoris, Viewed from in front. (After Kobelt.) 1, Bulb; 2, constrictor muscle; 6, glans of clitoris; 9, communication with the obturator veins; 13, cavernous body.

levator ani muscle embracing the vagina as they do the prostate gland in the male.

The *superficial fascia* and *Colles' fascia* have the same attachments as in the male, but differ in being perforated by the vagina.

The glands of Bartholin and Duverney are situated on each side of the commencement of the vagina behind the triangular ligament, and correspond to Cowper's glands in the male. Their ducts open on each side between the hymen and labium minus. It is not uncommon to have abscesses connected with these glands, to cure which they have to be dissected out.

The *clitoris* and nymphæ correspond to the penis in the male. The clitoris is composed of two corpora cavernosa and a rudimentary glans. It is much smaller than the penis, and is not perforated by the urethra. The corpora cavernosa are attached to the inner side of the pubic arch in front of the triangular ligament, and, as in the male, are covered by a muscle, the ischio-cavernosus (erector clitoridis). The glans is surrounded by a membranous fold, which is the homologue of the prepuce in the male.

The *vulvar cleft* opens on the surface between the two labia majora; anteriorly opening into this cleft is the urethra, and posteriorly is a recess called the fossa navicularis, and in the centre is the vagina. The space anteriorly between the clitoris and the urethra is called the vestibule, and this is bounded on each side by a labium minus.

The *labia majora* are two thick folds of skin covered with hair and united in front to form the mons veneris. In each labium are blood-vessels and dartous tissue as in the scrotum of the male, of which they are the homologue. The vestibule corresponds to the lower prostatic and membranous portion of the urethra in the male.

On separating the labia majora the nymphæ or labia minora are seen. These are folds of skin which are continuous above with the prepuce of the clitoris and below join the *labia majora* about the centre. As a rule they do not project beyond the labia majora, but in the dark races they are of larger size and project considerably beyond the vulvar cleft. In old age they are also more prominent.

The *hymen* is a thin fold of mucous membrane of various forms, which partially occludes the vaginal orifice; in some cases the vaginal orifice is completely closed, and then we have what is called an *imperforate hymen*. Occasionally the hymen is absent or has been destroyed by inflammatory action in childhood. Its presence is not necessarily a proof of virginity nor is its absence significant of the loss of the same. When the hymen has been ruptured, and in women who have borne children, the remnants are seen as small rounded elevations called "carunculæ myrtiformes."

The vessels and nerves of the female perineum do not differ essentially from those of the male; the pudic artery is smaller, while the superficial perineal artery going to the labia is larger. Owing to the small size of the clitoris as compared with the penis, the nerves and blood-vessels supplying it are much smaller.

The Perineal Body, or the so-called perineum of the obstetrician, fills in the space between the vagina and the rectum; in section it is triangular in shape, with the base of the triangle downward, corresponding to the skin between the posterior part of the vagina and the anterior border of the anus. Anteriorly is the fossa navicularis, and posteriorly is the rectum. The perineal body measures at its base about one and one-quarter inches from before backward, and laterally extends from one tuberosity to the other; in this space is the tendinous point of the perineum, to which are attached several muscles, such as the levator ani, sphincter ani, transversus perinei, and sphincter vaginæ. Laterally we have the ischio-cavernosi muscles. Running across the perineal body we have a transverse septum which, in the female, is very strong and consists of connective tissue, yellow elastic tissue,

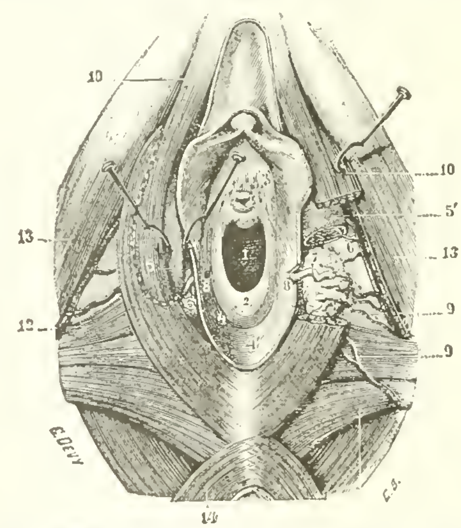

FIG. 3801.—Dissection of the Vulvo-vaginal Orifice with the Glands of Bartholin. 1, Orifice of vagina; 2, hymen; 3, meatus urinarius; 4, navicular fossa; 5, bulb of vagina; 6, vulvo-vaginal or Bartholin's glands; 7, 8, duct with opening cut through orifice of vagina; 10, constrictor vaginæ partly resected on left side to show the glands of Bartholin; 11, transversus perinei muscle.

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and involuntary muscular fibres; it can be felt as a hard body when examined through the posterior commissure of the vagina. The "perineum" is a highly distensible body, as is well seen in childbirth, when it is almost obliterated. Above the perineal body the vaginal and rectal walls are in apposition, loosely connected with areolar tissue. This so-called perineum is frequently torn in first labors, and if the rent be not sewed up immediately so as to enable union by first intention to take place, the vaginal orifice will be much enlarged and the support of the perineal body be lost. Occasionally these rents extend into the rectum, and a very miserable condition results, there being partial or complete incontinence of fæces. Operations undertaken for the repair of this condition are most successful even when of old standing. It is, however, much better to repair the rent as soon as possible after its occurrence.

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Tearing of the perineum with general relaxation of the pelvic floor and increase in the intra-abdominal pressure predispose to prolapse of the uterus. This condition is rarely seen in the nullipara or in well-to-do multipara. It is the hard-working woman, who gets up to work too soon after childbirth, in whom this condition is most frequently seen. *Francis J. Shepherd.*

PERIOSTEUM, ACTINOMYCOSIS OF.—Actinomycosis is rarely primary in the periosteum; but the periosteum is not infrequently involved by direct extension from actinomycotic processes in neighboring structures. In primary actinomycosis of the mouth the periosteum of the jawbone is first involved, later the bone; in actinomycosis of the lungs the process may extend to the pleura and thence to the periosteum of the ribs and vertebræ. In these cases of secondary extension there occurs first an *actinomycotic periostitis* with formation of granulation tissue. As a result of this a superficial caries is produced and the interior of the bone becomes involved. Here the process develops more rapidly, the bone becomes filled with granulation tissue, and expands into a honeycombed shell. Over this the periosteum may develop irregular masses or spicules of bone or thick layers of fibrous tissue. The microscopical picture is that of a strong reactive inflammation; numerous mast and plasma cells are present. The clinical and diagnostic features are given under the head of *Actinomycosis*.

Aldred Scott Warthin.

PERIOSTEUM, TUBERCULOSIS OF.—Primary tuberculosis of the periosteum is regarded by most writers as a very rare condition; but it probably is of not infrequent occurrence. Though the majority of cases of primary tuberculosis of the bones are of myelogenous origin, there can be little doubt that numerous cases begin as a *tuberculous periostitis* (*periostitis tuberculosa*). The process begins with the formation of a granulation tissue beneath the inner layer of the periosteum. This shows little tendency to caseate, but on the other hand becomes ossified. Small tubercles are found in the early stages, but the process shows a great tendency to self-healing through the formation of bone (ossifying periostitis). As a result of such healing, exostoses or hyperostoses are formed. The writer believes that many of the so-called inflammatory local hyperplasias of bone are tuberculous in origin. In other cases the process may break through the periosteum and a tuberculous sinus or a "cold abscess" may be formed; or in some cases the bone becomes involved, and the clinical picture becomes that of a bone tuberculosis. Superficial caries may follow, either with or without the formation of deep foci. As in the case of gummatous periostitis, pseudo-cysts may be formed by the liquefaction of encapsulated caseous areas. The cyst wall may be bony. Secondary tuberculosis of the periosteum is very common in connection with bone or joint tuberculosis. *Aldred Scott Warthin.*

PERIOSTEUM, TUMORS OF.—The primary tumors of the periosteum belong wholly to the connective-tissue growths. They are both benign and malignant; the former, usually arising from the inner osteogenetic layer of the periosteum, are covered by its outer fibrous layer; the latter break through the fibrous layer and invade the neighboring tissues. Occasionally both benign and malignant forms may arise from the outer layer.

Benign Growths.—The *osteoma* is the most common benign growth of the periosteum, occurring usually as a circumscribed bony growth, termed an exostosis. The periosteal osteomata are classed by some writers under the general term *osteophyte*; but by others the latter term is used to indicate a very small bony growth of the periosteum. Larger, more diffuse periosteal osteomata are known as *hyperostoses*. A *circumscribed hyperostosis* differs from an exostosis in being less circumscribed and more superficial. According to their structure the periosteal osteomata may be classed as: *exostosis eburnea*, composed of hard compact bone without marrow spaces; *exostosis spongiosa*, composed of spongy bone about equally made up of bone tissue and marrow spaces; and *exostosis medullaris*, containing very large marrow spaces. The marrow in the exostoses presents the same general appearance as the bone marrow proper. According to histogenesis the periosteal exostoses may be divided into two classes: those arising from the connective-tissue of the periosteum (*exostosis fibrosa*), and those of cartilaginous origin (*exostosis cartilaginea*). The former may arise either from the inner or from the outer layer of the periosteum; in the first case they are immovable (*immovable periosteal exostosis*), in the latter they are movable (*movable periosteal exostosis*). The cartilaginous exostoses may arise from a proliferation of the periost-perichondrium, usually from the epiphyseal cartilages. They occur most frequently in young children and are usually multiple. In other cases cartilage may first form from the periosteum, and this may later develop into bone. Exostoses are found most frequently on the cranial bones, the bones of the trunk, and the long bones of the lower extremities. Many of them are not neoplasms strictly, but are hyperplasias of inflammatory origin.

Chondroma of the periosteum is of less frequent occurrence. It may develop from the inner layer (*immovable periosteal chondroma*) or from the outer layer (*movable periosteal chondroma*). The cartilage may be formed from pre-existing cartilage (*epiphyseal*), or from connective tissue, or from embryonal inclusions of cartilage *Anlage*. They occur most frequently upon the short bones of the extremities, the shoulder blades, the ribs, and the femur. They are very likely to undergo secondary changes: myxomatous degeneration, calcification, etc. They show a marked tendency toward malignancy. *Osteochondroma* of the periosteum sometimes occurs; and there is also a peculiar growth, the *osteoid chondroma*, which may reach an enormous size. It is found chiefly on the long bones of young individuals and shows a tendency to become malignant. The surface of the growth is usually smooth, the cut surface partly hyaline and transparent, partly lamellated and reticular.

Fibroma of the periosteum is rare. It occurs most frequently in the periosteum of the bones of the mouth and nose (fibroid epulis and fibroid polyps). Through excessive development of blood-vessels the growth may assume the character of a telangiectatic fibroma. It is also very likely to become calcified (*fibroma ossificans*) or to undergo myxomatous change. Malignant changes may develop.

Myxomata arise rarely from the periosteum. They are seldom pure myxomata, but present the appearance of myxochondroma, myxofibroma, myxosarcoma, etc. They form round or oval masses covered on the outside by a dense layer of fibrous tissue.

Lipomata of the periosteum are known as parosteal lipomata. They are very rare, and are nearly always congenital. They usually contain areas of striped muscle fibres. The exact nature of these growths is not yet known. They have been reported as occurring on the anterior surface of the cervical vertebræ, body of the pubis, frontal bone, scapula, etc.

Angiomata of the periosteum are very rare. They

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have been observed on the cranium and sternum. An ectatic condition of the blood-vessels is very common in all of the tumors arising from the periosteum.

Pseudo-cysts may be formed beneath the periosteum as the result of the liquefaction of the contents of subperiosteal hæmatomata or of subperiosteal tubercles or gummata.

Sarcoma is the www.libtool.com.cn primary growths of the periosteum, and—next to the periosteal exostosis—of most frequent occurrence. It may occur at any age, but is more frequent in the young. The periosteal sarcomata may occur in any part of the skeleton, but are more frequently seen near the ends of the long bones, particularly of the lower extremities. They may be divided into the *hard* and the *soft* forms. The soft growths show a variegated surface, and usually contain areas of softening and extravasation; the firmer whitish portions of the growth may be homogeneous or fibrous. The harder growths are usually whitish, and present a more or less fibrous, radiating surface. As a rule, the growths are more or less nodular. Originating in the majority of cases from the inner layer of the periosteum, the growth assumes a more or less spindle shape and tends to surround the bone. Later, it breaks through the periosteum and invades the soft tissues adjacent.

Microscopically, the periosteal sarcomata represent nearly every form of sarcoma: round cell, spindle cell, polymorphous cell, giant cell, alveolar forms, fibro-sarcoma, osteosarcoma, osteoid sarcoma, chondrosarcoma, osteochondro sarcoma, myxosarcoma, angiosarcoma, and numerous combination forms. The most common variety is the spindle-cell form containing bone or osteoid tissue. The most cellular, and consequently the softest forms, are the most malignant. The malignancy of the different varieties varies somewhat with the location. The giant-cell epulis of the jaw is of relatively slight malignancy, but a growth of the same structure on the long bones is much more malignant. The hard fibrosarcoma, and the osteo-, chondro-, and osteoid sarcoma, often show relatively slow growth and but little tendency to set up metastases; but under certain conditions any one of these forms may take on an increased malignancy. Metastases of periosteal sarcomata usually appear first in the lungs, later in the lymph glands, and finally in any part of the body. The metastases are frequently of a softer and more cellular nature than the primary, but may develop bone or osteoid tissue or even cartilage.

As the result of the growth of the periosteal tumor the bone may become infiltrated and rarefied, and in some cases undergo spontaneous fracture; or in other cases there is set up, in the neighborhood of the tumor, an ossifying osteomyelitis which leads to the most marked sclerosis of the bone. New bone is very frequently formed in the sarcoma, particularly next to the old bone upon which the tumor rests, so that the latter seems to spring from an osseous base. In other cases trabeculæ or delicate spicules of bone may be formed in a radiating manner through the tumor mass, or irregular bony masses or spicules may be scattered through it (ossifying sarcoma or osteosarcoma). The degeneration of portions of the growth, as is commonly seen in the softer varieties, may lead to cyst formation, or to ulceration, abscess formation, or gangrene, as the result of secondary infection. Large hæmatomata may result from hemorrhage into the tumor. With the exception of the epulis and the hardest forms, sarcoma of the periosteum usually runs a malignant course. The growths show a great tendency to recur after operation, and as a rule they give rise to metastases.

Secondary tumors of the periosteum are not infrequent; both sarcoma and carcinoma may invade the periosteum from primary growths of neighboring structures. Secondary carcinoma is the more frequent. Caries and secondary involvement of the bone may result. An ossifying periostitis is almost always set up, so that the secondary tumors come to be more or less surrounded by newly formed bone, or contain irregular bony masses or spicules.

Aldred Scott Warthin.

PERIOSTITIS. See *Osteitis,* etc.

PERISTALSIS. See *Intestinal Movements.*

PERITONEUM. (ANATOMICAL.) See *Abdomen.*

PERITONEUM, NEW GROWTHS OF.—Primary tumors of the peritoneum are relatively rare; secondary involvement by malignant tumors, which are primary in some one of the abdominal or pelvic organs, is on the other hand of very frequent occurrence. Further, tumors which are primary in the retroperitoneal tissues are to be placed in a separate class from those which are primary in the tissues of the peritoneum proper, that is, which develop either from the endothelium or from its basement membrane.

Primary Peritoneal Growths.—The most important of the primary growths of the peritoneum is the *endothelioma,* often called *endothelioma carcinomatosum* or *endothelial cancer.* By some writers it is spoken of as *primary carcinoma* of the peritoneum, but the latter usage is confusing and should be avoided. The designation primary carcinoma of the peritoneum should be applied only to those rare carcinomata of the peritoneum which arise from the columnar epithelial cells of embryonal inclusions of intestinal *Anlage.* The primary *endothelioma* of the peritoneum forms multiple flat plaques or flattened nodules, which are more or less confluent or bound together by flattened cords or strands. Rarely the nodules may be larger and more elevated. About the larger plaques there are often seen numerous minute flattened nodules, solitary or becoming confluent into little groups. The color is usually white and the consistency soft; in some cases it is hard and firm (endothelioma fibrosum). The peritoneum about the plaques is more or less thickened. In many of the nodules a yellowish caseous centre is present, the appearances closely resembling small caseating tubercles. A serous or sero-fibrinous exudate, usually hemorrhagic, is often present in the early stages; in the advanced stages it is invariably so. Microscopically the flattened tumors are found to consist of a firm connective-tissue stroma enclosing cords and strands of cells, which are often low columnar, and arranged upon a basement membrane after the manner of gland cells; so that the tumor possesses a distinctly *tubular* character. In many of the tubule-like cords an apparent lumen may be seen. The surface endothelium is usually absent over the larger plaques and nodules, but over the small ones it may be greatly thickened, forming a layer consisting of many strata of cells. Simple necrosis and caseous necrosis are found throughout the larger growths, and occasionally there is a mucoid change. The vascular supply is usually rich. The cells of the tumor appear to rise both from the surface endothelium and from the endothelium of the lymph spaces and vessels (*endothelioma lymphangiomatosum*). The anastomosing cords and strands follow the lymphatics. Metastasis into the solid organs is rare; secondaries when found occur in the pleura, dura mater, or other serous membranes. The pleura may be involved by direct extension. The growth is identical in structure with the flat tubular endothelioma of the other serous membranes; and it should be borne in mind that the peritoneal growths may be the result of direct extension from the pleura or they may be metastatic. The writer has seen one case in which the peritoneum, pleura, and dura seemed equally involved; and the only apparent reason for assigning the primary origin to the peritoneum was the greater area involved in the case of this membrane.

Primary angiosarcoma of the peritoneum occurs very rarely. It may develop as a plexiform angiosarcoma, consisting of newly formed blood-vessels, whose walls proliferate and form cylindrical masses of cells. Myxomatous change is not infrequent in these growths (*myxoangiosarcoma*), and under such conditions the tumor may be mistaken for a colloid carcinoma. In other cases the sarcoma may show the structure of a *perithelioma.* Kaufmann describes a case in which the entire perito-

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neum was covered with small warty or flattened nodules of grayish-red color and very vascular. Ascites was present, and the surface of the growths was covered with a thick fibrinous exudate.

Primary carcinoma of the peritoneum is of very rare occurrence. The cases observed have been of a cylindrical-cell variety, with mucoid change (colloid carcinoma), and the growth was diffused over the peritoneum. According to Birch-Hirschfeld the origin of these growths is from the epithelium of embryonal "rests" of intestinal *Anlage*.

Primary benign tumors of the peritoneum are rare. *Lipoma, fibroma, myxoma*, and *chylangioma* have been observed. The lipomata arise chiefly as tumor-like hyperplasias of the epiploic appendices or from the omentum. The cases of fibromata and myxomata reported as arising in the peritoneum are of somewhat doubtful nature. Inflammatory hyperplasias of connective tissue may have been mistaken for neoplasms. The majority of the benign growths undoubtedly arise in the retroperitoneal tissues. Polypoid lipomata of the peritoneum may become freed through tearing of their pedicles; as free bodies they are likely to become calcified.

Mesenterial cysts (*chyle cysts, cystic lymphangiomata*) are of rare occurrence. They have been observed in children. They form bladder-like, thin-walled cysts, which often reach a large size, holding several litres of fluid. The intestines may be adherent to the anterior surface of the cyst, and thus give rise to percussion signs of an area of tympanitic dulness passing over an area of absolute dulness.

Decidua-like proliferations of the peritoneum occur during pregnancy. They are usually confined to the pelvis, but may spread over a larger part of the peritoneum. After delivery they undergo resolution and become calcified.

Secondary Growths.—Secondary carcinoma of the peritoneum is of very frequent occurrence. The primary is most often located in the stomach, pancreas, gall-bladder, intestine, testis, ovary, or uterus. The peritoneum may be involved *by contiguity, by continuity*, or *by metastasis*. In the latter case a *dissemination* or *implantation metastasis* may occur over the entire peritoneum; the deeper parts, the pelvis, flanks, and root of mesentery, showing the most extensive growth. The dissemination of the growth is aided by the accompanying ascites, which is often very great. This may be secondary to the development of the carcinoma, or it may occur before the latter. It is usually hemorrhagic in character. In some cases the development of the peritoneal secondaries is very rapid, partaking of the nature of an inflammatory process, and giving the clinical picture of a peritonitis (*peritonitis carcinomatosa*); or in other cases the secondaries may form scattered or confluent nodules (*carcinosis peritonei*). In the latter case ascites may or may not be present; in the former it is always present to a greater or less extent. The nodular and the diffuse forms pass into each other without sharply defining lines.

The general characteristics of secondary carcinoma of the peritoneum depend upon the nature of the primary growth. *Adenocarcinoma* forms usually nodular peritoneal metastases; they are chiefly located on the under surface of the diaphragm, in the flanks, pelvis, and omentum. The nodules are white, soft, often showing mucoid change. The arrangement along the lymphatics is often very striking. Confluence of the nodules gives rise to flattened warty masses. *Medullary* carcinoma forms soft nodules of large size, showing necrosis, umbilication, hemorrhage, etc. The metastases of this variety into the peritoneum are less common than are those of the other forms. *Scirrhous* carcinoma forms a diffuse fibroid thickening of the entire peritoneum, accompanied by peritonitis which often covers up the appearances belonging to the new growth. The small intestines may be contracted into a hard mass not larger than the fist. The appearances are those of a chronic fibroid peritonitis rather than of a new growth, and the condition is often mistaken for the same. On section the thickened serosa is hyaline, hard, and tendon-like. In all cases in which such fibroid change of the peritoneum is found, the lymph glands should be carefully examined for metastases, secondary scirrhus being more easily recognized in the lymph glands than in other structures. The pylorus, gall-bladder, and prostate should be thoroughly examined for the primary, which may be of insignificant size. The diffuse *mucoid* or *colloid carcinoma*, which is usually primary in the stomach, gall-bladder, or testis, produces very marked and characteristic appearances in the peritoneal cavity—particularly in the omentum and in the neighborhood of the stomach. The entire peritoneum may be infiltrated. The serosa, in particular of the omentum, is greatly thickened, covered with glassy, translucent, yellowish or yellowish-red masses containing mucin. The omentum may be changed into a thick, homogeneous mass, through which run strands and fibres of connective tissue enclosing the colloid substance (honeycomb appearance). The smaller, younger nodules may be white, opaque, and firmer. The *cystocarcinoma* of the ovary or testis may give rise to extensive peritoneal metastases, the entire surface of the membrane being sometimes composed of cysts filled with a mucoid substance. The peritoneal cavity may become entirely filled with a colloid-like mass. Psammocarcinoma of the ovary may give rise to peritoneal metastases, containing calcareous masses.

Secondary Sarcoma of the peritoneum is more rare; melanotic sarcoma, myxosarcoma, lymphosarcoma, osteosarcoma, chondrosarcoma, spindle-cell sarcoma, and angiosarcoma have been reported.

Primary cystadenoma of the ovary may give rise to implantation metastases or may involve the peritoneum by continuity, spreading first over the broad ligament and then over the peritoneum. In the case of the papilliferous cystadenoma or surface papilloma of the ovary, portions of papillæ may be broken off and transported by gravity, peristalsis, or movement of ascitic fluid, and may develop over the peritoneum, wherever they may lodge. Rupture of an ovarian cystadenoma may lead to the covering of the peritoneum with mucoid or colloid material, which, becoming partially organized, gives rise to the condition known as *pseudomyxoma peritonei*. This is not of the nature of a neoplasm, but represents a reaction on the part of the peritoneum, tending to organize the foreign substance spread over its surface. If in the colloid or mucoid substance living epithelium or portions of papillæ are transported, these may grow and form benign growths which later may become malignant. As a rule, such transported epithelium usually dies or forms small cysts which remain stationary after reaching a certain size.

Transplantation Metastasis.—In puncture for the relief of ascites or in operations for the removal of malignant tumors, abdominal metastases may be set up in the puncture or in the seat of surgical wounds (*inoculation metastases*).

Dermoid cysts and *teratomata* occur in the peritoneum of the pelvis, in the mesentery, and in the omentum. In the latter case a primary tumor of the ovary may become adherent to the omentum and later lose its connection with the former organ.

Pseudo-cysts arise from collections of exudate between peritoneal adhesions.

Primary retroperitoneal tumors are much more frequent than those primary in the peritoneum. *Lipomata* of large size (sixty-three pounds) have been reported. They may be mistaken for ovarian cysts. It is important to note that the retroperitoneal lipoma forms an elastic, fluctuating tumor, from which on aspiration no fluid can be drawn (pseudo-fluctuation). *Myxolipoma, fibroma, myxoma, fibrosarcoma, myxosarcoma*, and *angiosarcoma* of the retroperitoneal region have been described. The writer has seen a round-cell sarcoma, apparently primary in the retroperitoneal tissue, weighing eighty pounds. The retroperitoneal organs were not directly involved and showed only changes due to pressure. Secondary ma-

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lignant tumors in the retroperitoneal lymph glands are of frequent occurrence in carcinoma of the uterus, etc. (See also *Omentum.*) *Aldred Scott Warthin.*

PERITONEUM, SURGICAL AFFECTIONS OF.—The anatomy and physiology of the peritoneum are discussed under the heading *Abdomen* (*Anatomical*). The pathology of acute and tuberculous inflammation will be found in the article on *Peritonitis, Septic and Tuberculous*, in THE APPENDIX. Under the heading *Diaphragm* will be found a description of subphrenic abscess and its treatment, while additional information in regard to the peritoneum may be found in the articles entitled *Abdomen* (*Surgical*); *Abdominal Tumors*; *Appendicitis*; and in the article immediately preceding this. In the present article the surgical treatment of lesions of the peritoneum is briefly given.

Acute traumatism of the peritoneum is of little significance apart from traumatism of the organ which the peritoneum covers. The effect of direct injury to the peritoneum is often the formation of adhesions between opposed peritoneal surfaces. A familiar illustration of this is seen in umbilical and inguinal herniæ. Such adhesions will produce slight or serious symptoms, according to their situation and extent. If the attachments are between unimportant organs (for instance, between the omentum and the parietal peritoneum), occasional discomfort may be the only result. If more sensitive organs are involved (for example, the stomach or the intestine) the pain suffered may be very great and the function of the affected organ may be seriously interfered with. Furthermore, such adhesions in the form of bands are a not infrequent cause of intestinal obstruction.

Adhesions due to a single traumatism or to an acute attack of inflammation tend to atrophy, and in the course of time they may completely disappear. Thus the scar of a laparotomy may for a time be attached to visceral peritoneum, while at a second laparotomy performed some months afterward it may be found entirely free. Adhesions are due to a loss of peritoneum resulting from traumatism or inflammation. If, therefore, raw surfaces can be avoided at operation, resulting adhesions will be reduced to a minimum. This can be accomplished in several ways. The peritoneum can be sutured over the pedicles of tumors and over fresh wounds. Or, if the peritoneum in the vicinity is not sufficient for the purpose, the omentum may be used to cover the raw surface by stitching it in place; or grafts may be cut from the omentum and stitched over the raw surface; or, finally, sterile peritoneum from the ox may be stitched over the raw surface. This method has been recently advocated by Morris, who has given the name "cargile membrane" to artificial peritoneum of this sort.

For clinical and therapeutic purposes acute inflammation of the peritoneum is best divided into circumscribed and diffused, or general peritonitis. If the circumscribed peritonitis is not purulent, it may be treated by rest, external cold, etc., unless the organ from which it springs requires more radical treatment—for example, circumscribed peritonitis due to threatened perforation of the appendix. If the circumscribed peritonitis is purulent, such symptomatic treatment is dangerous, since no one can say how soon the inflammation may break through the fibrinous adhesions which circumscribe it and spread to other parts of the peritoneum. Therefore it should be relieved by incision and drainage.

The prognosis and treatment of diffuse or general peritonitis are in a most unsatisfactory state, partly on account of the difference of opinion as to what constitutes a diffuse peritonitis, and partly because of the difficulty of determining, even when the abdomen is open, how extensively the peritoneum is inflamed. Some surgeons would limit the term general peritonitis to those cases in which every portion of the peritoneal cavity is involved in the inflammation. Such a widespread inflammation rarely occurs, and is perhaps never recovered from. It seems better, therefore, to use the term diffuse or general peritonitis as indicating inflammation, not limited by well-marked adhesions, having a tendency to extend and sufficiently widespread to make the general symptoms much more prominent than the local ones. Such general symptoms usually become prominent when the inflammation extends to the peritoneum covering the small intestine. Thus peritonitis may exist for a long time in the pelvis, or in the lesser peritoneal cavity without giving rise to the well-known symptoms of general peritonitis. There are also many cases of appendicitis in which, if operation is performed early, the appendix is found not shut away from the general peritoneal cavity. To describe such a case as one of general peritonitis, merely because the surrounding coils of intestine are more or less covered with a fibrinous exudate which has not had time to mat them firmly together, is entirely misleading, and yet this is frequently done by writers who have reported cures of general peritonitis. It is therefore impossible to state the prognosis in a given case or a hundred cases of true diffuse peritonitis other than to say that the prognosis is bad. But it is by no means hopeless.

Unfortunately, the ideas of treatment of diffuse peritonitis are widely at variance, so that one can do no more than to state the different methods by which responsible surgeons believe that they have saved their patients. If diffuse peritonitis is threatened, though not well established, the action of the intestine can be stimulated by the use of cathartics or stopped by opiates, while the rectum and perhaps the colon can be emptied by injections of water, salt solution, soap-suds, oil, etc. Some surgeons employ opiates to decrease peristaltic action, on the ground that peristalsis tends to spread the inflammation; while others claim that the salvation of the patient depends upon increased peristalsis, which will increase the resorptive power of the peritoneum. To decide between these two plans of action is particularly difficult, because no one can say whether a threatened diffuse peritonitis would or would not have spread and killed the patient had the treatment been of a different character. When the inflammation has extended to the peritoneum covering the small intestine, the intestine is paralyzed, and cathartics have no effect, and there is certainly no indication for the use of opium.

In considering the operative treatment of diffuse peritonitis it will be well to take up the steps in the operation one at a time, since there is no general agreement in regard to any one of them. Some surgeons advocate a single incision and some multiple incisions, the latter in the hope of obtaining a more thorough drainage. At any rate, the incision or incisions should permit the surgeon to inspect and cleanse so much of the peritoneal cavity as may be involved in the inflammation.

The second step in the operation is the cleansing of the affected peritoneum from pus, fibrin, and foreign materials, fæces, etc., if such be present. This may be done by irrigation with sterile hot one-per-cent. salt solution or by wiping the peritoneum with gauze compresses wrung out of such solution, or with dry compresses. If irrigation is employed, it should be abundant, so that the abdominal cavity may be quickly flushed. Some surgeons bring the small intestine out of the abdominal wound and others omit this step, which is spoken of as evisceration. The object of cleansing is to remove in the shortest possible time and with the least possible loss of heat the greater portion of the infectious exudate. How best to accomplish this with the least injury to the peritoneum is a question to be settled by the individual surgeon. Probably moist gauze is less irritating to the peritoneum than dry gauze.

If irrigation is employed the fluid which remains after cleansing may be sponged out, or it may be left in place. Some surgeons fill the abdomen with salt solution and close the abdominal wound, claiming that the dilution of the infectious material and the increased resorption from the peritoneum thereby produced are of the greatest benefit to the patient.

If the intestine is greatly distended with gas, some

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surgeons empty it by puncture or by one or more short incisions. Such openings are forthwith closed by Lembert sutures. Others take advantage of the operation to inject into the lumen of the small intestine an ounce or more of saturated solution of sulphate of magnesia, believing that the strong peristaltic action which often follows will markedly benefit the patient.

Those who leave fluid in the abdominal cavity suture the wound without drainage. The patient is then placed in bed with the hips elevated so that the diaphragmatic portion of the peritoneum in which the lymphatic circulation is the most active shall be the most dependent portion. Others pass gauze or glass or rubber drains in various directions, either through the chief abdominal wound or through other wounds made especially for drainage in the lumbar and iliac regions, or into the vagina, or even into the rectum in case of pelvic suppuration. Mikulicz's handkerchief drain may also be used. [See *Abdomen. (Surgical).*] Rehn recommends that a tube be passed through the mesentery of the small intestine and allowed to emerge in either loin, so that irrigation may frequently be made through it.

After-treatment consists in the application of heat externally and within the rectum, the subcutaneous injection of cardiac stimulants if necessary, and the subcutaneous or intravenous injection of salt solution; the object of all of these procedures being to combat shock. If the patient is troubled with vomiting, the stomach should be washed out. No opium should be given, and only so much morphine subcutaneously as is absolutely necessary to control pain.

Tuberculosis of the peritoneum may be accompanied by an abundant serous exudate or it may give rise to a fibrinous exudate with adhesions and contractions, or it may assume an ulcerative form.

The prognosis is in general an unfavorable one, although many cures have been reported as the result of both internal and surgical treatment. Recovery is more likely to follow operation when the disease is present in the serous form; but even in such cases one should be careful not to mistake a temporary improvement after operation for a permanent cure. As far as is known Spencer Wells was the first to open the abdomen of a patient having tuberculosis. He did so through a mistake in diagnosis. The patient recovered. Since then many surgeons have operated intentionally, and the good results have been variously attributed to the entrance of light or air, to the mechanical irritation of the peritoneum, or to a simple escape of the serous exudate. A more careful examination of the results of operation makes it doubtful whether such an exploratory laparotomy has any great therapeutic effect. It seems more probable that most of the patients who have recovered after such a laparotomy would have recovered without it, while operation has often a distinctly bad effect upon a patient whose tuberculous peritonitis is associated with fever. The abdomen is usually opened by a three- or four-inch incision in the median line. The fluid which is present is allowed to escape and is carefully sponged out and the various peritoneal pouches may or may not be dusted with powdered iodoform. The abdominal wound is closed by suture, or a drain may be left in its lower angle for a week or more. The shock of such an operation is naturally slight and most patients rapidly recover. A certain amount of fluid quickly appears, but may be resorbed. If it is not, a second operation may be performed. Such a quick recovery from operation may be looked for in the serous and fibrinous forms of the disease, while operation performed upon a patient suffering from purulent or suppurative tuberculous peritonitis will very likely be followed by intestinal fistula and death. Of course, if a focus for the disease is found in some organ which can be safely sacrificed it should be removed. An accompanying disseminated serous tuberculosis will probably be cured if its original focus is removed. But, as stated above, many patients who appear cured at first afterward suffer from a recurrence of the disease or die from tuberculosis in some other organ. However, as the risk of operation is so slight, it seems justifiable in these cases even if it is a mere aid to the natural forces of the body in their effort to overcome the disease.

Benign tumors of the peritoneum, or, strictly speaking, of the subserous tissue, are fibroma, lipoma, and myxoma. Such tumors usually develop in the root of the mesentery, in the mesocolon, or in the omentum, and are described under the headings *Omentum* and *Retroperitoneal Tumors.* In the mesentery are also found serous, chylous, and hemorrhagic cysts as well as congenital dermoid and teratoid cysts. Echinococcus cysts are found in the peritoneal cavity, where they develop after the rupture of some primary cyst of the liver or other organ. Actinomycosis, starting usually from the cæcum, may produce in the peritoneum inflammatory swellings, some of which will contain the characteristic pus of this disease.

The treatment for benign tumors is their radical removal. This also applies to echinococcus cysts when they are so situated as to make removal feasible. If they are not removable, they should be drained externally. Actinomycosis should be treated by removal, if possible, but, if this is not practicable, by curetting, cauterization and drainage, and by the internal administration of iodide of potassium.

Malignant tumors of the peritoneum are secondary to malignant disease of some abdominal organ. Under such circumstances hundreds of metastatic nodules may be scattered over the peritoneum. There is generally a sero-hemorrhagic exudate. Such a condition is of course inoperable and the abdomen should be closed at once. A metastatic nodule in the peritoneum may be excised for microscopical diagnosis and the wound closed by one or two stitches. Thus one avoids the risk of troublesome hemorrhage which may follow excision of a portion of the primary growth.

Plastic operations upon the peritoneum for the sake of covering raw surfaces have been spoken of above and are also described under the heading *Omentum,* for it is the omental peritoneum which is usually employed for grafting.

Edward Milton Foote.

PERITONITIS, SEPTIC AND TUBERCULOUS. See THE APPENDIX.

PERITYPHLITIS. See *Appendicitis.*

PERONINE—benzyl-morphine hydrochloride, C_6H_5-$CH_2.O.OH.C_{17}H_{17}NO\ HCl$—is an odorless, bitter, white powder, composed of prismatic crystals and having the nature of an alkaloid. It is soluble less than one per cent. in cold water and in ten parts of boiling water, and is nearly insoluble in alcohol and chloroform. It is closely related to codeine, dionine, heroin, and morphine.

For the treatment of the cough of tuberculosis, Schroeder, who was the first to study this drug, considered it intermediate in value between codeine and morphine. His report, however, covers only twelve cases, in two of which it produced sweating and difficult expectoration, and in two others of which it failed to influence the cough. Nowak, in eighteen cases, found the cough less frequent and intense, but dry, and expectoration more difficult. At times there were burning in the bronchi and copious perspiration. Munk reports good effects on cough even after morphine and codeine had proved inefficient. He also found peronine calmative to an epileptic who suffered from frequent attacks of frenzy. All the writers agree that there is no habit formation. Mayor found it to be three times as toxic to rabbits and guinea-pigs as is codeine, and believes its cardio-depressant effects too pronounced to permit its use in medicine. Other writers, however, report no unpleasant effect on cardiac, respiratory, or digestive functions.

Besides its antitussive action, peronine is slightly analgesic and hypnotic. It is employed in tuberculosis, whooping-cough, emphysema, bronchitis, and similar affections in doses of 0.02–0.05 gm (gr. $\frac{1}{3}$–$\frac{5}{6}$). Schroeder

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had no untoward effect from 0.08 gm. (gr. 1¼), though nausea and constipation followed larger doses.

W. A. Bastedo.

PERRY SPRINGS.—Pike County, Illinois. Two hotels, capacity 350.

ACCESS.—Viâ Wabash Railroad to Griggsville or Perry station, thence by hack nine and six miles, respectively; also from St. Louis viâ Illinois River to Naples, seven miles distant, where steamers land daily.

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This attractive health and pleasure resort is located among some hills on the west bank of the Illinois River. The surrounding country is covered by luxuriant forests and intersected by numerous deep ravines, narrow valleys, and clear, winding streams. The extreme temperature ranges are 100° F. in summer to −20° F. in winter. The climate is moderately dry and clear most of the time. The springs are three in number, and are located about two hundred yards from one another. The temperature of the water ranges from 50° F. in summer to 48° F. in winter. The water from the iron spring is supplied, hot or cold, to fourteen bath-rooms. The following table contains the analyses of the three springs, as furnished by Dr. Engleman, No. 1 being the iron, No. 2 the magnesia, and No. 3 the sulphur springs:

ONE UNITED STATES GALLON CONTAINS:

Solids.	No. 1. Grains.	No. 2. Grains.	No. 3. Grains.
Calcium bicarbonate	15.89	19.75	19.66
Magnesium bicarbonate	17.01	14.81	10.49
Iron bicarbonate	.55	.40	.27
Aluminum silicate	......	......	.27
Potassium and sodium silicate	2.64	2.28	3.45
Sodium silicate (salt)	0.12	.38	.58
Sodium sulphate	.44	1.10	1.49
Potassium carbonate	1.59	1.45	1.46
Total	38.24	40.17	37.67

No organic matter.

The waters are said to be of considerable efficacy in stomach, liver, and kidney troubles.

James K. Crook.

PERSIMMON.—*Diospyros.* Under the name persimmon, both the bark and the unripe fruit (chiefly the latter) of *Diospyros Virginiana* L. (fam. *Ebenaceæ*) are considerably employed as astringents, particularly in the southern United States. The bark looks not unlike oak bark with the corky layer still upon it. The fruit in the unripe condition is green, drying dark brown, of globose form, and nearly an inch in diameter. It contains several flattened oval or ovoid seeds. Before maturity the persimmon is one of the most astringent of substances, but after thoroughly maturing, and especially after being attacked by frost, this astringency is mostly lost and it becomes sweet and edible. The only important constituent of both drugs is the tannin, and their uses are purely astringent, similar to those of geranium, sumac, etc. The common method of employment in the household is in the form of an infusion or decoction; only the fluid extract is employed by the medical profession. The dose of either the bark or the fruit should amount to 2, 4, or even 8 gm. (ʒ ss. to ʒ i. or ij.).

Henry H. Rusby.

PERSODINE. See *Persulphates.*

PERSPIRATION. See *Skin, Functions of.*

PERSULPHATES.—The alkaline persulphates have recently come into notice because of their excessive content of oxygen and the ease with which this is liberated. Their action may be likened to that of hydrogen dioxide. A five per cent. solution of *sodium persulphate* kills most bacteria, and a half-per-cent. solution will check their development. The fatal dose for a rabbit (*Bull. gén. de Thérap.*) is 0.4 gm. per kilogram of body weight, and for a dog 0.75–1.0 gm. per kilogram.

In three- to five-per-cent. solution it constitutes a good wet dressing for lupus and ulcers (Kionka). Internally, it acts as an antipyretic in fever, and is said to improve the appetite and digestion in tuberculosis, anæmia, neurasthenia, etc. The dose of sodium persulphate is 0.1 gm. (gr. iss.), or from one to two teaspoonfuls of *persodine*, which is a 12 to 1,000 aqueous solution of the sodium salt.

Ammonium persulphate is useful as a test for albumin or indican in urine. In the presence of albumin a ten-per-cent. aqueous solution forms a turbid, grayish zone at the line of contact.

In testing for indican a crystal of ammonium persulphate is added to a mixture of equal parts of hydrochloric acid and urine. On shaking this with chloroform, the latter on settling forms a blue layer if indican is present.

W. A. Bastedo.

PERUSCABIN, benzoic acid benzyl ester, is an artificial product representing the active constituents of balsam of Peru. It is odorless, non-staining, and non-irritating, and is highly recommended by R. Sachs for the treatment of scabies. Diluted with three parts of castor oil, it is applied over the whole surface every twelve hours. The cure is absolute, and no irritation whatever is produced, even in an area affected with eczema or dermatitis.

W. A. Bastedo.

PES GIGAS.—Pes gigas, or macropodia, is the name given to a condition of congenital hypertrophy affecting

FIG. 3802.—Pes Gigas. (From *Journal of Tropical Medicine*, 1903.)

either the foot alone (whence the name) or the leg and the foot. It may be unilateral or bilateral, the former being the more common; the left side is more often affected than the right. Pes gigas is found in two forms:

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(1) a form in which the hypertrophy is *true* or *symmetrical;* here the whole foot, or leg and foot, suffer a general hypertrophy, the symmetry and contour of the part being observed, and the only abnormality being the enormous size. (2) The *false* or *asymmetrical form*, in which only certain parts are affected; this is the more common variety, and generally shows itself in enormous development of one or two toes, or in large fatty excrescences, or in hypertrophy of some of the muscles of the calf of the leg. (See Fig. 3802.) The cause of pes gigas is unknown.

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The skin is always involved, and, in addition to the hypertrophic condition, the cutaneous sensibility may be absent or diminished; it is never increased. In hypertrophy of the toes the nails generally enlarge *pari passu* with the other parts. The subcutaneous fat is increased in amount and is apt to be irregularly disposed in lumps. When the toes are affected the metatarsal and phalangeal bones are always enlarged; but this enlargement is general, and the only deformity noted is an outgrowth at the extremity of the bone, at the junction with the articular cartilage. The condition of the joints involved is variable; sometimes the motion is normal, sometimes it is limited, and sometimes there is complete ankylosis. Passive mobility may or may not be elicited; the ligaments are thickened.

The *treatment* is not satisfactory. (1) *Pressure* in various forms has been recommended; but, besides being tedious in its application, uncertain in its effects, and decidedly painful, it is not free from danger; and hemorrhage, ulceration, and erysipelas have ensued from this method of treatment. (2) *Ligature of the main artery* has also been suggested; but this method, too, has not been characterized by brilliant results. (3) *Amputation of colossal toes* and judicious trimming of superfluous tissue will give a presentable and serviceable extremity. This is probably the best procedure. *R. J. E. Scott.*

LITERATURE.

Anderson: St. Thomas' Hosp. Rep., N. S., 1882, vol. xi.
Jacobson: Article "Pes Gigas," in Heath's Dict. of Practical Surgery.

PETECHIÆ.—These are small, round, blue-red or purple spots or points in the skin, or in the serous or mucous membranes, that cannot be made to disappear by pressure. They are usually not elevated above the surface. They are caused by minute extravasations of blood into the subepithelial or subserous tissue. They arise for the greater part through diapedesis, and occur chiefly, though not exclusively, on the dependent portions of the body, particularly over the legs. They are often localized in the hair follicles. In the serous membranes they are found most often in the posterior wall of the pleural cavity, and on the posterior portion of the epicardium and pericardium. In the mucous membranes they occur most frequently in the conjunctivæ and mouth, but may be found in any part of the body. According to their etiology petechiæ may be classed as *traumatic, infectious, toxic,* and *neuropathic.*

Petechiæ may be produced by the bites of fleas (*purpura pulicosa*). These may be mistaken for purpura or other hemorrhagic diseases. They may be distinguished from the latter by the fact that the puncture caused by the flea shows as a darker point in the centre of the spot, and by their greater abundance over the trunk. Localized petechiæ may occur also as the direct result of certain forms of trauma, and may be of medico-legal importance in the establishment of the occurrence of trauma.

Petechiæ occur also in the course of many of the acute infections: *scarlet fever, variola, diphtheria, endocarditis, plague, yellow fever, cholera, anthrax, septicæmia, measles, typhus fever, rheumatism, typhoid, acute yellow atrophy, etc.* The cases in which such hemorrhages occur are usually more severe than the non-hemorrhagic ones. The different forms of the primary purpuras are also characterized by the occurrence of petechiæ in the skin and mucous membranes: *purpura simplex, purpura rheumatica, morbus maculosus Werlhofii,* and *Barlow's disease.* In the last-named, innumerable minute hemorrhages may occur throughout all of the internal organs. In *scurvy* petechiæ occur in the skin, in the mucous membranes, and in the pleura, pericardium, endocardium, and peritoneum. It is very probable that the purpuras are infectious diseases, in part caused by the streptococcus, in part by bacteria not yet recognized.

Petechiæ may result also from a lowered nutrition of the vessel walls, as in *starvation, pernicious anæmia, leukæmia, cachexia of malignancy,* etc. It is very probable that in these conditions there is an intoxication which is the chief factor in causing the changes in the capillary walls. Petechiæ occur also in *icterus, nephritis,* poisoning with *bromine, iodine, phosphorus, arsenic, snake-venom,* etc. Petechiæ have also been observed to follow the use of *quinine.*

In chronic passive congestion of marked degree petechiæ may be formed in the body surfaces and also in the internal organs.

Petechiæ may arise as the result of excessive emotion, or during the hysterical or hypnotic state (stigmatization).

As diagnostic and prognostic aids petechiæ are of great significance. The size, location, conditions of occurrence, etc., are all very important factors.

Aldred Scott Warthin.

PETRIFACTION.—The deposition, in the tissues, of solid, crystalline, amorphous, or granular salts of lime, magnesium, or uric acid is known as *petrifaction* or *petrifying infiltration.* When the deposit consists of lime salts or of a combination of salts of lime and magnesium, the process is usually spoken of as *calcification* or *calcareous infiltration.* A physiological calcification takes place during the process of ossification of the skeleton; in this case the deposit of lime in osteoid tissue is an essential step in the development of a new tissue. All other deposits of lime salts within the body tissues must be regarded as being of a pathological nature.

With the exception of the new formation of bone in the repair of fractures and in tumors, calcification is essentially a retrograde change, the precipitation of the phosphates and carbonates of lime and magnesium occurring only in degenerating, dying, or dead tissues. In old age a deposit of lime salts occurs in the walls of the arteries, in the costal and laryngeal cartilages, in the walls of the capillaries of the lungs, stomach wall, and kidneys. This phenomenon is explained as due to an excess of lime salts in the blood, resulting from an excessive absorption of lime salts from the bones. Preceding the deposit of lime salts there occur certain retrograde changes characteristic of old age—hyaline change of the blood-vessel walls, etc. This calcification of old age is of such common occurrence as to warrant its being regarded as physiological. The resorption of lime salts from one tissue and their deposit in another is known as *metastatic calcification.* Calcification of the mature placenta is also of such frequent occurrence as to be regarded as physiological. The presence of brain sand in the choroid plexus and pineal gland is so universal that this may also be included under the head of physiological.

Calcification occurs most frequently as a sequel to fatty degeneration, hyaline change, cloudy swelling, simple or caseous necrosis. It is found in sclerotic vessels, endocardial thickenings, hyaline thickenings of dura, peritoneum, pleura, and pericardium, in the interstitial tissue of hyaline goitre, in corpora fibrosa of the ovary, old tubercles, gummata, old abscess cavities, inflammatory exudates, and in thrombi (arterioliths or phleboliths). A deposit of lime salts may occur in anæmic or hemorrhagic infarcts, focal necroses, in dead ganglion cells, in encysted trichina, and in the necrotic areas of tumors. It occurs also in osteoid and hyaline connective tissue of tumors, and in psammomata. The connective-tissue stroma of both carcinomata and sarcomata not infrequently shows calcification (*sarcoma* and *carcinoma petrificans*). Myofibromata of the uterus very frequently

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show a greater or less degree of calcification. Lime salts are also deposited in the dead fat cells in cases of fat necrosis. Calcification of the renal epithelium follows the cloudy swelling produced by such poisons as mercuric chloride, carbolic acid, bismuth, aloin, etc. Retained decidua or chorion, or portions of the dead fœtus and its membranes, may become calcified (lithocelyphopaedion), or the sac may rupture and the fœtus escape into the peritoneal cavity, later becoming calcified (lithopædion). In diseases of the bones characterized by a resorption of the lime salts, the latter may be deposited in other tissues of the body.

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Calcified tissues are hard and white and sharply outlined; the area affected may be large or small. The lime salts may be dissolved out by the action of acids, in the case of carbonates with the formation of carbonic acid. Microscopically, deposits of carbonates or phosphates stain deep blue or violet with hæmatoxylin.

A deposit of uric-acid salts occurs particularly in gout. The gouty deposits consist chiefly of sodium urate with small amounts of carbonate and phosphate of lime. The tendon sheaths, synovial membranes, ligaments, articular cartilages, kidneys, skin, and subcutaneous tissues are chiefly affected, but the deposits may ultimately be found in nearly every organ of the body. The larger deposits, called *tophi*, form large rounded masses, of a white, plaster-like substance, which are found particularly in the joints and tendons.

The individuals exhibited in museums as "petrifying" or "ossifying," are either cases of myositis ossificans or of scleroderma.

Petrifaction of the tissues of the body after death may occur under certain conditions, but is probably very rare. The majority of cases reported as such are in reality examples of adipocere formation. Very little is known with certainty regarding the petrifaction of the cadaver. Petrified or fossilized bones of the human race are very rare. Such have been reported to have been found in caves and in bog deposits whose waters were impregnated with iron and lime. In old bones there may sometimes occur a crystalline arrangement of phosphate of lime, or the bony structure may become so impregnated with mineral elements that its color and consistency become greatly changed. It is very probable, however, that a complete replacement of the elements of the bone or of the body tissues with mineral constituents is of very rare occurrence. (See also *Calcification*.)

Aldred Scott Warthin.

PETROLATUM.—The word *petrolatum* stands, both in Latin and in English, as the official title in the United States Pharmacopœia for an unctuous derivate of petroleum, obtained by distilling off the lighter and more volatile constituents of the oil and purifying the residue. Three grades of petrolatum are official, the difference being in consistence only. They are entitled, severally, *Petrolatum Liquidum*, Liquid Petrolatum; *Petrolatum Molle*, Soft Petrolatum; and *Petrolatum Spissum*, Hard Petrolatum. The first of these grades is of the consistence of oil; the second is soft, like lard, and corresponds to the well-known proprietary substances *vaseline* and *cosmoline*; and the third is hard, like cerate. When the word "petrolatum," without modification, is used in prescription, "soft" petrolatum is dispensed. Petrolatum consists principally of a mixture of paraffins (hydrocarbons of the formula C_nH_{2n+2}), but probably also contains some olefins (hydrocarbons of the formula C_nH_{2n}), which, by their softer consistence, tend to increase the unctuousness of petrolatum. Petrolatum is a whitish or yellowish material, more or less fluorescent, tasteless, and with no odor, except when heated when a faint odor of petroleum is perceptible. It is entirely amorphous, and, in fluid condition, makes a transparent liquid. It is neutral in reaction. It is insoluble in water; scarcely soluble in alcohol, or in cold absolute alcohol; but soluble in boiling absolute alcohol, and readily soluble in ether, chloroform, disulphide of carbon, oil of turpentine, benzin, benzol, and in fixed or volatile oils. When heated on platinum foil, it is completely volatilized without emitting the acrid vapors of burning fat or resin.

Petrolatum owes its medicinal value to its combining with the physical attributes of the semi-solid fats the chemical peculiarity of the paraffins, of being practically unalterable and indifferent to chemical agents. Petrolatum neither hardens nor turns rancid by exposure, and can be treated with any chemical likely to be prescribed medicinally in an ointment without being itself attacked thereby. The substance is therefore available, either by itself as a simple unguent, perfectly bland and changeless, or as the fatty basis for medicated ointments.

Edward Curtis.

PETROSULFOL is a sulphur-containing bituminous product closely resembling ichthyol, but with a less disagreeable odor. It is miscible with water or oil, and is used as a general succedaneum for ichthyol.

W. A. Bastedo.

PHAGOCYTOSIS.—Phagocytosis is the term applied to the ingestion of solids by living cells. That leucocytes were capable of taking up inert particles when introduced into the animal body or even when mixed with the freshly drawn blood of such animals as the newt had long been known, when Haeckel pointed out the similarity between such processes and the engulfing of food particles by unicellular organisms. Roser went further in suggesting that resistance to infection by bacteria and other living irritants was due to the phagocytic properties of the cells of immune animals.

It is to Metchnikoff and his followers, however, that we are indebted for much of our knowledge concerning this particular physiological function of cells. In his researches on the comparative pathology of inflammation phagocytosis in many types of organisms was studied and the capacity of their cells for dealing with various solid particles determined.

It does not lie within the scope of this article, however, to give *in extenso* the opinions held by Metchnikoff and others relative to immunity excepting in so far as they bear upon the mechanism of phagocytosis, the factors which influence it, the fate of the matters enclosed by cells, and the value of the process as illustrated in the life histories of organisms.

The Mechanism of Phagocytosis.—Before the ingestion of solid particles by cells is possible the two must be brought together. In the case both of the amœboid unicellular organisms and of the wandering cells of the higher animals, this is brought about by the attraction of the cell to the particles. (See the section on Leucocytes, under *Blood*.) The attraction exerted by particles upon motile cells is probably operative only over a limited area, and although there is some difference of opinion concerning the matter, it would appear that a certain amount of the solid particles being dissolved in the fluids containing the cells may stimulate them to approach the particles or under other conditions to repel them.

Amœbæ or other single-celled organisms are brought into the sphere of influence of food particles and bacteria by diffusion currents, and micro-organisms may by their own motility come into such a position as to be more easily engulfed. Jennings and Moore have shown that when paramecia and other infusoria pass by their own movements from a less attractive into a more attractive solution, they tend to remain there because their movement in the initial direction is arrested and reversed just as they are about to leave the agreeable environment. By a series of reverses they are kept swimming backward and forward across this attractive sphere and thus accumulate, not by initial attraction toward, but by inability to go away from, the agreeable environment. It remains to be proved whether any such explanation can be adapted to the accumulation of leucocytes in the neighborhood of bacteria and their toxins.

In the higher organisms provided with lymph or blood channels or both, the transportation of wandering cells to the vicinity of foreign particles is passive, although

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their arrest at the margin of the vessel walls and their later emigration is an active process in response to stimulus. Fixed cells like the endothelium of the lymph- and blood-vessels, serous cavities, and the spleen pulp may throw out pseudopodia and entangle and ingest bacteria which are brought to them by the circulation. They may even bud off the large mononuclear leucocytes which are so markedly amœboid and phagocytic, but proof that these after engulfing bacteria or other particles may again become fixed is wanting. It is a common thing for a wandering phagocytic cell to be later engulfed with its contents by fixed cells, especially endothelial cells.

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Phagocytosis is to be observed in a multitude of ways, but perhaps as simple a demonstration as any is a modification of that used by Kanthack and Hardy. A drop of fluid from the posterior lymph sac or peritoneum of a frog is withdrawn by a capillary pipette, placed in the centre of a clean cover-slip and lightly inoculated with a fresh culture of *bacillus anthracis, bacillus filamentosus*, or some other large non-motile organism. The drop is inverted over a vaselined hollow ground slide, or, better still, a ring of filter paper may be placed upon a slide and the drop of inoculated lymph inverted over the hole (Miss Greenwood's method). The filter paper should be thick enough to prevent the drop from coming in contact with the slide, and should be moistened with water from time to time to prevent the desiccation of the lymph. This method provides plenty of oxygen. Such a preparation may be kept under observation for hours at room temperature, and the leucocytes, of which in the frog there are fewer varieties than in mammals, remain active and may be seen to attack the bacteria according to a definite plan. A better method, especially for demonstration to large classes, is to inoculate a culture directly into the peritoneum of the frog and to withdraw drops for microscopic study from time to time. Observation may be made while the cells are living as outlined above, or smears stained with eosin and methylene blue may be prepared at various stages.

It will be seen that the coarsely granular oxyphile (eosinophile) and hyaline (large mononuclear) leucocytes are actively attracted to the chains of bacilli, the former being generally the first to attach themselves. Their granules exhibit streaming movements before, and usually disappear immediately after contact. The lymphocytes (small mononuclears) seem to take no active part, although they become included in the plasmodium formed by the other two varieties of leucocytes and the chains of bacilli which become bent into sharp angles and finally tightly compressed. The individual cells seen to become a part of the plasmodium, soon lose their outline, and in unstained specimens cannot be differentiated. The plasmodium later breaks up, and the component cells again become free in from five to nine hours. The coarsely granular oxyphile cells which have lost their granules and whose protoplasm has become amphophilic upon contact with the bacilli sometimes regain their granules with their oxyphilic reaction. In the hyaline (large mononuclear) cells, however, at this stage frequently one or more vacuoles can be seen which contain chains of bacilli doubled upon themselves so that from two to five or more bacilli are included. The included bacilli are undergoing degeneration as evidenced by their swollen, granular, or generally "wilted" appearance. Kanthack and Hardy after a very extended series of observations concluded that with fully virulent bacilli the coarsely granular oxyphile cell is called into action first, and through contact with the bacilli, by a process of "extra-cellular" digestion or neutralization, works them harm, after which phagocytosis on the part of the hyaline cells becomes possible. They maintained that this is true not only for frogs but for mammals, and were convinced that phagocytosis as the initial movement is possible only where non-virulent bacteria or other relatively inert particles are employed.

The difference in the *modus operandi* of these two leucocytes has been very graphically illustrated in a more recent publication by Hardy in which he was able to measure accurately under the microscope the rate of growth of chains of bacillus filamentosus (non-virulent) which had been introduced into a drop of frog lymph and observed under the microscope for a number of hours. He found that in those bacilli which had come into contact with coarsely granular oxyphile cells no growth took place. Those in contact with hyaline cells or lymphocytes grew out into long filaments, as did also the free bacilli. Where one end of a chain was enclosed within a vacuole of a hyaline cell growth in that direction was arrested, although division of the bacilli at the other end of the chain went on. It will be seen that the material ("slime") extruded or exuded by the coarsely granular oxyphile cell at the time of the disappearance of its protoplasmic granules, or perhaps, more correctly speaking, that contact of the bacilli with the changed protoplasm—true phagocytosis not taking place—had the same inhibitory effect upon the growth of bacilli as had the contents of the digestive vacuole of the hyaline cell. The vacuoles of phagocytic cells probably all contain a ferment. Such has been shown to exist in the food vacuoles of the amœba by Krukenberg, Reinke, and Greenwood. Further, the ferment fluid has been shown to be acid, although secreted by an alkaline protoplasm. In these vacuoles whatever is capable of digestion goes into solution and serves as food for the cell, while the insoluble remnants are extruded.

It is impossible to hazard any opinion concerning the exact nature of such digestive fluids or mechanism, particularly when considering the destruction by phagocytosis of bacteria against which animals have been rendered immune. It has been suggested by Ritchie as quite possible "that by virtue of one set of powers a phagocyte may kill a bacterium, by virtue of another set of powers it may digest it, and the latter process may be the same as ordinary proteolysis, as it occurs in connection with the intestinal glands of an animal." It must be remembered, however, that typhoid bacilli will develop in solutions of pancreatic ferment possessing sufficient activity to digest fibrin, and it is well known that in artificial digestions with all the common ferments antiseptics must be employed in order to prevent overgrowth of putrefactive and other bacteria. Certain observers, including some of the Pasteur school, even go so far as to suggest that nearly all kinds of ferment activity in the animal body are facilitated by, if not largely dependent on, the presence of bacteria.

One is therefore forced to ask whether the phagocytic inclusion and digestion of bacillus typhosus by the cells of an animal immunized against that micro-organism is accomplished in exactly the same manner and by the same ferment activity as would be the cholera vibrio had the animal been rendered resistant against that organism. It does not seem possible that by repeated immunizing doses of a given micro-organism the phagocytic cells can be so altered as completely to change their digestive mechanism. It is well known, however, that bacteria are frequently engloberl, and later during their growth, or by their production of substances which may neutralize or destroy the digestive ferment, the phagocytes may be destroyed, although similar cells may later by a process of immunization acquire the property of seizing and also digesting the same bacteria.

Further discussion of these matters will be necessary in considering the questions of what cells are phagocytic, the fate of enclosed bacteria and other masses, the economic uses of phagocytosis, and the relation of phagocytosis to present-day theories of immunity.

What Cells are Phagocytic?

In unicellular organisms phagocytosis affords a means of securing food and for defence. In more highly developed organisms with the greater specialization in other functions that of phagocytosis is assigned to certain cells, particularly those of mesodermal origin. When micro-organisms or particles obtain access to the body fluids they may be carried to any part of the body unless dis-

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posed of or arrested. Similarly, when irritant particles or micro-organisms are localized in the body, phagocytic cells and those with other defensive activities may be hurried to the front by way of the lymph and blood channels. It may be well to consider first the free or wandering cells which are phagocytic, and secondly those which are fixed.

1. Phagocytosis in Free Cells (see also section on Leucocytes under *Blood*). If we look upon phagocytosis as an active process the red blood cells may be excluded.

Lymphocytes (small) are not phagocytic. Their protoplasm is so scanty as to leave no room for inclusion of particles nor have they been shown to be actively motile.

Coarsely granular oxyphile cells (eosinophile), although infrequent in normal blood, are more plentiful in lymph, and in tissue spaces they are abundant. Kanthack and Hardy consider them to be never phagocytic. Mesnil, a pupil of Metchnikoff, states that they may be phagocytic. I have always looked upon them as never phagocytic until two years ago we encountered one undoubted case of inclusion in, and partial digestion of, *B. filamentosus* by one of these cells in an exudate resulting several hours after an intrapleural injection of the organism into a guinea-pig. The eosinophile granules were perfect, and the bacilli were contained within a vacuole. Phagocytosis on the part of these cells must be extremely rare. They appear to act rather by a process of extracellular paralysis or digestion of bacteria.

The finely granular oxyphile (polymorphonuclear) leucocytes, or "microphages" of Metchnikoff, are the chief phagocytes of the blood. Where irritants are applied to vascular areas these cells very quickly appear in the foci, emigrating rapidly from neighboring vessels. In pus formation, in the fibrinocellular exudates of diphtheria and pneumonia, and in exudates in serous cavities and many other sites, these cells are present in vast numbers. In pneumonia there may be present in the hepatized area many times the total number of these cells normally present in the whole body. Where do they come from? In certain infections the manufacture of these cells in the marrow of the long bones is tremendously stimulated (Muir, also Roger), so that following the initial temporary diminution of leucocytes in the blood the increased output is sufficient to supply all demands. The subcutaneous injection of staphylococcus pyogenes aureus into the tissues of rabbits, and serial observations on the resulting abscess formation (Hohnfeldt) afford an excellent opportunity of studying chemotaxis and phagocytosis in connection with these cells. Their phagocytic properties and modes of action may be studied in smears of gonorrheal pus, in purulent fluid in cases of cerebrospinal meningitis, and in pus from abscesses. The sequence of changes in inflammation in which finely granular oxyphile cells bear a part may be well observed when fluid from the abdomen is withdrawn from time to time after intraperitoneal injections of various micro-organisms (Pfeiffer, Durham, and others). These cells possess the capacity for engulfing carbon and other insoluble pigments and of digesting pieces of fibrin, cell débris, bacteria, and other soluble materials. Vacuoles, evidently digestive, may often be seen surrounding the particles, although not always. This variety of leucocyte is, in short, instrumental in the removal of inhaled pigment particles, hemorrhages into the tissues, fibrinous exudates, and other detritus, while in resisting the pyogenic micro-organisms it is probably the chief factor.

The hyaline (large mononuclear) leucocytes or "macrophages" of Metchnikoff are seemingly derived from the endothelium of vessels and from the spleen and lymphatic glands. The phagocytic work in those tissues where the transportation facilities of the blood stream are not readily available is dependent to a great degree upon these cells. Kanthack and Hardy believed that only in case of feebly virulent bacteria and non-irritant particles are they capable of immediate action. That they do operate after other cells have been engaged is evidenced by the fact that other cells, such as the finely granular oxyphiles, are very frequently found in various stages of disintegration enclosed within them. The intraperitoneal or intrapleural inoculation of non-virulent bacilli into guinea-pigs illustrates this well. Mallory believes that where an irritant of a low grade of virulence is present, proliferation of the fixed cells and phagocytosis are prominent features. In typhoid infection this is true, and hyaline cells are especially active phagocytes, the finely granular oxyphiles being inconspicuous. In tuberculosis and leprosy phagocytosis is common, and endothelial cells are particularly active. In purulent infections the finely granular oxyphile and not the hyaline cell is the chief phagocyte. In the lungs inhaled carbon pigment and broken-down blood pigment—in pneumonia of heart disease—are contained in large amounts in large flat cells with rounded or oval nuclei. Whether these are hyaline leucocytes or desquamated alveolar epithelium cannot always be determined. Hyaline cells are the connecting link between endothelium and leucocytes, and Muir has pointed out that in inflammatory leucocytosis increased activity in and production of hyaline cells can be found evidenced in the lymphatic sinuses of lymph glands and by the mitotic figures in free hyaline cells.

Other varieties of leucocytes have not been recognized as phagocytic, and, in fact, little is known concerning their activities.

2. Phagocytosis in Fixed Cells.—The endothelial cells are markedly phagocytic for bacteria and other particles which are brought to them in the blood or lymph. They engulf particles by throwing out pseudopodia, and within limits they are quite amœboid. It has been suggested that in extremely small vessels where the endothelium composes a large part of the vessel wall, vaso-constriction or dilatation may depend upon thickening or thinning of these cells as a response to direct stimulation by materials flowing in the blood or lymph. This, if true, has an important bearing not only on inflammation, but upon the vascular phenomena of fever. In considering the finding of pigment particles in fixed connective-tissue cells as in those of the supporting tissue of the lung, or in glands, there is a question as to their exact mode of entrance. It is among the possibilities that free leucocytes act as phagocytes and wander by way of blood or lymph channels or between or through other cells until the particles ultimately reach the location in which they are found. Or the original phagocytic leucocytes may have died and set free the pigment to be taken up by a second leucocyte, or by an endothelial cell, or by a connective-tissue cell. Or the original leucocyte with its contained particles may have been bodily engulfed by a growing connective-tissue or other fixed cell. Evidences of such a process are not wanting. In phagocytosis on the part of epithelium—superficial or in glands—the problems are just as complicated. When bacteria enter the liver through the portal circulation and are then engulfed and killed or attenuated by the liver cells and ultimately extruded or excreted into the bile capillaries, it is likely that the endothelial cells of the portal capillaries act first and that these yield up their contents to the liver cells. Whether epithelial cells such as those in the milk glands can take up living bacilli and excrete or secrete them in a virulent condition so that they are eliminated through the ducts, is a question. Adami has suggested that such is the case where tubercle bacilli are found in the milk of cows whose udders bear no evidence of tuberculosis. Many other matters bearing upon this question might be discussed, such as the methods of excretion of bacteria and solid particles by way of the kidney, tonsillar infection in tuberculosis, etc., but they do not lie within the scope of so limited an article as this.

The Fate of Enclosed Particles.—When insoluble pigment particles are found in situations to which they could not have been swept by currents of lymph or blood, amœboid phagocytes have probably been the carriers, and such cells may set free their contents either before or after death.

Undoubtedly through phagocytosis many bacteria are killed, but, as we have seen, not all of those which are

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taken into the interior of phagocytes are destroyed. Metchnikoff has isolated single leucocytes which contained micro-organisms, and in a drop of broth under the microscope he has watched the bacteria increase within the cell until it was filled and finally destroyed, the micro-organisms escaping into the broth. In many cases of infection observation would warrant the belief that bacteria may be engulfed and carried considerable distances by phagocytes, which are then destroyed, the bacteria liberated, and a new focus of infection is set up. In many infections phagocytosis is pronounced throughout the whole course of the disease. This has constituted a difficulty for those who advocate the phagocytic theory of immunity. In such chronic diseases as leprosy, tuberculosis, and glanders, bacilli, apparently many of them living, are to be found enclosed in phagocytes. In epidemic cerebro-spinal meningitis and gonorrhœa—diseases of a more acute nature—one of the diagnostic points in connection with microscopic examination is the demonstration of the diplococci within the cells (finely granular oxyphile). It would therefore appear that while phagocytosis is undoubtedly an important factor in resistance to infection, there are distinct steps, namely, attraction of leucocytes which then engulf bacteria and later digest them. That digestion of bacteria does not always follow their enclosure in phagocytes is apparent.

The Factors which Influence Phagocytosis.—Anything which checks chemotaxis interferes with phagocytosis. It has been conclusively shown that highly virulent bacteria are less apt to attract wandering cells and induce phagocytosis than are more attenuated microbes of the same kind. For instance, if attenuated anthrax bacilli be inoculated in one ear of a rabbit and virulent anthrax bacilli be inoculated in the same manner and dose in the other ear of the same rabbit the results are quite different (Metchnikoff). In the one ear the attenuated bacilli induce a tremendous accumulation of leucocytes, while in the other ear fluid is poured out into the tissues with little or no attraction of leucocytes.

The state of resistance of the animal is also important. Immunization to anthrax renders an animal capable of responding to a dose of virulent bacilli by an accumulation of leucocytes, while a similar dose in an untreated animal induces a huge outpouring of fluid.

The presence of soluble bacterial products in a definite locality tends to favor the attraction of leucocytes from the neighboring blood-vessels, while the circulation simultaneously of the same materials in large quantities in the blood stream tends to prevent it. This is illustrated (Roger, Ruffer) by inoculating the bacillus of symptomatic anthrax into the subcutaneous tissues of a rabbit when leucocytes rapidly accumulate at the site of inoculation and abscesses result. If another rabbit be similarly inoculated, while in addition an intravenous inoculation is made, there is tremendous outpouring of fluid, but no leucocytosis at the site of the subcutaneous injection, and death results in a few hours. Hence phagocytosis is apt to occur when the invading bacteria are not too virulent, when the resistance of the host is great, and when the irritants and soluble products are present in much greater abundance at a point or points outside the vessels than in the circulating blood.

The economic uses of phagocytosis have been dealt with more or less fully in the preceding portions of the article, and need be only mentioned here. As a factor in nutrition evidences of the importance of phagocytosis decrease as we ascend in the scale of development. For instance, in the amœba observation would tend to show the extreme importance of phagocytosis in this connection, while in the higher animals proof that it takes a great share in the securing and assimilation of food is wanting, although such may yet be forthcoming. As has been stated, pigment and solid débris, such as exudates, hemorrhages into the tissues, dead cells, and tissues of all kinds are largely removed by phagocytes. In the spleen phagocytic inclusion of dead blood cells and animal and vegetable parasites is always demonstrable. Many more examples could be quoted were it necessary. In their attraction to, inclusion of, carrying away, and destruction of invading organisms the phagocytic cells may be exhibiting characteristics largely acquired in exercising their more physiological functions.

Phagocytosis in Relation to Present-day Theories of Immunity.—Ehrlich's brilliant experiments and deductions (see article on *Immunity*) have necessitated a remodelling of many of our ideas, and Metchnikoff in accepting Ehrlich's views has attempted to harmonize phagocytosis with the activities of complements and immune bodies. Ehrlich believes that immunity against bacteria (or other cells) depends upon the original possession or artificial induction of a special substance, "immune body," which firmly unites with the bacteria and thus enables another substance, "the complement," which is present normally in the animal to kill the bacteria. The immune bodies are more resistant to heat than are the complements. In the serum obtained from an immunized animal both immune body and complement may be found, although Metchnikoff believes that both are liberated from leucocytes (microphages and macrophages) by "phagolysis," and that in the body the final action of the complement on the bacteria takes place only within the cell during phagocytosis, even should the immune body have been free in the fluids.

It has long been known that bactericidal substances are more abundant in the leucocytes than in the fluids of the body. More recent work of Denys and Leclef seems to show that from rabbits immunized against streptococcus the serum when mixed with leucocytes from such an animal was no more destructive for streptococci than when mixed with the leucocytes of a normal rabbit, while by itself it was practically not bactericidal at all. Two antibodies seemed essential for the destruction of the streptococci: one was to be found in the immune serum, and the other was afforded equally well by the leucocytes of the normal or treated rabbit.

Bulloch's work on hæmolysis tends to show that in the rabbit an increase of finely granular oxyphile cells in the blood accompanies the formation of complement and that activity of mononuclear leucocytes is related to the formation of immune body.

There seems to be as yet no information available concerning the *exact* source of complement and immune body. We are not justified in assuming because a substance is bactericidal in test-tube experiments that it is operative as such in the body. We have seen already that the coarsely granular oxyphile cell acts deleteriously upon virulent bacteria, and that it is not markedly phagocytic. There are doubtless other cells which are antibacterial and non-phagocytic. In assuming that the same cells produce both immune body and complement, Metchnikoff is not borne out by the observed facts, although he admits that the former is more likely to be liberated into the body fluids than the latter.

The digestion of bacteria by phagocytes Metchnikoff apparently considers to be due to a ferment which seems to be the same sort of thing as Ehrlich's complement.

It is not quite clear whether his "cytases" include complement which remains fixed in the phagocytes, the immune body which under some conditions escapes into the fluids, and in addition special "stimulines," which acting on the phagocytes cause them to approach bacteria and engulf them. Ritchie, in his admirable critical review of the subject, asks very pertinently how the so-called education of leucocytes is brought about. He suggests that in the case of immunization by repeated intraperitoneal injections of cholera vibrios it is perhaps possible that in the later injections the especially active phagocytes may have been the same individuals engaged in the former encounters with the vibrios.

Although the life history of a leucocyte is probably short, he suggests that such "sensitized" leucocytes might even be attracted from distant parts of the body. It is easily seen that while admitting such possibilities he leans to the view that the active leucocytes in each succeeding injection are new ones probably derived from the bone marrow or lymphatic sinuses.

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To limit the formation of the active substances of Ehrlich to the phagocytic cells of the body as Metchnikoff has done, further complicates an already complicated but otherwise satisfactory theory of immunity. There seems to be ample evidence that there are many other active factors in the protective mechanism than those afforded by phagocytosis. Phagocytes are undoubtedly important, but not all the phenomena of immunity can be expressed in terms of phagocytosis. *F. F. Wesbrook.*

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PHARMACOPŒIA.* — (Greek φαρμακοποιία, from φάρμακον, medicine, remedy, and ποιεῖν, to make, to prepare; Latin, *pharmacopœa* or *pharmacopœia*; German, *Pharmakopöe*; French, *pharmacopée*; Spanish, *farmacopea*, etc.). A *pharmacopœia*, in the modern sense, may be defined as a work published by some recognized authority, for the purpose of securing uniformity in the kind, quality, strength, and composition of simple and compound remedies used in the practice of medicine. It may either be of a local character, or it may apply to a whole country. During the early history of pharmacopœias, the term was also often applied to works written or published by individuals, without the official sanction of governmental or professional authority. The Greek word φαρμακοποιία occurs in later Greek medical writings under its proper meaning, "the preparation of medicines," or "the art, or business, of preparing medicines." As the title of a book treating of this subject, however, it is probably not older than the beginning of the sixteenth century.

Ancient and Mediæval Precursors of Pharmacopœias.— While the ancient nations did not possess any works which could be fully set side by side with our modern pharmacopœias, yet the gradually accumulating mass of facts relating to the preparation and practical use of medicines resulted in the composition of numerous works which treated at least incidentally of this subject. In giving an account of the literature relating to the latter, we shall confine ourselves to those works the influence of which has, in one way or another, extended to our times.

Egypt has furnished us the oldest existing documents containing formulas and directions for the preparation of medicines. The oldest known is the *Papyrus Ebers*, dating from the year 1552 B.C. (see *Med. Rec.*, 11, pp. 247–251), which mentions a large number of simple remedies, and also contains numerous formulas of compounds, often in the form of regular pharmacopœial recipes, accompanied by signs and terms expressing weights or measures, precisely as is customary at the present day.

The *Medical Papyrus of Berlin* (see Woenig, "Die Pflanzen im alten Aegypten," Leipsic, 1886), written about 1350 B.C., contains a great number of formulas, with exact statements as to ingredients, and weights and measures. These formulas are for both internal and external remedies, including enemata. The remedies are mostly simples, plant parts, gums, resins, etc., with a few metals, liquors, and well-known liquids, including urine, bile, blood, and fæces of various animals.

In addition to these written documents, there existed also formularies sculptured in stone, one having been found upon the walls of a regular pharmaceutical laboratory or *asi t* (see Woenig, *loc. cit.*, 372) in the temple of Edfu.

India.—An examination of the oldest Indian literature, that of the Vedas, Brahmins, and Sutras, reveals little but superstition as to both diseases and remedies. The principal medical works of the Hindoos, viz., those of Charaka and Susruta, cannot be traced back beyond the eighth century A.D. (see *New Remedies*, 1876, 229), the foundations evidently having been derived from the Greeks. Most of these medical works are characterized, and their meaning is obscured, by the poetic or metrical style employed in them. Four or five centuries then elapse before we meet with any other notable writings of this kind. Among the later medical treatises the most important are "Ashtângahridaya," by Vâgbhata, and the "Bhâvaprakâça," by Bhâva, both of them only a few centuries old. These contain likewise many formulas interwoven in the text. Regular treatises on pharmacy, or formularies, are not numerous (to the former belongs the "Prayogâmrita" of Vaidyachintâmani, and others); but treatises on materia medica or glossaries of simples are much more common. The most extensive of these is the "Nighanturâja," by Narahari, of Cashmere, being a dictionary of products of nature, etc., with synonyms. Another smaller but useful work is the "Madanavinoda" of Madanapâla.

Greece.—The writings of Hippocrates (about 460–377 B.C.) were the first, as well as the most important, in the early history of Greek medical literature. Although none of his genuine writings is devoted exclusively to the preparation of specific medicines, numerous such directions are contained in them, and the pharmaceutical art became developed during the succeeding centuries in proportion as the rational treatment of disease, upon the foundation laid by Hippocrates, spread through the cultivated nations of Europe and Western Asia.

Of those works which are known to have exerted a permanent influence upon the formularies of later times, that of Andromachus of Creta, Nero's court physician, next requires mention, being a sort of poetic formulary. He also wrote a poem on Theriac and its preparations, which for centuries was highly influential in medical practice. About 65 A.D., Servilius Damocrates composed similar pharmacological poems, his compound of theriac, thus treated, being subsequently known as "Confectio Damocratis." In about 78 A.D., Dioscorides wrote his famous Ὕλη ("Materialia"), a most valuable cyclopædia of simples, which became one of the chief sources of pharmacological writers down to the Middle Ages.

The next important Grecian medical writer was Claudius Gallinus (131 to about 210 A.D.). His numerous writings exerted an influence equal to that exerted by the works of Dioscorides. Two of them treat especially "on the composition of medicines according to the places" (of application) "and according to classes." His numerous complex mixtures gave origin to the term "Galenical."

Of later writers, the more important are: Aëtius, of Amida, in Mesopotamia (sixth century A.D.), who gives numerous formulas for plasters, salves, etc.; Alexander, of Tralles, in Lydia (525–605 A.D.), and Paulus, of Ægina (seventh century A.D.), both of whom likewise quote many formulas in their writings. Passing now over several centuries, we find no author worthy of mention until we come to Nicolaus Myrepsus, of Alexandria (second half of thirteenth century A.D.), who compiled an "Antidotarium" (δυναμερόν), or formulary, containing not less than two thousand six hundred and fifty-six formulas, in forty-eight chapters. This work was written in Greek, but only the Latin translation has been published (first edition, Basle, 1549). It is also entitled "Antidotarium Magnum" (not to be confounded with the "Antidotarium Parvum" of Nicolaus Præpositus). In spite of its encyclopædic character, this formulary did not acquire as much reputation as the less extensive works of Mesue or of Nicolaus Præpositus.

Rome.—Previous to C. Plinius Secundus (23–79 A.D.) only the writings of M. Porcius Cato (234–149 B.C.) interwoven in agricultural treatises, need be mentioned. In the great work on "Natural History" by the former, many subjects relating to materia medica are treated. The "Compositiones Medicæ of Scribonius Largus" (first century A.D.) is the first literary production, having the nature of a formulary, of Roman origin. It contains the first correct description of the method of obtaining opium. A treatise by Rufus of Ephesus on cathartics was for a long time influential. Many other more or less important works by Romans were written in Greek.

Arabic Countries.—The Arabs were the first to develop the art of the apothecary and to establish regulations re-

* This article is practically a reprint of those contributed by Dr. Charles Rice to the preceding edition of this work and to the Supplement (Vol. IX.); the records, I might add, have been brought up to date, and a few changes have been made in the interest of economy of space. *Henry H. Rusby.*

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garding the quality and price of his medicines, and specifying which of them were to be kept in stock for instant use. Their advent infused new life into the torpid condition of the medical and other sciences.

At the end of the ninth century, Shâbûr ben Sahl wrote a sort of dispensatory under the title of "Ibdâl" (Haji Khalfa, ed. Flügel, i., 142), and about the middle of the twelfth century Abû'l Hassan Hibet-allah ibn Talmîd composed a similar work, entitled "Krabadin" or "Grabaddin" (Arabic, *qarâbâdîn*, or *qrâbâdîn*), which was commonly followed by Arabic apothecaries. The most important of these works was that composed by the younger Mesue (Mâswiyah el-Mârdînî, died 1015 A.D.), of Maridin, on the Euphrates, and of which only the Latin translation is extant, under the title "Antidotarium, seu Grabaddin Medicaminum compositorum." This remained for a long time the chief canon of pharmacy. It contains a large number of formulas arranged in twelve chapters, each treating of a different form (for instance, Pilulæ, Cerata, etc.) under which medicines are applied or administered. Not less than four Italian translations of this work appeared previously to the year 1500, and the Latin text was often reprinted.

The writings of the most celebrated of all Arabic physicians, viz., Avicenna (Abû 'Ali Hussain ben Abdallah, Ibn Sinâ, 978–1036 A.D.), also contain many formulas which were incorporated in subsequent collections.

Other writers, whose works contributed in this direction, were Ibn Wâfid el-Lachmî (about 1050 A.D.), called Albenguefit in mediæval literature, whose work on simples has been published only in Latin translation. Serapion the younger (Ibn Serâbî, about 1070 A.D.) was the author of a similar work, but this was much more esteemed and made use of than the former.

The most important Arabic writer on materia medica is Ibn Baitâr (about 1197–1248 A.D.). His work on simples and foods, based on his own observations and on the works of Greek, Arabian, Persian, and Syrian writers, is a perfect storehouse of information, and has exerted considerable influence upon the development of therapeutics and pharmacy among his countrymen.

Persia has little of interest to present in this direction. If we except a treatise on materia medica, based upon Greek, Arabian, and Indian sources, written by Alberwi (ninth century A.D.), we meet nothing of interest until the close of the seventeenth century, when Father Ange de la Brosse, de St. Joseph, published at Paris (in 1681) the "Pharmacopœa Persica, ex idiomate Persico in Latinum conversa." That this is no translation of an original Persian work has been recognized many years ago by Dr. Hyde, who supposed it to be the work of Père Matthieu. Leclerc ("Histoire de la Médecine Arabe," Paris, 1876, ii., 481) reports that it is a translation of an Arabic work existing in manuscript in the National Library at Paris. It bears internal evidence of the intimate acquaintance of the author with European medicines, some of which were probably then unknown to Persians, while others which were known (such as opium) are omitted. In 1771 Mîr Mohammad Hussain, of Khorasan, wrote a Persian pharmacopœia, and subsequently an encyclopædia of materia medica ("Makhzan el-adwiya," "Treasury of Medicines") of considerable merit.

Mediæval Europe.—Up to about the fifteenth century the apothecaries in European countries situated to the north of the Alps did not prepare many compounds themselves, owing to the difficulty of importing the numerous, often bulky, and perhaps scarce, crude materials. They were in the habit of obtaining the finished preparations from Italy, where the art of pharmacy was in a flourishing condition. Among the works written during the Middle Ages, which either served themselves as pharmacopœias or formularies or at least contributed to their compilation, may be mentioned the following: The "Antidotarium" (also called "Antidotarium parvum," to distinguish it from the "Antidotarium" of Nicolaus Myrepsus) of Nicolaus Præpositus, of Salerno (first half of the twelfth century), consisting of about one hundred and fifty alphabetically arranged formulas for compounds. This compilation, together with Mesue's "Grabaddin" (see under Arabic countries), constituted the most celebrated formulary of the Middle Ages (first edition, Venice, 1471). Other important works of this period are the following: "Compendium Aromatariorum" (1st edition, Bologna, 1488), by Saladinus Asculanus, a useful and much used work, in which much attention is devoted to the description of drugs and their mode of preservation; "Luminare Majus," by Manlius de Boscho (1st edition, Venice, 1496), a highly esteemed dispensatory. A counterpart of this is the "Luminare Minus" (Venice, 1517), of Quiricus de Augustis de Torthona. The "Antidotarium Florentinum" (1st edition, Florence, 1489; often reprinted) is the first pharmacopœia or formulary published in Europe under governmental authority.

History of Pharmacopœias. — The literature of pharmacopœias is very extensive, and an exhaustive account is beyond the limits of this work. Yet, since a reliable list or sketch of at least the more important pharmacopœias is often of great use to those who have to consult medical works published in previous years, a condensed account of them is here given, arranged by countries; among the latter being included, for the sake of completeness, most of those which possess no regular pharmacopœia of their own, but use some other work either from choice or by command.

Note.—In quoting editions of the less important pharmacopœias, only the date of the first one is usually given. A plus sign (+) behind the date indicates that several editions followed. In some cases the date of several or of all editions is given. The word "pharmacopœia" is usually abbreviated to save space.

Argentine Republic.—This country possesses no pharmacopœia, although commissions have long been maintained, at least nominally, for preparing one. The "Farmacopea del Pais," although a mere fiction, has been legally recognized, and the French, Spanish, and Italian authorities are variously followed.

Austria-Hungary.—In 1729, the Vienna Pharmaceutical Society published a dispensatory under the title of "Dispensatorium Pharmaceuticum Austriaco-Viennense," which was repeatedly revised and reprinted. In 1739 appeared the "Dispensatorium Medico-Pharmaceuticum Pragense," which also saw several editions. An official pharmacopœia prepared by order of Government by Stoerck, Jacquin, and Well, was published in 1774 under the title "Ph. Austriaco-Provincialis." This was several times revised, and also translated into German as well as into Dutch, the Netherlands at that time forming a part of the Austrian empire. After the loss of the Dutch provinces a fresh start was made, and the first pharmacopœia proper appeared in 1812, under the simple title, "Pharmacopœia Austriaca." The subsequent editions appeared in—1814 (ii.), 1820 (iii.), 1834 (iv.; this being full of misprints was republished in 1836); 1855 (v.); 1869 (vi.).

A supplement to the Austrian Pharmacopœia was published in 1879, and a new edition (Editio VII.) went into effect on the 1st of January, 1890. The Austrian Pharmacopœia is rather small, comprising only five hundred and seventy-eight titles. Its text is in Latin. From the year 1795 a special military pharmacopœia was maintained, its last revision dating from 1872.

Up to 1871 the Austrian Pharmacopœia was valid for the whole empire, but in that year a separate volume was supplied for Hungary, and this was republished in 1888 under the title "Magyar Gyogyszerkonyv, Masodik Kiadas." This work comprises five hundred and sixteen articles, and possesses both Hungarian and Latin texts on opposite pages.

The first Croatian pharmacopœia was published in 1888, under the title "Hrvatsko-Slavonska Farmakopea," being practically a duplicate of the Hungarian in Slavonic and Latin texts.

Belgium.—Previous to 1823, there existed the Pharmacopœia Belgica of 1659, and various pharmacopœias representing the different cities, as those of Brussels (1639 +),

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Gand (1652+), Leyden (1638+), Liège (1741), Lille (1640+), Antwerp (1661, 1665, 1812), as well as the Austrian Pharmacopœia which was official from 1774 to 1805, when it was superseded by the Pharmacopœia Batava. Owing to changes in political conditions these cannot be considered to be Belgian national works in the present sense. Such a one, however, appeared in 1823, republished in 1854 as the "Pharmacopœia Belgica Nova," of which a "second," and the latest, edition appeared in 1885. This work closely resembles the French Pharmacopœia, though without its conspicuously numerous blunders. The text is in Latin and French, the former being specified as the official.

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Bolivia has no pharmacopœia. The French is that mostly used, though in the western portion the Spanish is common. Through the works of Cernowicz, the Portuguese Pharmacopœia has considerable influence in the eastern provinces.

Brazil also is without a pharmacopœia, though many attempts to compile one have been made. The Spanish, Portuguese, and French works are largely used, and the work of Cernowicz is highly influential.

British Empire.—Up to the year 1864, England, Scotland, and Ireland possessed each its own pharmacopœia. That for England was first published in 1618, under the title "Ph. Londinensis," by the London College of Physicians. It was several times reprinted with slight alterations, until 1650, when its second revision was published. The succeeding revisions appeared in 1677 (iii.); 1721 (iv.; in this edition vegetable drugs were for the first time defined as to origin); 1746 (v.; in this edition a great advance was made; many of the old complicated formulas were curtailed and shorn of useless material); 1788 (vi.); 1809 (vii.); 1824 (viii.); 1836 (ix.); and 1851 (x.). Besides the official editions, the text was incorporated into many other works, such as commentaries or dispensatories, either written for it alone or for all the British Pharmacopœias together. It was also translated into various other languages, even into Hindustani (Calcutta, 1824).

The first pharmacopœia for Scotland was published by the Edinburgh College of Physicians in 1699, under the title "Pharmacopœia Collegii Regii Medicorum Edinburgensis." The subsequent editions or re-issues were very numerous.

The first pharmacopœia for Ireland appeared at Dublin in 1807, under the title "Pharmacopœia Collegii Medicorum Regis et Reginæ in Hibernia." Previously, however, a specimen pharmacopœia had been prepared and circulated already in 1794, and again in 1805. The Dublin Pharmacopœia was revised in 1826 and 1850.

In 1864 appeared the first "British Pharmacopœia" under the medical act of 1858. Many inconsistencies occurred in that work, chiefly due to the difficulty encountered in reconciling the differences between the three countries. In 1867 a new edition was produced by the general medical council, and to this a supplement, containing thirty-four additions, was published in 1874. In 1885 a new edition was produced by Professors Attfield, Redwood, and Bentley, under the direction of the Medical Council. Although showing a great advance over its predecessor, this work was far from satisfactory, owing to the fact chiefly that the editors were not empowered to avail themselves of the assistance and experience of other experts. Some of the principal errors were corrected in a subsequent supplement. In 1886 Attfield was appointed "reporter on the British Pharmacopœia to the Medical Council," his duty being to submit to the Medical Council annually a synopsis of current publications bearing upon the contents of the British Pharmacopœia, and making suggestions for its future improvement. The third reprint of the British Pharmacopœia appeared in 1888, and a supplement thereto in 1890, containing forty-four new articles. In the preparation of this supplement the pharmaceutical profession of Great Britain was graciously invited to suggest desirable additions or improvements, but not yet to assist in the actual work of revision. The fourth and last edition of this work was published in 1898, and is by far more satisfactory than any of its predecessors. It shows not only a much broader relation with other modern pharmacopœias, but its editors have evidently profited greatly by the suggestions emanating from the British medical and pharmaceutical professions. The metric and English equivalents of weights and measures stand side by side in the text as well as do the Fahrenheit and Centigrade equivalents of temperature. The nomenclature of the titles is excellent, the name of the special article preceding that of its class, as "Cardamomi Semina." In this practice it is at an agreement with the United States, but not with the German Pharmacopœia. In the botanical nomenclature of its definitions, no principles, properly speaking, are followed, current custom in Great Britain, even when erroneous, being taken as the guide and facts and principles being twisted when necessary to constitute a defence. The descriptions are sufficiently full, and are given in simple and judicious, yet not unscientific style. The tendency in this, as in other modern pharmacopœias, is toward the elimination of antiquated and worthless articles, as well as those of complex composition.

The usefulness of the British Pharmacopœia is restricted by a wholly selfish, unscientific, and unprofessional refusal to permit the quotation of any portion of its text, even for purposes of comment or criticism.

One of the dependencies of Great Britain, viz., *India*, has a pharmacopœia of its own. In 1842, Dr. W. B. O'Shaughnessy issued, by order of Government (under the authority of the East India Company), "The Bengal Dispensatory" (Calcutta), as a precursor to "The Bengal Pharmacopœia and General Conspectus of Medicinal Plants" which he published at Calcutta in 1844. In 1868 a "Pharmacopœia of India" was published at the same place by Dr. Ed. J. Waring, under authority of the Secretary of State for India. This is now in force, alongside of the new British Pharmacopœia. The main object of issuing a separate pharmacopœia for India was officially to encourage and authorize the employment of East Indian drugs, among which are many possessing very valuable properties. A most useful companion to this work is the "Supplement to the Pharmacopœia of India," by Moodeen Sheriff, published by order of the Government of Madras, in 1869. This work contains synonyms of the pharmacopœial articles in fourteen languages. A revision of the pharmacopœia of India is in contemplation.

In 1887 the British Pharmaceutical conference produced the "Unofficial Formulary," containing thirty-seven articles, to which nine were added by a supplement published in 1889. The abbreviation of the title of this work is "U. F. B. P. C."

Central American States.—These states have no pharmacopœias, and there is the greatest want of uniformity in the authorities followed, the Mexican Pharmacopœia not wielding the influence which would naturally be expected of it.

Chili.—In 1886 appeared the "Farmacopea Chilena," prepared by Dr. Adolfo Murillo, and published in Leipsic. Its text is Spanish, and it bears much resemblance to the French Pharmacopœia, though containing far fewer errors.

China.—This country has, of course, no official pharmacopœia, though there are numerous works of an unofficial character treating of such subjects, the best known and most extensive being "Pen tsao kung mu," of Lis hi-chin, published about 1560 A.D. While containing much of value, its basis is of course largely superstitious.

Denmark.—In 1658 the "Dispensatorium Hafniense" was published at Copenhagen, and this was several times reprinted. The first official pharmacopœia appeared in 1772, the second in 1805, and the third in 1830. The last mentioned was, however, counted as the first work, the others not being regarded subsequently as deserving of the name. Hence the next edition, published in 1868, was designated as "Editio Secunda." Supplements to it appeared in 1874, 1876, and 1886. On August 1st, 1893,

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a new edition went into effect. The text of the work is in Danish, the titles are in Latin. Much similarity exists between the Danish, Norwegian, and Swedish pharmacopœias, which is the result of deliberate design, as these countries are closely allied in customs, traditions, and language. A separate military pharmacopœia is in existence.

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Ecuador.—The statements made concerning Bolivia apply also to Ecuador.

France.—In 1353 King John, "the good," commanded the apothecaries to follow the "Antidotarium" of Nicolaus Præpositus. Strict regulations regarding the practice of pharmacy were made in 1536, and frequently afterward. As early as 1546 a "Ph. Lugdunensis" was published at Lyons, which was several times reprinted. A French "Paraphrase sur la Pharmacopée" was issued by Briçon Bauderon, of Mascon, in 1588+. In 1590 the Paris Faculty of Medicine was directed to prepare a dispensatory; but, as nothing was done, Parliament, in 1597, ordered twelve members of the faculty, designated by name, to prepare the work. The order was, however, not obeyed. Several French cities early possessed pharmacopœias of their own, thus: Burdigal ("Ph. Burdigalensis," 1643); Strasburg (Ph. Argentoratensis," 1725+); Toulouse ("Codex Medicamentarius, seu Ph. Tolosana," 1648, 1695); Valenciennes ("Ph. Valentianensis," 1651). A new "Pharmacopée de Lyon" was also published by Vitet in 1788. The last-named work, to a slight extent, answered the purpose of a revised edition of the last Paris Pharmacopœia in some localities. In 1637 the "Ph. Parisina" appeared as a precursor to the first official Paris Pharmacopœia, which was issued in 1639 under the title "Codex Medicamentarius, seu Ph. Parisiensis, in lucem edita a Ph. Harduino." Revisions of this appeared in 1645, 1732, 1748, 1758. No further revision appeared then until, after an interval of sixty years, a national pharmacopœia was issued in 1818, under the title: "Codex Medicamentarius, seu Ph. Gallica," the text being in Latin. In the second and following editions the French language was chosen for the text, only the synonyms of the titles being given in Latin. These editions appeared in 1827 (ii.), 1839 (iii.), 1866 (iv.), and 1884 (v.). The last revision was a very unsatisfactory one, as the revisers did not seem to have paid attention either to the other new pharmacopœias (United States and German) which had appeared a short time previously, or to the copious literature relating to pharmacopœial improvements. Immediately after the work had been issued very numerous errors were discovered in it, so that the Government was compelled to make a fresh issue, in which one hundred and thirty-two alterations were incorporated; and a special pamphlet entitled "Erratum," was shortly afterward sent out, in which eighty-three additional changes were directed to be made. But this list of errata is not only itself not free from errors, but is far from being complete. In connection with the French Pharmacopœia should be mentioned the well-known work of Dervault, "L'Officine," constituting an exhaustive commentary and supplement to the pharmacopœia. In some foreign countries, which do not possess a pharmacopœia of their own, this work is frequently followed as the principal authority, being used either in the original French or in Spanish translation.

Germany.—The first official formulary published in Germany was that of Valerius Cordus, published after his death by the city of Nuremberg in 1546, under the title "Pharmacorum omnium quæ quidem in usu sunt conficiendorum ratio; vulgo vocant Dispensatorium pharmacopolarum" (see *Am. Drug.*, 1887, 21). The work contains formulas of Galenical preparations, taken chiefly from ancient writings, with few simples. Some of the titles continue to the present day, though in some cases the composition has utterly ceased to correspond therewith. The work was often reprinted at home and abroad. There is a Paris edition of 1548, three of Lyons (1552, 1559, 1599), two of Venice (1556, 1563), etc. In the Nuremberg edition of 1592, great advances were made, several American drugs (sassafras, sarsaparilla, and tobacco) being introduced, chemicals first appearing (alum, borax, saltpetre, etc.), as well as some artificial salts from ashes of plants and other substances. Extracts and distilled waters were also added. Equally important changes occurred in the next edition (1598), white arsenic, corrosive sublimate, calomel, and oil of vitriol being among the additions. The next edition (1612) was little changed. The fifth and last edition appeared in 1666, and showed great changes, many for the worse, some for the better, such as the introduction of cinchona, jalap, balsams of Peru and Tolu, tinctures and many new chemical salts, under the then prevailing alchemistic nomenclature. This edition contained nearly all classes of preparations of which we still make use, organic proximate principles being of course unknown. It certainly formed the basis upon which subsequent European pharmacopœias were constructed.

In 1538 the physicians of Augsburg prepared a sort of pharmacopœia under the title, "Conclusiones et Propositiones Universam Medicinam Complectentes," containing formulas which were afterward generally followed. Augsburg was at that time the chief *entrepot* of the German trade with Italy and the Levant; hence many of the imported medicines came by way of Augsburg. In 1564 the first edition of the "Ph. Augustana" was published, which was often revised, and Cologne followed the example in 1565, by the publication of a "Dispensatorium," which was replaced by a "Ph. Coloniensis" in 1627.

The disunited condition of the countries inhabited by the German nation up to within recent times has been the means of bringing into the world a large number of independent pharmacopœias, for separate cities or principalities, of which a list follows here: Stralsund ("Actuarium Ph. Stralsundensis," 1645); Quedlinburg ("Quedlinburgensis Officina Pharmaceutica," 1665); Brandenburg ("Dispensatorium Brandenburgicum," 1698, forming the starting-point of the later Prussian pharmacopœias); Hanover ("Ph. Hanoverana," 1706; last edition, 1861); Hamburg ("Dispensatorium Hamburgense," 1716; "Codex Hamburgensis," 1835, 1845); Ratisbon ("Disp. Pharm. Ratisbonense," 1727); Munster ("Disp. Monasteriense," 1739); Würtemberg ("Ph. Wirtembergica," 1741; last edition, 1847); the Palatinate ("Disp. Med.-Pharm.," 1764); Brunswick (Disp. Pharm. Brunsvicense," 1777); Würzburg ("Pharm. Herbipolitana," 1778; last edition, 1796); Westphalia ("Disp. Westphalicum," being identical with Piderit's "Pharmacia Rationalis" [see under Saxony], 1779); Fulda ("Disp. Fuldense," 1787); Bremen ("Pharm. in usum . . . Bremensis," 1792); Schaumburg-Lippe ("Disp. Lippiacum," 1792); Oldenburg ("Ph. Oldenburgensis," 1801); Hessen ("Disp. Electorale Hassiacum," 1806; "Pharm. Hassiæ," 1827, 1860); Erfurt ("Neue Pharmakopoë" . . . von Trommsdorff, 1808, was introduced by order of the French in place of the "Prussian Ph."); Saxony (in 1806, Piderit's "Pharmacia Racionalis," Cassel, 1779–81 was prescribed as Ph. In 1820 appeared "Ph. Saxonica," the last edition in 1837); Bavaria ("Ph. Bavarica," 1822, last edition in 1859); Schleswig-Holstein ("Ph. Slesvico-Holsatica," 1831); Baden ("Ph. Badensis," 1841).

Many of these were revised and republished a number of times.

The most important of all former German pharmacopœias has undoubtedly been the Prussian. This had its beginning in the "Brandenburg Dispensatory" of 1698, the last revision of which, or the sixth edition, appeared in 1781. In 1799, the first "Ph. Borussica," was published. The next editions came out in 1801 (ii.), 1813 (iii.), 1827 (iv.), 1829 (v.), 1846 (vi.; this is considered to have been the best pharmacopœia of its time); 1862 (vii.). Four editions of a separate Military Pharmacopœia were also published, the last one in 1868.

The problem of a united pharmacopœia for all German states had often been agitated, but in vain. In 1861 Dr. Walz proposed the publication of a German Pharmacopœia by private enterprise, which was to be recommended for adoption, or at least as a pattern, to the different German States. The work appeared in 1865, under the

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title "Pharmacopœa Germaniæ." Among the compilers were two Austrians, as it was at the time believed that the work might be accepted by all German-speaking peoples. But the war of 1866 rendered the project, as originally conceived, nugatory. A second edition was published in 1867, in which the Austrian members were omitted. Yet even this failed of recognition. It was only after the establishment of the German empire that the desired object was attained. In 1872 was issued the first "Ph. Germanica," superseding all the separate pharmacopœia at that time in force in German countries. Some amendments to this were published in 1873. When the time for a new revision arrived the Government invited all medical and pharmaceutical bodies and prominent individuals in both professions to submit proposals regarding the new revision. Contributions were received from a large number of sources, and these were printed by Government in a large folio volume of six hundred and ninety-one pages. The Committee of Revision, consisting of thirty-three members, under the presidency of Dr. Struck, held only a few personal meetings, but the work of the commission was much facilitated by the fact that the Government from time to time issued printed circulars among the members. The final draft of the work having been first printed in German (fol.), the work appeared in its official Latin garb in 1882, and went into force on January 1st, 1883. An official German translation was likewise published; and an English translation, by C. L. Lochman, appeared at New York in 1884.

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A standing committee, appointed by the German Pharmaceutical Association, almost immediately undertook a critical revision of this work, and in 1887 a permanent pharmacopœia commission was created by the Government. In 1890 the third edition appeared under the title, "Arzneibuch für das Deutsche Reich. Dritte Ausgabe. Pharmacopœia Germanica. Editio III." The Latin language was abandoned and the text made wholly German, with the exception of the titles of the articles. In the work of its revision the pharmacopœia committee of the German Pharmaceutical Association was of the greatest value.

The example set by the United States (1886 to 1888) and Great Britain (1887), in preparing national formularies of unofficial preparations was followed by the pharmacists of Germany in 1891, when the German Pharmaceutical Association published a similar work under the rather awkward title: "Arzneimittel welche in dem Arzneibuch für das Deutsche Reich (Dritte Ausgabe; Pharmacopœia Germanica, Editio III.) nicht enthalten sind" (= "Remedies which are not contained in the Arzneibuch," etc.). This contains eight hundred and eleven articles.

The fourth and last edition of the German Pharmacopœia was published in 1900. It exhibits the degree of progress which might reasonably be expected at the close of a decade so noted for research and criticism as that between 1890 and 1900. An unfortunate departure, however, is that of the uniform omission of the authorities of botanical names. In those cases in which there is but one such authorship, hence but one interpretation of the name, the omission is not serious; but there are some instances in which actual doubt as to what plant is intended may exist. Another unfortunate custom is that of placing the class name of a drug in advance of its individual name, in the title, as "Flores Malvæ" instead of "Malvæ Flores."

The influence of the German Pharmacopœia extends far beyond the geographical limits of the German empire. Outside of the United States Pharmacopœia there is probably no other, even not excepting the British, which is so frequently drawn upon by prescribers in this country.

Greece.—The first Greek Pharmacopœia was published in Athens under King Otto I., in 1837, under the title, "[illegible] φαρμακοποιία . . . παρὰ [illegible], Ξα[illegible] [illegible], [illegible] Σαρτωρίου," etc. ("Greek Pharmacopœia . . . by Joannes Bouros, Xaverios Landerer, Joseph Sartorius," etc.). It was based on the French, Bavarian, and various other German pharmacopœias existing at that time. The text is in Latin and modern Greek, side by side. Synonyms are given in Italian, French, English, German, and Turkish, wherever possible, but among them are many mistakes. In 1868 Professor Landerer had the work reprinted, with a supplement (παράρτημα) of the newer preparations, an etymological glossary, and a table of antidotes. This reprint was officially recognized by Government. In general it must be said that the work is very far behind the time.

Hayti has no pharmacopœia of its own. The French Codex is mostly followed.

Hawaiian Islands.—The United States Pharmacopœia is generally followed.

Hungary.—See Austria.

Italy.—Italy was the first country in Europe in which an official pharmacopœia was published. This was the "Antidotarium Florentinum," first published at Florence in 1498. Other similar works appeared at Mantua ("Antidotarium Mantuanum," Venice, 1559); Bergamo ("Ph. Bergomensis," 1580); Venice ("Ph. Veneta," 1617; "Codice pharmaceutico," 1790); Messina ("Ph. Messanensis," 1629); Naples ("Antidotarium Neapolitanum," 1649); Turin ("Ph. Turinensis," 1736); Sardinia ("Ph. Sardoa," 1773; the last edition, "Farmacopea per gli Stati Sardi," of 1853 is still in force); Bologna ("Antidotarium Coll. Med. Bononiensis," 1783); Genoa ("Formulario farm.," 1791); Ferrara ("Farm. Ferrarese," by Campana, 1799, etc.); Parma ("Ph. Parmensis," 1823; another edition of this appeared in 1839 for Piacenza, Parma, and Modena together). The Church States, Tuscany, Lucca, and many other Italian provinces follow a dispensatory published by Orosi, under the title "Farmacologia teorica e practica ovvero Farmacopea Italiana." Lombardy and Venice use the Austrian Pharmacopœia; Naples uses, besides other works, the "Ricettario farm. Napolitano," 1859. Throughout Italy a new work by Ruata, entitled "Farmacopea Nazionale e Generale, Materia Medica e Terapia" (Verona and Padova, 1883) is now frequently employed.

Although a commission for the publication of a national pharmacopœia was appointed years previously, the draft, under the presidency of Professor Canizzaro, was not reported until 1884, and the work was not published until 1892. Meanwhile, different portions of the country used such works as were prescribed by their local authorities, the army using the Sardinian Pharmacopœia of 1853. The present work is entitled, "Farmacopea ufficiale del Regno d'Italia" (8vo, Roma). This work was one of the first to introduce statements regarding the percentages of active constituents of drugs such as belladonna, jaborandi, and colchicum; yet methods of assay are not prescribed, so that the utility of the procedure is questionable.

Japan.—In 1880 a commission of twenty-one members, several of them Europeans in the service of the Japanese Government, under the presidency of Mr. Hosoakwa, undertook the work of preparing a pharmacopœia, which was published in August, 1886, as an octavo volume of nearly four hundred pages, the text in Japanese, under the title, "On yaku zuki Nippon yaku kiyoku ho." It consisted of an introduction, preface, and body, the latter comprising four hundred and seventy-five titles, followed by general directions for keeping certain drugs and preparations, lists of reagents and volumetric solutions, lists of articles always to be kept on hand, list of separanda, maximum doses, tables of specific gravity and of elements, a Japanese and Latin index, list of errata, table of doses for adults and children, then another list of errata. The official text was in Japanese, the scientific chemical, botanical, and zoological terms in Latin, in Roman characters, with Japanese transliteration. In the treatment of the subject, the United States, British, and German Pharmacopœias were mostly followed, but the text showed also independent and careful work on the part of the compilers. The sign [illegible], placed under an unusual quantity of a powerful remedy, is to be used by prescribers for the same purpose as the exclamation

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point in European practice, viz., as an evidence that the prescriber intentionally ordered a large dose. The second edition of this work appeared in 1891, under the title "Pharmacopœia Japonica. Editio Altera. Tokyo, Anno xxiv. Meiji (1891)." It is wholly in Latin. It resembles its predecessor in general appearance and construction, but in the nomenclature of chemical substances, the last German and Austrian pharmacopœias have been followed as guides.

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Liberia.—The United States and British pharmacopœias are usually followed.

Mexico.—The Pharmaceutical Society of Mexico, in 1874, published a pharmacopœia which was officially recognized by Government. It was one of the best pharmacopœias of its time. In 1884 a second edition was issued by the same society, the text of which was already completed at the close of 1881. Its title is "Nueva Farmacopea Mexicana de la Sociedad Farmacéutica de Mexico." It presents among other special features a very copious materia medica, paying particular attention to native products. The text is in Spanish in two columns. In general the work rather corresponds to what we would call a dispensatory, as it treats also of the medical properties and uses of the several drugs and preparations, and covers a good deal more ground than is usual for a pharmacopœia. It is a very carefully prepared and meritorious work.

Netherlands.—The frequent political changes in the Low Countries were not without influence upon the existence or validity of its pharmacopœias. Among the earlier works of this kind which may be mentioned here are the following, in cities now belonging to the Netherlands: Amsterdam ("Ph. Amstelodamensis," 1636; last edition, 1792, see below); The Hague ("Ph. Hagana," 1652; last edition, 1758); Utrecht ("Ph. Ultrajectana," 1656; last edition, 1749); Louvain ("Ph. Lovardensis," 1687; last, 1745); Haarlem ("Ph. Harlemensis," 1693; last, 1741); Dort ("Ph. Dordracena," 1708; last, 1766); Rotterdam ("Ph. Roterodamensis," 1709; last, 1835); Alcmar ("Ph. Alcmariensis," 1723); Groningen ("Ph. Groningana," 1724, '30). At one time the Netherlands belonged to Austria, hence the "Ph. Austriaco-Provincialis" was made official and a Dutch translation of this was published in 1781. After the establishment of the Batavian republic (1795–1806) a commission was appointed to draft a pharmacopœia. This was completed and published in 1805 under the title "Ph. Batava," and was a work of great merit, being by far the best of its time. This work has been extended and commented upon by Niemann (1811, second edition, 1824) in an excellent manner. In 1851 appeared the first "Ph. Neerlandica," the text being both in Latin and in Dutch. It had much resemblance to the French Codex. A revised edition, both in Latin and in Dutch, appeared in 1871, the Latin version being, as in the first edition, the official text. It contained six hundred and fifty-five titles. In 1884 a Government commission was appointed for revising this work, and a new edition appeared in 1889 under the title, "Nederlandsche Pharmacopee. Derde Utgave (= third edition), 's Gravenhage, 1889." Excepting the titles of the articles, the text is entirely in Dutch. A Latin edition soon appeared under the title "Pharmacopœia Neerlandica. Editio tertia. Haga Comitis, 1889." It was specially decreed, however, that the Dutch edition was to be considered the official one.

In 1891 the Rotterdam branch of the Netherlands Pharmaceutical Society (Nederlandsche Maatschappij ter Bevordering der Pharmacie) followed the lead of other countries, by issuing an unofficial formulary under the title: "Supplementum op de derde Utgave der Nederlandsche Pharmacopee . . . 's Gravenhage, 1891." It contains five hundred and seventy-three articles.

Norway did not possess a pharmacopœia of its own until 1854, the Swedish Pharmacopœia being used in the country up to that time. The "Ph. Norwegica" was revised in 1870, and this second edition was reprinted with additions in 1879. It contains some five hundred and ten titles. The text is in Latin. It much resembles the Swedish and Danish pharmacopœias, but the influence of the German Pharmacopœia is clearly perceptible.

Paraguay.—The French, Spanish, and occasionally other pharmacopœias are usually consulted.

Peru.—The French, Spanish, United States, and British pharmacopœias are usually drawn upon.

Poland.—See *Russia*.

Portugal.—In 1704, Cætano de Santo Antonio published a "Pharmacopea Lusitana Galénica" at Coimbra. This was republished at Lisbon (as "Ph. Lusitana," or, "Ph. Ulissiponense") in 1716, and twice reprinted. In 1785 appeared de Poiva's "Farmacopea Lisbonense." The first official pharmacopeia was published by Dr. Tavares in 1794, under the title "Farmacopeia Geral para o Reino e Dominios de Portugal." In 1825 this was supplanted by the "Ph. Lusitana," and this was followed in 1838 by the "Codigo Pharmaceutico Lusitano" (revised 1858). Finally a new "Pharmacopêa Portugueza" was issued in 1876. This is a very good work, prepared with care and judgment. The text is in Portuguese, except the synonyms of titles, which are in Latin. It has been shorn of the obsolete rubbish of the therapeutics of former times.

Roumania issued a pharmacopœia in 1861, under the title "Pharmacopœa Romana." A second edition, revised, appeared in 1874. The text throughout is in Roumanian, without Latin synonyms. It bears some resemblance to the Austrian Pharmacopœia, but has some distinctive features of its own.

Russia.—Up to the year 1866 Russia had no official national pharmacopœia, except one for the army which was first issued in 1765. In 1779 a revised and much improved edition of the latter appeared, under the title "Ph. Castrensis Rossica." This was followed in 1789 by a special pharmacopœia for the navy ("Ph. Navalis," last revised in 1869). Both of these were superseded in 1808 by the "Ph. Castrensis Ruthenica," edited by Wylie, of Moscow. This was several times revised, last in 1866. A civil pharmacopœia appeared as early as 1778 at St. Petersburg (reprinted in 1782), under the title of "Ph. Rossica," and a second edition in 1798 (reprinted 1803); but these were not officially recognized, the pharmacists being compelled to consult almost every prominent European pharmacopœia when putting up prescriptions. That which was most followed, generally, was the "Ph. Borussica." In 1866 the first official civil pharmacopœia was issued. This was followed by new editions in 1871, 1880, and 1891. The title is "Rossiiskaya Pharmakopeya," edited by the Medical Council in the Department of the Interior, by order of his Imperial Majesty, etc. Great care was bestowed upon the two last editions, the best features of the German Pharmacopœia being incorporated into it. The text is in Russian, the main titles and synonyms, however, and the names of the ingredients entering into the preparation being in Latin. A special pharmacopœia for the use of the imperial court was published in 1874. Hence there are four Russian pharmacopœias in existence—the military, the naval, the civil, and the court pharmacopœia. The military work is in some respects a sort of dispensatory, as it goes more into details.

A separate pharmacopœia was published for Poland, in Warsaw, in 1817, under the title, "Ph. Regni Poloniæ," but this does not seem to have long remained in force. On the other hand, Finland published a pharmacopœia of its own ("Ph. Fennica") in 1819 (at Abo). Later editions of this appeared at Helsingfors in 1850 (ii.), 1863 (iii.), and 1885 (iv.). The text of this is in Latin. It is closely allied to the several Scandinavian pharmacopœias, and in certain features still more closely to the last German Pharmacopœia. In extent, it is one of the smallest, comprising only about four hundred articles.

Spain.—Previous to the appearance of a national work, local pharmacopœias had been in existence in the following cities: Salamanca ("Ph. Salamanca," by J. Bravo, 1588); Barcelona "(Ph. Catalana," 1686); Almeria ("Ph Almeriana," 1724); Saragossa and Valencia ("Officina Medicamentorum," 1601, 1698, 1739); Madrid ("Ph. Ma-

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tritensis," 1729 +). In 1521 was published at Madrid the "Examen Apothecariorum," composed in 1497 by Pedro Benedicto Mateo, which has been found by Mallaina to be a veritable pharmacopœia. The first national pharmacopœia ("Ph. Hispana") appeared in 1794. This and the next three editions, viz., of 1798, 1803, and 1817, were written in Latin. The fifth (1865) and sixth editions (1884) are in Spanish with Latin synonyms of the titles. The "Farmacopea Oficial Española" appears to have made the least progress of any. Even the last edition, here and there, betrays an adherence to unscientific, empirical, or obsolete remedies and methods. Besides, it bears internal evidence of the influence of the new French Codex. In the number of articles, of which it contains nearly one thousand seven hundred, it is only exceeded by the last-mentioned work.

Attempts have been made to prepare a separate pharmacopœia for *Cuba*, but no tangible results have been reached thus far.

Sweden.—A "Ph. Holmiensis" was published at Stockholm in 1686. The first work, bearing the title "Ph. Suecica," appeared in 1705, but without special authority. The first official pharmacopœia appeared in 1775, and the succeeding editions in 1779 (ii.); 1784 (iii.); 1790 (iv.); 1817 (v.; in this edition the chemical portion was edited by Berzelius, and the botanical and zoölogical by Swartz; it was the most advanced and perfect pharmacopœia of its time); 1845 (vi.), and 1869 (vii., with supplement of 1879). The last edition has been several times reprinted with amendments. It has much resemblance to the Danish and Norwegian (see under Denmark). The text is in Latin, and the number of titles is six hundred and seventy seven.

Switzerland.—A "Ph. Helveticorum" was published at Geneva in 1677. In 1684 there appeared in the same city an edition of Charas' "Pharmacopea Regia Galenica et Chymica," which was followed as authority for a long time. The Basle Medical Society, in 1771, published a "Ph. Helvetica" (containing an introduction by A. de Haller). A "Ph. Genevensis" appeared in 1780, and was reprinted several times afterward. In 1852 an elaborate draft of a pharmacopœia for the Canton of Berne was published at Berne under the title "Pharmacopœæ Bernensis Tentamen." This may be regarded as the precursor of the "Ph. Helvetica," published in 1865 at Schaffhausen, by the Swiss Pharmaceutical Society. The latter work has been recognized by law in most of the cantons, but not in all. A second edition appeared in 1872, and a large supplement in 1876.

The text of this pharmacopœia is in Latin, and has much in common with the German Pharmacopœia. A new work, "Pharmacopœia Helvetica, Editio III.," was issued in 1893.

The Canton of Tessin has a pharmacopœia of its own, published in 1848. Geneva uses the French Codex.

Turkey.—The Imperial Medical School at Constantinople has directed the use of the French Codex. Other foreign pharmacopœias, however, are also in use.

Uruguay.—The French and Spanish pharmacopœias are chiefly in use.

Venezuela.—The French and Spanish pharmacopœias are mostly in use. Long since, the medical faculty at Caracas took initiatory steps to prepare a national pharmacopœia, without result so far.

Charles Rice.
Revised by *Henry H. Rusby.*

PHARMACOPŒIA, UNITED STATES.—HISTORY.—The first pharmacopœia in the United States was published at Philadelphia, for the use of the Military Hospital of the United States army, located at Lititz, Lancaster County, Pa., in 1778, under the title, "Pharmacopœia simpliciorum et efficaciorum in usum nosocomii militaris ad exercitum fœderatarum Americæ civitatum pertinentis, hodiernæ nostræ inopiæ rerumque angustiis, feroci hostium sævitiæ, belloque crudeli ex inopinato patriæ nostræ illato debitis, maxime accommodata" ("Pharmacopœia of the more simple and efficacious [preparations] for the use of the Military Hospital of the Army of the United States of America; specially adapted to our present poverty and distress, due to the ferocious cruelty of the enemy and to the bloody war unexpectedly brought upon our fatherland"). Only one copy of this edition is known to exist, which is in the surgeon-general's office at Washington. Of a second edition, there appears to be likewise only one copy known (see *Am. Jour. Pharm.*, 1881, 483). This was issued in 1781. Upon the title page appears the name of Dr. William Brown, as author. It is entirely in Latin, in thirty-two pages. It contains eighty-four internal and sixteen external remedies. Previous to the year 1820, various European pharmacopœias, chiefly those of London, Edinburgh, and Dublin, were used in the United States, though the want of a national pharmacopœia was, to some extent, filled by Coxe's "American Dispensatory" (first edition, Philadelphia, 1806 +), and Thacher's "American New Dispensatory" (first edition, Boston, 1810 +). In 1808 the "Pharmacopœia of the Massachusetts Medical Society" was published at Boston, and in 1816 the "Pharmacopœia of the New York Hospital" at New York. The first impetus to a national pharmacopœia was given in 1817, by Dr. Lyman Spaulding, in a plan laid before the Medical Society of the County of New York. (For details of the history of the "Pharmacopœia of the United States of America," consult the latter work, sixth edition, New York, 1882, pp. v.–xiii.). The first convention for the formation of a national pharmacopœia assembled at Washington on January 1st, 1820, at which time the several drafts previously prepared by the several district conventions were consolidated and revised. The finished work was published at Boston, on December 15th, 1820, both in Latin and in English. A second edition appeared in 1828. Before adjourning, the convention provided for a future revision of the work, by arranging for the call of a convention in 1830. Owing to a misunderstanding, however, two separate conventions were held in this year, one meeting at New York, and the other at Washington, and two separate pharmacopœias resulted from this, one being published at New York in 1830, the other at Philadelphia in 1831. Fortunately, the bodies who had met at New York subsequently abandoned the plan of continuing a separate revision in the future, and in 1840 the third general convention assembled again at Washington. The Committee of Revision appointed at this convention was authorized to request the co-operation of the colleges of pharmacy, and this resulted in the contribution of much valuable material. The new revision was published in 1842, the text being for the first time only in English, the Latin being restricted to the titles and synonyms. At the next convention, in 1850, the incorporated colleges of pharmacy were for the first time invited to participate in the deliberations. Previous to this, only incorporated medical societies had been invited to send delegates. The fourth edition of the work appeared in 1851, and a second edition of this in 1855. The next two conventions met at the appointed time, in 1860 and 1870, and the fifth and sixth editions of the pharmacopœia were issued in 1863 and 1873, respectively. Several years before the next succeeding convention (in 1880), a very lively interest was awakened in the proposed new revision of the work, and several plans were advanced, looking toward a radical change in the manner of revising and controlling the revision of the pharmacopœia. A large amount of preliminary work was also bestowed, principally on the part of the American Pharmaceutical Association, upon the plan and contents of the next edition. The convention which assembled at Washington, in 1880, was the most representative of any that had so far been held, and after a general plan of revision had been adopted, a Committee of Revision and Publication was appointed, consisting of twenty-five members, residing in various parts of the United States. This committee has made a detailed report of its proceedings in the preface to its work, which appeared toward the end of 1882 (see "United States Pharmacopœia," 1882, pp. xxvii.–xxxiii.). The title page designates this as

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the "Sixth Decennial Revision"; consequently, this was the *seventh* edition of the work. In this revision radical changes were made, the intention being to render the work as independent of commentaries as was possible. The arrangement was alphabetical throughout, all crude drugs and chemicals being defined and accompanied by descriptions or by tests of identity and purity. Actual weights and measures were replaced by a system of parts by weight, except in the case of fluid extracts. Many obsolete articles were dropped, and many new ones admitted, the total number of accepted titles being nine hundred and ninety-seven. The general verdict of all competent critics, both at home and abroad, was that this was one of the best pharmacopœias ever issued, and that it did not suffer by comparison with works that appeared later.

It having been long felt that the pharmacopœia contains a considerable number of preparations which are not frequently prescribed, and are retained only in order that, if called for, their uniform composition may be insured, the American Pharmaceutical Association undertook the compilation of a "National Formulary of Unofficial Preparations," primarily designed to establish uniform formulas for any compound used in legitimate pharmacy or prescribed by physicians, and for which there is no recognized official standard. It was believed that this formulary might eventually be made the repository of all such pharmacopœial articles as are no longer deemed of sufficient importance to be included in the official list. This work was published in 1888, under the above title, and has proved very useful. In May, 1890, the Decennial Convention for Revising the Pharmacopœia met at Washington, and resulted in the election of a committee of revision, consisting of twenty-six members, located in different sections of the country, and gave instructions for the "Seventh Decennial Revision, or the "Eighth Edition," which was published by the committee itself, and went into effect on January 1st, 1894. The most important features introduced into this work were the substitution of the metric system of weights and measures for "parts by weight"; the reference of the standardizing of preparations by chemical assay, and of such assay processes to the discretion of the committee, the committee subsequently deciding upon the adoption of such standards for only a few drugs and preparations; volumetric methods were made to replace, as far as possible, gravimetric methods; articles protected by proprietary rights were excluded; important changes in chemical nomenclature and notation were adopted, though radical measures were rejected; in botanical nomenclature the Rochester code was adopted as authoritative; ninety articles were dropped and eighty-eight were added; the word *official* was adopted to replace "officinal." This work was received universally as representing the most advanced, yet sufficiently conservative standard among pharmacopœias, and the advances in it have so far commended themselves to the medical and pharmaceutical professions during the decade since its appearance, that further progress in the same directions has been generally urged, particularly in that of an extension of the list of assayed drugs and preparations. It may be safely said that the Pharmacopœia of 1890 has done more than any of its predecessors for general pharmaceutical education, and to only a lesser degree for medical education. At the present time (January 1st, 1903), the work of the Eighth Decennial Revision is nearly completed. Soon after the meeting of the convention of 1900, death removed the beloved and highly talented chairman of the revision committee, Dr. Charles Rice, and Prof. Joseph P. Remington was elected as his successor. The interest in this revision, throughout the country, has been general and hearty, and the committee has worked with the greatest enthusiasm. Of the many important changes in the pending publication some are fairly radical. The work of revision and that of publication have been assigned to distinct bodies; the former to a committee of twenty-five members, as before, the latter to a board of trustees, a regular incorporation having been effected for this purpose. Among the special features of this revision the following are worthy of note: Whenever possible, articles are to be standardized on the basis of chemical assay; physiological standards may also be represented in the requirements for antitoxin, notwithstanding the instructions of the convention to the contrary, the committee having decided that the importance of the subject demands even so dangerous a precedent as this; although the descriptions of crude drugs are to retain, so far as is consistent with clearness and accuracy, the simple language of the preceding edition, yet simple descriptive terms are to be introduced, wherever necessary, to facilitate the detection of elements of adulteration entering into powdered drugs; a wonderful advance over the instructions of 1880, which forbade the introduction of any characters which could not be seen with a lens magnifying "about ten diameters"; doses are to be specified, and, finally, the revolutionary principle has been accepted that proprietary rights of limited duration in a meritorious drug, provided that the conditions render it amenable to standardization and resulting control, do not constitute an objection to its recognition by the Pharmacopœia, and a sub-committee has been appointed to determine what proprietary articles can properly be admitted under this rule.

Authority of the Pharmacopœia.—The authority of a pharmacopœia may be legal or professional, and may be established either before the existence of the work, by the legal or professional appointment of its compilers, or thereafter, through its adoption by a government or by a representative professional body. In either case it occupies a special office, and all matters pertaining to it are therefore denominated *official*, or, according to older usage, "officinal." Thus we have official and unofficial drugs, medicines, reagents, and other substances, as well as official titles, synonyms, definitions, descriptions, tests, formulas, processes, doses, etc. The professional authority of the Pharmacopœia is not compulsory, except as a violation of such of its provisions as have professional sanction involves professional disrepute. Its legal authority, established by statutes, with penalty attached, is of course so. In this way the United States Pharmacopœia has been made the legal authority in many States, as well as wherever the jurisdiction of the national Government extends.

Objects and Scope of the Pharmacopœia.—In the definition given under *Pharmacopœia*, it is stated that the standards named apply to the "medicines used in the practice of medicine"; not merely to those whose merits justly entitle them to such use. The object of the book is to provide a means of assuring the user of a drug or medicine that he shall receive that for which he calls. The right of each individual to such assurance, regardless of whether his selection of the article is well advised, is obvious, and constitutes the chief basis of procedure in the preparation of the book. The selection of the articles to be made official is thus based upon the fact of their common use. Since very many worthless or very inferior articles are in common use by physicians as well as among the laity, the recognition of such in the Pharmacopœia is thus called for. On the other hand, many valuable drugs are brought forward without ever attracting much attention or coming into general use, so that the mere fact that the compilers of a pharmacopœia believe a new drug to possess merit does not justify them in recognizing it. Such a drug must first establish at least a probability of coming into general use before it shall receive recognition. From the above, it follows that "the recognition of a drug by the Pharmacopœia is not evidence, *prima facie*, that it possesses merit, nor the absence of such recognition that it does not." It also follows that the Pharmacopœia is not to be regarded as a guide to the practitioner in the selection of his remedies, but rather as an index to the general conditions of practice in such respect and as an authority for testing the genuineness of the articles treated by it. A knowledge of the merits of the articles, and an ability to make a judicious selection, are supposed to be gained from a

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study of text-books and other literature relating to therapeutics. It may be added that experience in the United States has repeatedly demonstrated the fact that the introduction of an article to the Pharmacopœia has very little weight by itself in extending its use.

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In spite of these considerations, the compilers of our Pharmacopœia do recognize a certain responsibility for favoring the worthier articles; so that at their periodical revisions they are disposed to employ a liberal construction of the above guiding principles and to lean toward the expurgation of the more worthless articles and the introduction of meritorious ones whenever the conditions will possibly justify them.

There is another class of important articles which many physicians, even among the more intelligent, see with surprise to be denied a recognition in the Pharmacopœia, notwithstanding that such denial is a natural necessity; such articles, namely, as are, for one reason or another, not subject to any official definition, description, or standardization. Of this class the most conspicuous examples are found among copyrighted articles. In these cases it is the names alone which are copyrighted and which have a fixed identity. Absolute ownership of these names is conferred by the copyright, and there is no stipulation as to the use which is to be made of them, except that they shall be arbitrary, that is, not descriptive of the article to which they are applied. They may be meaningless, or they may be devised with the object of misleading the public, as by naming the syrup of a well-known fruit, whereas, if such were the real origin of the preparation, its name would be descriptive and would at once lose the copyright protection. Furthermore, the substance to which the name is applied may be changed or substituted at the will of the owner of the name and as often as he desires. Manifestly, control and standardization by a pharmacopœia of an article so named is an impossibility. The case is quite different with those articles which are protected by patents of limited duration, either upon the product itself or upon the process by which it is prepared. Such protection provides for publicity and freedom at the end of the patent period. Ethical views regarding such protection have of late undergone a very great change. Here, as in many other parts of the medical field, rationalism has replaced blind and arbitrary ruling, and the *cui bono* standard has come to be applied, with the result, as stated below, that certain important, not to say absolutely necessary drugs which enjoy limited protection are to be recognized in the forthcoming edition of our Pharmacopœia.

Official Names and Definitions.—The official Latin and English titles call for little discussion. They constitute, like other names, a basis for specifying the respective articles, and their use in preference to that of any other names by which the articles may be known, enables the prescriber to secure the support of official, and in many cases of legal authority, which he might find it difficult to obtain if he used an unofficial title, subject to different applications in different localities, and perhaps even in professional literature. In special cases, when the latter condition exists so as to involve special danger of misunderstanding, the Pharmacopœia may also recognize one or more synonyms.

The official definition is intended to be a full statement of what constitutes the article named by the title and at the same time limits it by the exclusion of all else. In the case of pure chemicals or pure substances of natural origin, as alkaloids and glucosides, the chemical formula usually constitutes a complete definition. If the article is not required or expected to be absolutely pure a statement of the allowable amount, and perhaps of the nature, of the impurity frequently forms a part of the definition. In the case of animals or plants or their parts, the definition states clearly what part or parts shall be employed. The terms used in naming such plants and parts are those authoritatively employed in zoology and botany. In cases in which zoological or botanical authority is divided, as in the rules of botanical nomenclature, the compilers decide which method and rules shall be employed, and a statement to that effect is incorporated into the introduction of the book. The family or natural group to which the animal or plant pertains is also named in the definition. This is, strictly speaking, superfluous to a definition, but proves convenient and instructive.

When the living part is to be taken or collected in some particular stage or condition, as "in full bloom," "in the second year of its growth," "when full grown," "fully ripe," etc., this fact also is stated in the definition, as is any change which is to be made in it in preservation or preparation, as "the dried root," "a prepared exudation," "an inspissated juice," a bark "kept one year before being used," or "not kept longer than one year," etc. In special cases, a note may be appended to a definition specifying some danger to which the article is peculiarly liable, and stating how the same may be avoided. In a few cases, when the facts regarding the origin of an article are unknown, as in the case of the root of an unknown species of Smilax, or when the number of species yielding the article is indefinite or inconveniently large for specification, the definition cannot be made fully to accomplish its purposes. The best possible must then be done with it and the description must be relied upon, to accomplish the remainder.

Official Standards.—The standards of the Pharmacopœia are physical, chemical, and physiological, and are incorporated into the descriptions.

The description, in other cases than those referred to above, is not to be regarded as partaking of the same nature as the definition, but as a statement of the tests which are to be applied by one having the article in hand, for the purpose of employing the specified standard. These standards and tests may be qualitative or quantitative. The ordinary physical test is included in the description of the drug as regards color, surface, and other external appearances, hardness, weight, fracture, structure, odor, and taste. Chemical standards, qualitative or quantitative, do not differ from those ordinarily employed in chemistry. Physiological tests are by many regarded as excluded by the general nature and uses of a pharmacopœia. Nevertheless, many of the physical tests, such as peculiar effects upon the nose or tongue, the pupil and other organs, may fairly be denominated as physiological and the extension of this class of standards in the pharmacopœia in the future is to be anticipated.

Preparations.—Among the several preparations to which drugs are subject the Pharmacopœia makes a selection, in each individual case, based upon the nature of the article, on both pharmaceutical and therapeutical grounds, and these preparations are enumerated just after the description. In those cases in which a small amount of the drug enters into some other article or preparation merely as an adjuvant, and not especially for its own medicinal effect, such article or preparation is not regarded as a preparation of that drug and is not thus named. Proximate principles, such as alkaloids, glucosides, fixed and volatile oils, also, are not treated as preparations. There are a number of instances in which neither pharmaceutical nor therapeutical considerations can determine a selection, and here no preparation is specified, though opinions are not wanting to the effect that at least one official preparation ought to be supplied for every official drug. The preparations thus named are then treated, in the regular alphabetical order of their titles, as official articles, their formulas and methods of preparation being given in full detail and in some cases definite standards being supplied, similar to those above described for the drugs themselves. The question has been much mooted as to whether a preparation can be considered to be official if, made strictly in accordance with the formula and of a quality fully equal to that resulting from the official process of manufacture, it differs merely in some variation from the latter. The question is a delicate and not unimportant one. It is urged upon the one hand that the principal object of prescribing an official process is to insure the quality of the preparation, and that if departures from it be permitted, a tendency

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to laxity may be encouraged. Upon the other hand, it is clear that in large manufacturing operations the methods of the retail pharmacist are impracticable, and even that a better result may be otherwise attained. The view of this subject, which has always been taken, at least in modern times by the revisers themselves, is that a deviation from the process is permissible, provided that a satisfactory preparation is insured.

Doses.—The United States Pharmacopœia has never heretofore been willing to assume the responsibility involved, or which might be involved in particular cases, by the adoption of doses. The possibility that the prescribed dose might in individual cases act disastrously, and that the compilers of the Pharmacopœia might be held responsible for having authorized it, has always acted deterrently. At length, however, a method has been devised by which, according to the highest legal advice, a system of official dosage can be adopted which will be free from this danger. Doses are therefore to be introduced into the forthcoming edition, although their exact limitations have not yet been made public.

The Appendix.—The Appendix of the Pharmacopœia containing lists, definitions, descriptions of reagents, tables of atomic weight, thermometric equivalents, alcohols, acids, and other important chemicals, of saturation, equivalents of the English and metric systems of weights and measures, is of great importance, possessing an authoritative value for accuracy and a facility for reference which, without any regard to the subject matter found in the body of the work, entitles the latter to a convenient position upon the shelf or table, not only of every physician and pharmacist, but of every person whose work brings him into contact in any way with physical or chemical science.

Use of the Pharmacopœia.—The use of the Pharmacopœia by pharmacists is incomparably greater than that by physicians, and to this fact is in great part due the higher degree of accuracy and care and the more definite knowledge of the former profession regarding the materia medica. Not only is this true, but it is undeniable that the most serious shortcomings of the medical profession in matters therapeutical might be largely eliminated were they to rely more fully upon reference to this work. While it is true that the Pharmacopœia provides no information directly concerning therapeutics, yet it contains very full information, and of the most reliable character, concerning materia medica, fundamental to therapeutics and, in turn, the highest teachings of therapeutics constitute its basis as to preparations and dosage, and as to a majority of the drugs treated.

Henry H. Rusby.

PHARMACOPŒIAS, GENERAL AND INTERNATIONAL.—Many works have been published, which are designed to comprise the text of all, or at least the most prominent pharmacopœias. Among the earlier authors of such works are Lemery, Charas, Spielmann, Swediaur, Quincy, Brugnatelli, etc. Of more recent works the following deserve special mention: A. J. Jourdan, "Ph. Universelle" (Paris, 1828, second, ed. 1840); P. L. Geiger, "Ph. Universalis" (Heidelberg, 1835-45); B. Hirsch "Universal-Pharmakopöe" (Leipsic, 1885, vol. i.).

Many years ago efforts began to be made to bring about greater harmony in the different pharmacopœias, and the proposition was finally made to inaugurate an International Pharmacopœia. Opinions differed greatly for a long time, not only as to whether the plan was feasible at all, but also in regard to details. Steps were finally taken to have a draft of the work prepared, but national jealousy on several occasions rendered its acceptance impossible. It was not to be expected that each civilized nation would abandon its own pharmacopœia, specially adapted to the habits of its own people and its own domestic resources, for one elaborated without regard to such considerations, and possibly introducing unfamiliar preparations or changing the strength of such as were in common use. The utmost that could be expected was that the different nations, whenever revising their own pharmacopœias, would gradually approximate such preparations as were regarded worthy of international regulation to the proposed standard. Another hope which was expressed was this, that the International Pharmacopœia might be used and followed as an *independent* work in different countries in this way, that prescribers would designate preparations contained in it in their prescriptions. A plan has been presented for the establishment of a common pharmacopœia for the American continent. This is too wide a scope to be feasible at present. But it *is* feasible to prepare a pharmacopœia for all the Spanish-speaking countries in Central and South America, provided all political differences are waived for the sake of the benefit which may accrue from the result. After some uniformity has been reached in Central and South America, it remains to be seen how much further it can be carried. At the International Pharmaceutical Congress, held at Brussels in 1886, the draft of an international pharmacopœia was presented by the president of the International Commission, Baron A. von Waldheim, of Vienna. Yet, in its preparation the other members of the commission had not been sufficiently consulted, and the draft was not accepted. Other meetings of this Congress have been held since, the seventh taking place at the close of the meeting of the American Pharmaceutical Association in Chicago in 1893. At this time what may be regarded as the first practical step toward reaching an international agreement was taken when the American Pharmaceutical Association appropriated $1,000 toward defraying the expense of preparing and publishing an international pharmacopœia, to be confined to the treatment of potent remedies. In 1897 the Congress met again at Brussels, but did not approve of this proprosition for a restricted pharmacopœia, and again indorsed the idea of a large and comprehensive work. In the mean time, no steps have been taken toward carrying out that plan, and the less visionary representatives, led by the American and British contingents, have gone ahead with the initial steps in the direction of preparing a work treating of potent remedies. A report on this subject has been submitted to representative bodies in the different countries, and there seems to be some prospect that important results may follow.

Instead of attempting the almost impossible, the advocates of uniformity in medicines appear to be willing to bring about the desired end by natural means, that is, by first causing the consolidation of the pharmacopœias of contiguous countries, particularly those in which the same language is spoken. Thus, Germany has long ago displaced the host of local pharmacopœias in existence previous to the establishment of the empire by a single national work. Italy has done the same. The Scandinavian countries also contemplate doing this. It is easy to foresee that there never will be an international pharmacopœia which will replace each individual national one. The best that can be hoped for is a work containing the description, definition, requirements of purity and strength of what may be called international remedies, single or compound, and even this cannot be introduced without risking danger from the administration of preparations the strength of which as contained in the international pharmacopœia differs from that prescribed in the national pharmacopœia of the dispenser.

Charles Rice.
Revised by *Henry H. Rusby.*

Universal Pharmacopœia.—In this place should be mentioned the work by Dr. Bruno Hirsch, of Berlin, entitled, "Universal-Pharmakopöe. Eine vergleichende Zusammenstellung der zur Zeit in Europa und Nordamerika gültigen Pharmakopöen" (Universal Pharmacopœia. A Comparative Digest of the Pharmacopœias in force at the present time in Europe and in the United States). This work contains practically the whole text of the several pharmacopœias (except that of Portugal) in such a way that the similarities and differences of the requirements of the several texts are shown at a glance

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in connection with each subdivision of an article. It is a work of reference indispensable for every revision committee in this and other countries for many years to come. *Charles Rice.*

PHARYNX, ANATOMY OF. See *Tonsils, etc.*

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PHARYNX, DISEASES OF: ACUTE INFLAMMATIONS.—In the text-books, generally, the use of the term pharyngitis is somewhat confusing, as tonsillitis, uvulitis, and palatal inflammation, as well as inflammation of the pharynx proper, are loosely included in the term. While in nearly all inflammations of the pharynx the contiguous structures anteriorly are involved, yet, as diseases of these structures are considered elsewhere in this work, the term pharyngitis, as here used, will be definitely limited to inflammations of the pharynx proper, except in treating of the throat complications of the acute fevers.

Simple Acute Pharyngitis.—Acute inflammation of the pharynx is usually accompanied by inflammation of other portions of the upper respiratory tract, and there is commonly more or less nasal occlusion. Acute inflammation, not septic or traumatic, strictly limited to the pharynx, is very rare.

Etiology.—As a rule the acute disease is either the lighting up of a subacute inflammation or an extension of acute nasopharyngitis. As etiological factors may be mentioned: bad air, poor food, sedentary habits, alcoholic intemperance, excessive use of tobacco, and in general anything that tends to lower the vitality. Digestive disorders, nasal obstruction, sudden atmospheric changes, influenza, and tonsillitis are frequent causes. Heredity plays an important part, and rheumatism and gout are sometimes factors. As traumatic causes may be noted, irritant poisons, flame, hot water, steam, foreign bodies.

Pathology.—There are hyperæmia and congestion of the blood-vessels in the submucosa, with pressure on the mucous glands and lessening mucous secretion during the first stage. In the second stage, congestion is somewhat relieved and the secretion is poured out, the tenacity of the latter depending on the amount of fibrin present. If the amount of fibrin be very great, there is formed a false membrane which is non-infectious.

Symptoms.—The attack is usually sudden and is ushered in by a feeling of malaise and chilliness rather than a distinct chill. The temperature rarely goes beyond 101°–102° F. The digestive system is usually deranged, the appetite is lost, the bowels are constipated, the tongue is furred, and the breath is foul. Pain in the muscles of the neck and back is common; there is generally headache and often there is aching of the joints. At first there is dryness of the throat and the surface of the mucous membrane is shiny and smooth. Later, the secretion becomes abundant and the membrane thickened and rough from hypertrophy of the lymphoid follicles. The voice becomes thick and husky and there is fatigue on talking, even when there is no apparent involvement of the larynx. In the attempt to get rid of the mucus the patient hawks and hems rather than coughs, while the dryness, or later the thickening, causes frequent efforts at swallowing. The feeling at first is as though there was a hair in the throat; later, it is that of a larger foreign body. Pain is a constant symptom, being increased by the efforts at swallowing. When the group of follicles just back of the posterior pillar is much involved, pain referred to the ear is usual, being conveyed through Eustachian involvement or by means of the glossopharyngeal or Jacobson's nerve. The sense of taste may be decidedly obtunded, especially if the lingual tonsil is involved; but this symptom is rather an accompaniment of nasal obstruction. The color of the mucous membrane varies from pink to dark red, and the superficial blood-vessels show much enlargement. The attack may be limited to one side, but it is nearly always bilateral.

Prognosis.—This is favorable, but at the same time the disease manifests a strong tendency to become chronic, by reason of the continuance of the exciting causes and the impossibility of putting the organ at rest. The duration varies from three or four days to two weeks, according to the severity of the attack and the general health of the patient.

Treatment.—This should begin with a saline cathartic, preferably preceded by one or two grains of calomel in triturate. Tincture of aconite in one-minim doses hourly seems to have a special action in pharyngeal inflammation; but, if the pain is considerable, phenacetin, five to eight grains every three or four hours, or Dover's powder, may be given. If there be a rheumatic diathesis, the salicylate of strontium, five grains every three hours, will prove of value, while in tonsillar complications salol, five grains every four hours, or salipyrin, ten grains at like intervals, will be better.

Quinine is recommended, but it is most likely to be of service when the tonsillar involvement suggests mild sepsis. In the early stage cold externally by wet compresses or a cold coil will give relief; later, heat will be more agreeable. A four- to six-per-cent. solution of nitrate of silver brushed lightly over the pharynx is useful, but one of the newer albuminous silver compounds, as protargol in ten-per-cent. spray, will be less irritating and just as good. Lennox Browne pronounces guaiacol —fifty per cent. in sweet almond oil, used with brush or spray—to be the best of all local applications. This burns sharply, but is followed by an anæsthetic effect. While gargles do not reach much of the posterior wall of the pharynx they do reach the contiguous parts, and any one who has personally used a gargle knows the comfort which follows its use. If a patient does not know how to gargle it is not well to rely on the method, as in such cases it is nothing more than a mouth wash. The best gargles are on the order of the Dobell solution, used hot. If carbolic acid is disagreeable, it may be omitted and the solution made up with equal parts of cinnamon water and peppermint water. In the early stage a spray of mentholated benzoinol, from two to four grains of menthol to the ounce, may be more agreeable than a watery application. Later, a gargle or spray of tincture of chloride of iron will hasten recovery.

Demulcents in the form of lozenges are often grateful. They may contain menthol in minute dose combined with guaiacum or eucalyptol.

Shurly recommends, for the mitigation of local distress, a tablet of biniodide of mercury (gr. $\frac{1}{60}$ to gr. $\frac{1}{30}$) to be held in the mouth till dissolved, the dose being repeated every two or three hours till five or six have been taken. In the second stage, if the secretion continues profuse for too long a period, atropine or aconitine, gr. $\frac{1}{1000}$ to gr. $\frac{1}{500}$ every two or three hours, will hasten recovery. Steam inhalations are generally worse than useless, although sometimes temporarily soothing in the earliest stage.

Gangrenous Acute Inflammation of the Pharynx. —This disease is ordinarily classed under infective or phlegmonous pharyngitis, the severer forms being accompanied by sloughing. Including all forms under this title, one writer will give the prognosis in infective pharyngitis as very grave, while another, limiting the term to the milder cases, will state that the prognosis is uniformly favorable. The gangrenous form of infective pharyngitis is very likely to arise from localization of the infecting germ in typhoid, diphtheria, scarlet fever, and other infectious diseases. In such cases the infecting material probably reaches the point of localization through the blood instead of from absorption through the mucous membrane, as seems to be the case in the milder, more superficial forms in which the streptococcus is the infecting germ. The prognosis is very grave, both from the severity of the local process and from the development of septicæmia. Treatment is directed chiefly to the systemic infection, elimination being encouraged and stimulants given. Locally, mild antiseptic solutions are of most use.

Gouty Pharyngitis.—This occurs as a manifestation of the general disease, but may appear quite independently of involvement of other parts.

Lermoyez and Gasne give the following diagnostic

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data: (1) Sudden onset, acute evolution, and sudden disappearance. (2) Sharp febrile symptoms, depression. (3) Very acute pain, out of proportion to the local appearances. (4) Tendency of inflammation to diffuse itself over the pharynx and spread toward the larynx, ordinary quinsy being more localized. (5) Dark red and œdematous appearance of pillars of fauces, uvula elongated, and posterior wall of pharynx swollen. (6) Absence of exudation. (7) The glands at the angle of the jaw not involved. Colchicum is to be used in the treatment of such cases. Locally, soothing gargles, or preferably sprays, are indicated.

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Herpetic Pharyngitis.—(Synonyms: Common membranous sore throat; Aphthous sore throat; Benign croupous angina.) Herpes of the throat, which is a milder disease than the skin affection, appears as a discrete eruption, the individual spots measuring 6–8 mm. in diameter and being located on the posterior wall of the pharynx or anterior surface of the faucial pillars. The *etiology* is varied. The local manifestation is probably due to a peripheral degeneration of the nerves of the affected area. The general condition has a very considerable etiological significance, disorders of the alimentary tract and many febrile diseases acting as causes.

The earliest *symptoms* are dryness of the throat and pain of a burning or stinging character. The constitutional symptoms are as a rule slight, fever if present being of mild grade. The eruption may be unilateral or bilateral. The vesicular stage is seldom observed, the vesicles rupturing early and the excoriated mucous membrane becoming covered with a thin, soft membrane which is easily wiped off. Labial herpes is usually also present. The disease lasts for from eight to sixteen days, but has a very considerable tendency to recur. *Diagnosis* is made from other membranous anginas by the mildness of the symptoms, the labial herpes, and the thinness and superficial character of the membrane.

Little local *treatment* is necessary; bland sprays or gargles, and applications of silver nitrate (two or three grains to the ounce), or of resorcin (ten grains to the ounce of glycerin) will be found useful. If pain is considerable orthoform may be used.

Membranous Pharyngitis.—Non-diphtheritic membranous pharyngitis, the term being limited to cases in which an actual pseudomembrane develops on the pharynx,—whether or not the tonsils and palate be also involved,—is a very rare disease. In nearly all individuals there is a well-developed strip of glandular tissue lying just back of the posterior faucial pillar. In ordinary lacunar tonsillitis it is quite common to find this follicular area involved in the exudative process. The exudation from the several follicles in the strip may coalesce and give the appearance of a narrow membranous strip on either side of the pharynx. This condition, which is frequently spoken of as a membranous sore throat, is properly only an acute exudative follicular pharyngitis. Kyle describes a membranous pharyngitis: "An acute infectious process in which there forms on the mucous membrane surface a highly coagulable albuminoid material which constitutes a false membrane and occurs along with desquamation of the superficial epithelium." Such a condition must be very rare.

Emil Mayer in 1900 described a case due to Friedländer's bacillus, and was able to collect thirteen of the same kind from the literature. In measles there is sometimes developed in the pharynx a streptococcal membrane which resembles very closely the membrane that is formed in diphtheria; its presence constitutes a grave complication.

The *diagnosis* of membranous pharyngitis is not always easy. Localized areas of epithelial necrosis, or herpetic pharyngitis after the vesicles have ruptured, cannot be distinguished by the naked eye from false membrane. This frequently leads to mistakes in diagnosis, and the terms herpetic pharyngitis and membranous pharyngitis are frequently used synonymously. The greatest care is needed in differentiating this condition from diphtheria, and it is commonly accepted that any case of membranous sore throat is to be treated as diphtheria until a diagnosis is positively reached.

The *prognosis* is generally favorable except in the streptococcal variety, in which the outlook is more serious.

Treatment.—The systemic treatment should be the same as for diphtheria in the severer varieties. Locally, disinfectants and detergents are indicated. A spray of pyrozone, hydrozone, or any high-class hydrogen peroxide solution is of value. The ordinary commercial solutions of hydrogen peroxide are sometimes very irritating to the throat and should never be used. Löffler's toluol solution is also effective. It should be applied with a swab, and care should be taken to squeeze out the excess.

Pemphigus.—Cases of pemphigus of the pharynx are occasionally reported. The bullæ are rarely seen before rupture. The acute disease is attended by headache, pain, and fever. The duration is from one to three weeks, but there is a strong tendency to recur and become chronic, especially in the aged. The disease is differentiated from diphtheria by the bacteriology, the easy removal of the exudate, the absence of glandular enlargement, and the mildness of the constitutional symptoms. Adhesions are very likely to form and should be carefully guarded against. The *treatment* is about the same as for herpes.

Rheumatic Pharyngitis.—Rheumatism of the pharynx is occasionally observed, but perhaps not so often as the descriptions would ordinarily lead one to believe. It is claimed that extensive ulceration of the pharynx may result directly from rheumatism. The diagnosis is made from the history of the patient; from the sharp pain, especially on swallowing, which is out of proportion to the redness of the mucous membrane, and varies in severity as a rule several times in the twenty-four hours; and from the prompt relief afforded by the salicylates. The local treatment should consist of hot gargles, together with the external use of a chloral liniment or a twenty-five-per-cent. ointment of ichthyol.

Traumatic Pharyngitis.—This is an acute inflammation of the pharynx due to wounds, foreign bodies, caustics, and the inhalation of dust or vapors. Children are especially liable owing to their frequent mistakes in swallowing hot or caustic fluids. Persons working in dust or in caustic vapors are also liable to pharyngitis of this type. Any foreign body that may become lodged in the throat or may lacerate the mucous membrane as it passes through the pharynx may give rise to inflammation with œdema and at times abscess formation. In any traumatic pharyngitis there is danger of the inflammation and œdema extending to the glottis with fatal results. In the aged or enfeebled the irritation caused by the swallowing of a bit of crust or a small piece of eggshell, or any such material, may give rise to fatal inflammation.

Treatment.—In the case of a foreign body, if it be still present, prompt removal should be effected through the natural passages if possible; if not, by external pharyngotomy. Often, however, it is found that the offending body has been removed or swallowed, and that only the effects are to be combated. Soothing applications should be made—oily sprays containing from three to six grains of menthol to the ounce, Dobell's solution, and adrenalin chloride, 1 to 4,000, to be repeated every two hours or oftener. Bland fluids only should be swallowed, all solid foods being avoided. If œdema threaten, scarification should be done to a sufficient extent to afford relief.

Urticaria of the Pharynx.—Urticaria may make its appearance in the pharynx either after or before its occurrence on the skin, but always in conjunction therewith. Those cases of supposed urticaria localizing themselves in the pharynx are probably cases of angioneurotic œdema (which see).

The causes of pharyngeal urticaria are naturally those of the affection in general, *e.g.*, shellfish, small fruits, stings of insects, drugs (copaiba, cubebs, quinine, capsicum, turpentine), the neurotic, rheumatic, and gouty states, genital disorders, pregnancy, constipation, etc. There is a form of acute febrile urticaria which develops suddenly and usually appears at the same time on the

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chest and in the mouth. The characteristics of the affection in the pharynx are the sudden invasion with cough, dyspnœa, and local irritation. Locally the mucosa shows a condition resembling that of inflammatory œdema.

The *prognosis* is never bad except in those rare cases in which the malady extends to the larynx, when we may have a dangerous dyspnœa. At times the tongue is badly swollen.

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At the onset of the attack the system should be cleared out with emetics and purgatives, enemata, etc., so as to remove the exciting cause. Large doses of the alkalies should then be given. Locally ice pellets, weak sprays of cocaine, adrenalin, antipyrin, etc., will generally give quick relief. The occurrence of dyspnœa must lead us to prepare for either intubation or tracheotomy. It must be remembered that articles of food ordinarily harmless may at times precipitate an attack.

Intubation or tracheotomy may become necessary if the swelling increases rapidly. Insufflations of morphine sulphate, gr. ⅙–gr. ss. in an inert powder, may be required for pain, or, if there be much abrasion of the mucous membrane, orthoform may be more effective. In the case of escharotics the indications are practically the same; viz., to use anodynes and emollients.

Ulcerative Septic Pharyngitis.—(Synonyms: Infective pharyngitis; hospital sore throat; suppurative pharyngitis.) This is a form of infective pharyngitis which occurs in persons reduced in health by hard work in unsanitary employments. Work in the dissecting room, exposure to septic secretions from wounds, attendance on diphtheria or scarlet fever patients, are frequent causes of the disease in medical students and physicians. The streptococcus is the usual infecting organism, but the staphylococcus is generally associated with it.

Pathology.—The ulceration is the result of the action of the infecting bacteria on the epithelium: they first cause necrosis of the superficial cells; then, entering the deeper layers, they obstruct the blood supply and cause further necrosis. According to the virulence of the infecting organism and the resistance of the tissues the ulceration may remain superficial or may extend deeply, in the latter case resulting in the phlegmonous or gangrenous form.

Symptoms.—The attack usually begins with languor and headache, quickly followed by a rigor, high temperature, rapid pulse, and other accompaniments of fever. If the deeper tissues are involved, all symptoms are graver and delirium occurs early. The tongue is heavily coated and the breath is foul. Locally, the first symptom will be dysphagia, the throat gradually becoming dry and swollen, and filling up with foul mucus, requiring constant clearing and causing the patient much suffering. The pain may be felt in the ear and may extend low down in the pharynx. Both tonsils are involved, the inflammation being as a rule superficial, but the cervical glands are frequently much swollen and painful. The ulcers which are usually lenticular in shape and covered with a grayish exudate are often seen on the tonsils and palate as well as on the pharynx. The local lesions are often so slight as scarcely to seem a sufficient cause for the great systemic disturbance.

Diagnosis.—Any acute pharyngitis may be accompanied by ulceration, but the local and systemic symptoms are not so severe as in the septic form. The rapid development and the determination of the precise character of the invading bacteria will aid in diagnosis.

Prognosis.—In the more superficial form this is favorable provided the sufferer be removed to more hygienic surroundings. If the disease penetrate to the deeper tissues, the prognosis is exceedingly grave on account of the liability to sloughing, to extension to the larynx, and to the development of septicemia.

Treatment.—Constitutional treatment with active tonics—iron, strychnine, quinine, etc.—is very necessary. Alcoholic stimulants are often required. The antistreptococcus serum should be of especial value in these cases, but clinical evidence of this is not yet assuring. Locally ice internally and externally is indicated in the earliest stage, but later if the symptoms become more severe, hot applications should be used. Alkaline sprays or gargles should be used frequently. If any astringent applications be made to the ulcers they should be of the mildest character and very gently applied. A spray of four or five grains of menthol to the ounce of benzoinol will sometimes prove grateful. If the pain be very severe, orthoform in powder should be used two or three times daily. Careful attention to the cleansing of the throat by the nurse, who thus largely relieves the patient of the necessity for voluntary muscular action of the parts, will add greatly to his comfort.

Pharyngitis in the Exanthemata and in Other Fevers.—*Erysipelas.*—Erysipelas of the pharynx and contiguous structures may appear as an independent disease or as a complication of a cutaneous attack. If it occurs consecutively to erysipelas of the skin the infection may extend to the pharynx by way of the nose, mouth, or ears, or by metastasis.

The attack begins with fever, and there are sharp pain in the throat and difficulty in swallowing. Immediately, or after one or more days, the pharyngeal mucous membrane becomes swollen and glistening and covered with ropy mucus or muco-pus. Vesicles, filled with serum, blood, or pus, and varying in size from one-sixteenth to one-half of an inch in size may appear. In severe cases abscesses or gangrenous areas may develop. Involvement of the tonsils, accessory sinuses, and middle ear is very likely to occur. The glands of the neck are swollen and tender. Early *diagnosis* is difficult unless there have been a previous erysipelas of the skin. Later, the very general involvement of the pharynx and the characteristic appearance just described serve to make the diagnosis clear. The *prognosis* is grave, as extension to the larynx may occur with fatal result.

Treatment.—The general treatment should be the same as for erysipelas elsewhere; it should be of a supporting character, with large doses (twenty to thirty minims) of tincture of chloride of iron every three hours. Locally, ichthyol is of value; from ten to thirty per cent. in glycerin should be painted on the inflamed mucous membrane three times daily. Alkaline cleansing sprays should also be used. Ice internally and externally may be soothing and useful early; at a later stage heat will be better.

Influenza.—In nearly all cases of influenza of the respiratory tract the pharynx and fauces are involved. A reddened area passing down on either side of the soft palate is frequent enough to be of considerable value in the diagnosis of the disease. The tendency to pass into a chronic inflammation is rather stronger than it is in simple acute pharyngitis. The inflammation may be very intense, and superficial necrosis of the epithelium on the anterior pillar of one side, with whitish exudation which looks like a very thin membranous deposit, may be very suggestive of diphtheria. The local treatment is that of simple acute pharyngitis. The following formula, which is to be used as a spray every two hours, has been found by the writer to be very serviceable in this and other infectious forms of pharyngitis: ℞ Pyrozone, fl. ʒ i.; borolyptol, fl. ʒ vi.; water, q.s. ad fl. ℥ iij.

When the inflammation is more intense, soothing alkaline solutions will be found to answer better, while tincture of chloride of iron, two minims to the teaspoonful of glycerin and water, swallowed every two hours, will hasten resolution.

Intermittent Fever.—It is well recognized that a pharyngitis may be due to malarial poisoning. The *symptoms* are those of simple inflammation, except that pain may be sharper and redness less marked. *Treatment* is that of the systemic disease with simple alkaline gargles or sprays for the local condition.

Measles.—Inflammation of the pharynx and fauces is generally so marked in measles that a diagnosis can often be made from the pharyngeal picture alone, before the eruption appears on the skin. The mucous membrane is deeply injected, the eruption appearing in blotches or points, while the surface presents a distinctly rough appearance. A membranous exudation due to the streptococcus sometimes forms on the pharynx and tonsils and

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constitutes a very serious complication. True diphtheria may appear as a complication, rendering the prognosis much graver than in either disease alone. The *treatment* of the usual throat condition should be by alkaline sprays, such as Dobell's solution, followed by an oily spray of one or two grains of menthol to the ounce of benzoinol.

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Pneumonia.—The pneumococcus seems at times to enter the blood through the pharynx and tonsils, determining an attack which is characterized by the irregular range of temperature, varying from 100° to 105° or 106° F. one or more times in twenty-four hours. There is little or no cough, the symptoms being purely those of a blood infection. The disease may run a course of seven to ten days without localizing in any organ, or it may after three or more days localize as a lobar pneumonia, much simplifying the attack; or it may localize in any of the parts of the body now recognized as subject to the invasion of the pneumococcus. Careful inspection of the throat will detect redness of the pharynx and fauces, the redness of the anterior pillars being not so bright as in influenza and following more closely the border of the tonsil. A culture taken from the throat will reveal the pneumococcus in almost pure culture and will render explicable some otherwise obscure fevers. The cases seen by the writer have been in children, ranging in age from fifteen months to five years. Local treatment is of doubtful value, mild detergent sprays being indicated if anything be used.

Scarlet Fever.—The pharynx and tonsils furnish almost the earliest manifestations of the disease. Before any rash has appeared on the skin the vivid red of the pharynx and fauces will suggest the onset of scarlet fever. A little later a bright rash will appear on the soft palate, while the previously reddened pharynx and tonsils will become darker and covered with thick mucus. The involvement of the tonsils and pharynx is fairly typical of the severity of the disease, the milder cases showing only slight redness and moderate tonsillar folliculitis, while in malignant cases there will be an intense inflammation of all the tissues of the pharynx with more or less membranous exudation and with great swelling of the glands below the jaw. Between these two extremes will be seen all grades of inflammation. The inflammation is very likely to extend to the pharyngeal tonsil and through the Eustachian tube to the middle ear. Ulceration of the tonsils may appear early, while ulceration of the pharynx or pillars is a later manifestation of the disease, rarely occurring before the fifth day and often much later. In the case of a membranous deposit the membrane may be diphtheritic, caused by the Klebs-Loeffler bacillus, or it may result from the action of streptococci or other micrococci.

Deep inflammation and even sloughing are more likely to result from streptococcal infection, and lymphatic involvement is more pronounced in such infection. It has been strongly urged recently that scarlet fever must be recognized as an etiological factor in perforations of the faucial pillars and the soft palate. Generally such perforations are accepted as positive evidence of syphilitic disease; and while in the vast majority of instances this is undoubtedly the causative factor, yet it is well to remember that scarlet fever may cause the condition.

Treatment.—Attention to the throat early and sedulously is essential in the management of this disease. In case of severe neck symptoms the ice-bag or a Leiter coil may be used, to be followed later by hot applications. The use of an alkaline spray alternating with an antiseptic spray, such as the pyrozone mixture previously mentioned, will prove very satisfactory. The tincture of muriate of iron in glycerin, as ordinarily prescribed in these cases, is very efficacious; two or three drops to the drachm of glycerin is quite strong enough.

Smallpox.—As in the other eruptive fevers the throat manifestations are quite marked in smallpox. Redness with inflammation may appear several days before the skin eruption, but the rash is usually apparent on the skin before it is seen in the throat. In hemorrhagic smallpox, however, ecchymoses may be seen in the pharynx before the skin eruption appears. In severe cases there may be pseudomembrane with much pain. The *treatment* is that of any acute pharyngitis—detergent and disinfectant sprays or gargles. Severe pain may require applications of orthoform, cocaine, or menthol.

Typhoid Fever.—Inflammation of the pharynx is not uncommon in typhoid. There is usually some injection of the mucous membrane, with dryness and sometimes a difficulty in swallowing. A faucial exudation is occasionally seen during the third week. This pseudomembrane is very thin, but is adherent and is characterized by the presence of staphylococci. As true diphtheria occasionally complicates typhoid a bacteriological examination may be necessary for diagnosis. In case of considerable involvement of the pharynx and fauces, detergent washes will be beneficial. Involvement of the larynx is much more serious than that of the pharynx.

Varicella.—Some involvement of the pharynx and palate is usual if the skin eruption be at all marked. The vesical stage is short, the vesicles breaking early and leaving excoriations. If there be much pharyngeal discomfort a gargle, such as the following, is of value: ℞ Sodii biborat., sodii bicarb., āā gr. l.; acid. carbol., gr. xvi.; tr. myrrhæ, fl. ʒ iv.; glycerinæ, fl. ℥ ij.; aq. cinnamom., q.s. ad fl. ℥ viij. M. Sig.: Dilute with an equal part of water and gargle every two hours.

Gustavus P. Head.

PHARYNX, DISEASES OF: ACUTE PHLEGMONOUS PHARYNGITIS.—(*Ludwig's Angina.*) Various names have been applied to this affection. Among them may be mentioned the following: erysipelas of the pharynx, diffuse cervical abscess or phlegmon, submaxillary bubo, infectious submaxillary angina, sublingual abscess or phlegmon, subhyoid phlegmon, gangrenous induration of the neck, cynanche cellularis maligna, cynanche sublingualis rheumatica. While early writers asserted a specific individuality for this disease, later authorities regard it as a septic sore throat with a peculiar localization, not differing etiologically from phlegmonous pharyngitis, erysipelas of the pharynx, or acute œdema of the larynx, all of which seem to represent merely different degrees of virulence of the same infecting agent.

The question of primary development and localization depends probably upon the seat of original infection, and it is difficult to distinguish definitely a line of demarcation between the purely local and the less complicated, as distinguished from the œdematous and purulent forms. The application, clinically, of general bacteriological principles to this group of septic inflammations harmonizes to a certain extent former conflicting views.

Ludwig's angina is a diffuse phlegmonous inflammation of the floor of the mouth and of the intermuscular subcutaneous tissue of the submaxillary region. It may end in resolution, abscess, or gangrene.

Gerster defines it as a phlegmonous destruction of the submaxillary gland characterized by alarming and extensive dense œdema, caused by the unyielding character of the fascial envelope of the gland, which œdema is most manifest about the latter vicinity, namely, the floor of the mouth.

Its possible epidemic character can be explained by the simultaneous exposure of various patients to the same septic influence. As a sequel to or complication of infectious maladies, it has been observed more often in typhus fever.

As yet no special pathogenic germ of the disease has been found, and where examinations have been made only the ordinary microbes of suppuration have been present. It is only in respect to the site of the disease that it may claim special consideration. The location in which the pus originates is a triangular pyramidal space with the following boundaries: The apex (below) corresponds to the point where the mylohyoid muscle borders the genioglossus. The base (above) stretches along under the tongue. The external wall (oblique) is made up of the internal face of the inferior maxilla and the mylo-

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hyoid muscle, the internal wall (vertical) by the genioglossus and the hyoglossus. The mucous membrane of the floor of the mouth and the *glandula sublingualis* close its cavity on top. It is through this channel, however, that the infection gains entrance, so that the affection of the submaxillary gland is in many, if not all, instances secondary.

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The *symptoms* are constitutional and local. The former are in general those of pus formation, but it is important to bear in mind that the pathological process may also give a distinctly asthenic type of symptoms, with an overwhelming prostration and low temperature.

The local symptoms, in addition to the prominent swelling of the neck, present the following diagnostic points: First, and most diagnostic of all, there is a peculiarly hard and wooden-like induration of the affected region, sharply defined from the surrounding normal tissue; second, the thrusting forward and upward of the tongue toward the palatal vault by the accumulating inflammatory products; third, severe dyspnœa, with the possibility of laryngeal œdema; fourth, the sensation of pressure as from a hard pad or button like swelling at the inner aspect of the dental arcade. With all of these there are associated the ordinary features of a phlegmon. Swallowing is painful, if not impossible, on account of the muscular infiltration, and the patient may not be able to open the mouth.

The *prognosis* is always grave and the rate of mortality high, one series of cases reporting over fifty per cent. of deaths. Death most frequently results from sepsis, or from suffocation due to laryngeal œdema.

The condition must be differentiated from osteomyelitis of the lower jaw, simple adenophlegmon of the submaxillary gland, and the rare disease known as Fleischman's hygroma. In the first there is no limited focus of inflammation. The entire bone is affected, the inflammatory process is more generalized, and the subhyoid region is rarely involved. In the second, adenophlegmon, the inflammation is superficial, the gland and its capsule are easily accessible, there is no wooden-like hardness, superficial incision gives exit to pus, and the process is localized at the outset behind the internal face of the maxilla. In the third the diagnostic points are suddenness of onset, location in the median line, and lack of either constitutional or local evidences of inflammation.

The *treatment* must be based upon three principles: First, early and free incision; second, careful subsequent antisepsis; and third, constitutional support. The condition is one of ptomaïn poisoning. The cause must be removed, and the effects already produced must be vigorously counteracted.

Gerster demonstrates that the object of the incision is not so much to evacuate pus as to relieve tension. He supports the modern view that the submaxillary gland is the focus of the disease, and attaches much importance to the fact that pressure over the œdematous area rarely causes pain except directly over the gland. If such evidences appear, delay in operating is not justifiable.

The operation must be done under general anæsthesia, for deep tissues must be explored, in close proximity to important vessels and nerves.

Fluctuation may be delayed because of the pus being confined within a fibrous capsule. Early incision may evacuate nothing more than an ichorous discharge, while pus may form later, but tension is thus relieved and the consequent dangers of suffocation are much lessened.

Deep lateral incision over the submaxillary gland, operation through the mouth, and even external incision in the median line are all to be condemned.

The most effective method is that suggested by Gerster, namely, to lay bare the entire submaxillary region by a careful dissection before making the incision for evacuating the abscess.

To be effective the incision must penetrate the mylohyoid muscle.

Following incision irrigation with bichloride (1 to 1,000) or boric acid (1 to 100) must be carefully carried out, and stimulants and tonics administered according to indication. The application of cold to the neck, if of any value at all, can be of service only in the very earliest stages.

Hydrogen peroxide may assist in the separation of the sloughs.

A good *résumé* of the literature of this subject is given by J. E. Newcomb in the New York *Medical Journal*, November 23d, 1895. *D. Bryson Delavan.*

PHARYNX, DISEASES OF: CHRONIC AFFECTIONS.—1. Simple Chronic Inflammation.—In this form of inflammation the morbid process usually localizes itself on the pharyngeal mucosa proper, the surrounding structures escaping. Occasionally it localizes itself in the faucial pillars and may then be properly called chronic faucitis.

A frequent cause is the continuous action of irritants such as excess in alcohol, tobacco, dusty occupations, etc. Many cases are associated with chronic nasopharyngitis. In many cases also the malady is but one feature in a general catarrh affecting the entire food tract, for to the latter and not to the respiratory tract does the pharynx functionally belong. Acid fumes, over-use of the voice, abnormal humidity of the air, high temperatures, are all to be reckoned as possible causes. It may be difficult to isolate the exciting factor, for many of the cases come on so gradually that it is difficult to determine any special reason for their occurrence. Undoubtedly the modern method of living in overheated houses is a powerful predisposing agent.

The changes set up in the mucosa are those of a proliferative inflammation. The vessels may show an initial hyperæmia, but the essential change is the formation of new connective tissue in the deeper layers of the membrane. Mucous glands are here scanty, but secretion from the membrane as a whole is increased, and in view of the abnormal surroundings it soon becomes viscid. Occasionally nodular veins may be seen coursing over the posterior wall of the pharynx.

The most prominent symptom is local irritation, but actual pain in swallowing is rare. Owing to the co-involvement of the stomach, there are more or less morning retching, nausea, and even vomiting. These conditions may make examination of the throat extremely difficult. The breath may be sour and offensive. Constipation and flatulency are frequent. Cough and huskiness of the voice are not uncommon. Hemorrhage occasionally takes place from a ruptured capillary. The mucosa is dark and beefy in appearance, but this feature does not extend farther forward than the posterior pillars. The pharyngeal wall may be covered with tenacious secretion. The grade of severity of the symptoms is generally conditioned on the amount of accompanying nasopharyngitis.

Treatment should be first directed toward the correction of any vicious habits in eating or drinking. Excesses in tobacco and all alcohol must be cut off short. The former are indicated by a dry glazed look, and the latter by a red, angry appearance of the mucosa. To facilitate a thorough examination of the throat, we may use ice-water gargles, bromide sprays, bromides internally, and even weak cocaine sprays. I have generally found it necessary to interdict, during treatment, tea, coffee, and all very hot or highly seasoned fatty and greasy foods. All food must be thoroughly masticated, and but little fluid should be taken at meals. Attention is now to be given to the gastro-enteric tract. Cholagogues, salines, alkalies with bitters, etc., here find a proper application. Attention in detail to the foregoing matters will often obviate the necessity for local treatment. For topical use we may employ solutions (twenty grains to the ounce) of silver nitrate, the zinc salts (the chloride excepted), alumnol, or protargol. For such remedies as are applied by cotton carriers, the oleostearate of zinc, made of zinc stearate in mentholated albolene, forms an agreeable viscid menstruum. Before any of these are applied, the mucosa should be thoroughly cleansed with a

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warm, alkaline spray. Gargles are of secondary value here, as the puckering of the throat surfaces, incident to their use, gives only a partial contact with the mucosa.

2. Chronic Follicular Inflammation.—This variety practically limits itself to the pharyngeal wall proper, the faucial structures not being involved. It is of clinical importance because the symptoms are out of all proportion to the mild appearance of the lesion.

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The brunt of the process falls on the lymphoid follicles and is one expression of "lymphatism" or the tendency of all lymphatic structures to take on overgrowth during the earlier periods of life. While during the very early years this tendency is more noticeable in the nasopharynx, it may become localized, as time goes on, in the pharynx proper. Bad hygiene is an important causative factor. The subvariety of the disease called "granular," because the smallness of the follicular enlargements gives the mucosa a granular appearance, has been referred to a systemic hyperacidity; but this view is objectionable, in that it invokes the relation of the mucous glands to the condition, they becoming stopped up by the action of the acidity which precipitates their mucin. Improper vocal effort, both overuse of the voice and use under improper conditions, may lead to follicular enlargement; hence the familiar name of "clergyman's sore throat."

As noted above, the follicular enlargement may be granular or may occur in the form of large masses like red beads on the pharyngeal wall. At times it may be localized behind the posterior pillars, the appearance presented being not unlike that of columns or bead-chains. This is the "pharyngitis lateralis" of some writers. These longitudinal deposits may fuse with the pillars, but are generally of a darker hue. The follicles nearest the mouths of the muciparous glands are the most involved. In all cases the process is essentially a hyperplasia, an actual increase in the number of lymphoid elements, especially about the efferent channels of the nodes themselves. This hyperplasia may involve the entire thickness of the mucosa or it may confine itself to projections from the surface. At first the enlargements are soft, but they harden and become smaller with time. The process seems to involve the tendrils of the sensory nerve fibres, though whether merely by compression or in some other way not understood is uncertain. This nerve involvement accounts for the relative severity of symptoms.

The most prominent symptom is pharyngeal dysæsthesia increased by swallowing or vocal effort. Secretion is not as a rule increased. It may be blood-streaked by the rupture of a superficial vessel. The tonsils often become adherent to the faucial pillars, and from the frequent efforts at hawking the uvula becomes elongated. The voice is husky and a nervous, irritable cough is present. The patients become very neurotic, and this fact in turn aggravates pre-existing symptoms. The disease continues indefinitely unless treated, though it does not seem to predispose to lesions of the air tract below.

Treatment calls for the same general measures as for simple chronic pharyngitis, and in addition for the destruction of the enlarged follicles. Any of the caustic acids or the electro-cautery may be used for this purpose. A small iron wire, heated in the flame of a spirit lamp, will answer. A drop of a two-per-cent. solution of cocaine injected into the area of puncture makes the latter practically painless. Six or eight punctures may be made at each sitting, an antiseptic spray being used on the intervening days. The minute sloughs should be allowed to come away before treatment is resumed. Curetting of the entire area has been advised. Internally we may give the iodides in small doses and the various alkaline mineral waters freely. It is unlikely that the latter are of real service unless they correct some underlying diathesis. Tobacco should be cut off. Alcohol may be used sparingly. Nervous patients need arsenic, strychnine, and phosphorus.

3. Chronic Atrophic Inflammation.—In this variety there is an actual atrophy of glandular tissue and of the other elements of the mucosa. Some authorities look on the process as merely the terminal stage of the ordinary catarrh; others as a separate affection. It may occur alone, but is more often associated with similar lesions in the nose and nasopharynx. It may be a sequel of severe local acute conditions such as occur in the exanthemata and diphtheria, and is not infrequently a feature of diabetes and chronic Bright's disease.

There may be a proliferation of new connective tissue, so that in the earlier stages, before the follicles have atrophied extensively, they appear to lie on a whitish bed and the whole membrane is very dry. This is the so called "pharyngitis sicca."

The main symptoms are an uncomfortable feeling of dryness with more or less pharyngeal dysæsthesia. The mucosa may be covered with thick, dry, tenacious secretion. Removal of this, which strings down from the nasopharynx, may uncover a rather red subacutely inflamed area.

Treatment calls for restoration of the nose and nasopharynx to the normal and for the correction of any vicious habits. Persistent dryness should always lead to an examination of the urine, for the underlying cause may thereby come to light. The dried mucus should be removed by warm, alkaline sprays, and for home treatment the patient may inhale mentholated steam or the vapor of menthol in association with eucalyptol and compound tincture of benzoin. For topical application we may use ichthyol in glycerin (ten to thirty per cent.) or the familiar Mandl's solution—iodine gr. v., potassium iodide gr. x., carbolic acid ♏ij., and glycerin ℥ ss. The writer has had much satisfaction with solutions of mucin. This comes in the form of tablets containing gr. v. each of mucin and bicarbonate of soda, and gr. i. of menthol, the latter giving an agreeable odor and flavor, and serving to keep the solution in warm weather. For the latter purpose thymol may also be used. Mucin seems to restore moisture to the mucosa and maintain it simply in virtue of its hygroscopic properties. The above tablet, which has the appearance and odor of pepsin, may be added to half an ounce each of sterilized water and sterilized lime water, shaken well, and applied either on a cotton carrier or in spray. If the latter be used, the spray tube should be flushed out with clean water at intervals so as to prevent clogging. The tablets may also be given to the patient for use as troches.

It must be remembered that treatment is at best only palliative, for advanced stages of the affection present a condition practically irremediable.

4. Rheumatic and Gouty Inflammations.—A. *Rheumatic Inflammation.*—Rheumatic pharyngitis occurs in two forms: (1) acute, and (2) chronic.

In the acute form we find the same list of predisposing and exciting causes as for rheumatism in general. The local changes follow the same sequence as in acute catarrhal inflammation, except that the grade of inflammation is less severe, is apt to be localized in patches, and causes an amount of pain out of all proportion to its apparent intensity. An inflammation of the fibrous fascia of the pharynx is possible.

The course of an attack is somewhat as follows: Local symptoms—burning, dysphagia, and dryness—first appear, and are followed by a mild attack of fever and constitutional depression. After two or three days these disappear, the pain suddenly shifting to the muscles of the neck, back, or extremities, possibly to some joint. The swallowing of the saliva continues to be annoying. Inspection may show livid patches or streaks in the throat. The pain is somewhat peculiar and stinging, so that those affected learn to recognize it. The sudden onset, the character of the pain, the history of rheumatism, and the sudden shifting of the local storm area form a fairly definite clinical picture which lasts for four or five days. In the writer's opinion, a diagnosis from mere inspection of the fauces cannot be made. Some writers have reported pharyngeal ulcerations which proved to be resistant to every other mode of treatment, but healed under anti-rheumatic measures.

Treatment calls for the exhibition of the usual remedies

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for rheumatism, together with local anodynes and sedatives.

In the chronic form we find the same list of causes as for chronic muscular and joint rheumatism. It is more common in men than in women, and the period from the twentieth to the sixtieth year marks its age limits. The onset may be sudden, but it is generally very gradual, and patients come under observation only after months or even years of indefinite pharyngeal pain. This is often referred to the region of the hyoid bone. Ingals finds the lesion more common on the right side. From this site the pain may radiate to or be felt on one side of the larynx, in the tonsils, trachea, side of the base of the tongue, etc. The parts within reach are painful on pressure, and are generally so during swallowing or phonation. Continuous speech is especially tiresome. Curiously enough the pain may disappear during eating. It is very capricious as to character, localization, and intensity. All combinations in these respects are possible. The gastro-enteric tract is generally sluggish. Inspection reveals nothing constant. An area of congestion may surround the painful spot. The affection may be confounded, as far as subjective symptoms go, with almost any common inflammation of the throat, and each must be ruled out by exclusion, special stress being laid, for rheumatic pain, on the shifting of the area of annoyance, a change of severity according to the weather, and a history of the rheumatic diathesis.

The treatment is identical with that of the chronic rheumatic state in general plus the use of local sedatives. To the areas of tenderness we may apply solutions of aconite, morphine, metallic astringents, etc. Ingals advises the use of applications of the following mixture: Morphine sulphate, gr. iv.; tannic acid, gr. xxx.; carbolic acid, ♏ xxx.; and glycerin and water, of each fl. ℥ ss. This may be used as a spray by the physician or applied in one-half strength by the patient at home. Internally he gives three grains each of salol and extract of phytolacca every few hours.

B. Gouty Inflammation.—As in rheumatism gouty manifestations in the pharynx may be either acute or chronic.

The acute form occurs in those of a lithæmic diathesis, in heavy eaters who indulge in but little exercise, and in those who have lead poisoning or renal changes. The outbreaks are more common in cold weather and follow dietetic excesses, over-indulgence in wine, heavy mental or emotional strain, etc. Most of the patients are between thirty and forty years of age.

So far as concerns pathology, nothing more than a catarrhal inflammation can be found. There is a patchy hyperæmia with redness and œdema of the pharyngeal wall, possibly with swelling of the soft palate and uvula. The tonsils may be moderately enlarged and the larynx congested.

The *symptoms* are pain, out of all proportion to the apparent severity of the inflammation, irritable pharynx, coated and flabby tongue, scanty and high-colored urine. After a series of such attacks the teeth may appear large from retraction of the gums and they have a yellowish appearance. Diagnosis must be made from rheumatism and from simple neuralgia. Assistance is derived from the presence of tophi or other gouty manifestations elsewhere. The pain may suddenly leave the throat and appear in the joints, usually bearing the brunt of gouty outbreaks.

Treatment calls for the exhibition of colchicum and the use of local sedative washes, as for rheumatism.

In the chronic form of gouty pharyngitis we find a dark-red discoloration of the uvula, soft palate, faucial pillars, and tonsils, the "angina uratica" of the older writers. Occasionally an acute œdema of the parts is added. At times the process localizes itself in the corner between the posterior and lateral pharyngeal walls, which may be swollen and red. In young patients the mucosa may be covered with mucus or muco-pus; in older patients it is more apt to be dry and glazed, with a network of enlarged vessels or scattered livid spots. In one case there was a daily casting off of lime salts from the mucous follicles.

The *symptoms* consist of attacks of sharp pain radiating to the ears, irritable cough with the expectoration of pellets of viscid mucus, intense throat irritability, and disordered gastro-enteric tract. Possible symptoms are spasmodic obstruction of the nose (alone or with coryza), dysphagia, laryngeal spasm, modification of voice, and rapid vocal fatigue. There is always a tendency to acute exacerbations. The urine shows an excess of oxalates, phosphates, and urates.

Treatment comprises an anti-gout regimen and local sedatives. The mineral waters are of especial service. One of the best local applications consists of menthol gr. x., and terebene ♏ xv. in liquid paraffin.

5. Syphilitic Inflammation.—For information as to present-day views of the nature of the syphilitic virus, other articles in this Handbook must be consulted. It may be said in passing that acute and chronic inflammations of the pharyngeal mucosa distinctly predispose to specific infection.

The initial lesion may appear on either the soft palate or the tonsils. A chancre, more or less indurated, is present with later erosions from irritation or ulceration. There is invariably enlargement of the cervical glands, and in due time constitutional symptoms develop.

Erythema appears in from the sixth to the sixteenth week or later. The mucosa on the lips, cheeks, tonsils, uvula, soft palate, and posterior pharyngeal wall has the appearance of passive congestion. The areas involved vary in size from a pea to a penny. The erythema is symmetrical and shows a sharp demarcation from the surrounding tissue. This demarcation and symmetry are strongly suggestive, for otherwise the mucosa appears as if only ordinarily inflamed.

The mucous patch may occur at any time, though it is generally one of the "secondary" manifestations. It poisons the buccal secretions and is therefore especially dangerous. The patches are ovoid and shallow, possibly symmetrical, and represent areas with an exudate of serum and a free supply of imperfectly developed cells. Without treatment these areas and their surrounding zones of tissue ulcerate and cicatrize, the cicatrix being stellate.

The gumma appears in from five to fifteen years after infection. Its favorite site is on the posterior surface of the soft palate. This lesion rarely passes over anatomical boundaries, that is, it does not extend directly in front of the faucial pillars, above the pharyngeal tonsil, or to the larynx. It appears as a diffuse infiltration, may form rapidly, and may undergo rapid destruction. It may be nodular, in which case there is a bulging of the superjacent mucosa. There is an infiltration of the tissues and vessel walls with small round embryonic cells embedded in a gelatinous basement substance. The mutual crowding of these cells shuts off the blood supply, and the whole mass breaks down into a cheesy consistency surrounded by a zone of granulation tissue, which later becomes fibrous. Abscess formation is rare. Destruction does not pass beyond the confines of the original deposit. Large areas may give way while bands of fibrous tissue pass from one point to another, thus distorting the parts. Fluids may therefore regurgitate into the nose and the soft palate becomes adherent (rarely completely so) to the posterior pharyngeal wall. The hard palate may become involved and perforated and occasionally a large vessel is eroded. Gummata are more rarely absorbed in the pharynx than elsewhere. Occasionally the course is so acute that immense destruction occurs in a very few days.

The *symptoms* of the initial lesion are painful swallowing and enlarged glands, that is, nothing outside of what may accompany an ordinary sore throat. The diagnosis is often indecisive until cutaneous lesions appear. In erythema we find a peculiar stiffness of the throat muscles and painful swallowing. In the mucous patch there is extreme sensitiveness increased by all irritants and by overuse of the voice. Nutrition may be interfered with.

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Fresh patches appear in groups occupying, in order of relative frequency, the soft palate and uvula, anterior surface of anterior pillars, tonsillar convexities, and anterior surface of the posterior pillars. A patch on one side may by contact symmetrically reproduce itself on the other side. A fresh patch is strongly suggestive of a recent application of silver nitrate. A few cases have been seen with a thick exudation suggestive of diphtheria and attended with marked constitutional symptoms.

The *symptoms* of the gumma are mainly mechanical. After ulceration has occurred pain may be severe. The typical tertiary ulcer is deeply excavated with sharply defined edges, surrounded by an angry red zone and covered with bright yellowish pus.

The *diagnosis* of the advanced lesions is not difficult; but the same is not true of the earlier ones. At first sight the patients may present nothing but the lesions of an ordinary sore throat. A most careful examination should be made, together with an investigation into the possibility of infection. All apparently simple catarrhal cases not yielding to treatment must be regarded as suspicious, and also those cases presenting a persistent dysphagia without apparent cause.

Treatment must be prompt and energetic. Alcohol, tobacco, condiments, and all irritants must be given up. The tooth brush must be used regularly and followed by rinsing with some weak antiseptic. If deglutition be extremely painful a weak cocaine solution may be used before eating. The patient must be told that he is a potential source of danger to others, and strict hygiene in every sense must be enforced. Local lesions should be cleansed with an alkaline spray and dusted with orthoform, or argyrol (silver vitellin) may be applied in thirty-per-cent. watery solution. For home use as a cleansing agent we may order bichloride solution, 1 to 3,000, or black wash. Each mucous patch should be touched with silver-nitrate stick. Indurated areas may be painted with a solution of bichloride, two grains, in sulphuric ether, five drachms. On fissured ulcerations a ten-per-cent. solution of iodoform in ether may be sprayed. Small palatal perforations may heal under the combined effect of constitutional treatment and the application to their edges, thrice weekly, of mono- or trichloracetic acid fused on a probe. Sometimes an obturator may be fitted, with advantage to the act of swallowing.

Constitutional treatment must be adapted to the existing stage of the disease (see article on *Syphilis*). Deformities and stenoses must be treated according to the requirements of each individual case.

6. Tuberculous Inflammation.—In the vast majority of cases pharyngeal tuberculosis is secondary to deposits in other parts of the body. The primary form is, however, possible, and forms about one per cent. of all cases of acute tuberculous inflammations of the upper air passages. As opposed to this rarity is the virulence of the disease. Favorite seats of invasion are the uvula and soft palate, especially the anterior surfaces of these structures; then come the tonsils, posterior pharyngeal wall, and hard palate.

The general causes are those of tuberculosis in general. The exposed position of the parts would seem to predispose them to infection, but their constant movement in normal function tends to clear away morbid material before it has had time to penetrate the tissues. Some authorities believe that the saliva offers a distinct barrier to the acclimatization of the tubercle bacillus, while other forms of bacterial life, with which the oral cavity swarms, are also inimical to bacillary growth. Infection may come through the blood and lymph, through the inspired air, and through foodstuffs.

The disease may manifest itself in two forms: (1) the ordinary miliary tubercle; and (2) a papular lesion confined to small areas, and especially apt to settle on the anterior surface of the soft palate. In both the microscopical picture is the same, viz., a small round-celled infiltration of the connective tissue gradually extending into the vessel walls. Then follow endarteritis, obliteration, cheesy softening, and ulceration. It is difficult to find either bacilli or giant cells in scrapings from the surface or in bits of tissue removed.

On inspection we may note either the miliary deposits studding the mucosa and apparently shining through it as white points, or there may be the larger papular masses extending in the primary cases as a fringe of small excrescences along the anterior pillars. After a while these deposits break down into characteristic ulcers. These may by their coalescence involve a large area. The uvula becomes swollen, œdematous, and exquisitely painful. Cases of perforation of both the soft and the hard palate are on record. The general appearance of other pharyngeal surfaces is one of anæmia due either to the endarteritis or possibly to a toxic vaso-constriction.

The most constant *symptom* is early and constant pain in the affected areas. The palatal muscles are swollen and stiff with resulting dysphagia. Food accumulates in the pharyngeal recesses and may get into the nasopharynx. Cough is present and the accumulation of saliva is excessive. Speech is hesitating, but the voice is not changed unless the larynx is involved. Later the cervical glands are enlarged. If the process is confined to the tonsils the difficulty in swallowing is much less. Owing to the latter symptom the patient is loath to take food, and the emaciation incident to the constitutional malady is hastened.

Diagnosis is based upon the characteristic appearance of the parts and the coexistence of tuberculous lesions in other parts of the body. Syphilis must be excluded in doubtful cases by the results of treatment. The two diseases may coexist. The typical tuberculous ulcer is shallow, with a surface flush with the surrounding mucosa, with the same color, covered with ropy mucus and possibly with a periœdema; in cases complicated by syphilis the ulceration is extremely sluggish, has a dirty-looking secretion, and is but little painful.

The *prognosis* is as a rule bad, though a few recoveries have been reported. The local condition is but one feature of a constitutional involvement. Healing of the ulcerations will greatly conduce to the tolerance of living, even though the constitutional deterioration goes steadily on.

Every hygienic and tonic measure possible should be instituted. Climate does not seem to be of much service in pharyngeal tuberculosis. All sources of buccal irritation should be removed, the teeth placed in order, and the food should be pultaceous. The patient will often find it easier to gulp food down than swallow it in the conventional way. The plan most in vogue at the present time for treating the ulcers is to curette them thoroughly under cocaine and then rub in solutions of lactic acid in water, beginning with say ten per cent. and gradually increasing up to eighty per cent., or even the pure acid. The ulcerated surfaces should be regularly cleansed with hydrogen peroxide, then with a weak alkaline solution, and finally dusted with some such powder as aristol. Enzymol, a proteid ferment, may be substituted for the peroxide. It is less irritating and just as efficient. Menthol in olive oil, twenty per cent., has its advocates. Morphine with cocaine or tannin may be cautiously applied, but the use of the first-named remedy should be avoided as long as possible. For the cough we may give heroin in one-twelfth grain doses every three hours. Orthoform is here used as a local anodyne with great advantage. It may be dusted on with equal parts of stearate of zinc or subcarbonate of bismuth. To insure its contact as long as possible with the affected parts we may use the excellent formula of Freudenthal, viz.: Menthol 10 gm., expressed oil of almonds 30 gm., yolks of two eggs, orthoform (12½ gm.), and water to make 100 gm.

7. Actinomycosis of the Pharynx.—This is an infectious, parasitic, and inoculable disease primarily attacking domestic cattle, but communicable from them to man. The original source of infection is grain. Bollinger says that oats grown on newly ploughed land are the main carriers of contagion, but that rye and other grains are at times similarly affected. In man the infection may

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arise by inoculation from animals, possibly from infected cereal foodstuffs, and doubtless often from the frequent habit of field workers of chewing bits of hay, straw, etc. Flies may carry the contagion. In one instance kissing was the method of conveying the disease.

It is difficult to swww.libtool.com.cnpharynx is affected, as reliable statistics on this point are lacking. We may refer to the figures of J. Israel, who found that out of five hundred cases the head and neck were involved in fifty-five per cent, and the throat and lungs in twenty per cent. Figures as to localization in the pharynx are not given. In the latter site the disease may be primary or secondary.

The infecting agent is an organism called the "ray fungus." Its exact place in classification is still a matter of dispute. By some it is called streptothrix actinomycotica; by others, actinocladothrix. It appears in the suppurative foci (hereinafter described) aggregated in small masses of a yellowish color. It can be cultivated in gelatin and more quickly in agar and beef serum. Its favorite temperature is about 95° F. For examination a bit of the suspected material should be smeared or teased on a slide, carefully dried in a flame and then stained a few minutes in a solution of picrocarmine, washed in water or alcohol, and mounted in glycerin. Sections of tissue are handled in the same way and mounted in glycerin or Canada balsam. The fungi appear yellow and the remainder of the field red. The actinomycotic tufts and single nodes may be recognized, scattered about in the field, and easily distinguishable from the surrounding red.

According to Leumann each of the yellowish masses may be subdivided into three zones: (1) An outer zone made up of club-shaped, wedge-like rays with rounded bases appearing when viewed in section to be set on star fashion and surrounded by large cells or by cells seeming to contain fragments of the fungi in their substance; (2) a middle zone made up of branching mycelial threads (furcated) passing from the centre to the periphery; and (3) an inner zone made up of cocci in chains. The threads are the active portion of the organism and the portion capable of artificial growth.

Certain observers have noted the presence of structures known as Rainey's or Mieschler's corpuscles. These are cylindrical tube-like bodies and are supposed to be due to the growth of the ray fungus inside muscular fibres. They are therefore rather a result than an essential element of the process.

When once infection has occurred extension is probably not through the lymphatics but by destruction of the vessel walls and the consequent easy access to the inner organs by the blood stream. The accompanying glandular enlargement is due to the admixture, with the ray fungi, of pus micro-organisms, notably the streptococcus pyogenes aureus.

Undoubtedly the mouth is the most frequent portal of infection: especially the alveolar processes of the lower jaw. Israel has found the fungi in the lacunæ of healthy tonsils, but they are harmless in the absence of solution of tissue continuity.

The first manifestation of infection is generally a periosteal abscess running the usual course and leading in about six weeks to true periostitis. The surrounding tissues are invaded, and suppuration appears between the chin and the hyoid bone, produced, be it remembered, not by the fungi but by pus cocci. Other cases begin as a gingivitis with spongy gums and alveolar stomatitis. From the foregoing sites the lesion attacks localities farther back, notably the pharyngeal wall. The tonsils and palatal arches are but rarely involved. Not infrequently the cheeks suffer. When once the pharynx becomes invaded, either primarily or secondarily, we note small reddish elevations looking not unlike a subacute pharyngitis upon a mucosa previously the seat of chronic changes. The adjacent tissues swell and then seem to lose their appearance of acute inflammation, becoming more like a zone of chronic infiltration, irregular in surface and firm to the touch. Suppuration soon appears with the development of angry-looking sinuses with undermined edges.

Aside from general pharyngeal discomfort, there are no *local symptoms*; actual pain is not constant. Later, comes the general deterioration due to the suppuration, but it is not accompanied by any special features. The characteristics, therefore, of the disease are: (1) The remarkable extension and induration of the parts; (2) the slow dragging course of the inflammation; (3) the extension of the process to the surface, after the lapse of several months, by a softening and final spontaneous evacuation, the pus being sero-sanguinolent; and (4) the quick healing of the local focus with apparently a favorable outlook, but the appearance of the infection in the neighborhood, or at a distance, with fresh vigor. Fatal symptoms are always tardy in development.

Diagnosis is called for from syphilis and from malignant disease, especially sarcoma. Sections of the latter may present appearances which strongly suggest actinomycotic tissue, but in the latter the microscope will reveal the ray fungi.

Treatment calls for radical excision if this is possible. Internally, large doses of the iodide of potassium have been given, and have apparently cured some cases. The internal use of silver nitrate has also been advised. Nearly every antiseptic has been used locally, but there is no specific. Without doubt bichloride is as efficient as any.

8. Glanders.—Glanders is a disease primarily affecting horses, and may be communicated from them to man and from one man to another. The exciting agent is the Bacillus mallei, resembling morphologically the B. tuberculosis, though somewhat shorter and thicker. Infection may be conveyed from an infected animal by the fine spray of coughing or sneezing, or by the handling of articles used about the animal.

In man the nasal structures are generally the portals of infection, and the process extends to the pharynx. It begins with evidences of a low-grade inflammation, and changes with the formation of granulation tissue containing the characteristic bacilli in swarms. Suppuration soon follows along the avenues of lymphatic distribution. Pus intoxication rapidly develops, the suppuration showing a distinct tendency to burrow. Cartilage and bone may be attacked.

The *symptoms* are those suggested by an area of local infection. Following the latter we have, within a few days, pain and swelling with degenerative changes. When the pharynx becomes affected we have interference with deglutition and phonation. There is a breaking down of the cervical submaxillary and sublingual glands, with occasional fistulæ opening externally. Finally, the general picture of septicæmia develops.

In these days of early examination of all suspicious discharges there is not much danger of overlooking a case of acute glanders, but there are cases in which the only evident changes are those of a subacute pharyngeal catarrh with variable pain, slow glandular involvement, and indefinite and remitting constitutional symptoms. The pharynx shows reddened elevated areas, over which are scattered small undermined ulcers from which dirty pus exudes. At first the pharyngeal functions are not greatly hampered, but increase of the infected areas may mechanically block the breathing and food channels so that death follows from general exhaustion.

Diagnosis is called for especially from the destructive lesions of syphilis. A history of possible glanders infection will of course put us on our guard. This we supplement by the detection of the Bacillus mallei. Some of the chronic cases have been mistaken for ulcerating sarcomata; in such doubt inoculation tests should be made.

The acute form of the disease is rapidly fatal. The use of mallein, an artificial product from potato culture of the Bacillus mallei, may be used for purposes of diagnosis, as it gives a reaction similar to that of tuberculin. Its curative properties are still *sub judice*, but in

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view of the gravity of the situation it should always be tried. No positive means of cure is at present known. Supporting treatment merely retards the inevitable end.

Some of the chronic cases are said to have ended in recovery, but the vast majority have been fatal within two years. In these cases treatment should consist of thorough curetting of the infected area, the use of antiseptic washes, and the administration of strychnine and iron in full dosage. Some authorities recommend the pushing of the iodides as in tertiary syphilis.

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9. Retropharyngeal Abscess. — These cases are often overlooked, because no digital examination is made of the pharynx, the observer contenting himself with mere inspection. The affection should always be suspected in a child with difficulty in breathing and swallowing without apparent cause.

The phlegmon forms in a flat shallow cavity behind the pharynx and œsophagus, limited posteriorly by the spinal aponeurosis and anteriorly by a connective-tissue sheath. Its lateral boundaries are sheaths which stretch from the aponeurosis to the lamellar spinal sheaths. Above is the basis cranii, and below, the mediastinum. The contents are sympathetic ganglia and lymph nodes receiving drainage from the neck, nasopharynx, and pharynx. Externally are important vessels and nerves. The above is the most frequent site of the abscess, but lateral sites are possible; many of the latter are doubtless but "pointings" from a central focus.

The inflammation begins in the lymph nodes and extends to the cellular tissue. It may, however, begin in the latter from irritation, as from instruments or a foreign body. In children in whom the disease is far more common than in adults, infection may come from such conditions as otitis media, erysipelas, pharyngitis, etc. An antral empyema is recorded as the cause of one case. In children of the tuberculous, syphilitic, and lymphatic diatheses, there is always a lessened resistance to infection, and it is in just such children that the malady is most common.

In infants the first symptom may be refusal of the nipple; then follow a metallic cry, dysphagia, and dyspnœa. In older children there is the usual sore-throat symptom complex, and inspection may at once reveal the nature of the trouble, but *palpation should never be omitted*. This may reveal a soft, boggy tumor, which pushes forward the soft palate, and in which perhaps fluctuation may be felt. Lateral cervical swelling is also possible.

The main danger previous to rupture lies in possible laryngeal œdema with bulging of the entire larynx forward, and consequent asphyxia. Burrowing may lead to infiltration of the cervical tissues and death from sepsis. The most common danger is rupture during sleep, escape of the pus into the lower air passages, and speedy asphyxia.

Pus accumulation may occur within twenty-four hours after initial symptoms; other cases may last several weeks, or even several months if they are tuberculous in origin. Diagnosis is called for from coryza, tonsillitis, croup, and even diphtheria.

Immediate evacuation of the pus is necessary. The child must be held in a good light with open mouth, a gag being used if necessary. With a protected blade an incision should be made from the middle of the fluctuating area to its bottom. *Immediately after incision, the child which has been held with its head forward should be inverted so as to allow the pus to run out of the mouth.* Meanwhile the finger which was *in situ* directing the incision, should be passed into the sac so as thoroughly to open it and thus prevent refilling. Lateral pressure of the pus will direct the large vessels outward so that there is little practical danger of injuring them. In one case sudden death occurred as the incision was made. Œdema of the glottis was not present, but the pneumogastric nerves had been stretched by the pressure of the pus. Death was ascribed to reflex syncope. In cases with much cervical swelling lateral incision from the outside has been suggested. Some have even recommended this procedure for central fluctuation, the escape of pus into the lower air passages being thereby prevented.

10. Pharyngeal Mycosis.—Over one hundred organisms are found in the healthy mouth. The most common are the oïdium albicans, actinomyces, aspergillus fumigatus, bacillus fasciculatus, the fungus causing nigrities linguæ or "black tongue," and various species of leptothrix. By common usage the term pharyngeal mycosis, when used without modification, refers to the affection characterized by the growth of the leptothrix. It was first described by Fraenkel in 1873, receiving the name mycosis tonsillaris benigna. It occurs on the tonsils, tongue, pharyngeal wall, faucial pillars, epiglottis, and rarely in the nose, nasopharynx, and larynx.

The fungus clings to the epithelia and often prefers a healthy to a diseased surface, above which it appreciably projects. It is of horny consistency and is removed with difficulty. Threads may connect the isolated deposits so that the general appearance is that of roots with running tendrils. If a portion be teased out and examined in glycerin under the glass, we note a mass of epithelia surrounded by irregular granules in which are embedded the spores of various species of leptothrix. These spores are arranged in link-like processes, their ends being rounded or club-shaped. The processes vary in length, and may be curled up at the ends in hair-like filaments. Besides these bodies there are round or oval, highly refractive bodies arranged in colonies or scattered among the branching spores. The link-like processes are the mycelia of the fungus, and staining with methyl blue will show alternating colored and uncolored segments. The fungus has never been cultivated outside the human body.

As clinically seen the affection follows previous pharyngeal inflammation, deposits of tartar on the teeth, altered reaction of the buccal fluids, disordered digestive states, etc. There is no reason to believe that rheumatism or gout has any direct causative relation. Incidentally it may be said that the same fungi have been found in fœtid bronchitis, tracheal ozæna, pulmonary gangrene, rhinoliths, tonsilloliths, vesical calculi, the tongue coating of low febrile states, in the lachrymal duct, intestines, vagina, and fæces. At any site they may precipitate lime salts from fluids holding the same in solution.

In 1895 Siebenmann advanced a different view as to the nature of the familiar pharyngeal mycosis, claiming that it was essentially a hyperkeratosis of the mucosa. All tonsils exhibit this in a varying degree, and this collection of hyperkeratosed epithelium is a constant menace to the integrity of surrounding structures.

The *symptoms* are pharyngeal dysæsthesia, cough, difficulty in swallowing, sensation as of a foreign body, and occasionally reflex pain in the larynx. Possibilities are fever, enlarged submaxillary glands, and congestion of the palate and uvula. Periods of improvement and relapse succeed each other without any treatment whatever. The affection is in no wise dangerous, and it alarms patients out of all proportion to its gravity.

Treatment.—In treating a case the teeth must be placed in proper condition, the digestion regulated, and for a time at least all sweets must be cut off. Climatic changes may give surprisingly favorable results. Nearly every caustic has been suggested for the destruction of the roots of the fungi; mere superficial clipping off is useless. The only reliable measure is the use of the galvano-cautery plunged into each crypt harboring a root of the fungus. If the cautery is unavailable, chromic acid fused on a probe will answer.

James E. Newcomb.

PHARYNX, DISEASES OF: FOREIGN BODIES. See *Air Passages, etc.*

PHARYNX, DISEASES OF: MALFORMATIONS, DEFORMITIES, AND NEW GROWTHS.—The consideration of this subject naturally requires its division into two parts: (1) Malformations and Deformities; and (2) New Growths.

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REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.

I. Malformations and Deformities.

There are two kinds of malformations which affect the pharynx—stenoses and dilatations. We will take up these subjects in the order named.

Stenoses may be congenital or postnatal, and they may be incomplete or complete. The congenital stenosis or atresia is accompanied by pocket-like dilatations or pouches. These malformations are to be ascribed to prenatal anomalies of development. The constrictions are most often found in that part of the pharynx which lies adjacent to the cricoid cartilage of the larynx, but they have been met with also in the upper part of the pharynx, at the junction of the oral and nasal portions of this cavity.

Fig. 3803.—Diaphragm of the Pharynx. (Case of Dr. S. S. Bishop.)

The lower constriction appears as a ring-like septum of mucous membrane, which may reduce the calibre of the tube by one-half or more of its diameter, and cases of complete atresia have been reported. Fortunately, these stenoses may exist without being productive of suffering so long as they do not become the seat of an inflammatory process.

The palatal, or high, stenosis is formed by a membrane which stretches from the soft palate backward and outward to join the posterior and lateral walls of the pharynx. Cases of diaphragm of the pharynx resulting from scarlet fever, such as the writer has reported, and syphilitic adhesions, may be mistaken for congenital stenoses, but a close examination may reveal scar tissue, which is indicative of a previous inflammation.

Postnatal malformations are the result of two classes of causes, intrinsic and extrinsic. Intrinsic causes, or those which have their origin in the pharynx, are such as scarlet fever, lupus, syphilis, diphtheria, and traumatisms. Extrinsic causes, or those which operate from without the pharynx, are in the nature of deformities of the spine, tumors, and abscesses.

Intrinsic stenoses are most often due to syphilitic adhesions which spread out above the oral pharynx and connect the posterior pharyngeal wall and posterior columns of the fauces with the soft palate. The diaphragm thus formed may be partial or complete. The appearance of this adventitious tissue, and the presence of suggestive scar tissue, together with more or less inflammatory destruction of the adjacent soft parts, will simplify the diagnosis. The differentiation is still further facilitated when perforations of the hard palate are present, for these sequels are particularly characteristic of syphilis.

Syphilitic membranous adhesions are sometimes found connecting the posterior pharyngeal wall with the base of the tongue, or a syphilitic stenosis may be formed at a point opposite to the cricoid cartilage of the larynx, where the congenital stricture is most often located. These membranous diaphragms are perforated, and, like the prenatal stenoses, they may cause little or no inconvenience so long as they are not involved in any inflammatory action, and they are not prone to such attacks.

Scarlet fever is sometimes responsible for these membranous obstructions. Such a case was reported, with an accompanying photographic illustration (Fig. 3803), by the writer in 1898.* The subject was a young lady who had had an attack of scarlet fever when she was a small child. The age at which she was sick could not be ascertained. The nasal pharynx was found to be separated from the oral portion by an adventitious membrane, which extended from the posterior columns of the fauces and the arch of the soft palate downward laterally and backward to the lateral and posterior walls of the pharynx opposite to the base of the tongue. Its general direction from the palatal attachment, instead of being nearly horizontal, closely approximated a vertical plane. In the centre of this diaphragm was an oval opening, the long diameter of which was vertical. Through this perforation the posterior wall of the pharynx was visible, and nasal respiration took place. The patient complained of no serious inconvenience resulting from this anomaly, except that food would lodge behind the membrane and demand her attention to wash it out so as to prevent decomposition and its results.

Suppurative processes of the pharynx in the course of other diseases may produce anomalies similar to the one which I have just described. Such diseases are diphtheria, smallpox, lupus, and erysipelas. In such instances the pharyngeal symptoms become very prominent and distressing during the inflammatory stage. The constitutional disturbances are pronounced, the cervical glands may be involved, the difficulty of swallowing is marked and becomes evident to the patient's friends. Inspection of the throat reveals the characteristics of an intense degree of inflammation: redness and tumefaction of all the surfaces involved, œdema of the soft palate and uvula, and, in the advanced stage, suppuration and ulceration. These characteristics of inflammatory affections which eventuate in pharyngeal stenoses should put the practitioner on his guard against such results.

Traumatic causes of pharyngeal stenoses are in the nature of scalds, such as the accidental drinking of hot liquids by children, and the chemical action of caustics, such as carbolic acid, potash, etc.

Treatment.—The treatment of stenoses of the pharynx may most conveniently be considered under two headings—general and local. In the case of syphilitic adhesions general treatment should first be instituted, and should consist of the exhibition of the iodides and mercury according to the principles laid down in the article on syphilis. The local treatment formerly consisted of systematic dilatations by means of graduated bougies, but the firm, fibrous character of the membrane does not lend itself encouragingly to this method of treatment, for the stenosis returns after the dilatations are discontinued. The knife also was much in vogue in early days for the eradication of these anomalies, but we now have, in the electric cautery, a much safer and more certain means of removing adventitious tissue.

* See "Diseases of the Ear, Nose, and Throat, and their Accessory Cavities," by S. S. Bishop, 2d edition, p. 416.

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A practically bloodless and painless operation is possible by means of the electric-cautery dissection after the application of suprarenal extract and cocaine to the field of operation, as follows: A fresh or preserved saturated solution of the suprarenal gland is applied to the periphery of the membrane which is to be removed. The writer reverses the method usually employed in the application of suprarenal solution and cocaine, and applies the suprarenal preparation first for the following reasons: If the blood-vessels of the tissues to be operated upon are first contracted, the blood current is so far diminished in volume as to reduce to a minimum the amount of cocaine that is taken into the circulation. Hence there is less liability to the toxic manifestations of cocaine. Moreover, when it is possible to contract the tissues before applying cocaine to them the anæsthetic penetrates relatively deeper and produces a more profound degree of anæsthesia. By observing this rule of procedure it is possible to employ a stronger solution of cocaine than would be safe if the order of application of the remedies were reversed. I have demonstrated the importance of these facts in a long series of operations.

Cocaine should be applied to the surfaces to be severed, not by means of a spray, but by the cotton applicator, care being taken that the surplus of the cocaine solution is expressed from the cotton pledget on the carrier before the application is made. This is necessary in order to prevent any excess of cocaine from running down into the larynx or the œsophagus. Strong solutions of this very toxic remedy must be either avoided, or employed in the pharynx with the greatest caution. For the sake of emphasizing this statement it is excusable to cite a case which was brought to the attention of the writer by a former clinical assistant. He was about to operate on a patient's throat after having applied cocaine, but before he began the operation alarming symptoms developed, and the patient suddenly expired in his chair. It must be kept in mind that in these throat operations an extensive surface must be cocainized, and that, therefore, a large amount of the drug may be absorbed. The writer has seen numerous cases of collapse and acute mania result from its employment in operations where the surfaces requiring anæsthesia were of much smaller area, but these unfortunate manifestations were probably due to the use of sprays that medicated other parts, in addition to those which were operated upon. I believe that such accidents can be avoided by the use of weaker preparations than those commonly employed, since they are often of twenty or thirty-three per cent. strength, and by taking the precautions already advised. The writer attributes to these reasons the fact that he has never had any such distressing experiences as those mentioned above. It is better not to apply to the pharynx solutions of cocaine stronger than from four to eight per cent. I speak in detail of these matters here in order to avoid repetition in treating of pharyngeal procedures under local anæsthesia later. The operation, after cocainization, consists of passing a bent electrode, at a white heat, through the periphery of the obstructing membrane, carrying the electrode, as it burns its way, throughout the whole circumference of the diaphragm. Care must be exercised not to encroach upon the surrounding tissues, which we do not wish to attack. After the membrane has been thus severed, if any hemorrhage occurs, the suprarenal extract must again be applied; but if the electrode is properly used and is not allowed to cool before being removed from the tissues, little or no hemorrhage follows.

It is advisable to keep the patient under observation for a few hours after the operation in order to anticipate any secondary bleeding that might occur. Should any tendency to the formation of exuberant granulations appear, they may be suppressed by the application of the silver-nitrate pencil. If a ten-per-cent. solution of this remedy be painted over freshly operated surfaces, there is far less danger of hemorrhages, and the desired effects of the operation are enhanced.

Little in addition need be said regarding stenosis due to lupus, but the present indications are that we are justified in expecting beneficial effects from the *x*-ray treatment.

Extrinsic causes of pharyngeal stenosis may consist of tumors, such as an aneurism or a goitre, or the cervical portion of the vertebral column may be deformed or diseased, or a retropharyngeal abscess may encroach upon the lumen of the cavity; but the treatment of these conditions obviously does not lie within the limits of this article.

Dilatation of the pharynx may affect the whole, or only a part, of the cavity. It generally exists in the form of a pouch, which is comparable to the aneurismal distention of an artery. The congenital variety is to be attributed to an intra-uterine developmental anomaly.

The acquired, or postnatal, form probably occurs in consequence of an imperfectly developed, or weakened, area of the tunic of the pharynx, which yields to undue pressure. Contributory to these causes are the habits of improperly masticating food, and a hasty manner of forcing large and irregular boluses of food down the gullet. It is easy to conceive that these repeated distentions of the pharynx tend to carry the mucous membrane between the surrounding muscular fibres, especially where the latter may be weak or defective. A pouch so formed may continue developing until it becomes several inches long. It is most likely to be found extending downward and backward between the vertebræ and the œsophagus. Generally this diverticulum consists of the mucous and submucous coats of the pharynx, but it has been found to be enclosed in the œsophageal cellular membrane. Occasionally these pouches extend to one side, and are sufficiently prominent to appear as a tumor in the side of the neck.

The most prominent and constant symptom is a difficulty in swallowing. Food lodges in the pouch and forms a temporary tumor, which obstructs the act of deglutition, until the pouch is emptied automatically or by the patient. He generally learns, however, that by digital pressure and manipulation of the tumor he is able to express the contents and enjoy relief. Unless this is done the imprisoned food may decompose and set up an inflammatory condition. Indeed, such an inflammatory process has given rise to the formation of adhesions which have resulted in a closure of the sac and a consequent permanent cure. But a less fortunate termination of such an inflammation may be the occurrence of sloughing of the surrounding tissues.

Other distressing symptoms arising from the ejection of food retained in the pouch are in the nature of an irritation of the lower respiratory tract. For example, the emptying of food into the larynx occasions violent spasms of coughing, and some particles may even reach the bronchial tubes and cause attacks of bronchitis or pneumonia.

The *diagnosis* of this condition is made with comparative facility. The obstruction to swallowing, the tumor which disappears and recurs, or which can be dissipated by pressing out its contents, the ejection of undigested food in the absence of actual vomiting, the entrance of particles of food into the larynx subsequently to, instead of during, a meal, together with the results of an examination with the throat mirror and digital exploration, afford a mass of evidence that is of a pathognomonic character.

The *prognosis* is not a cheering one. Without operative interference the condition is rarely corrected. In an occasional instance an inflammatory process is instituted which eventuates in a spontaneous closure of the pocket and a resulting cure. But there is always the danger of retention and putrefaction of food. In some cases patients must needs subsist on a fluid diet in order to avert such results; but in conditions that lend themselves favorably to operative measures the anomalies may be corrected.

Treatment.—We may best consider this subject under two divisions—palliative and curative. Palliative treatment rests mainly with the patient. By avoiding hurried

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eating and imperfect mastication he removes the principal cause of acquired pharyngeal pouches, for it is the forcing of boluses of food through the cavity that distends the mucous coat of the pharynx and pushes the membrane between the fibres of its muscular tunic. After a meal during which ingesta enter the pouch he should manipulate the distended sac with his fingers until it is emptied, and he may even be able to wash it out by means of a properly curved syringe. By this means the fermentation and decomposition of retained food may be prevented.

When the diverticulum is situated at the side of the neck the patient may be able to prevent it from filling if he will press upon it with his fingers, or if a compress be worn over it at meal time. If these means do not suffice, and if the symptoms become urgent, it may become necessary to resort to an operation.

Operative Treatment.—The simplest and most promising measure of this nature consists in the application of the electric cautery to the periphery of the pharyngeal mouth of the sac. Cocaine should first be applied to the field of operation, the surgeon being careful to observe the precautions already mentioned. After this preparation for the adhesion of the adjacent borders of the pouch rectal alimentation is resorted to for a few days. In certain cases it may be necessary to operate after the methods employed in pharyngotomy or œsophagotomy, suturing the edges of the divided mucous membrane to hasten recovery and insure the subsequent integrity of the pharyngeal cavity.

II. New Growths.

Neoplasms of the pharynx will be considered under the following classification:

1. *Epiblastic and hypoblastic.*	2. *Mesoblastic.*
Papilloma	Fibroma
Adenoma	Lipoma
Cystoma	Angioma
Carcinoma	Sarcoma

Fortunately the pharynx is not so often the seat of neoplasms as are the nose and some other areas; but when growths do occur in the pharynx they give rise to warranted apprehension, even if they are of a benign nature, since, as Virchow has observed, they may take on a malignant character. More particularly is this true of tumors situated, as these are, in a passageway which renders them subject to frequently repeated disturbances and irritation. A still further important consideration is the hindrance which they may cause to the acts of swallowing and breathing, and the consequent impairment of nutrition and deficient oxygenation of the blood. To these genuine reasons of anxiety may be added the tendency to recurring attacks of inflammation to which these growths predispose the subject, and the proneness of the inflammatory process to invade the larynx and lungs.

Papilloma.—This is an epithelial tumor of a benign character, which occurs less frequently in the pharynx than in the larynx and mouth. The structure consists of epithelial cells, with a framework of connective tissue beneath the epithelial proliferation. Within this tissue, and separated from it by the membrana propria, is the vascular area. What has been said relative to the transformation of innocent tumors into malignant ones applies with especial appropriateness to papillomata, since no other growths are so likely as these to undergo degeneration. Add to this fact the exposed situation in the pharynx and the frequently repeated irritation to which their location subjects them, and all of the conditions favor their malignant transformation. Aside from the pillars of the fauces and the tonsils, the most common location of papillomata in the pharynx is the posterior wall. They vary in size from a hempseed to a cherry.

The *diagnosis* of pharyngeal papilloma ordinarily presents little or no difficulty, particularly when no inflammatory process is present. But since they are often associated with an inflammatory condition, or follow it, in such cases there is room for doubt. Then a section should be taken from the base of the tumor, or tumors if they are multiple, for a microscopical examination. The growths have a warty or cauliflower shape, and are of a pale pink or gray color when not made red by irritation or inflammation. Their glistening appearance is due to the reflection of light from the secretions which moisten their surface.

Unless they attain to a considerable size they do not provoke any symptoms sufficiently marked to call attention to their presence, such as a sense of a foreign body in the throat, or impeded deglutition or respiration.

The *prognosis* of papillomata of the pharynx is favorable, provided that they do not undergo a transformation into carcinomata or sarcomata. They rarely become larger than a small-sized grape, and so long as they remain of an innocent nature no suffering is experienced.

Treatment.—Treatment consists in extirpation and cauterization of the seat of attachment. This is best effected by means of the electric cautery, which accomplishes both purposes at the same time. Or the tumor may be severed close to the surface from which it springs, by means of the scissors, knife, or the cold snare; but the base should be well cauterized afterward either with the electrode, or the silver nitrate, or one of the other chemical caustics, in order to lessen the likelihood of a regeneration or degeneration of any tumor tissue which may remain.

Adenoma.—True adenoma does not occur in the pharynx proper. Adenoid vegetations in the nasopharynx are discussed under the heading of *Tonsils.*

Cystoma.—The true cystic tumor, or that in which the wall of the cyst is produced from a matrix of embryonic cells, and the products of tissue proliferation of the cells lining the cyst wall constitute the contents of the sac, is rarely, if ever, met with in the pharynx. Retention cysts, however, occur as the result of an inflammatory process, which causes a stenosis or closure of the duct leading from a gland, with the result of distending the duct, as the glandular secretions accumulate behind the stricture until the consequent tumefaction becomes apparent. The continued accumulation of the contents of the sac causes sufficient pressure on its walls to account for the degeneration of its epithelial lining and for the atrophy which is present in the attenuated membrane. These cysts are generally found in adult life, or in those who have passed the meridian of life.

Treatment.—A simple and effective method consists in opening the sac and destroying its walls. This may be accomplished by an electrode, which serves the double purpose of dividing the wall and destroying the cyst after the contents escape. Or the opening may be made with a knife, after which the walls of the sac are destroyed by a curette. Then the parts had best be treated with tincture of iodine or a ten-per-cent. solution of silver nitrate.

Carcinoma.—When cancer exists in the pharynx proper it is generally either secondary to the same affection of adjacent tissues, such as the tonsils, the soft palate, the œsophagus, or the larynx, or it is associated with such an affection; and as diseases of these structures are considered in other sections, in order to avoid repetition the reader is referred to their proper headings.

Fibroma.—Fibromata are found in various parts of the pharynx, but they are more common to the nasal portion than to the oral division of the cavity; and they more frequently spring from the basilar process of the occipital bone. A fibroma is a representative tumor of the mesoblastic type. Like the submucous tissue from which it takes its origin it is a connective-tissue growth, and is the offspring of a highly vascular area. It is made up of mature fibrous tissue from a matrix of fibroblasts. The growth of this neoplasm is always slow, and frequently there is a tendency toward a myxomatous degeneration, or it may undergo transition into a sarcoma. As it is most often seen in the superior portion of the pharynx it is pear shaped (Fig. 3804), but it may be sessile, and it is a product of youth rather than of old age,

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for it is rarely encountered above the age of thirty or forty years.

The *symptoms* referable to pharyngeal fibromata are determined by the position and size of the tumors. Located in the upper or nasal portion of the pharynx they interfere with nasal respiration and impair the resonance of the voice. They sometimes attain to enormous proportions, extending forward into the nasal fossæ, crowding forward the nasal and orbital bones, protruding and separating widely the eyes so as to constitute the unsightly deformity known as "frog face," and giving rise to persistent headache. Extension of the growth upward causes encroachment on the cranial cavity, evoking cerebral symptoms. If the direction of the tumor is principally downward it causes frequent efforts to swallow, and it may produce sufficient pressure on the soft palate to impede its movements in speech and deglutition. When it reaches the aperture of the larynx it may even threaten suffocation. Mouth-breathing is a prominent symptom, and hemorrhages frequently occur as the tumors are exceedingly vascular. Impaired respiration, mental torpor, and "thick speech" characterize large growths; and when pressure is produced on the orifices of the Eustachian tubes, the proper ventilation of the middle ears is interfered with and the hearing becomes defective. A copious muco-purulent discharge is sometimes present.

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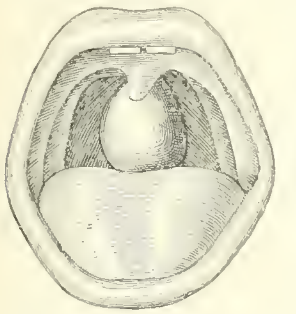

Fig. 3808.—Fibroma of the Pharynx.

The *diagnosis* of fibromata is not attended with serious difficulties. Their occurrence in young persons and their slow growth are characteristic. From mucous polypi they are recognized by their firm, dense substance. They are distinguished from adenoid growths in the vault of the pharynx by the soft, spongy, lobulated appearance of the latter and their occurrence in the very young only. Fibromata are dense, smooth, and of a dark red color.

Prognosis.—It should not be forgotten that, as Virchow says, "fibroma only needs an increase in the size of its cells and a diminution of the cement substance to change it into a sarcoma." The location of a fibroma in the pharynx subjects it to a great amount of irritation; hence it is thereby predisposed to a degenerative transition into a sarcoma and to attain to large dimensions. Unless the growth can be removed, or unless its development can be repressed until the patient has passed his twenty-fifth year, the prognosis is grave.

Treatment.—Curative results have been claimed by numerous writers from injections of alcohol, caustic potash, chloride of zinc, dilute acetic or hydrochloric acid, etc., into new growths. It is asserted that if alcohol will produce contraction and atrophy of tissues, as occur in the cirrhotic liver of the inebriate, it will have a similar effect on a neoplasm, into the parenchyma of which it might be injected. While some observers believe that the curative effect is produced, when the alcohol is injected into the interior of the tumor, by causing the formation of new connective tissue, with the obliteration of blood-vessels, lymphatics, and the parenchyma, others inject it into the circumference, maintaining that the new connective-tissue formation, girdling the periphery of the growth, will choke the afferent and efferent blood-vessels, cut off nutrition, and thus cause atrophy.

Electrolysis is especially indicated for growths having a sessile formation, which precludes the use of torsion or the snare. For this purpose a strong current is employed under general anæsthesia. Much has been claimed for the method of introducing medicaments with the electric current, or cataphoresis; but whenever it is practicable to remove the tumor in its entirety, this procedure should be preferred.

Operations.—There are several methods of operating from which to choose according to the size and situation of any given tumor. However, before detaching the growth it should be secured by passing a strong thread through it, in order to prevent it from falling into the laryngeal region of the throat and producing suffocation when the attachment is severed. The old method of removal by the cold wire snare is in quite general use, but on account of the great vascularity of these tumors and the consequent operative hemorrhage the electric snare recommends itself, since it sears over the tissues and closes the mouths of the blood-vessels with coagula as the tissues are being severed. For the same reason, in those cases in which the form and position of the attachments of these neoplasms lend themselves to such a procedure, the use of the electric knife at a white heat is advantageous. Torsion can be practised when the tumor is distinctly pedunculated.

Certain cases of pharyngeal fibromata can be operated on through the natural oral or nasal passageways by the method mentioned above. Others, either on account of peculiarities of attachment or by reason of excessive or irregular development, must be removed through the soft or hard palate, or by means of resecting the nasal bones or the superior maxilla. Sufficient room for operating may be obtained by dividing the nose along the side of the septum, beginning at the nasal process and cutting from within outward. If more room is required, the nasal process is resected; still better access is afforded by incising the upper lip in the middle line and separating its attachments liberally. The tumor is then detached by one of the methods already described, or by the periosteal elevator, or by blunt-pointed scissors, when it is drawn out with strong forceps. These are very bloody and dangerous operations, and may require a preliminary tracheotomy and ligation of the common carotid artery. However, since the details of these operations, as devised and modified by König, Dieffenbach, Langenbeck, Rouge, Ollier, Kocher, and others are given in other articles in this Handbook, they will be omitted here.

D. Bryson Delavan strongly favors the employment of electricity both for the purpose of cutting off the blood supply of fibromata and shrinking them preparatory to their removal, and for their extirpation as well. Electrolysis is recommended, either by the unipolar or by the bipolar method. Either one is attended with pain. The first is the more painful and slower of the two. The bipolar method is less painful and more rapid and extensive in its destructive effect. Some operators make use of so strong a current as from 80 to 340 milliampères. After reducing the volume of the tumor it is removed, preferably, by the incandescent wire snare, with the electric current of sufficient strength to burn its way slowly, so as to destroy the tissues thoroughly at the attachment, and to close the mouths of the severed blood-vessels. Delavan gives credit to Lincoln for introducing this method into America after the suggestions of Voltolini and Michel, and he presents, in addition to many cases collected by others, statistical data compiled by himself, which bear out the claims for the superiority of operations by the electrolytic needles and the electric snare through the natural passageways.

The statistical tables referred to cover the decade from 1891 to 1901, and include 30 cases operated upon by various surgeons who performed preliminary operations, such as resections of the nose, the superior maxilla, and the palate. There were 106 cases in which the method of operating was through the natural passages. Of these, 48 are classed as surgical and 58 as electrical procedures. Eliminating all of those cases in which the operators forgot to inform their readers regarding the nature of the results of their work, we have remaining 89 cases which are of actual value in determining the relative merits of the various methods employed. This shows 13 operations involving a preliminary intervention, with 54 per cent. of cures, 23 per cent. of deaths,

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23 per cent. of grave hemorrhages, and 17 per cent. of recurrences of the tumors. There were 29 cases in which various surgical procedures through the natural passages were resorted to, and the results were made known. The cures amounted to 86 per cent., the failures about 7 per cent., www.libtool.com.cn 17 per cent., and there were no deaths reported. There were 47 cases in which electrical operations were performed and the results recorded. The percentages were as follows: Cured, 81 per cent.; improved, 16 per cent.; failures, 2 per cent. No deaths were recorded. By combining all of those operations which were performed by way of the natural passages, for the purpose of comparing the results with those obtained after preliminary procedures, it will be found that the percentages are as follows: Cured, 83 per cent.; improved, 9 per cent. A comparison of the various methods is afforded by the following table:

ANALYSIS OF METHODS.

	Total cases.	Less cases in which results are not given.	Total complete histories.	Cured.	Improved.	Died.	Failure.	Hemorrhage.	Recurrence.
Resection of palate ..	9	−3	6	3	..	..	..	1	3
Resection of superior maxilla............	10	−4	6	4	..	2	..	1	1
Resection of nose	11	−10	1	..	..	1	..	1	1
Total	30	−17	13	7	..	3	..	3	5
Evulsion	27	−9	18	16	..	..	..	3	
Cold snare	21	−10	11	9	..	..	2	2	
Total	48	−19	29	25	..	..	2	5	
Electrolysis	34	−3	31	23	7	..	1		
Galvano-cautery loop.	15	−8	7	7					
Galvano-cautery loop with electrolysis ...	1	0	1	1					
Galvano-cautery	4	−0	4	3	..	..	..	.	1
Galvano-cautery with evulsion	4	−0	4	4					
Total	58	−11	47	38	7	..	1	..	1

LIPOMA.—A lipoma is a tumor composed of fatty tissue produced from a matrix of lipoblasts and may be either circumscribed or diffuse. Its occurrence in the pharynx is exceedingly rare, and the symptoms to which it gives rise are characteristic of a foreign body in the throat. When the growth is soft, it may be mistaken for an abscess; but the symptoms and history of pus formation are lacking, and an exploratory puncture is decisive of this question.

If the tumor is pedunculated, it can be removed by one of the methods described for fibroma, viz., by the cold or the hot snare or by the electric knife; otherwise electrolysis is to be preferred.

ANGIOMA.—This term is used in a broad sense by throat specialists to include all vascular tumors, in conformity with the classification of Virchow. Strictly speaking, the growth consists of new blood-vessels that communicate with the surrounding vessels, of interstitial tissue like that from which the tumor springs, and of the blood within the vascular spaces. In contradistinction to this definition, tumors that are made up of lymphatic vessels are designated as lymphangiomata. The oval group of veins beneath the mucous membrane at the back of the pharynx, known as Cruveilhier's submucous venous plexus, has been found so greatly engorged and tumefied as to cause a sensation as if a foreign body were in the throat, and an annoying cough. The surface presents a hard, lobulated, and purple appearance. Varicose veins are not uncommonly met with in the pharynx, and they may become so numerous and distended as to form groups that are comparable to clusters of currants or blackberries. Hemorrhages may be expected from these growths, particularly following any irritation, such as a digital examination.

Treatment.—If angiomata attain to a considerable size they may cause much discomfort and apprehension on the part of the patient, and they may even so encroach upon the surrounding parts as to impair their functions. A constant desire to swallow, embarrassed respiration and deglutition are not the worst features to consider, but profuse hemorrhages may demand an operation in order to insure the safety of the patient. In such cases the tumor should be completely extirpated. It is rarely sufficiently pedunculated to admit of removal with the cold or the hot snare; hence electrolysis is the most feasible method. Should thyrotomy be resorted to, it may be necessary to perform a preparatory tracheotomy.

SARCOMA.—As a primary disease of the pharynx sarcoma is rarely seen. It springs from the submucous connective tissue, and generally depends from the inferior surface of the body of the sphenoid bone into the pharynx. It is an atypical proliferation of connective-tissue cells from a matrix of fibroblasts of congenital or postnatal origin. Owing to the rich supply of lymphatic structure in this locality and its invasion by the sarcomatous cells the tumor may show a transition into the variety termed lymphosarcoma.

Like fibroma, a sarcomatous growth produces symptoms referable to respiration, swallowing, and the voice in degrees commensurate with the location, size, and shape of the tumor. The nasopharyngeal secretions are increased in quantity, to which is added, after ulceration occurs, a viscid, foul, and bloody discharge. If pain is present, it is in proportion to the amount of pressure exerted on adjacent structures. Although the discharge, which appears after ulceration takes place, is of a sanguineous character, the history of the growth may not present hemorrhages to a serious extent. In order to make a positive differential diagnosis, resort should be had to the microscope. The prognosis is unfavorable; the progress is toward a fatal termination.

Treatment.—If all of the diseased tissue can be removed, this should be done, provided that metastasis has not occurred. It is useless to operate if a part of the growth be left, for rapid reproduction will occur; and if metastatic tumors have formed in other situations nothing will avail from operative procedures on the primary tumor. But if the growth can be enucleated from a circumscribing pseudo-capsule, leaving no remnant of diseased tissue, and if no metastasis has occurred to render nugatory the result of the operation, it should be performed. Otherwise there is little to be accomplished beyond making the conditions as tolerable as possible by the use of cleansing, disinfecting, and astringent applications. *Seth Scott Bishop.*

PHARYNX, DISEASES OF: NEUROSES.—Neuroses of the pharynx consist of disturbances of sensibility, secretion, and motion.

ANÆSTHESIA OF THE PHARYNX.—This appears as a complete loss of the sensibility of the pharyngeal mucous membrane, or as a diminution of the same, and can be of either central or peripheral origin. When of central origin it is due to hemorrhage, tumors of the brain which cause compression of the vagus and glossopharyngeus nerves, inflammation of the brain, bulbar paralysis, tabes, or lateral sclerosis. It is seen in connection with epilepsy, after influenza, in anæmia and in hysteria, and is one of the sequelæ of severe general diseases, as pneumonia and especially diphtheria. Cocaine, eucaine, morphine, chloral, bromide of potassium, carbolic acid, and menthol, when used locally and internally, bring about anæsthesia of the pharynx. The reflexes usually fail, and there is occasionally a feeling of general pain, even in the presence of local anæsthesia.

The *diagnosis* is made by direct examination. In the case of anæsthesia of one side only, one-half will have the natural sensibility, while the affected portion will be insensitive to mechanical, thermal, or chemical irritations. When the anæsthesia is complete, the mucous membrane is everywhere affected. When the result of diphtheria,

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anæsthesia is often accompanied with paralysis of the muscles of the larynx and pharynx.

The *prognosis* depends entirely upon the cause, and is sometimes good and sometimes bad.

The *treatment* is based on the cause. Associated with diphtheria, the treatment is that of the general paralysis of diphtheria, and consists of measures to keep up the nutrition of the parts; careful feeding to prevent the introduction of particles of food into the larynx; the use of the constant and induced electrical current; and strychnine internally.

HYPERÆSTHESIA OF THE PHARYNX.—By this term is understood an increased sensibility due to central or peripheral irritations, whereby an extreme sensitiveness of the pharyngeal mucous membrane is brought about, which is described as pain, or is evident in the form of coughing, choking, retching, vomiting, and explosive belching of gases from the stomach.

Hyperæsthesia of the pharynx is a common manifestation, daily seen when an attempt is made at a laryngoscopic or rhinoscopic examination. It is often extreme, many persons retching, gagging, and almost vomiting whenever any instrument is brought near to the pharynx. Even the opening of the mouth and the drawing out of the tongue frequently elicits the strongest reflexes before the instrument has touched any part of the pharyngeal wall. It is common in persons apparently absolutely sound, but is more so in those who are very fat, in drinkers, smokers, and nervous persons. Local diseases, hyperæmia, acute or chronic catarrh, general hyperæsthesia, and increased general nervous sensibility intensify all the manifestations.

While it is a condition difficult to cure by any method of treatment, most persons after a while become used to manipulations in this region, and the treatment of the pathological condition present usually diminishes the sensibility.

Treatment consists in the local use of cocaine, menthol, chloral, bromide of potassium, various gargles, tannin, alum, and adrenalin, and in the avoidance of alcohol and tobacco.

PARÆSTHESIA.—Under this term are included various abnormal sensations, which are described as burning, pressure, itching, dryness, abrasions, lumps, or a sensation as of the presence of a foreign body in the pharynx. Among the foreign bodies complained of are pieces of bone, hairs, toothbrush bristles, needles, pieces of bread, cotton, portions of feathers—in fact, any substance that could possibly stick in the throat. Originally something may have lodged there, but as a rule it has been removed by retching or coughing before the physician was called. Hysterical and nervous persons of both sexes frequently complain of a lump in the throat (globus hystericus), of a burning pain, or of a feeling of icy coldness during the breathing.

Another one of the common forms of paræsthesia is the belief that there is a carcinoma in the throat, the circumvallate papillæ having been felt by the finger; and it is often extremely difficult to rid the mind of the individual of the idea that a new growth is present.

A feeling of extreme dryness, without material objective change, is frequent in mouth-breathers; in chlorosis, anæmia, and diabetes; and in users of morphine, atropine, or belladonna.

Paræsthesia is a more or less constant accompaniment of the chronic pharyngeal catarrhs. It is found in connection with tonsillar affections and with the various pathological changes of the nose and nasopharynx. Inflammations of the interarytenoid region, neuralgia of the superior laryngeal nerve, and affections of the central nervous system are also causative. It can occur as a reflex condition accompanying anæmia, chlorosis, hysteria, uterine and ovarian diseases, early phthisis, and hypochondriasis.

The *diagnosis* is dependent upon a careful examination of the entire pharynx, which must include an examination of the nasopharynx, tonsils and larynx as well, so that no possible source of irritation, direct or remote, shall be overlooked. The patient will usually tell whenever a painful area is touched with the probe. Sometimes there are several of these points, which disappear upon painting the area with ten per cent. cocaine. The course is very chronic.

Treatment must depend entirely upon the cause. So far as anything local can be found, appropriate treatment is to be given; while for general nervousness and hysteria the treatment appropriate to this condition must be applied.

SECRETORY NEUROSES.—Hypersecretion of the pharynx is a condition which not infrequently occurs, especially in singers. Individuals with apparently completely normal mucous membranes complain of an increased secretion of slimy mucus in the pharynx, nasopharynx, or larynx, making it necessary to swallow very often, and to spit a great deal when talking, the swallowed secretion being frequently vomited early in the morning. Examination shows more or less of this mucus on the back of the pharyngeal wall and around the velum palati. This condition is sometimes observed in old people. Its cause seems to be some disturbance in the nervous control of the secretory glands.

Treatment is only partially successful. The condition sometimes disappears of itself, but is liable to return. Belladonna has been recommended. Small doses of iodide of potassium or the syrup of hydriodic acid frequently do good by increasing somewhat the secretion of the glands, so that the slimy mucus is less thick and therefore less complained of.

There is also a condition of nervous lessening of secretion, with a feeling of great dryness, seen in connection with hysteria or the use of morphine or belladonna, and found in sufferers from diabetes.

NEUROSES OF MOBILITY. Cramp-like spasm of the constrictors occurs occasionally, most frequently in persons suffering from dyspepsia or some stomach affection; in general functional neurosis; occasionally in granular pharyngitis, hypertrophy of the side walls, and in connection with inflammatory processes at the base of the tongue. Cramp-like constriction of the muscles, interfering with swallowing, is found in connection with diseases of the brain, and is an accompaniment of tabes. It is most commonly seen as a tonic cramp in hysterical dysphagia. The muscles of the œsophagus are affected at the same time. In cramp of the muscles of swallowing, the passage downward of the mass of food is more or less interfered with. In hysterical dysphagia the swallowed mass is temporarily arrested at some point, usually with a sense of pressure and pain in the neck and around the sternum, then without further hindrance it passes into the stomach, or else with a feeling of suffocation, choking, and explosion of gases from the stomach it is vomited out. The swallowing of solid substances may be impossible for days or weeks

Cramp of the muscles of the soft palate occurs comparatively seldom. When of a tonic nature the velum is in close contact with the posterior pharyngeal wall, resulting in an altered tone and impossibility of breathing through the nose. The cramp may be of a clonic nature, affecting only single muscles of the velum, as the levator or tensor or the azygos uvulæ. The causes are very various, consisting of true alterations in the nerve supply, central and peripheral irritations, and pathological processes in the immediate neighborhood.

The *diagnosis* of the various forms of cramp-like action of the muscles is not always easy, since hysterical dysphagia can simulate many affections. It can be differentiated from true paralysis of the muscles of the pharynx by its intermittence, as the phenomenon is not constant. The use of the sound, careful observation of the patient, and the study of all the possible causes will usually enable one to make a diagnosis.

Prognosis depends entirely upon the pathology, as does also the *treatment*.

PARALYSES OF THE PHARYNX.—These are mostly of central origin. Acute and chronic inflammation of the brain; tumors; hemorrhages which bring about compres-

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sion of the vagus, accessorius, and glossopharyngeus nerves and their branches; as well as degenerative processes of the brain and medulla, such as bulbar paralysis, tabes, progressive muscular atrophy, and facial paralysis; lead intoxication; phthisis; grippe; pressure of carcinomatous glands upon the vagus or its branches—all these may have muscular disturbances of the pharynx as their sequelæ. Of the peripheral causes diphtheria and scarlet fever are the most frequent. Syphilis and general neuritis are also causative.

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Paralyses of sensation and of motion often occur together. Paralysis of the soft palate is the most frequent, and may be one-sided or double-sided, complete or incomplete. When it is one-sided, the palate is drawn sometimes toward the sound and sometimes toward the diseased side. The arch of the paralyzed side is deeper, while on the sound side the arch is higher and narrower. During phonation the velum comes toward the sound side. When the uvula alone is paralyzed, which is a frequent condition in pharynx or larynx catarrh and in paralysis of the vocal cords, it goes toward the sound side. In double paralysis of the velum, it hangs with the uvula straight down and shows no sign of active movement except in respiration, when the uvula moves slightly backward and forward; during phonation there is a slight attempt for it to reach the posterior wall. The voice has a very nasal tone. There is seldom difficulty in swallowing.

Paralysis of the constrictors of the pharynx, with or without accompanying paralysis of the velum and of the œsophagus, is most frequent in connection with diphtheria, scarlet fever, and the other infectious diseases and in bulbar paralysis. When the paralysis is limited to the constrictors, particles of food lodge at the base of the tongue and in the adjacent sinuses, and fluids pass easily into the larynx, producing intense cough and suffocation. If the superior constrictor alone is paralyzed, the particles of food may be thrown into the nose.

The *diagnosis* of paralysis of the muscles of the pharynx is very easy, but the condition is often overlooked, especially when the paralysis is incomplete. The incomplete paralysis often suggests adenoid vegetations or polypi in the nose. When brought about through inflammatory or mechanical causes there are redness, swelling, œdema, ulcers, and cicatrices. The cause of the paralysis is often difficult to find.

In central paralysis the electro-motor excitability is normal and can remain so. In complete peripheral paralysis the electro-motor excitability very rapidly diminishes and can be lost by the third week.

Hysterical paralysis begins suddenly, disappears suddenly, and comes again without apparent cause.

The *prognosis* and the treatment must depend entirely upon the cause. Prognosis is not good when the condition is of central origin, but good when of diphtheritic, rheumatic, infectious, or of local inflammatory origin.

Electricity is the best remedy. The faradic current can be used to advantage, although the galvanic current is preferable. When the paralysis has lasted any length of time both are indicated, as the faradic current helps maintain the nutrition of the muscle while the galvanic directly stimulates the nerve. When electricity is used one electrode should be placed on the cervical vertebræ or the anterior surface of the neck, the other on the pharyngeal wall against the paralyzed muscle. The pharyngeal electrode should be one in which the current can be turned off and on. Strychnine internally, and remedies which promote the general nutrition both of the local part and of the general constitution are to be used in addition to the electricity.

George L. Richards.

PHENACETIN.—(*Para-acet-phenetidin.*) This well-known and popular derivative of coal tar was introduced in 1887 by Dr. O. Hinsberg and Prof. A. Kast.[1] Its chemical formula is $C_6H_4OC_2H_5NHCH_3CO$. In the last revision of the British Pharmacopœia it was recognized as an official drug. The chemical relation of phenacetin to allied compounds will be readily understood by reference to the following formulæ:

Acetanilid, $C_6H_4\begin{cases}H\\NHCH_3CO.\end{cases}$

Exalgin, $C_6H_4\begin{cases}CH_3\\NHCH_3CO.\end{cases}$

Methacetin, $C_6H_4\begin{cases}OCH_3\\NHCH_3CO.\end{cases}$

Phenacetin, $C_6H_4\begin{cases}OC_2H_5\\NHCH_3CO.\end{cases}$

Phenocoll, $C_6H_4\begin{cases}OC_2H_5\\NHCH_2NH_2CO.\end{cases}$

Phenazone, or antipyrin, which is therapeutically allied to the above, is related only so far as all are derived from phenyl compounds; its formula is

$$C_6H_5N\begin{cases}COCH\\NCH_3CCH_3.\end{cases}$$

Phenacetin forms in white, glistening, scaly crystals, without odor or taste. It is slightly soluble in cold water, 1 part in 1,500; more soluble in hot water, 1 part in 70; and freely soluble in rectified spirits, 1 part in 16; it is also soluble in glycerin. The crystals melt at 275° F. A recognized test for phenacetin is the production of a deep red color when chromic acid is added to a cooled and filtered solution of one grain in twenty minims of hydrochloric acid diluted with ten times its volume of water. Sulphuric acid should dissolve it without color, and burned with free access of air it should leave no residue. The presence of paraphenetidin may be detected by melting forty grains of chloral hydrate in a water-bath, and adding eight grains of phenacetin and well shaking; a solution takes place which is colored violet, reddish, or bluish in tint, according to the proportion of the impurity present. Another test, though less delicate, is to add eight grains of phenacetin to one and a half drachms of iodine solution, 1 to 20,000; when filtered a pure salt yields a colorless liquid; a pink tint indicates the presence of paraphenetidin. Phenacetin does not form a bromine compound as acetanilid does, and this reaction furnishes a test for the presence of the latter salt; the addition of bromine water to a saturated solution of the suspected salt, imparts a yellow color; if acetanilid is present the solution becomes turbid, if it is absent it remains clear. The presence of acetanilid, exalgin, or methacetin may be detected by adding two grains to twenty minims of concentrated hydrochloric acid; phenacetin remains undissolved, the other salts enter into solution.

Phenacetin was introduced as an analgesic and antipyretic much superior to the other similar compounds, on account of its freedom from any toxic action. It rapidly established a reputation as one of the most safe of the numerous new antipyretics, and has been very extensively employed in all febrile diseases, and for the relief of pain in all its forms. Its action is not accompanied by the numerous unfavorable symptoms that are common to the coal-tar derivatives. The most frequent undesirable effect that may be caused by its use is the onset of sweating, more or less profuse. Although its composition is such that it may cause the alterations of the blood that are produced by exalgin, acetanilid, etc., the instances in which any such condition follows its use are extremely rare. Some cases, however, are reported in which there were paleness and coldness of the extremities, free perspiration, precordial pain, dyspnœa, shallow respiration, feeble pulse, cyanosis, and other evidences of collapse. Many of these cases of poisoning occurred in females, and generally followed the employment of large doses; but in one case only three doses of seven grains each were given. The presence of impurities, especially paraphenetidin, is undoubtedly the cause of many of the unfavorable symptoms. Very large doses have been given without any ill effects. A case is reported in which sixty grains were given daily for two weeks, as an anodyne; in another case one ounce and one drachm were given during one week to a patient with neuritis, and in

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a case of tetanus one ounce and five drachms were given in nineteen days. During experimental research upon animals, it has been given for a prolonged period in doses equal to one and two-thirds grain per pound of body weight without producing any derangement of the system, or causing any irritation to the mucous membrane of the stomach.[1]

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A series of experiments on animals by Drs. Cerna and Carter[2] have led them to the following conclusions: (1) Phenacetin in moderate doses causes a rise of the arterial pressure by acting upon the heart, and probably likewise by exerting a stimulating influence on the vaso-motor system. (2) In large amounts it causes a reduction in the pressure, which is largely of cardiac origin. (3) In small doses it increases the force of the heart by a direct action. (4) It increases the pulse rate chiefly by cardiac stimulation, and possibly also by influencing the cardio-accelerating apparatus. (5) In large quantities the drug reduces the number of pulsations, primarily by stimulating the cardio-inhibitory centres, and later by a depressant action on the heart. They also found that in large amounts it caused a marked quickening of the respiratory movements by a direct action on the medulla, and that where sufficient quantities were given to produce death it was due to respiratory failure. (See also *Phenocoll.*)

As an antipyretic it is given in doses of from five to ten grains, every hour or every two hours. It reduces the temperature slowly and effectively; during the first and second hours there is not much influence on the fever, but in the third hour its greatest effect is manifested. The continuation of the afebrile state varies, but usually after the fourth or fifth hour the temperature begins to ascend. The fall of the temperature results chiefly from a decrease in heat production, with a slight increase in the heat dissipation. The slow action of the drug is thought to depend on its insolubility. In chronic febrile troubles its action is not so marked, and a tolerance of the drug appears to ensue upon its prolonged administration. When there are pain, restlessness, and insomnia accompanying the fever, the beneficial effects of the drug are most marked. A sense of ease and comfort is produced, and a calm, refreshing sleep follows. By some it has been supposed to exert a decided hypnotic action, but careful observations in melancholia and mania have not confirmed this view. In typhoid fever it has proved of great service. From five to eight grains are generally sufficient to reduce the temperature to normal in about three hours; when it begins to rise again a second dose will prevent any hyperpyrexia for twenty-four hours. Many prefer to employ it in smaller doses frequently repeated—two grains every two or three hours and continued throughout the period of pyrexia; in this way it maintains the temperature at a low point and the fever runs a mild and uncomplicated course. In children it proves beneficial in all febrile disorders; single doses of two grains will produce a lowering of temperature, or it may be given in fractional parts of a grain every two or three hours; one-third of a grain having proved sufficient to subdue the fever and allay restlessness. For "*la grippe*" it has proved very serviceable, and has replaced the older antipyretics to a very great extent. In this disease the small and frequently repeated doses were of little avail, a single dose of ten or fifteen grains being generally sufficient to relieve the fever and the severe cephalalgia with which it was usually accompanied. One of its earliest applications was as an anti-rheumatic. It has no influence in warding off the cardiac and other visceral complications, but it reduces the fever and lessens the pain and swelling in the joints; to be of any benefit it must be employed in much larger doses than in any other febrile affection. At least fifteen or twenty grains must be given three times daily, and some state that a better effect is produced by thirty grains given twice in the day. In children five grains three or four times a day may be required. In painful affections unaccompanied by fever, and in the various forms of neuralgia, it requires to be given in the same full doses to secure a relief from suffering. A single dose of from fifteen to twenty grains will prove sufficient when any benefit is to be derived, while small and frequent doses exercise very little, if any, action in controlling the pain. Phenacetin has also acquired a reputation as a remedy for whooping-cough. It is given in doses of from half a grain up to two grains every four hours, and affords rapid relief to the severe paroxysms. It is also supposed to shorten the duration of the disease.

Compared with the allied drugs, phenacetin may be said to be more pleasant and safe, but less powerful and slower in its action; and perhaps less certain, as it frequently fails to produce the desired effect.

Iodophenacetin or *iodophenin* is a compound of iodine and phenacetin introduced by Dr. Scholvein, at a meeting of the Berlin Pharmaceutical Society, 1891. It contains fifty per cent. of iodine, and forms in steel-blue crystals, with an odor of iodine and a burning taste. Water decomposes the salt, liberating the iodine in a free state. It possesses the active germicidal and antiseptic properties of iodine, and owing to the looseness of its combination it was suggested as an intestinal antiseptic. The local irritation proved a source of discomfort, and toxic symptoms frequently followed its employment. It is now seldom employed. *Beaumont Small.*

[1] Centralb. f. gesam. Therap., April, 1887.
[2] Therapeutic Gazette, March, 1893.

PHENACETIN, POISONING BY. See *Synthetic Poisons, Organic.*

PHENALGIN—ammonio-phenylacetamid—is a fine white powder of ammoniacal odor and slightly alkaline taste. With water it makes an alkaline solution. It is a proprietary remedy of uncertain composition, stated to be an efficient analgesic, antipyretic, and antiperiodic. The ammonia present is intended to prevent depression of heart and respiration. Dose 0.3–1.3 gm. (gr. v.–xx.). *W. A. Bastedo.*

PHENAZONE. See *Antipyrin.*

PHENEGOL. See *Egols.*

PHENOCOLL.—(Amido-acet-para-phenetidin.) During the past few years our knowledge of the chemistry of modern antipyretics has so far advanced that new synthetical remedies are produced, the therapeutic properties of which have been carefully considered beforehand. Such a one has been prepared by German manufacturers and introduced under the name of phenocoll. It is said to be an antipyretic, possessed of all the favorable qualities of phenacetin, and devoid of any of its undesirable effects. It is obtained by replacing in phenacetin one hydrogen atom of the acetyl group by the amido group NH_2. Its formula is

$$C_6H_4OC_2H_5NHCOCH_2NH_2 + H_2O.$$

Phenocoll, the base, forms in white acicular crystals which have a tendency to mat themselves together. It is readily soluble in alcohol and warm water, but only slightly in chloroform, ether, and cold water. Dilute caustic alkalies, or dilute acids when cold, have no power to split up the compound, but by prolonged boiling it is resolved into its constituents. The most important characteristic of this compound is its power of combining with acids and forming soluble salts.

The *hydrochlorid of phenocoll* is the salt generally employed, but salts have also been formed with other acids. The *salicylate* occurs in long needles; it has a sweetish and not disagreeable taste, and is supposed to add some of the therapeutic properties of salicylic acid to phenocoll. It has been introduced to the profession under the name *salocoll.*

Phenocoll hydrochloride is a white, minutely crystalline powder, with a bitter, saline, but not disagreeable taste. It is soluble in cold water, about one part in sixteen, forming a neutral, stable solution. It is still more soluble in hot water and in alcohol.

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The superiority claimed for it over other antipyretics was based not only on its greater solubility and more rapid action, but also on its perfect harmlessness. The result of experiments by Dr. Isaac Ott, however, shows that in very large quantities it produces the same effects as phenacetin and similar compounds. He reports: (1) that upon frogs it produces a general paralysis, due to an action upon the cerebrospinal axis; (2) upon rabbits it produces a cyanotic condition of the ears, and reduces the force and frequency of the heart; (3) it kills through an action upon the centre of respiration.

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The investigations and clinical reports upon the action of this new remedy have been chiefly made in Germany and Italy, but Drs. Cerna and Carter, of Philadelphia, have done some very thorough experimental work, to determine the comparative action of antipyrin, phenacetin, and phenocoll. The following are their conclusions regarding its action on the heart and circulation:

1. Phenocoll, in ordinary amounts, has practically no effect upon the circulation.

2. Large doses diminish the blood pressure by influencing the heart.

3. Phenocoll reduces the pulse rate by stimulating the cardio-inhibitory centres. It then increases the rapidity of the pulse by paralyzing said centres. The final diminution is of cardiac origin.

4. Upon the blood itself phenocoll has no action.

As to the relative action of the three antipyretics that were experimented with, they sum all as follows:

1. Antipyrin, phenacetin, and phenocoll all fail to produce any effect on the heat functions of the normal animal.

2. Antipyrin produces a decided fall of temperature in the first hour after its administration in the fevered animal. This reduction is due to a great increase in heat dissipation, together with a fall in the heat production.

3. Phenacetin, both in septic and in albumose fevers, produces a very slight fall of temperature during the first and second hours after its ingestion by the stomach, but the greatest reduction occurs during the third hour after its ingestion. The fall of temperature results chiefly from a decrease in heat production, with a slight increase in the heat dissipation. The increase in dissipation is not as great as with antipyrin. Probably the delayed action of the drug depends on its insolubility.

4. Phenocoll causes in fever a very decided fall in temperature, which occurs during the first hour after the administration of the drug by the stomach. This reduction is the result of an enormous diminution of heat production, without any alteration of heat dissipation.

Phenocoll has been recommended as an antipyretic, analgesic, antirheumatic, and antiperiodic, but has not proved itself of particular value. Its action resembles that of phenacetin, but phenocoll requires to be given in larger doses. In some instances ill effects have followed its employment. Excessive sweating, dyspnœa, marked depression, rashes, darkened urine, and many other unfavorable symptoms have been reported.

Beaumont Small.

PHENOL-BISMUTH — $C_6H_5O.Bi(OH)_2$ — is a practically odorless and tasteless, white, non-irritant, and nontoxic powder, containing nineteen per cent. of phenol. Like other bismuth preparations, it is used as a mechanical sedative and antiseptic to the gastro-intestinal tract, but in addition, as shown by the urine, sets free some of its phenol. No poisonous effects have been noticed (Jasenski) from taking 5 gm. (gr. lxxv.) a day for three weeks. R. W. Wilcox says that it is superior to all other forms of bismuth in fermentative dyspepsias and in chronic gastritis marked by pyrosis, or boulimia. The dose is 1–5 gm. (gr. xv.–lxxv.) daily. *W. A. Bastedo.*

PHENOLPHTHALEIN — $C_6H_4.CO.C(C_6H_4OH)_2.O$ — is prepared by digesting ten parts of phenol, five parts phthalic anhydride, and four parts concentrated sulphuric acid for several hours, boiling the residue with water to remove soluble matter, and then boiling the remaining resinous substance in benzol. Phenolphthalein is a yellowish-brown powder, which, in 1 to 30 alcoholic solution, serves as an acid-alkali indicator in volumetric analysis. Colorless in acid solutions, it turns a brilliant pink on neutralization with an alkali. It is not, however, a safe indicator for the carbonated alkalies.

At the British Medical Association, 1902, Tunnicliffe reported over one thousand cases of its use as a cathartic. It may safely be employed in renal disease as it is excreted by the intestines and not by the kidneys. The dose is 0.15–1 gm. (gr. iiss.–xv.) in tablets, 0.3 gm. (gr. v.) being usually sufficient to purge an adult.

W. A. Bastedo.

PHENOL, POISONING BY.—This substance, now a very familiar antiseptic, is known more generally as carbolic or phenic acid, also as coal-tar creosote. True creosote, the characteristic ingredient of wood-tar, especially that from beech-wood, is not identical with phenol.

Phenol, as the common name indicates, has some acid properties, but is, more strictly speaking, an alcohol. Its formula is C_6H_5HO. When pure it is a colorless, crystalline, deliquescent mass, soluble in water, alcohol, and glycerin, with a well-marked odor, and a burning taste. The *crude carbolic acid* of commerce is variable in composition, and often consists of little else than neutral tar oils, which are destitute of any antiseptic qualities.

Applied to the skin, phenol produces a white superficial eschar; on the mucous surface the effect is more severe. A number of cases are recorded in which death has resulted from external application, even to a limited surface. The introduction, at a comparatively recent date, of phenol in antiseptic surgery has been responsible for several fatal cases.

When phenol is swallowed in moderate concentration an intense burning sensation is immediately experienced in the throat, œsophagus, and stomach, the mucous membrane becoming white and hardened. Vomiting of a frothy mucus occurs. The skin becomes cold, the lips and ears livid, pupils contracted and insensitive, and breathing difficult; the pulse may be 120 and irregular. The urine becomes dark-colored, and may be suppressed. These symptoms are soon followed by insensibility, with stertorous breathing. The appearances after death are largely those of local action of the poison, but the train of symptoms shows that, as in the case of nearly all other poisons, there is a distinct action on the nervous system to which the fatal result is largely due.

The fatal quantity is somewhat difficult to fix, owing to the great variation in strength of the commercial solutions, in which form the acid is generally encountered in cases of poisoning. In one case noted by Taylor a woman died in about half an hour after swallowing a wineglassful of, probably, a weak aqueous solution of phenol. The minimum fatal dose is given by some authorities as one drachm, but recovery from such an amount is possible. Half an ounce is almost invariably fatal. Fatal results have several times occurred rather rapidly, that is, in less than an hour.

The best antidote is alcohol—the strong commercial spirit for external application, common whiskey, or the commercial spirit diluted considerably, for internal use. The alcohol not only stops the action of the poison, but if the damage be not very great, it restores the condition of the tissues. Other chemical antidotes that have been advised are magnesium sulphate, sodium sulphate (these are supposed to form less active sulphonates), syrup of lime, and even vinegar. The manner in which the last-named acts is not explained, but it has been strongly recommended by some persons. After the severe symptoms have abated, the stomach should be washed out with tepid water. It is not advisable to attempt to produce vomiting either by emetics or by hypodermic use of apomorphine. *Henry Leffmann.*

PHENOL-SODIUM SULFORICINATE is a yellowish liquid soluble in water and alcohol, and recommended by Von Tovolgyi for tuberculous laryngitis. Used like lac-

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tic acid without preparatory anæsthetization of the throat, it reduces the tuberculous infiltration and favorably influences the dysphagia. It has also been used for diphtheritic throats and in skin diseases. *W. A. Bastedo.*

PHENOLURIA. See Urine. www.libtool.com.cn

PHENOSAL—$C_6H_4.OC_2H_5.NH.CO.CH_2.O.C_6H_4COOH$—is the aceto-salicylate of phenetidin, and occurs in sparingly soluble needles or plates of acidulous taste. In the alimentary tract it breaks up, yielding fifty-seven per cent. of phenetidin and thirty-four per cent. of salicylic acid. It is antipyretic, and is especially recommended in rheumatism. The dose is 0.3–0.7 gm. (gr. v.–x.) three or four times a day. *W. A. Bastedo.*

PHENOSALYL.—This compound antiseptic is the result of a series of experiments upon various antiseptics by Dr. de Christmas, in the Pasteur Institute, Paris. He has shown that when certain antiseptics are associated together in one and the same solution, the microbicide power is greater than that of the sum of the solutions of each acting separately. The preparation to which he has given the name phenosalyl is considered by him to be a most efficient antiseptic, its action on the various bacteria being exceeded only by sublimate. It has the following composition: Carbolic acid, 90 parts; salicylic acid, 10 parts; lactic acid, 20 parts; menthol, 1 part.

The three acids are heated up to the point of liquefaction, when the menthol is added. It is very soluble in glycerin, and in water to the extent of four per cent. *Beaumont Small.*

PHENOSUCCIN—pyrantin, para-ethoxy-phenyl succinimide, $C_6H_4.OC_2H_5.N(COCH_2)_2$—obtained by the action of succinic acid on para-amido-phenol, occurs in colorless needles which are insoluble in water and ether, but soluble in alcohol and acetic acid. It is antipyretic and antineuralgic in dose of 1–3 gm. (gr. xv.–xlv.) daily, clinical experience showing that it has no depressing effect except in large quantities. The sodium salt forms a sweetish solution with water. *W. A. Bastedo.*

PHENYL-ACETIC ACID—alpha-toluic acid, $C_6H_5.CH_2.COOH$—is obtained by boiling benzyl cyanide with potassium hydroxide solution. It occurs in white glassy scales of burning aromatic taste and soluble in hot water and alcohol. It is given in dose of 0.06–0.15 gm. (gr. i.–iss.) with cod-liver oil for tuberculosis of the lungs. *W. A. Bastedo.*

PHENYLHYDRAZINE—$C_6H_5.NH.NH_2$.—a colorless oily liquid which solidifies into tabular crystals. It is slightly soluble in water. An hydrochloride forms in colorless scales which are readily soluble in water. Phenylhydrazine is an intermediary product in the preparation of many antipyretics, notably antipyrin and hydracetine, but its toxic action is too marked to allow of its employment as a therapeutic agent. *Phenylhydrazine levulinic acid*, under the registered title of *antithermin*, was employed as an antipyretic in doses of five grains. It is now but little used, as its action is uncertain, and is not so safe as that of antipyrin and other similar preparations.

Phenylhydrazine is best known as a test for the presence of sugar in urine, and is known as Fischer's test. It was discovered by Prof. Emil Fischer, and depends upon the property of the sugar forming, in the presence of phenylhydrazine, crystals of phenylglucosazone. *Beaumont Small.*

PHENYL-SALICYLIC ACID—ortho-oxy-diphenyl-carboxylic acid, $C_6H_3.OH.C_6H_5COOH$—is a white powder, slightly soluble in water and more so in alcohol and glycerin, and is employed as an antiseptic dusting powder. *W. A. Bastedo.*

PHILADELPHIA, PA.—Philadelphia, founded by William Penn, was the first capital of the United States. The population was estimated January 1st, 1903, at 1,347,712. The city, situated at the confluence of the Delaware and Schuylkill Rivers, in latitude 39° 57' north, is nearly on a line with Madrid and Lisbon, and is about sixty miles from the sea in a direct line. The intervening portion of the State of New Jersey is almost a level plain, abounding in pine, oak, and other timber of second growth. To the westward the land rises gradually and the nearest mountain ridges are from fifty to one hundred miles distant. The highest elevation within the limits of Philadelphia is 450 feet. The mean annual temperature is 53° F., with extremes of —6° F. (1889) to 103° F. (1901). The extremes in 1902 were 12° F., February 5th, and 95° F. July 9th. Precipitation, 49.76 inches. Days with precipitation of 0.01 inch or more, 128. Snowfall, 32.2 inches, distributed as follows: January, 7.7 inches; February, 14.3 inches; March, 4.2 inches; December, 6 inches.

Clear days, 131; partly cloudy, 103; cloudy, 131. Thunderstorms, February, 1; March, 3; April, 1; May, 3; June, 8; July, 13; August, 9; November, 1; total, 39.

The prevailing direction of the wind was northwest and the maximum velocity was 52 miles an hour, from the north, on December 5th. While the mean temperature for the year is about 5.7° F. higher than at London, the mean for January is 3° F. lower, and for July 15° F. higher. The relative humidity at 8 A.M. and 8 P.M. is 75 per cent. and 68 per cent. The rainfall averages 43 inches, considerably greater than that of London (24.84 inches). London, however, exceeds Philadelphia, as well as New York, Boston, Chicago, and all the principal cities of the United States in the number of rainy days. There are about 129 clear days each year in Philadelphia, which is less than at Baltimore (141), at Denver (150), or at Phœnix, Arizona (259). The spring opens in Philadelphia two or three weeks earlier than at Boston, and autumn lasts longer. Roses may bloom through November. The winters are not generally severe. Comparatively little snow falls, yet there may be days or weeks of temperature below the freezing point. Philadelphia has 36 parks, the largest, Fairmount Park, containing over 3,300 acres, through which flows the Schuylkill River, spanned by four bridges. Within the limits of the park the river reaches a width of about one-fourth of a mile. At the northernmost boundary of the East Park the romantic Wissahickon stream empties into the Schuylkill, and the beautiful paths along its borders are favorite resorts for driving, riding, cycling, and walking, while the well-wooded hills that rise just beyond are attractive places for picnics. There is excellent boating on the Schuylkill and on the Wissahickon. Throughout the park at convenient places are houses of rest, restaurants, dairies, and playgrounds. The natural beauties of the grounds are preserved as far as possible. At the southwestern border of the park is the extensive Zoological Garden.

Fairmount Park is of inestimable value to the citizens of Philadelphia, and doubtless exerts a controlling influence on the death rate, particularly among children.

The general death rate of Philadelphia in 1902 was 17.67 per 1,000 population. It was lower than that of New York City (18.74), and reflects credit on the energetic measures adopted by the Bureau of Health. Careful and minute attention is paid to disinfection after contagious disease has been reported. Vaccination has been vigorously carried out. During the past year (1902) the deaths from smallpox numbered 231; from scarlet fever, 143; from diphtheria, 435; from diseases of the heart, 1681; from pulmonary tuberculosis, 2845, and from pneumonia, 2976. The deaths from consumption have recently fallen to second place, owing to a wider knowledge of the principles governing the spread of the disease and to the distribution of pamphlets showing how the disease may be prevented. The Pennsylvania Society for the Prevention of Tuberculosis has assisted in this way to limit the spread of the disease.

Great good will accrue from the recent gift of $1,000,000 by Mr. Henry Phipps for a systematic effort in Philadelphia to eradicate tuberculosis by the establishment of

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public clinics, sanatoria, and the dissemination of information as to the means of prevention. This will greatly aid the work of the Free Hospital for Poor Consumptives. The recent gift of Mr. Andrew Carnegie of $1,500,000 for thirty branches of the Free Library of Philadelphia, and the completion of the Boys' High School, a building which cost with its equipment $1,500,000, and which is probably the finest school building in the world, are notable steps toward the city's progress in education.

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Philadelphia is in a transition state with reference to great municipal improvements. Chief of these is the construction of enormous filtration beds at Torresdale, on the Delaware front, in the northeastern portion of the city, at Roxborough in the northern portion, and at Belmont in the northwestern portion. These are partially completed and will cost over $17,000,000, and they will insure a satisfactory water supply.

The Philadelphia Hospital, with its insane department and almshouse, is situated on the lower Schuylkill, and comprises within its walls a total population of about five thousand. Steps have recently been taken to remove the hospital for the insane and the almshouse to a new location below Torresdale, and on the property known as Blockley a new Philadelphia General Hospital will be erected. The original buildings constructed in 1834 will be torn down and new buildings erected in accordance with modern plans.

The Municipal Hospital for Contagious diseases will shortly be removed to a new site in the northeastern portion of the city. There are over fifty hospitals in Philadelphia. Chief of these is the Pennsylvania Hospital, the oldest institution of the kind in the United States.

The Medical Department of the University of Pennsylvania was established in 1765 by Dr. John Morgan, Dr. William Shippen, Dr. Adam Kuhn, and Dr. Benjamin Rush, who constituted the first medical faculty in America. The number of its graduates is 12,361, and with the sister schools of Jefferson College, the Medico-Chirurgical, and the Woman's Medical College, this school has had a strong influence in maintaining the high standard of medical education in the United States.

Philadelphia has long been famous for its teachers of medicine and surgery, and their contributions to medical literature, issued by the well-known medical publishers of the city, have carried the fame of American medicine throughout the world. The names of Benjamin Rush, Shippen, Physick, Wistar and Horner, Barton, Chapman, Pancoast, Gross, Stillé, Hodge, Pepper, Wood, Da Costa, Agnew, and Mitchell are household names in the medical history of our country. *Guy Hinsdale.*

PHILIPPINES, THE. See *Manila.*

PHIMOSIS. See *Sexual Organs, Male, Diseases of.*

PHLEGMON.—Definition.—To set exact limits to the term phlegmon is far from easy. Etymologically the word signifies no more than inflammation (the idea of "heat" or "burning" being equally present in both terms —*φλέγειν*—inflammare). Naturally, therefore, it has ever been loosely used. The concept has been merged, on the one side, into that of the so called cellulo-cutaneous erysipelas; on the other, into that of the localized abscess.

French and German surgeons use the word in its widest sense. By phlegmon they mean any pyogenic inflammation beginning in the subcutaneous cellular tissue; even furuncle and carbuncle are by some described as varieties of the class phlegmon. In this idea they usually classify phlegmons as (*a*) simple or circumscribed, a localized inflammation resulting in a localized abscess; and (*b*) diffuse or spreading.

English and American surgeons, however, have come rather generally to attach to the word almost exclusively the latter signification, that of a diffuse process.

Inclining to the latter view the writer would adopt Ziegler's definition and restrict the term phlegmon to that pathological process in which there occurs a more or less extensive inflammatory exudate of sero-purulent or sero-fibrino-purulent nature (often called purulent œdema), spreading rapidly in the subcutaneous or in any of the submucous tissues over a somewhat large area. The causative agent is, so far as we know, always bacterial. The process may spread deeply and involve muscles, fascia, and even periosteum, and may lead to pyæmia or septicæmia.

In this sense the term must include those cases which are usually called "phlegmonous erysipelas," for the pathological and even the clinical pictures are practically identical, and the etiological factor is the same. Phlegmonous erysipelas, however, will be found discussed under *Erysipelas* in this Handbook.

On the other hand, we have those comparatively mild cases of "cellulitis" which, after showing some tendency to spread, subside easily under hot applications, or spontaneously, without causing material anxiety. These, too, must be considered to be phlegmonous, though of a mild type, because their nature pathologically and bacteriologically is the same as that of the more severe destructive process with which we usually associate the idea of phlegmon. The essential—that of a spreading inflammatory exudate caused by pyogenic organisms—is the same; and the difference, one only of degree.

While the process usually has its main seat in the subepithelial structure, it may at times involve principally deep areas of areolar tissue, such as the mediastinum, the prevertebral, or the deep perineal region. In such cases the atrium of infection may not be evident.

Etiology.—Phlegmons are in all cases due to the invasion of micro-organisms in a soil unable to resist their growth. It is with reference to both our bacteriological and our clinical knowledge that the writer would suggest the following classification*:

I. Those caused by streptococci, staphylococci, or both; also those ascribed to rarer organisms, *e.g.*, pneumococcus, gonococcus, etc.

II. Those in which the entrance of gas-forming bacteria, with or without (but most often with) the above-mentioned organisms, leads to the development of a subcutaneous emphysema and gangrene in addition to the inflammatory signs of the ordinary phlegmon. This class is called "progressive gangrenous emphysema," "gangrène foudroyante," or "gas phlegmon."

III. Those caused by the extravasation of urine.

Such a classification is naturally far from arbitrary. The classes frequently overlap. For instance, a urinary extravasation is no doubt often, in part, a streptococcus phlegmon, and may be also in part a B. aerogenes capsulatus infection. The last-named is mostly combined with an infection of Class I. Class I. affords by far the greatest number of phlegmons.

It is evident that the discussion of the etiology of phlegmons must be almost entirely bacteriological. It will be in place, however, to say first a few words in regard to the *mode of entrance* of the organisms concerned. In general the *atrium* is a wound of some sort—from the most insignificant abrasion to the most complicated injury. As a matter of fact we find that phlegmons develop most frequently in connection with the more severe injuries. The contusion of the tissues in such cases renders them less resistant, while the recesses of large wounds offer greater opportunities, both for the entrance of infective matter and for the development of anaërobic bacteria, and also render cleansing less easy.

The classical descriptions of severe phlegmon, especially of the gaseous form, are those furnished us by military surgeons of the two preceding generations. Gunshot wounds and open fractures are clinically the injuries

* In the following discussion I have avoided the term "malignant œdema" because of its lack of exactness. It has evidently hitherto been used in a loose sense, to designate cases both of gas-bacillus infection (*i.e.*, gangrène foudroyante, progressive emphysematous gangrene, etc.) and of severe strepto- or staphylococcus phlegmon, as well as of phlegmon due to the bacillus of malignant œdema (Koch). Further, the term in itself suggests that the bacillus of malignant œdema is the causative factor, whereas late investigation has shown that this bacillus is but rarely at fault.

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most frequently complicated by phlegmon, punctured wounds less frequently, clean cuts least often of all. Two or three cases are on record of the development of gas phlegmon following a hypodermic injection, or the subcutaneous injection of saline solution. In some cases the wound of entrance is not in the skin but in a mucous membrane. Finally, in some cases, no point of entrance can be found.

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Going on to discuss more in detail the bacteriology of phlegmon, we shall have to treat particularly of: (*a*) the relative rôles of the pyogenic cocci; (*b*) the bacillus aerogenes capsulatus and other gas-forming bacteria; and (*c*) the nature of the phlegmon of urinary extravasation.

(*a*) Since the work of Ogston and Rosenbach in the early period of bacteriology (1880–85), it has been taught, and is still generally believed, that, while the staphylococcus is nearly always the cause of circumscribed abscesses, phlegmonous inflammation is due to the streptococcus pyogenes. More extended knowledge, however, has shown us that such a proposition, while possibly true in many cases, must suffer numerous exceptions. It would carry us beyond the proper limits of this article to go fully into the question of the streptococcus as a disease-producer. Nevertheless, inasmuch as the phlegmon has hitherto been considered a streptococcus inflammation *par excellence*, it may not be amiss to consider here whether such a conclusion is quite justified or not.

What is the relative etiological importance of these organisms in the causation of phlegmon? When we come to examine the literature of the subject, we find really a very small number of phlegmons, comparatively speaking, in which the streptococcus pyogenes has been found as the causative agent. Janowski[1] in his monograph upon suppuration, says: "Numerous experiments have shown that the streptococcus is not necessarily more virulent than the staphylococcus; on the contrary, that it produces decidedly less often than the staphylococcus its effect upon the organism of the host. It has been found also that whereas the streptococcus alone, or more frequently combined with the staphylococcus, occurs in many cases of small abscesses, it is discovered comparatively seldom in phlegmons, for which in particular it was claimed (Ogston and Rosenbach) to be characteristic. Thus Steinhaus,[2] examining 10 cases of phlegmon, found the streptococcus only once, and in that case combined with staphylococci. In the other 9 cases the latter alone were present. Janowski,[3] in 8 phlegmons found the streptococcus only once alone, in 4 cases staphylococci alone, and in 3 the two combined. Szczegolew[4] examined 21 cases and found the streptococcus alone only in 7."

In 19 cases occurring during late years in the Royal Victoria Hospital, Montreal, the bacteriological examinations revealed the staphylococcus (mainly aureus, or albus, or both) in 8; streptococcus pyogenes in 8; and in 3 a mixed growth.* It may thus be inferred that the staphylococcus (aureus or albus) plays at least as great a rôle in the causation of phlegmon as does the streptococcus pyogenes. I have been unable to find in the literature of the last few years any special discussion upon this point.

(*b*) *Gas Phlegmons.*—That variety of acute phlegmon which produces gas in the subcutaneous tissues has ever been greatly dreaded by the surgeon. The term *foudroyante* (gangrène foudroyante), given to it by Maisonneuve, expressed its terrible character. It was the "progressive gangrenous emphysema" of the older surgeons, and indeed still goes by that name. The Germans call it "Gasphlegmon."

With the modern method of treating wounds it is becoming a much rarer disease than formerly. The chapter of its etiology is still far from being closed; nevertheless, the researches of Welch and Nuttall, Flexner, and several others in this country, and of Fraenkel in Germany, have thrown a flood of light upon the question.

In 1891 Welch and Nuttall,[5] of Baltimore, discovered the organism to which they gave the name "bacillus aërogenes capsulatus." In 1893 Fraenkel,[6] ignorant of Welch's work, discovered the same organism independently, and gave to it the name of "bacillus phlegmonis emphysematosæ." It is by Welch's name that it has come to be most widely known. This organism is a strict anaërobe; and it is possible that the comparative paucity of thorough anaërobic work, both before and since 1892, may account for the fact of its not having been earlier discovered, and also for the fact that there exists still, after ten years, but a comparatively small literature upon the question. Up to a late period the bacillus of malignant œdema was held to be accountable for practically all cases of "gangrène foudroyante." In the last few years, owing to the publications of Welch and Fraenkel, the pendulum has swung to the opposite extreme, and the bacillus of malignant œdema is allowed but slight if any part in the causation of the gaseous phlegmon. Welch,[7] in a thorough discussion of the subject, in which he reviews forty-six cases of bacillus aërogenes infection, remarks on the need of a more accurate knowledge concerning the malignant œdema bacillus. Neither he nor Fraenkel could find it in their comparatively numerous cases of emphysematous gangrene; and he believes that older investigators worked with insufficient methods.

Fraenkel[8] regards the disease caused by his bacillus (which is identical with Welch's) as one *sui generis*, and that due to the malignant œdema bacillus as quite a different clinical entity, because in animal experiments the latter produced no gas.

Hitschmann and Lindenthal,[9] on the contrary, believe that gangrenous emphysema is an anatomico-clinical entity, but due to different infections. Of these the bacillus of malignant œdema would be the one most frequently found; Welch's bacillus next; while finally the bacillus coli communis and the proteus might be responsible for a few cases.

The most recent work upon this question is that of Silberschmidt.[10] His conclusions, based on extremely thorough and straightforward work, certainly carry weight. In three cases of phlegmon accompanied by the development of gas, he found in one the bacillus œdematis maligni; in another, an organism belonging to the "group of malignant œdema bacilli"; and in the third an undetermined non-pathogenic anaërobe. In all cases there was mixed infection; in the first with B. coli communis, in the second with streptococcus pyogenes, and in the third with staphylococci and streptococci. He concludes that the B. œdematis maligni may certainly cause the formation of gas in "gangrène foudroyante."

In a fourth case of infection and death, following the opening of a cold abscess of the femur, in which there occurred a gradual formation of gas in the course of the six days subsequent to the operation, Silberschmidt found, in addition to the ordinary staphylococci and streptococci, a strictly anaërobic streptococcus which produced a foul odor. He comes to the conclusion that gangrène foudroyante may be caused by a number of different organisms. He is inclined to ascribe typical gas gangrene to anaërobes alone. He contests the strict classification of Welch and Fraenkel, and agrees with Lindenthal and Hitschmann that the same clinical picture as is recognized to be due to Welch's B. aërogenes capsulatus may be produced by other anaërobes and in especial by the bacillus of malignant œdema.

There is some evidence in late literature to show that other anaërobic bacteria besides Welch's bacillus and the bacillus of malignant œdema may produce gas in the tis-

* The possibility of some degree of error in figures such as those quoted must be admitted. The difficulty of growing the streptococcus pyogenes on artificial media; the fact that, as Marmorek has shown, they soon exhaust the medium and refuse to grow further; their liability to be outgrown by the hardier staphylococcus; the frequent failure on the part of bacteriologists to examine stained slides of the original pus; and finally the fact that some streptococci are strict anaërobes, whilst anaërobic cultures are rarely set up as a routine practice,—all these points render an unqualified acceptance of statistics upon the point in question impossible, save in cases in which we know that very careful work has been done. Nevertheless the figures are extremely suggestive.

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sues *intra vitam*. Lindenthal[11] found an anaërobic bacillus (in conjunction with the B. coli communis) belonging to the group of the œdema bacilli, which both *in vitro* and in the tissues produced gas. He isolated it from cases of colpohyperplasia cystica, characterized by the formation of gas cysts in the vaginal wall with surrounding necrosis and cell infiltration.

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It has been claimed by various observers that the B. coli communis may cause gas formation in the tissues, especially in cases of diabetes. Such statements, in the light of our general knowledge concerning B. coli infections and concerning the rôle of anaërobes in gas production, must be viewed with considerable scepticism. The observations thus far have not been based upon sufficiently thorough work. The same may be said of the proteus Hauseri, for which similar claims have been made.

In this question of etiology we have been discussing the seed only. But the soil has also a great importance. These gas producing anaërobic organisms are ubiquitous in their nature; they are found in practically any specimen of earth, or dung, or dust. J. C. Friedman[12] has found seven different anaërobes in the cæcum and appendix of man, of which the B. aërogenes capsulatus was the most frequent. Why then are gas phlegmons comparatively so rare? The reason must be sought in the unsuitability of the soil. The seed is constantly being sown; but the soil nearly always destroys the seed, or at least refuses nourishment. Its resistance must be diminished before the seed can grow. And thus as a matter of fact we find that these infections nearly always complicate severe injuries; in the majority of cases recorded it is an open fracture. There is nearly always some chemical or mechanical lesion of the tissues. This was well proved experimentally by Berson.[13]

Symbiosis is also, without doubt, an extremely important factor. An old observation shows that the virulence of the streptococcus may be enormously increased by growing it with the B. prodigiosus. The greater number of the more severe septic processes are found bacteriologically to show mixed infections. In all six cases of severe infection reported by Silberschmidt there was mixed aërobic and anaërobic infection; and it is especially in the case of these anaërobic organisms that this question of symbiosis becomes of importance. For it has been demonstrated in the test tube that even a strict anaërobe will grow well enough in the presence of some oxygen, provided a hardy aërobic organism is inoculated with it. The latter probably uses up what oxygen is present, and thus creates a partially anaërobic atmosphere.

Practically the commonest germs found with the gas-producing bacilli have been the pus cocci, B. coli communis, B. typhosus, and putrefactive bacilli. For the B. aërogenes capsulatus, or the B. œdematis maligni to be found as the sole organism in severe or fatal cases of gas phlegmon is of rare occurrence.

It goes without saying that, apart from local injury and the symbiosis of bacteria, all such general diseases as reduce the vitality of the patient predispose to the development of a soil favorable to the invasion of disease germs. Thus, for instance, a phlegmonous erysipelas may be fatal in the advanced stages of tuberculosis or cancer; and the urinary extravasation of the strictured alcoholic is notoriously dangerous to life.

(*c*) In *urinary extravasation* the urine infiltrates the perineum, scrotum, penis, and frequently also spreads to the upper part of the thigh, the groin, and the lower abdominal region. Aseptic urine in the subcutaneous tissue in small quantities has been shown experimentally to produce but slight inflammatory reaction, or none at all. Nevertheless, clinically, the infiltration of urine seems to produce almost in every case a most decided inflammation. In many cases no doubt the urine is already infected. Even if not infected at the moment, as in cases of wounds of the healthy urinary tract, it is usually given every chance to become so by the necessary catheterization. Moreover, it is driven into the tissues not only with great force, but also in great quantity, the bladder muscle acting as a *vis a tergo*. Some of the organisms which most frequently infect the bladder decompose the urine with the formation of ammonium carbonate and often also of free ammonia. The B. coli communis, B. lactis aërogenes, or other bacteria belonging to the same group; the diplococcus ureæ liquefaciens, the proteus Hauseri are those most often found. The staphylococcus and streptococcus are also not seldom present, and would render still more acute the inflammatory process set up. When we consider what a powerful combination of factors for ill we have in these cases,—the mechanical distending action of the urine, the chemical action exerted by the products of its decomposition, the special inflammatory action of the bacteria present, and finally the run-down condition of most of the subjects,—we can understand how virulent the process often is, and how the patient so rapidly succumbs to the sepsis engendered.

Clinically we usually find the extravasation taking on a phlegmonous character very rapidly. A painful, vividly red swelling appears, and it needs no long time for the decomposed, frequently ammoniacal urine to cause breaking down and putrefaction of the tissues, with the formation of foul-smelling pus and very frequently gas. High fever soon sets in, and the general condition becomes rapidly bad. Frequently operation, even early operation, comes too late, and death follows with septic symptoms.

One point, that of the frequent presence of gas in these phlegmons, remains rather unsettled. Whether the colon bacillus can be accused is very doubtful; at the most it might produce gas in diabetics. It is possible again that the gas represents in part at least free ammonia from the decomposition of the urea.

Anaërobic bacteria, such as those concerned in gas phlegmon elsewhere, may be at the bottom of it, but I have been unable to find literature upon that point. Welch, in his exhaustive article[7] upon cases of gas-bacillus infection, shows that the B. aërogenes capsulatus may not only gain entrance to the body by way of the urinary tract, but also set up its own infection in the tract itself. The gas produced "may be either free in the cavity of the bladder, ureters, or renal pelvis, or contained within submucous blebs, or in both situations." But though the presence of this bacillus in the urine is well attested *inside* the urinary tract, I can find in a somewhat careful search of the literature no record of its having been demonstrated in urine *outside* the tract—I mean in extravasations. This is a point for future investigation.

Morbid Anatomy.—In discussing the morbid changes which occur in this disease, we take as our type the acute phlegmon of a limb which occasionally complicates a severe injury, and which is due to the ordinary pyogenic cocci.

The gross and microscopic changes in the tissues are practically the result of a very intense inflammatory process, and involve principally the subcutaneous cellular tissue, but also the true skin and in some cases the deeper structures. The skin becomes deeply red, and there often occurs a decided lymphangitis, so that clinically we see the well-known red lines running toward the neighboring glands. In the cellular tissue the organisms advance rapidly along the lymphatics and connective-tissue spaces, while the host reacts with a copious outpouring of inflammatory lymph. The parts become so infiltrated that there is imparted to the examining finger the hard sensation of brawn—a brawny œdema. The skin later assumes a dusky red tint, and exudation proceeds to the point of threatening gangrene. Occasionally gangrene actually occurs, the skin becoming marbled with purplish-red areas and being thrown off finally, either in patches or over larger areas.

If incisions are made in the early stage, say within the first day or two, there exudes nothing but a thin serum which may or may not be slightly turbid from admixture of leucocytes and flakes of fibrin. If the process has gone on to the "brawny" stage the cut surface shows a pork like aspect, or sometimes more like orange pulp, especially at the area of greatest intensity. A little later,

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vesicles filled with a turbid fluid may form in the skin, owing to localized exudation in the rete.

Meanwhile in the cellular tissues, if the case be severe, the inflammatory process goes on from mere infiltration to a coagulation necrosis. The necrosis is due not only to the mechanical distention of the exudate, with the venous thrombosis and general circulatory stasis which it produces, but also to the accumulation of bacterial toxins. It seems to be a frequent property of the organisms usually concerned (virulent streptococci or staphylococci) to cause intense and rapid necrosis of the parts infiltrated, while their peptonizing power remains in the background. Nevertheless, after the necrosing process has continued a variable time, there succeeds—if the patient have not succumbed to a fulminating septicæmia—a certain amount of liquefaction or peptonization, so that in the course of a few days we have in the subcutaneous tissues what might be called a lake of pus, in which float shreds and masses of sloughy tissue. After incision these shreds often have to be pulled or cut off, and resemble strands of "wet tow" or "wet chamois leather." If the liquefying process has been less active, we get a series of small ponds, or irregular bayous of pus, separated by isthmuses or peninsulæ of wholly or partly dead tissue.

If incision does not give vent to the pus, it requires no long time for the latter to find its way out through the skin. In such cases sloughy ulcers persist, through which shreds of necrotic tissue and pus are discharged, and healing takes place slowly by granulation. In rare instances it may burrow deeply and invade joints, destroy muscles and tendons, or corrode arteries. If deeply situated and covered by strong fasciæ—such as in the pelvirectal space, the retroperitoneal tissue, the mediastinum or under the fronto-occipital fascia—it may not seldom break through into hollow viscera, or attack the serous membranes.

The *microscopical phenomena* are largely those of ordinary inflammation—outpouring of inflammatory serum, diapedesis of leucocytes, phagocytosis, the accumulation of round cells in groups in the corium and in the septa between the fatty masses of the panniculus; the reactionary proliferation on the part of the lymphoid and fixed tissue cells; and the dilatation of the lymphatics, which are filled with organisms.

The microscopical appearances in detail will vary according to the severity of the infection. In mild cases, subsiding rapidly under incision, there is evidently comparatively slight reaction of the body cells; pus may not be found; and the exudate is reabsorbed. In the typical severe case the early extreme serous exudation becomes in the course of a few days invaded by a large number of leucocytes; the proteolytic ferments of the pyogenic bacteria come into play; necrosed tissue is liquefied, and pus is formed. This pus is not localized, but is distributed over considerable areas as an infiltration. Finally, in the fulminating cases we find again but slight evidence of any cellular reaction. The bacterial toxins kill before the individual defenders of the body can marshal to resist. Welch[7] has found this last-mentioned state of affairs to be especially true of pure infections with the B. aërogenes capsulatus. This bacillus, if pure, leads mainly to necrosis, the nuclei disappearing by karyolysis, while leucocytes and cellular reaction are remarkable by their absence.

The characteristic points, however, in ordinary phlegmon are the excessive primary exudate of serum, the comparatively late proliferation and advance of the leucocytes and other body cells, and the marked necrosing power of the microbic toxins.

While the above would represent the changes in the average severe case of phlegmon, many other less frequent types might be set up, dependent upon the situation of the process and its degree of virulence. Thus we have the deep phlegmon, situated underneath the deep fascia, in which the pus accumulates in the intermuscular septa, which it may infiltrate in long strands. The superficial structures meanwhile may show for many hours or for many days no sign of the underlying infection; yet sooner or later œdema develops. In mild cases the exudate may never become purulent and may be finally reabsorbed if incisions have not been made. At the other extreme, we meet the very malignant type in which the whole limb becomes, within twenty-four to forty-eight hours, intensely œdematous, while the patient succumbs, or the limb is amputated, before pus has time to form. Such cases are due probably to the extremest degree of virulence of the pus cocci.

In cases of emphysematous gangrene the above picture becomes more or less typically modified. The wound secretion, hitherto comparatively healthy, becomes increased and smells horrible; thin, fairly clear serum flows from the drainage openings; the parts around the wound become swollen; the neighboring skin begins to show, in spots or in patches, a purplish or blue-black coloration; air collects in the interstices of the subcutaneous tissue, giving to the examining finger a sensation of fine crackling. This emphysema, accompanied by extreme œdema, spreads rapidly up the limb; the skin takes on a special coloration, which was particularly noticed by the first observers and was compared to that of a dead leaf, or to that of Florentine bronze. Sometimes it looks like a week-old ecchymosis. The distended veins stand out in blue against this dark-brown background; here and there show up patches of a darker color, beginning gangrene, which, in this form of phlegmon, tends greatly to become extensive. The emphysema may extend so rapidly that its advance has been followed for inches during a few minutes' observation.

Clinical Course.—This will vary to some extent according to the nature and degree of virulence of the causative factor. If we take, as before, an ordinary case of rather severe wound infection, the signs are somewhat as follows. They may be considered as (*a*) local, and (*b*) constitutional.

(*a*) *Local.*—At a variable period following the infliction of the wound, but usually within three or four days, inflammatory signs appear in its neighborhood. The edges grow red and œdematous; the same condition spreads rapidly up the limb, invading the subcutaneous cellular tissue *per continuum*; at the same time pain of variable intensity is usually felt in the parts. The lymphatics may show as red lines in the skin leading up to the nearest lymph glands. The œdema may involve a whole extremity within thirty-six to forty-eight hours. Vesicles frequently form and are filled with turbid serum.

If numerous incisions are made at an early stage, the process may frequently be arrested and subside with or without the formation of pus. The converse of this picture is seen in those cases in which, in the absence or failure of operation, the inflammation extends rapidly beyond the limits of the extremity involved and attacks the trunk. *Exitus letalis*, within a very few days, is then the most frequent ending.

(*b*) *Constitutional.*—The symptoms are usually grave. Even the cases of slight or moderate severity are ushered in with chilliness, fever, general malaise, etc. In the very severe cases the chill is marked, the fever high, the pulse rapid; the patient may become somewhat delirious, and after a variable lapse of time sink into a typhoid condition and die of acute general sepsis. In other cases, especially in those whose resistance has been weakened greatly, the course may be of an asthenic type from the beginning, and the patient shows neither locally nor constitutionally any appreciable effort at throwing off the *noxa*. Cases of this nature are to be set down, in the present state of our knowledge, to infection with the streptococcus pyogenes, the staphylococcus aureus or albus, or to a combination of both; with the additional presence, in some cases, of still other bacteria, such as those of the colon group and proteus.

The ordinary severe case, left to itself or operated late, is characterized in its later course by the results of the extensive cellular necrosis. Through spontaneous or operative perforations pus and shreds of slough are discharged for many days or many weeks. If finally the wounds granulate up, the structures involved—skin,

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muscles, tendons, fasciæ, nerves, and arteries—are all involved in the reparative scar; and the patient may be left with an impotent limb. In some cases healing does not occur; suppurative fever continues; pyæmia or septico-pyæmia develops and ultimately leads to the death of the patient.

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When Welch's B. aërogenes capsulatus or, less often, the bacillus of malignant œdema enters the field, either alone or combined with the pyogenic cocci, the clinical picture is usually more grave. Our classical clinical descriptions are given by Maisonneuve and Pirogoff. In their day, with the abundance of military surgery, cases were much more frequent than now. Pirogoff divides the cases into two clinical groups. As I am unable to get access to the original literature, I paraphrase from Welch:[7]

"(*a*) In the very virulent there is but slight local reaction while the part goes on into crepitating gangrene. The emphysema and necrosis spread rapidly and the patient usually dies in a few days with symptoms extremely toxic and asthenic. (*b*) In the other group there is reaction. The emphysema is preceded and accompanied by local œdema or purulent infiltration, as well as by febrile reaction; it appears later after the injury, and spreads less rapidly. All gradations are, however, observed."

The cases in which phlegmon has been ascribed to the invasion of bacteria other than those mentioned above are very rare. Almkvist[14] describes a case of extensive infiltrating abscess of the foot in which gonococci alone were found. He refers to four similar cases in the literature.

A cellulitis of the orbit has been described as due to the influenza bacillus.[1] Netter[16] reports a case of phlegmon due to Fraenkel's pneumococcus.

Other than these I have been unable to find in the literature.

In addition to the above general consideration of phlegmon the writer has thought it advisable to make a few remarks upon the characteristics of phlegmon, in its various localizations, before going on to the questions of prognosis, diagnosis, and treatment.

Phlegmons of the Scalp.—The anatomical peculiarities of this region give an especial interest to the question of phlegmon. The parts are so unyielding that inflammatory processes tend to spread widely and to infiltrate. This is true of inflammations both above and beneath the fronto-occipital aponeurosis, but especially of the latter. The subaponeurotic connective tissue being continuous with the cranial periosteum, phlegmon, when it attacks the former, is extremely apt to destroy the latter and so lay bare the bone. The dangers of the subjacent, more or less inevitable, bone inflammation, or of vein thrombosis, are evident. The internal periosteum (*i.e.*, the dura mater) may easily become involved. Von Bergmann refers to cases of deep-seated brain abscesses arising solely by infection transmitted by contiguity along thrombosed veins. As compared with the superficial soft parts, the aponeurosis, together with the connective tissue binding it to the periosteum, necroses very easily. This is due largely to the manner of its blood supply. Whereas the main vessels of the superficial parts run horizontally to the surface and thus frequently escape injury in lacerated wounds, those supplying the aponeurosis and periosteum run mainly vertically to the parts nourished, and are apt to be torn across in wounds of the scalp. Moreover, the tension which the tight aponeurosis exercises upon any large exudate leads mechanically toward death of the tissue.

Diffuse phlegmon, therefore, of the scalp, especially if deeply situated, is one of the most formidable complications of contused and lacerated wounds. Fortunately, aseptic surgery has made it rare. The accompanying fever is high, and the resulting abscesses are numerous, while the liability to intracranial suppuration is not small.

The erysipelas which attacks deep scalp wounds is especially to be feared. The subaponeurotic connective tissue is in such wounds the part most injured, and the *locus minoris resistentiæ* thus created attracts, so to speak, a superficial erysipelas into the deep parts, and thus gives rise to a phlegmonous erysipelas.

Phlegmon occurs usually as a complication of wounds of the head, but also follows osteomyelitis of the cranium; or, again, it may be an extension from face phlegmons. Pain, swelling, high fever, and especially the swelling of glands behind the ear are the early *symptoms*. Early *diagnosis* is important, because here, if anywhere, is early and deep incision—down to the bone if the phlegmon is deep—necessary, if both extensive necrosis and also the danger of intracranial mischief are to be avoided. The incisions must be kept well open with gauze or drainage tubes.

Phlegmons of the Neck.—Inflammatory processes in the neck are usually circumscribed and end in abscess. The diffuse phlegmon is comparatively infrequent; it may arise primarily as such, or may be secondary to a localized inflammation.

It is caused by infection of wounds by extension from neighboring inflammations, either by contiguity or by the lymphatics through an adenitis. Rarely can it be ascribed to a hæmatogenic infection, as in pyæmia.

The clinical picture varies somewhat according to the anatomical region involved. Of these the most important is the *submaxillary phlegmon*, for which the ordinary term is *Ludwig's angina*. It is certain that Ludwig's angina is a name which has been too loosely used. Most frequently it has been confounded with other inflammatory processes which have as their most striking symptom an œdema of the glottis, such as phlegmonous erysipelas of the larynx, or acute perilaryngeal infection dependent on other causes. As a matter of fact the disease described by Ludwig, in 1838, was an acute infection of the connective tissue of the submaxillary spaces secondary to an adenitis of this region, the original lesion being usually a carious tooth, a mucosal ulcer, or a tonsillitis. The depth of the inflammation, the extreme pressure exerted on the exudate by the unyielding deep fascia covering the space, and the liability therefore toward involvement of neighboring organs (in especial the larynx) gave the disease a characteristic picture—that of a severe and frequently fatal infection. The term Ludwig's angina should be reserved for cases showing the above pathological condition.

Bacteriologically the streptococcus is found most frequently. In four cases reported by Leterrier the streptococcus was found twice, the staphylococcus aureus once, and in the fourth an undetermined bacillus. In four examined by Gasser, the streptococcus, combined with a very virulent B. coli communis, was found in each case (quoted by Jordan in the "Handbuch der praktischen Chirurgie").

Pathologically there are found a purulent infiltration of the connective tissue of the space, and an extensive inflammatory œdema of the floor of the mouth, the larynx, and the pharynx.

The *symptoms* are in general those of the acute phlegmon anywhere. But the local conditions add the characteristic signs of difficult or impossible deglutition, great dyspnœa, impossibility of opening the mouth, salivation, and *fœtor ex ore*. Death frequently follows in a few days with symptoms of general sepsis, or from laryngeal œdema if tracheotomy be not quickly done. The infection may kill in from two to three days. Such fulminating cases are due to an extremely virulent streptococcus toxæmia, and the earliest surgical interference may be insufficient to prevent death. In some cases of a milder degree of infection a localized abscess results, and breaks into the mouth or through the skin.

The *prognosis* has certainly brightened of late years. Delorme in 1893 was able to report a series of seven recoveries in cases operated early.

Treatment.—Incision should be practised at the earliest possible moment, even before pus can be diagnosed. It is best made a finger's breadth below and parallel to the alveolar border of the jaw. After superficial incision it is best to proceed deeply with a blunt-pointed instru-

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ment. With great dyspnœa tracheotomy should be done without hesitation.

Phlegmons may develop at the angle of the jaw and in the submental region; but in these situations they tend to localization and heal easily upon incision. Phlegmons may arise in the loose areolar tissue surrounding the large vessels of the neck, the vessel sheath. They come in frequency next to those of the submaxillary region, and originate most often from the deep cervical glands following anginal affections, carious teeth, otitis, etc. While infection in this region is frequently of the comparatively mild, circumscribed type, yet when the severe spreading type does occur, it is one of the most dangerous conditions possible. The swelling is deep and hard and may extend rapidly from the ear down to the clavicle, and from the spine to the trachea. The skin becomes reddened rather late, and wry-neck and trismus come on. Frequently death occurs from sepsis before pus forms. When abscess forms, the pus may sink into the mediastinum or axilla, and may cause compression of the trachea, œsophagus, large vessels and nerves, and these complications may be the immediate cause of death.

The *prognosis* is bad. *Treatment* consists in very early multiple incisions.

Complications.—Besides those already mentioned there may occur erosion and perforation of vessels. In the case of a vein, bleeding may be absent, if the vein has been occluded by a thrombophlebitis; in the case of an artery, however, there follows not infrequently fatal hemorrhage, although at times the bleeding is moderate and repeats itself at intervals. The carotids have been ligated in continuity in such cases with success.

Reclus[24] has described under the name of "phlegmon ligneux du cou," a rather chronic form of phlegmon, developing very slowly, of very hard consistence, and involving a large area on one side of the neck. It may simulate closely a new growth.

Phlegmons of the Axilla.—These are either subcutaneous or subfascial. They have their origin usually in a lymphangitis running from a primary infection in the hand, arm, or breast. Frequently the atrium of infection is scarcely to be found, and the first symptom is pain and swelling in the axillary glands.

The subcutaneous phlegmon is easy of diagnosis; more difficult is it when the phlegmon begins deeply under the pectoralis and spreads toward the axilla. With the ordinary constitutional disturbance we get a dull pain and a restriction of shoulder movements, especially of abduction. It is only after several days usually that a dilatation of superficial veins and a slight swelling over the pectoral region are seen.

Incision should be made, as soon as the affection is diagnosed, at the posterior edge of the great pectoral through the deep fascia, and then blunt dissection should be continued with the finger under the muscle, until the pus is reached.

Phlegmons of the Upper Arm.—In this region phlegmons of a comparatively mild nature and insidious onset are not infrequent on the inner side of the arm, and originate in inflammatory conditions of the lymphatics or lymph glands in the bicipital sulcus or in a bursitis olecrani.

Apart from the ordinary subcutaneous phlegmons Jaboulay[25] distinguishes cases in which the process is situated under the deep fascia running in the sheath of the vessels, thus forming a band along the inner side of the arm to the axilla, which upon abduction of the arm is painful. Naturally the fascia must always be split in order to lay open the focus.

Phlegmon of the Fingers and Hands.—Phlegmonous processes in the hand require especially early diagnosis and thorough treatment in view of the too frequent loss of function, sometimes of "earning power" (as the Germans call it), following upon failure or neglect in this particular.

The panaritia, confined to the terminal phalanx, are hardly to be considered here. Nor do the infections beginning in the periosteum and confined to one of the phalanges properly come into our classification of phlegmons. It is true that either of them may lead to phlegmonous processes, but to discuss them would lead beyond the limits of this article.

The important phlegmons of this region are those which involve the tendon sheaths, either primarily or secondarily. It is necessary to remember with regard to phlegmonous processes, whether in finger or hand, the anatomical peculiarities of the subcutaneous connective tissue. On the dorsal surface the connective-tissue bands, uniting skin to fascia, run at an acute angle, in fact nearly parallel to the long axis of the limb, thus allowing of a great deal of elasticity in the subcutaneous tissue. On the palmar surface the reverse is true; the connective-tissue bands run mainly vertical to the long axis of the limb, and are characterized by thickness and density. The result is that any inflammatory exudate occurring on the palmar aspect meets with great resistance in its spreading toward the surface, but finds an easy path toward the dorsum. Thus it happens that a marked cellulitis, with great redness and œdema, frequently appears on the dorsum of the hand, while the focus is really situated on the palmar surface and may, if beneath the palmar aponeurosis, have occasioned on that aspect of the hand no sign at all suggestive of inflammation. No doubt the cyanotic œdema of the dorsum in such cases is caused partly also by pressure on the deep dorsal veins as they pass forward between the metacarpals to join the palmar arch.

In such cases an exact examination is required, lest dorsal incisions be counted sufficient, and the one really necessary palmar incision down to the focus be overlooked. The one criterion available is an exact localization of the point of greatest tenderness. The whole hand should be examined for this area with a blunt-pointed probe. The point of greatest tenderness will always correspond with the primary spot of infection; and as a matter of clinical experience that focus is in the great majority of cases on the palmar side.

With regard to infections of the tendon sheaths we must remember their anatomical relationships to each other. The thumb sheath runs up to a point under the annular ligament, while that of the little finger extends under the annular ligament, and in some cases a short distance up the arm. Both communicate with the large palmar bursa. Infection of either of these two may lead by continuity, even in the absence of direct communication, to involvement of any or all the others.

The course is frequently very acute. In a very few days the sheath may be filled with pus; and, being normally but poorly nourished, it necroses very readily. In such cases the necessity for the promptest surgical interference is exceptionally evident; expectant treatment is apt to leave a practically useless hand. If not opened early the infection may spread to the deep connective tissue and cause an extensive phlegmon of the palm; it may extend from here up beneath the annular ligament and cause a deep phlegmon between the muscles and tendons of the forearm. The possible further danger of septic thrombophlebitis and pyæmia is well known. Even nowadays such progressive phlegmons, which might have been arrested in the hand by proper interference, lead occasionally to amputation of the arm. Failing this, convalescence extends over months, and at the end the patient is left with an arm whose usefulness is largely destroyed. The importance of early interference in, for instance, the case of a workingman is enormous. Rather too long and too deep a cut than too small or too late a one. It is scarce possible for it to be too early. It is wise in incising the palm for a deep infection, to push forward bluntly with a pair of forceps after getting through the skin. A counter opening on the dorsum with through-and-through drainage is often advisable. General anæsthesia is probably the best for these extremely painful phlegmons of the hand.

With regard to after results a certain amount of fixity of the tendon involved is scarcely to be avoided. Yet if massage, hot bathing, passive movement, and electrization of the corresponding muscles be instituted as soon

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as possible, a satisfactory amount of function may not infrequently be recovered. The endothelium clothing tendons and tendon sheaths (as indeed everywhere in the body) possesses a large capacity of regeneration, provided function be restored early; but if fibrous tissue be allowed to contract into a scar and produce adhesions, it can evidently never be replaced by endothelium. Thus orthopedic measures to be successful must be instituted as early as possible.

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Phlegmons of the dorsal surface are much rarer and less dangerous.

Phlegmons of the Foot.—Deep phlegmons, underneath the plantar aponeurosis, cause, as in the hand, inflammatory signs on the dorsum, long before anything appears on the sole, and may lead, if care is not exercised, to incision in the wrong place. If the process invades the tendon sheaths in the neighborhood of the ankle-joint there is apt to follow rapid extension up the leg.

Incisions should be made when possible so that the scar will not be exposed later to pressure.

Periproctal Phlegmons.—The atrium of infection in this important class of phlegmons is in the great majority of cases in the rectum. Slight abrasions from the passage of fæces, scratches produced by hard and pointed bits of food—such as fish bones—small ulcerations caused by stagnation of fæces in the lacunæ of Morgagni—all these represent opportunities for the invasion of pathogenic germs. Moreover, it must be admitted that infection may occur with an intact mucosa, through the lymphoid tissue in the wall, in analogy with the same process in the tonsils. Catarrhal inflammation, ulcers of any kind, inflamed hemorrhoids, may be the starting-point of a phlegmon. Infection of the anal skin, *e.g.*, eczema; extension of inflammations of neighboring organs, such as urethritis, Cowperitis, prostatitis, and in the female Bartholinitis—all these may give rise to a phlegmonous periproctitis.

The intelligent treatment of these phlegmons is inseparable from a knowledge of the anatomy of the parts. Without going too deeply into this question, we must remind the reader that the perirectal connective tissue—that tissue namely in which phlegmons mainly run their course—is divided into an inferior or superficial, and a superior or deep portion; the former called the ischiorectal fossa, the latter the pelvirectal space.

It is the levator ani muscle with its enclosing fasciæ, the superior and inferior diaphragmatic fasciæ (or, as it usually appears in English literature, the two layers of the triangular ligament), which divides the two spaces.

Phlegmons, therefore, may be superficial (*i.e.*, situated in the ischiorectal fossa), or deep (*i.e.*, in the pelvirectal space); or they may spread sometimes through both regions. In the first case they may extend to the perineum, scrotum, groin, or thigh, while in the second case they spread by direct continuity into the pelvic and thence into the abdominal retroperitoneal areolar tissue, and so up to the kidneys or in front over the anterior abdominal wall. These are naturally much the more dangerous. Portions of the peritoneum, even of the bowel, may become gangrenous, and septic peritonitis develop. Death most often results in from two to ten days. Such phlegmons are fulminating in character. Inasmuch as virulent anaërobic gas-producing bacteria are invariably to be found in the fæces, it becomes evident that periproctal phlegmons may at any time assume the fulminating type of emphysematous gangrene, or "gangrène foudroyante." The bacteriological aspect of the question has already been discussed.

Another type, described especially by Kraske in connection with a wound, is characterized by gas formation, but with a much milder course. It is said that the B. coli is the etiological factor; but such a conclusion, in view of recent work upon the anaërobes in gas phlegmons, must appear at least dubious.

The onset is insidious; locally the wound shows often nothing but a breaking down of the granulations and slight œdema in the neighborhood. Fever is slight or absent. Gradually, however, there develops a tissue emphysema and small gas-containing abscesses, with necrosis of the tissues near the wound surface. At times metastases develop, even in the absence of fever or chill. Ultimately the patient becomes both restless and sleepy (if the apparent paradox be allowed), then somnolent, and in the course of weeks usually succumbs. Recovery is quite rare.

Some authors describe a third form, characterized by gangrene, called the "diffuse, gangrenous phlegmon." This is, however, merely a variety of the fulminating type of phlegmon.

In the above we have been speaking especially of the severe spreading forms of the disease. They may be complicated, or not, by gas formation, and their *prognosis* is an extremely bad one. When infection is less virulent we get a more circumscribed inflammation, with early formation of abscess. The acute ischiorectal abscess is often styled a phlegmon, but within the limits of this article it can hardly be considered such.

Infections of the pelvirectal space are much more frequently spreading in type. *Diagnosis* is here difficult on account of their deep situation. Still, careful digital examination will often discover an inflammatory mass causing the rectal wall to bulge inward. Even before such swelling occurs, the presence of rectal and vesical tenesmus with deep pelvic pain should lead to a probable diagnosis of pelvirectal phlegmon. If left alone, or diagnosed late, the condition is apt to cause extensive abscesses and break through into neighboring organs or the skin, when it does not lead to a fatal issue.

Treatment.—This is of course early incision. This should never be made through the rectal wall, no matter how tempting a pointing abscess may be; for in such case drainage is poor and fæces enter the abscess cavity. The incision, both in ischiorectal and in pelvirectal infections, should be through the ischiorectal fossa. When the abscess is deep—*i.e.*, pelvirectal—the levator ani should be exposed, and then a blunt instrument should be passed between the two heads of the muscle, where they reunite beneath the prostate. The opening should be made secure by a large stiff drain.

Phlegmons of the Testicle.—Phlegmons in this region acquire a special interest from their tendency to gangrene. They originate mostly from phagedænic ulcers or wounds of the penis, urethra, and perineum; or from suppurative cavernitis of the corpus cavernosum; or from urinary extravasation, or as a result of suppurative periproctitis. They are characterized by an extremely tense swelling of the scrotum, with frequent ending in gangrene of the skin, the inflammation often spreading rapidly on the abdomen and the thigh, and also deeply to the tunica vaginalis and the cord. In this last case it leads on not infrequently to phlegmon of the pelvic cellular tissue and even to peritonitis.

In virulent infections, and especially with urinary infiltration, also when the phlegmon connects with paraproctitic processes, there frequently develops gas in the infiltrated tissue. Especially in these cases is the gangrene apt to be deep and extensive. The bacteriology of this condition has already been described.

It is a point of considerable practical interest and importance that an ordinary infective phlegmon, arising from some focus in the anal gut or the ischiorectal fossa, may spread with great rapidity and severity over the perineum, scrotum, and the neighboring parts, and thus simulate a urinary extravasation so closely as to induce surgeons of experience to do median perineal cystotomy.

Phlegmons of the Thoracic Wall.—These are fortunately rare, for the *prognosis* is always grave. They usually spread from a purulent axillary adenitis and invade most often the anterior wall, lying upon the fascia underneath the greater pectoral. They may arise primarily in the deep fascia from penetrating wounds. Usually they break through the skin, rarely into the pleura. Kümmell,[25] of Hamburg, describes one case which, extending from an empyema, spread over the whole of the

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right side of the back and down over the gluteal region, as far as the great trochanter.

Diagnosis may be extremely difficult in the early stages. The one symptom at that time is extreme pain over the whole side of the chest, so severe as to make respiration difficult. This, with the accompanying fever and chill, causes the condition to be mistaken for pleurisy. It may be several days before redness of the skin, or fluctuation at some point, renders the diagnosis unmistakable. A careful consideration, however, of the nature of the pain, and of the severe constitutional signs, ought to permit fairly early diagnosis.

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Kümmell[25] reports that of ten cases in the Eppendorf Hospital only two recovered; the rest all died of general sepsis. No doubt some of these belonged, however, to the old days of "expectant" surgery. At the present day earlier diagnosis and radical incisions ought to save a much greater proportion.

PHLEGMONS OF THE ŒSOPHAGUS.—Phlegmon in this region is situated in the submucous tissue and is very rare, but may be extensive. Some cases described as phlegmons are evidently small localized abscesses. When pus has formed it tends to break through into the œsophagus or the trachea, rather than to spread through the mediastinum or into the pleural cavity. It may follow the arrest of a foreign body in the œsophagus, or represent the extension of a phlegmonous gastritis. In a few cases no cause can be ascertained.

The *symptoms*, apart from those of constitutional disturbance, are mainly of local origin—difficulty of deglutition, with pain along the course of the œsophagus, especially behind the sternum and radiating to the back; nausea; cough; occasionally vomiting of purulent material.

Diagnosis is extremely difficult except in cases in which the history of the stoppage of a foreign body is clear.

Treatment.—With the œsophagoscope a prominent abscess may be discovered and opened. In severe cases the question of external incision must be considered, if the symptoms indicate a lesion above the thoracic cavity. Apart from these indications treatment must be expectant.

GASTRIC PHLEGMON.—Cases of this kind are usually diagnosed with certainty only post mortem. The phlegmon complicates carcinomatous disease not infrequently, simple ulcer but rarely. Occasionally it is caused by foreign bodies or traumatism. It involves mainly the submucosa. The stomach wall is usually immensely thickened, inflamed, and œdematous. Perforation may occur in either direction. Clinically the picture is that of acute gastritis with peritoneal symptoms and fever.

Kinnicutt[29] has lately described a striking case.

PHLEGMONS OF THE LARYNX.—In perilaryngeal phlegmons the symptom which dominates the clinical picture is naturally that of a dangerous œdema of the larynx. And yet, for the sake of an exact knowledge of the subject, the writer feels inclined to offer a prefatory note of protest against the loose, slipshod way in which the term "œdema of the larynx" or "œdema of the glottis" has been so generally used, as if it represented a disease entity, instead of being, as it is, merely a symptom. It may be due to entirely non-inflammatory causes, such as severe nephritic or cardiac disease, in which it appears as part of a general anasarca; or to the pressure of a tumor causing local stasis. When of inflammatory origin the œdema may be the result of a primary infection in the submucosa, occurring in the course of infectious diseases as a metastasis; or of a primary local erysipelas (if we admit that such really does occur). On the other hand, it may be caused secondarily by extension of some inflammation of neighboring parts. It is under this heading that the laryngeal phlegmon is ranged; such a phlegmon may have arisen in the floor of the mouth, or in an adenitis at the angle of the jaw; or it may have developed from a peritonsillar or peripharyngeal infection, or, from an infection located in the connective tissue of the neck; or finally its starting point may have been in the areolar tissue of the submaxillary triangle, this last representing Ludwig's angina in the strict sense of the term.

These phlegmons are accompanied by the usual local and constitutional signs. In this place it is necessary to speak only of the dominating sign of local laryngeal œdema, when it is of any severity. The symptoms depend mainly on the diminution of the laryngeal opening. The obstruction occurs usually by swelling of the aryepiglottic folds. Thus we have inspiratory dyspnœa and hoarseness. Pain may be constant, but is increased by swallowing.

The one point upon which emphasis must be laid is that the submucous infiltration may develop with extraordinary rapidity. While this is true of infective œdema, it is especially so of the traumatic œdema. The breathing must be constantly watched. A tracheotomy may become necessary at any moment, and indeed many patients have died for lack of it. von Ziemssen's rule was, "never under any circumstances to leave a patient suffering from œdema of the larynx, and rather to do a tracheotomy with a penknife, if proper instruments are not at hand, than to let him suffocate."

While the *prognosis* of phlegmons generally is never especially bright, it becomes decidedly darker when they become complicated, as in this region, by laryngeal œdema. Sestier (quoted by von Bruns in "Handbuch der prakt. Chir.") found in 213 cases of œdema glottidis (no doubt of various causation, not solely of phlegmonous origin) 158 deaths. Of the total number 30 had had a tracheotomy done. No doubt present-day methods would show much more favorable results.

As regards *treatment*, besides the matter-of-course incision for the original phlegmon, the surgeon must be constantly in readiness to do a tracheotomy for the secondary œdema laryngis. Where the necessity stops short of a tracheotomy, ice should be given, and the ice-bag kept applied externally. Intubation is contraindicated.

COMPLICATIONS.—These are mainly of the nature of metastatic inflammations. Suppurative synovitis and arthritis complicate phlegmonous erysipelas not uncommonly. The same result may be brought about by direct extension of the inflammation into the deep structures. An infective pneumonia has been described as due to a streptococcus metastasis from phlegmonous erysipelas. Endocarditis and albuminuria are rare.

Septicæmia, pyæmia, or septico-pyæmia not infrequently develop from a phlegmonous focus. Septic inflammations of the various serous membranes may come on, especially following streptococcus infections—pleurisy, empyema, peritonitis, meningitis. The B. aërogenes capsulatus may also cause peritonitis or meningitis.

DIAGNOSIS.—There is really no other disease from which it is necessary to differentiate phlegmon when superficial, as it usually is. The question of diagnosis comes in only as between its own various forms. It is desirable, however, to distinguish these, both for therapeusis and for prognosis. The rapid development of gas and of gangrene and its fulminating character distinguish easily cases of *gangrène foudroyante* from those of ordinary phlegmon (Class I.); but less easily from cases of urinary extravasation. A late case in the Royal Victoria Hospital, Montreal, of a B. aërogenes capsulatus phlegmon, starting from the rectum and involving scrotum, penis, and groins, simulated so perfectly a urinary extravasation that it was only at post-mortem that the absence of the latter could be made quite certain. Still, in most cases, a diagnosis should be made from the previous history of urinary trouble, and from an examination of the urinary tract.

The diagnosis of a deep, subfascial phlegmon may occasion considerable difficulty. The deep pain, the fever, and other signs of constitutional disturbance will point plainly enough to an infected condition; but to determine the exact localization of the process, whether it is in the soft tissues or in the bone, *i.e.*, an acute osteomyelitis, may be far from easy. In acute osteomyelitis the pain is apt to be more severe, more localized; while subcutaneous œdema develops to a less extent and rather later.

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Moreover, acute osteomyelitis occurs almost constantly during adolescence and develops at an epiphyseal end. As a matter of fact it is really nothing more nor less than a phlegmon of bone; and its treatment is the same as for phlegmon of the soft parts.

In the case of phlegmons of Class II.—gas phlegmons—a very early diagnosis is of great importance for successful therapeusis. Bloodgood[26] has reviewed these cases from the surgical standpoint in a very thorough manner, and I quote from him.

"Unquestionably in gas-bacillus infections an early diagnosis is always possible, and not at all difficult. In any recent wound with symptoms of infection, one should at once make cover-slips from the fluid in the wound. The presence of large bacilli, morphologically like the gas bacillus, even with the absence of gas bubbles or emphysema, is practically, in the majority of cases, pathognomonic of a gas-bacillus infection. If one finds in addition air bubbles in the fluid, or emphysema in the tissues, plus the presence of bacilli in cover-slips, there is practically no question about the diagnosis."

Under the head of treatment I shall quote further remarks of Bloodgood, which are a corollary to the above.

I suppose we may assume that a phlegmonous erysipelas, *i.e.*, a phlegmon of the deeper structures developing by extension from a true erysipelas of the skin, is a pure streptococcus infection. If we have any faith in antistreptococcus serum, we must be careful in such cases not to overlook in the general phlegmon the coexistence of the cutaneous erysipelas; for in such cases, if in any, would the serum have a chance to do good.

Prognosis.—The outlook in any of our three classes of phlegmon is usually grave; but by all odds gravest in the phlegmon of gas gangrene. The fulminating cases of ordinary phlegmon (Class I.), which kill in a few hours, are rare. More often the patient dies of the infection during the first week or two after the onset. If he escapes then, he may die later of chronic suppurative fever and pyæmia. If he recovers, he may be left with a functionally impotent limb.

In cases of gas gangrene (Class II.) the prognosis, without operation, is practically always toward a fatal ending. With early and proper treatment it is by no means so black as our predecessors have painted it; and it is yearly becoming less grave. The earlier and more thorough the operation is, the brighter becomes the outlook.

Welch[7] says that results are better after amputation than after incisions only. Of the cases collected by him of emphysematous gangrene, affecting primarily the extremities, the recoveries numbered 68 per cent. after amputation, and 33⅓ per cent. after incision without amputation.

Treatment.—The treatment of phlegmon may be considered under the three headings—non-operative, operative, and serum-therapy.

Non-Operative.—Naturally this can be thought of only in the mildest cases. Take, for example, a cellulitis orginating in an infection of the hand, and spreading with greater or less rapidity up the forearm. The surgeon incises such cases almost invariably as soon as he sees them, and counts the disfiguring scars—so disfiguring, especially on the back of the hand—as not to be weighed for a moment in the balance. Let us admit, upon the whole, that he is right. And yet, how often does the general practitioner apply in these cases hot antiseptic formentations alone, and see his conservatism, or the patient's disinclination to the knife, justified by the event! There is room here for the exercise of the nicest surgical judgment. The writer believes that in the early stages of these spreading cellulitis cases, mild types of phlegmon as they are, hot antiseptic applications or the hot continuous bath should be tried first; that, however, both the local and the constitutional symptoms should be watched carefully and almost continuously. If, after a variable number of hours, to be judged by the intensity of the process, the infection is evidently advancing, multiple incisions should be practised.

Some surgeons prefer cold applications, especially in phlegmons of the deeper regions, such as the perilaryngeal or periœsophageal. Elevation of the part and absolute rest are matters of course.

It may be mentioned at this point that Credé's ointment[27] (a salve containing fifteen per cent. of soluble metallic silver) has been strongly recommended by some in the treatment of septic infection of wounds. It is usually rubbed into the skin after the fashion of the mercurial ointment in the treatment of syphilis; and it is claimed that the formation in the blood of powerfully bactericidal silver salts effects a general antisepsis of the entire organism (Werler[28]). The writer is unable from personal experience to give any opinion upon the question; but the method of treatment has not come into wide use.

Operative.—This will vary, according to the case, from a few superficial incisions to the amputation of a whole extremity. Multiple incisions are the rule in moderate cases. After incisions the parts should always be kept enveloped in hot, wet antiseptic dressings or in the continuous bath. The value of the latter in severe local infections has been particularly demonstrated by the experience of the great Hamburg clinic, and more lately by that of various hospitals elsewhere.

Incisions in the early stages must be numerous and they must enter the subcutaneous tissue, so as to allow of the escape of as much of the infected serous exudate as possible. In the later stages, with a large amount of pus present, they must be extensive enough to secure a free opening for the pus wherever it may happen to be; that is, the pus must be followed relentlessly into all recesses, and counter openings must be freely made. Necrotic tissue should be removed as thoroughly as possible. Rubber drains of a good size should be inserted into the main openings. Copious hot irrigation with bichloride solution should be used. Care should be taken not to place the incisions too near each other, for fear of gangrene of the intervening skin from lack of blood supply.

Verneuil prefers to incise with the thermo-cautery in order to avoid the considerable bleeding which frequently occurs. This is of doubtful advantage. A certain amount of bleeding is more likely to do good than harm, by relieving the congestion of the part, and also by removing some part of the infective material.

The serious question of amputation must often be weighed. The tendency of the inflammation to spread rapidly and deeply over the larger part of the limb must be our main guide to the virulence of the infection and the necessity for amputation. The constitutional disturbance, in especial the height of the fever, has less significance, for in the grave asthenic cases reaction may be comparatively slight. In general it may be said that when we have an intense œdema, steadily and rapidly advancing, which has approached the proximal joint of the limb and which shows the dusky hue of threatening gangrene; and when the constitutional signs are severe, or when the patient is in an asthenic typhoid condition—in other words, when clinically we have before us the excessively severe, fulminating, or almost fulminating, type of infection, then amputation at the joint is urgently called for. In most of such cases the indication for such radical procedure will have been made absolute by the failure of previous multiple incisions to arrest the advance of the œdema. It will be a question for individual judgment whether an earlier amputation through the shaft of the humerus or the femur may not be advisable.

Even when the infection has spread beyond the limb on to the trunk, amputation at the joint should still be done; for recovery in such cases has been recorded, and indeed not so very infrequently. Amputation through the forearm or leg must be a rare thing. It might be considered in cases of fulminating gangrene or spreading emphysematous gangrene; but the lesion in such cases has usually spread beyond the knee or elbow by the time it is accurately diagnosed, so rapid is its advance.

The above remarks are applicable especially to cases of Class I., those of ordinary phlegmon. Cases of Class II., gas gangrene, require, from their especial virulence, con-

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sideration apart. Bloodgood in his admirable article in "Progressive Medicine," 1900, has summed up the indications so well that I need only quote them:

"If the infection is recognized early and the destruction of the soft parts and bones is not extensive, free incisions with immediate continuous bath treatment should be tried. If the general symptoms of infection are not immediately relieved, amputation should be done. If, however, the infection is recognized late, one should take no risk, but amputate at once. An early diagnosis will often save life; and from many observations an amputation may not always be necessary."

The treatment of cases of Class III., urinary extravasation, is treated of elsewhere in the HANDBOOK. Here it need only be said that multiple incisions and free drainage, as for any other kind of phlegmon, fulfil the main indications.

Serum-therapy.—The question of serum-therapy in streptococcus affections is one which is yet far from settled. It is well known that Marmorek prepared his original antistreptococcal serum from a streptococcus obtained from a case of pseudomembranous angina. Great expectations were entertained of the new serum in all diseases supposed to be caused by the streptococcus, and Marmorek went so far as to request of accoucheurs that it be used in puerperal sepsis to the exclusion of the tried clinical methods of curetting and irrigation. These early hopes were doomed to disappointment. Clinically it soon became evident that the new serum had but little curative power, while experimentally it was shown that Marmorek's serum was totally inefficacious against diseases of streptococcus causation other than that of the original one. Thus cases of phlegmon, erysipelas, and puerperal sepsis remained nearly always unbenefited.

Since these early experiences, large numbers of isolated cases of all kinds of supposedly streptococcus infection have been reported. With the exception of a certain number of favorable, occasionally even of brilliant results, these reports tend to demonstrate the general inefficiency of the serum. Petruschky examined the question especially in regard to phlegmon, and came to a conclusion entirely unfavorable to Marmorek's serum.

The conclusion generally arrived at[17] was that the streptococcus genus was composed of a number of species, which, however similar in morphology or cultural characteristics, differed materially in the matter of their immune sera. Of late years a close study of the streptococci has discovered a considerable number of these more or less differentiated species. Van de Velde,[18] in Denys' laboratory at Louvain, has endeavored by immunizing with a number of these different streptococci simultaneously, to overcome this difficulty, and to produce a serum which he calls "polyvalent"—a sort of shotgun serum which if it missed one streptococcus might hit another. This "polyvalent" serum, it is said, has met with slightly more success than the original, but has not come into general use.

On the other hand, within the last year or two, various workers have tried to demonstrate the essential unity of all the various streptococci with the exception of that of *Pferdedruse* (our *Strangles*). Streptococci cultivated from cases of tuberculosis, measles, erysipelas, scarlatinal angina, abscesses, phlegmons, puerperal sepsis, angina in acute rheumatism, ulcerative endocarditis, and *Pferdedruse*, were examined thoroughly by Meyer[19] in respect to their morphology, virulence, hæmolysis, growth in filtrate of their own culture medium, and their specific immunizing sera. Similar investigations have been conducted by Widal and Besançon,[20] Menzer,[21] and Marmorek.[22] All tend to prove the "unity" of all the various streptococcus families, except that of Pferdedruse. If they are a unit, why then should any antistreptococcus serum fail to do good? Much further investigation is needed.

The whole question is beset with difficulties. There is the one already mentioned, that one variety of streptococcus apparently will not immunize against another. So long as it is impossible to say to which particular streptococcus a given infection is due, the use of Marmorek's serum or of any other antistreptococcus serum remains largely a matter of chance. Further, it is becoming more and more evident that the streptococcus does not play such a dominating rôle in many infections as has been believed. Certainly in the case of phlegmons we have reason to believe that the staphylococcus, Welch's gas bacillus, the bacillus of malignant œdema, and other less known organisms, may either singly or in symbiosis with each other or with the streptococcus, cause infections which it has hitherto been the custom to ascribe, usually without thorough bacteriological investigation, to the streptococcus alone.

Phlegmons, in which bacteriological examination carefully conducted both aërobically and anaërobically has shown infection with but one organism, are rare; and it is reasonable to believe that in many cases in which antistreptococcus serum has been given with negative results the infection has been one, not of the streptococcus, but of one of the other organisms mentioned; or, at least, of a symbiosis of the streptococcus with these others in which the streptococcus played the minor part. In this connection a case[23] reported from St. Petersburg is interesting. It refers to a septicæmia treated without the least benefit with antistreptococcus serum. Following this insuccess, antistaphylococcus serum was administered, with brilliant results. The writer refers to another case in St. Petersburg, one of ulcerative endocarditis, in which antistaphylococcus serum gave a similar good result. Unfortunately cultures were not made; yet the facts are suggestive. We have been in the habit of ascribing without careful investigation the causation of many diseases to the streptococcus, and perhaps quite wrongly.

Another point which may explain the general insuccess of the serum is this: that if we are to believe Aronson,[24] the antistreptococcic sera on the market contain comparatively very small quantities of anti-bodies.

In view of all these difficulties, all that can be said is that the practitioner, in desperate cases, may use antistreptococcus serum on the off-chance of its doing good; but he must await more certain bacteriological knowledge before he can use it with judgment or with any sure hope of its success. His main reliance must be placed on early diagnosis, and prompt and thorough surgical treatment.

Edward Archibald.

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PHLORIDZIN.—$C_{21}H_{24}O_{10}.2H_2O$. A glucoside obtained from the root-bark of the apple, pear, cherry, and other fruit trees. It forms in fine, colorless, silky needles,

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soluble only in one thousand parts of cold water, but freely soluble in boiling water. It is only slightly soluble in alcohol. It melts at a temperature of 222° F., but becomes solid again at 226° F., and melts a second time at 335° F. Phloridzin is very similar to salicin, and heated with potash it yields phloretic acid, which is homologous with salicylic and anisic acids.

It has been employed as an antipyretic in doses of fifteen to thirty grains, but is not now used.

Phloridzin is utilized in physiological research, as it has been found to induce artificial diabetes. When given to the extent of eight grains per pound of body weight it causes polyuria and an excretion of sugar which continues for twenty-four or thirty hours, and is not influenced by diet. It sometimes produces diarrhea, but no other ill effect has been detected, unless the drug is administered for a prolonged period, when marked emaciation and debility supervene. Phloridzin acts directly upon the renal epithelium, permitting the escape of sugar from the blood and lessening the amount of sugar held in solution in the blood. *Beaumont Small.*

PHONATION. See *Larynx, Physiology of the.*

PHOSOTE—creosote phosphate—is a colorless syrupy liquid, containing eighty per cent. of creosote, but with only a slight odor and taste of this substance. It is employed in tuberculosis as an easily borne form of creosote, and is given in dose of 0.7–1.3 gm. (gr. x–xx) three times a day. *W. A. Bastedo.*

PHOSPHATOL is a thick, reddish-yellow liquid prepared by the action of phosphorus trichloride on creosote in alcoholic soda solution. It has a burning taste, is slightly soluble in water, and is readily soluble in alcohol and oil. It can be given in milk or wine or in capsule in the same dosage as creosote. *W. A. Bastedo.*

PHOSPHORIC ACID.—By *phosphoric acid* is signified, in medicine, a solution of common or orthophosphoric acid (H_3PO_4) in water. Two grades of strength of such solution are official in the United States Pharmacopœia, as follows:

Acidum Phosphoricum, Phosphoric Acid. This preparation represents eighty-five per cent., by weight, of orthophosphoric acid and fifteen per cent. of water. It is a colorless fluid, without odor, but with a strongly acid taste. Its specific gravity is 1.710. It mixes in all proportions with water or alcohol. It should be preserved in glass-stoppered bottles.

Phosphoric acid is intensely acid and irritant, but does not immediately corrode living tissues and coagulate albumin, as do the majority of the strong mineral acids. In any considerable quantity, however, this grade of the acid would prove a sharp, and very likely fatal, irritant poison if swallowed without dilution. This strength of acid is rarely prescribed in medicine, being official simply as a convenient solution to be kept in stock by the druggist for the making of the following, the commonly prescribed preparation:

Acidum Phosphoricum Dilutum, Diluted Phosphoric Acid. This grade of the acid is compounded by mixing one part, by weight, of the foregoing strong acid with seven and a half parts of distilled water. The solution thus contains ten per cent. of orthophosphoric acid, and has the specific gravity 1.057. This acid resembles in general properties the other diluted mineral acids (see *Sulphuric Acid*), but is distinguished by having a pleasanter flavor (its acidity resembling that of the fruit acids) and by being, as a rule, better borne by the stomach than its congeners. It may, therefore, be used for the common purposes of the mineral acids, to allay thirst, improve digestion, repress tendencies to sour fermentation of the contents of stomach or bowels, and to check morbid sweating. By many it is further claimed that phosphoric acid, ingested, tends to revive an exhausted nervous system, to excite the sexual function, and generally to enhance nervous activity and power. By such claimants the acid is regarded as the therapeutic equivalent of uncombined phosphorus; but certainly it fails in that most pronounced therapeusis of free phosphorus, the frequent cure of neuralgia. A special claim for phosphoric acid, of capability to lessen the excretion of sugar in diabetes, is now probably pretty generally abandoned. Diluted phosphoric acid may be given in doses of from twenty drops to a teaspoonful or more, three times a day, the dose to be largely diluted with water, or with syrup and water. The precaution obtaining with the giving of other mineral acids, of taking the draught through a tube and rinsing the mouth after the swallowing, need not be insisted upon in the case of this acid.

Edward Curtis.

PHOSPHORIDROSIS.—Luminous sweating is a decidedly rare affection. Cases have been reported in which this curious phenomenon was observed after the ingestion of phosphorus and the eating of phosphorescent fish. It is probable that the phosphorescence is due to bacilli; for several species of photobacteria have been found, most of them being derived from fish.

Charles Townshend Dade.

PHOSPHORUS.—Phosphorus is available for medicinal purposes in the form of the element itself, or as it occurs in the special compound *zinc phosphide*, a compound that readily yields free phosphorus upon swallowing, under the conditions present in the stomach. Phosphorus is official in the United States Pharmacopœia under the title *Phosphorus*, Phosphorus. It is a solid body, of the appearance and consistence of white wax. It has a peculiar and disagreeable odor. On exposure to air, it gives off white fumes, luminous in the dark and of a garlicky odor. Phosphorus is insoluble in water, but dissolves in 350 parts of absolute alcohol at 15° C. (59° F.), in 240 parts of boiling absolute alcohol, in 80 parts of absolute ether, in about 50 parts of any fatty oil, and very abundantly in carbon disulphide, the latter yielding a solution which must be handled with the greatest care to prevent danger from fire. If left exposed to the air, phosphorus takes fire spontaneously. Accordingly it must be kept carefully under water, in a secure and moderately cool place, protected from light.

In its physiological relations, as in its chemical, phosphorus is unique. It is locally exceedingly irritant—even corrosive, although, strangely enough, in some experiments bits of solid phosphorus have lain embedded in the connective tissue of animals for weeks without exciting any local reaction. Ordinarily, however, upon skin or mucous membrane phosphorus in substance excites inflammation, possibly followed by ulceration and gangrene of the area exposed to contact. Even the fumes of phosphorus may inflame exposed mucous membranes, such as the conjunctiva and the mucous membrane of the mouth and respiratory tract, and inflame even to consecutive necrosis any accessible periosteum. Thus used to arise in match factories, in the days before the use of allotropic phosphorus, cases of necrosis of the jaw, the periosteum being generally reached by the poisonous fumes through the avenue of some defective tooth. Taken internally, even therapeutic doses are very apt to irritate the stomach, as shown by loss of appetite, nausea, uneasiness, and even pain and tenderness at the epigastrium, or, in higher grade, by the additional symptoms of vomiting and diarrhœa. Flatulence and eructations of phosphoretted gases are further disagreeable local effects of the medicine upon the digestive apparatus. Phosphorus when swallowed is readily absorbed, but exactly in what chemical status has not been definitely proven. That it reaches the blood, in part at least, as uncombined phosphorus dissolved by the alkalies of the intestinal juices or by fats is, theoretically, certainly not impossible, and is the obvious suggestion of many chemical considerations. On the other hand, that some portions undergo various grades of oxidation is again perfectly possible and likely.

The constitutional effects that follow the internal tak-

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ing of phosphorus are symptomatic of modifications of nutrition. In therapeutic dosage in health there is ordinarily little obvious derangement beyond what may be a reflex of the gastric irritation set up by the drug; and, anatomically, the most striking result of the medication is a tendency, proven by dissection of animals,[1] toward increased activity of development of bone. Cartilaginous epiphyses ossify with undue speed and completeness, spongy bone tissues increase in thickness, and compact bone in hardness. And a similar special tendency toward nutritive activity in *nervous* tissues, under the administration of phosphorus, is commonly, and probably rightly, inferred from the two facts, first, that in nerve tissue, as in that of bone, compounds of phosphorus are prominent normal constituents, and, secondly, that many morbid derangements of nerve function which are fairly referable to malnutrition or to exhaustion of nerve tissue, tend to abate under a régime of phosphorus medication. A special aphrodisiac action has been claimed for phosphorus, but cases in which any effect of this nature has been observed have probably been cases of previous debility or exhaustion of the sexual function, in which the renewed sexual desire is simply the natural consequence of restoration of power through improved nerve nutrition. In originally vigorous subjects several series of observations have shown that phosphorus does not produce any direct aphrodisiac effect.[2]

In over-doses, single or continued, phosphorus profoundly deranges nutrition, inducing fatty degeneration of glandular and other tissues, and hemorrhages. Death may result, or an impairment of health from which recovery is slow and difficult. For a detailed discussion of this singular poisonous operation of phosphorus see article *Phosphorus, Poisoning by.*

The therapeutic application of phosphorus is the internal administration of the drug for the bettering of deranged conditions of the nervous and the bony structures. Thus it is among the standard remedies to try in neuralgia. Naturally enough, the more recent the case, the greater the chance of relief and of cure, and unless relief comes within forty-eight hours, the medicine will probably fail altogether (Ashburton Thompson). In other nerve derangements it may be said, broadly, that in such as belong to the category of the naturally curable ones, recovery may perhaps be hastened by the use of phosphorus; but that in the incurable or difficultly curable nervous diseases the agent generally does little or no good. Thus the high hopes at one time formed of the avail of phosphorus in such maladies as epilepsy and locomotor ataxia have utterly failed of realization; but in such conditions as so-called nervous prostration, or incipient dementia, the drug is often of distinct benefit. Similarly phosphorus has been praised in osteomalacia and in rickets.

In the important matter of the *dose* of phosphorus, there is much difference in the practice of different physicians. Some confine their dosage to 0.0006 gm. (gr. $\frac{1}{100}$), thrice daily, while others begin at once with 0.003 gm. (gr. $\frac{1}{20}$), given with the same frequency, and aim to increase to double the amount, under guidance of the effects wrought—curative to the disease on the one hand, or irritative to the stomach on the other. Certainly, the larger of the doses cited are well borne in a very considerable number of cases, and certainly, also, the same may succeed, and speedily too, in curing a neuralgia, where the minute dose of the timid prescriber utterly fails of all impression upon the disease.

The *mode of administration* is an all-important matter in the case of phosphorus, since by faulty prescribing the dose may be unduly irritant or nauseous on the one hand, or inert on the other. In general, phosphorus must not be given in substance, no matter how extreme the subdivision, because of irritation; and in prescription in solution a solvent must be sought that will hold the phosphorus secure against oxidation, and at the same time not furnish too disgusting a potion. The most generally serviceable solvent, where the preparation is to retain the fluid condition, is a fixed oil, freed from contaminating oxygen and water by a preliminary superheating. Squibb has strongly advocated cod-liver oil,[3] fearing vegetable oils because of an alleged tendency of phosphorus in solution in the same to "develop poisonous properties," presumed to be "due to the formation of hypophosphorous acid." Sweet almond oil is, however, the most generally selected of fatty solvents, and has been adopted by the United States Pharmacopœia as the basis of the official oily preparation. Chloroform and ether are inconveniently volatile for the making of a permanent fluid preparation, and carbon disulphide is too disgusting and noxious. Absolute alcohol can be made the basis of an efficient fluid mixture, as in the official spirit of phosphorus and its derivate, elixir of phosphorus. For pills of phosphorus the plan should be followed of actually *dissolving* the phosphorus in some fluid, which either itself hardens, by cooling, to a solid, or which, incorporated with some indifferent powder, will form a pill mass. In either case, the indispensable feature is secured that phosphorus is in true solution still, although the pill as such is of course a solid. An obvious practice for the making of such pills is to dissolve phosphorus in melted resins, which on cooling reacquire the solid condition with, now, the phosphorus held in solution. But while these resinous pills are easy to make and to take, there is strong reason to fear that the contained phosphorus may easily be allowed and even helped to oxidize. The pharmacopœial procedure given below is probably as free from objection as any.

In whatever form or dose phosphorus be given, a cardinal rule, insisted upon by almost all who have had much experience with the medicine, is that the administration should never be upon an empty stomach, nor, on the other hand, *immediately* after eating.

The phosphorus preparations of the United States Pharmacopœia are as follows:

Oleum Phosphoratum, Phosphorated Oil. Phosphorus is dissolved by gentle heat in sweet almond oil which has been previously heated for fifteen minutes to a temperature of 250° C. (482° F.), and then cooled and filtered. After the phosphorus is fully dissolved and the solution cooled, a small charge of ether is added thereto. The finished product contains one per cent. of phosphorus and nine of ether. By measure, one minim represents about gr. $\frac{1}{117}$ of phosphorus (United States Dispensatory). Phosphorated oil should be clear and with a decided taste and smell of phosphorus, and the few drops which will constitute a dose (see remarks on dosage, above) may be given in capsule or in emulsion, flavored by a trace of oil of peppermint, or of gaultheria, or of bitter almond. The official emulsion of *almond* forms a convenient vehicle for an emulsion, flavored as just described. Phosphorated oil must be kept in small, glass-stoppered vials in a cool place, and the phosphorus keeps best when the vials are completely full.

Pilulæ Phosphori, Pills of Phosphorus. Phosphorus is dissolved in chloroform by gentle heat and the solution added to a mixture of acacia and althæa in a mortar. A little glycerin and a little water are next poured on, and the whole is rapidly beaten to a pill mass, which is immediately cut up into the proper number of pills. Each pill is then coated with a solution of balsam of tolu in ether, and when the coating is dry the pills are put up in well-stoppered bottles. These pills contain, each, 0.0006 gm. (gr. $\frac{1}{100}$) of phosphorus, and from one to five pills will constitute a dose. (See remarks on dosage, above.)

Spiritus Phosphori, Spirit of Phosphorus. This is a solution of phosphorus in absolute alcohol of the strength of 1.2 per cent. of phosphorus. It is official for the making of the elixir of phosphorus.

Elixir Phosphori, Elixir of Phosphorus. This preparation is a mixture of the spirit of phosphorus, glycerin, and aromatic elixir, with a flavoring of oil of anise. It is a transparent liquid, containing about 0.00025 gm. (gr. $\frac{1}{250}$) in each cubic centimetre (♏ xvi.). Unofficial, but well known and much used, is an alcoholic solution of phosphorus devised by Ashburton Thompson, of England, and commonly called *Thompson's Solution of*

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Phosphorus. It is prepared as follows: One grain (0.065 gm.) of phosphorus is dissolved in fl. ℨ v. (16 gm.)* of *absolute* alcohol by the aid of heat, and the solution added to a *warmed* mixture of fl. ℥ iss. (56.25 gm.) of glycerin and fl. ℨ ij. (6.68 gm.) of alcohol. When the resulting mixture has cooled ♏ xl. (2.13 gm.) of spirit of peppermint is added. The preparation should be a bright, clear, colorless solution, wherein the odor and taste of phosphorus are almost completely masked by the pungency of the alcohol and peppermint. It is essential that the alcohol used to dissolve the phosphorus be literally *absolute;* and in such case the preparation, if kept in well-filled and well-stoppered bottles out of the light, will keep unaltered long enough for the treatment of an average case. If all the phosphorus be and remain dissolved, the solution contains 0.003 gm. (gr. $\frac{1}{20}$ nearly) in 4 c.c. (fl. ℨ i.)—a scant teaspoonful. The dose, averaging from one-third to one small teaspoonful, is best taken clear, but if too sharp in that condition, may be taken in water, the mixture to be made only at the time of each administration.

Under no circumstances should phosphorus be prescribed as an ingredient of extemporaneous composite medicinal mixtures.

Zinc Phosphide: Zn_3P_2. A peculiar compound of phosphorus, which practically amounts to a medicinal preparation of the element itself, is what is official in the United States Pharmacopœia under the title *Zinci Phosphidum,* Zinc Phosphide. This compound appears as a finely crystalline powder, or as crystalline lumps. It is gray-black in color, with a metallic sheen on broken pieces, and gives faintly the odor and taste of phosphorus. It is insoluble in water or alcohol, but dissolves in sulphuric or hydrochloric acid, with evolution of hydrogen phosphide. Zinc phosphide must be kept in small glass-stoppered vials.

This compound is lacking in the vigorously irritant action of phosphorus, yet even in therapeutic doses may easily upset the stomach and even excite vomiting. From its ready decomposition by acids it yields, in the stomach, some medicinally active condition of phosphorus, and its administration is therefore followed by therapeutic results similar to those attained by the use of the uncombined element. The phosphide is, however, not so certain as preparations of phosphorus itself, and is probably most commonly turned to as a last resort in cases in which phosphorus persistently disagrees. Zinc phosphide contains one-fourth of its weight of phosphorus, and the dose therefore ranges from 0.003 gm. (gr. $\frac{1}{20}$) to 0.016 gm. (gr. $\frac{1}{4}$). It may be given in pill form, and, unlike phosphorus, may be prescribed in combination with other medicines, avoiding only acids, which decompose it. After swallowing, however, the certainty of medicinal action will be enhanced by effecting this same decomposition through the agency of an acid draught, such as lemonade or a little vinegar. The most disagreeable features of the drug are a tendency to eructations of phosphoreted hydrogen and to disturbance of the stomach. With the larger of the doses mentioned above nausea is not at all unlikely.

Edward Curtis.

[1] Wegner: Virchow's Archiv, June 22d, 1872.

[2] See Phillips' Materia Medica and Therapeutics, Inorganic Substances, p. 51.

[3] Note on the Administration of Phosphorus, E. R. Squibb, M.D., Proceedings of the Am. Pharmaceutical Assn. for 1876, and pamphlet, Philadelphia, 1877.

PHOSPHORUS, POISONING BY.—It is doubtful if there is another substance among the many common poisons which is of so much interest to the toxicologist as is phosphorus—an interest arising from an historical viewpoint, and because of the desire to discover the mysterious causes of its insidious action on living organisms. Moreover, we meet with the anomaly that, unlike most of the other inorganic poisons, and especially arsenic, antimony, and nitrogen, members of the same group in the Periodic System, this element is toxic in its free or elemental state, while its compounds (save the hydrides) are practically non-toxic.

* In calculating the metric equivalents regard has been paid to the specific gravities of the several fluids.

Phosphorus was unknown to the layman as a poison prior to 1840. Shortly after the popularization of matches, about the year 1833, the public became acquainted with its deadly nature, and because of the ease with which the material could be procured, poisonings by phosphorus became alarmingly frequent. In no country have the number of cases been so numerous as in France, where from 1840 to 1880 there were 336 criminal cases of poisoning by this element. The maximum number in a single year was 94 in 1860, or, if we consider the period 1851–70, we find that out of a total of 793 deaths due to poisons 267, or 33.7 per cent., were due to phosphorus, while during this same period 287 are charged to arsenic. France still heads the list in the number of cases of poisoning by this element, which usually equal, or even exceed annually, those due to arsenic. The substitution of "Parlor" and "Safety" or "Swedish" matches (invented by Böttger in 1852) for the yellow phosphorus match was immediately followed by a decrease in the criminal use of phosphorus; the decrease was also due in part to the fact that it became known to criminals that a process had been devised by which the poison could be easily and surely detected (the Mitscherlich method).

Homicidal poisonings are now rare. The majority of cases are due to attempts at suicide or to accidents among children.

Only "yellow" phosphorus, the hydrides of phosphorus, and the phosphides of certain elements, such as calcium and zinc, are of toxicological interest.

Yellow Phosphorus.—The general properties of this almost colorless, wax-like substance are too well known to require review. A word as to its solubility is, however, necessary. In water pure phosphorus is practically insoluble; in fact, it has been asserted that what is thought to be a solution represents merely exceedingly fine particles in suspension, or else that it is a solution of the vapor. According to Hartmann 1 litre (about ℥ xxxiv.) of water at 38° C. (100.4° F.) will take up 2 mgm. (gr. $\frac{3}{100}$) of phosphorus; while in oils its solubility varies from 1 to 100, to 1 to 10,000 parts, according to the nature of the oil and various conditions, such as temperature, etc. In bile phosphorus is readily soluble, 100 parts of this fluid dissolving 15 to 25 parts.

Because of the low solubility of phosphorus in most of the fluids of the body, only slight action generally follows the ingestion of large fragments of this substance. When taken, however, in a finely divided condition the action is very violent.

Poisoning by phosphorus usually results from matches, phosphorus pastes (vermin killers), or phosphorus oil (Oleum phosphoratum).

Matches.—The modern "parlor" and "safety" matches are usually harmless, so far as poisoning by phosphorus is concerned, owing to the fact that they are made of non-toxic red phosphorus and an oxidizing agent, such as potassium chlorate. The matches of a decade ago, known variously as "friction," "brimstone," "sulphur," "lucifer," "phosphorus," etc., matches, are to be charged with by far the majority of deaths. The heads of these matches contain on an average about five per cent. phosphorus, the limits varying from three to seven per cent. A single head usually contains from $\frac{1}{3}$ to 1.5 mgm. (gr. 0.005 to 0.023). In these matches the sticks after being dipped in sulphur are tipped with a mixture of glue or dextrin containing coloring matter, phosphorus, and an oxidizing substance such as lead nitrate, lead peroxide, nitre, potassium chlorate, or some similar compound. Dissolving these heads in water or a warm liquid yields a liquid in which the phosphorus exists in an emulsion in an exceedingly finely divided condition.

Phosphorus Pastes are now seldom employed, though formerly they were in great demand for destroying rats and other vermin. Here the phosphorus exists very finely divided with flour, lard, and sugar or molasses as a basis.

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These pastes vary greatly in composition. They contain, on an average, about two per cent. of phosphorus, but may contain as high as five per cent.

Phosphin.—The hydride H_3P is the only one of importance. One-fourth to one-half per cent. in air causes death in animals in twenty to thirty minutes, while 0.2 per cent. will produce symptoms of asphyxia in a few minutes. In man, when it is breathed in very small amount in air for any length of time, the symptoms closely resemble those produced by phosphorus vapors. Under this head there is another possible source of phosphorus, or rather phosphine, poisoning. It has been suggested that there may be a reduction of phosphates in the intestines by bacteria (a form of auto-intoxication well known in the case of reduction of sulphates to hydrogen sulphide). Some have even gone so far as to claim that acute yellow atrophy of the liver is due to this cause. This action of bacteria is well established for sulphur, arsenic, and antimony compounds; but although it is to be expected for compounds of phosphorus by analogy, all investigations have given thus far negative results with pure cultures of powerfully reducing bacteria, the reduction being carried only to phosphites.

Fatal Dose.—The weight of phosphorus which constitutes a fatal dose is quite uncertain. An examination of the records shows such a variation that it is difficult to make an accurate statement. The fatal dose seems to depend, more than is the case with most inorganic poisons, upon the nature of the material containing the poison, the state of division of the phosphorus, the nature of the material in the alimentary canal, and the idiosyncrasy of the individual. As regards matches, we find that a child has died after sucking the heads of 2 matches. In another case 8 heads caused death. Sixteen match heads have caused the death of an adult; and Tardieu cites a case in which 101 matches were immersed for seven or eight minutes in a cup of hot coffee with a resulting solvent action so low as to permit the matches when dry to be ignited by rubbing in the usual manner, yet the poisonous draught caused very dangerous symptoms. Other records show that where death has resulted from swallowing match heads the number of these taken in each case has varied from 60 to 3,000; and that, on the other hand, recovery has followed prompt medical aid where from 3,000 to 4,000 match heads have been taken.

In the case of Oleum phosphoratum it is probable that a dose of 200-250 mgm. (gr. iij.-iv.) will produce dangerous results, and that 500-600 mgm. (about gr. vij.-ix.) will almost invariably prove fatal.

Phosphorus itself, finely divided in hot water, has in a few instances been employed for homicidal and suicidal purposes. Although the smallest fatal dose recorded is about 8 mgm. (gr. $\frac{1}{8}$), this is abnormally low. It is believed that the toxic dose of well-dissolved or exceedingly finely divided phosphorus is probably about 15 mgm. (gr. 0.23), and that the fatal dose lies in the neighborhood of 150 mgm. (gr. ij.-iij.). Recovery has followed a dose of over 300 mgm. Occasionally cases are met with which seem to indicate that phosphorus may at times have a slight accumulative tendency. With animals the doses may be safely set as follows:

	Fatal dose. Grams.	Therapeutic dose. Grams.
Horses and cattle	0.5 to 2.00	0.010 to 0.050
Sheep and swine	.10 to .30	.002 to .005
Dogs	.05 to .10	.0005 to .002
Fowls and cats	.01 to .03	.0005 to .001

The most susceptible animals per kilogram weight are fowls, the next swine, then dogs. According to Naunyn parrots alone seem to be relatively immune.

Fatal Period.—This is quite variable, but there can be no doubt that phosphorus should be classed as a slow poison. The usual period lies between one and four or five days, with most deaths falling on the second or the third day; yet life may sometimes be prolonged until the seventh day, or very rarely until the seventeenth to the twentieth day. Several cases of remarkably rapid death are recorded. Caspar cites the case of a young woman who took 194 mgm. (gr. iij.) of phosphorus in an electuary and died in twelve hours, while Habershon is authority for the statement that death has taken place in thirty minutes.

Symptoms.—The differences in the symptoms between acute and chronic poisoning are chiefly only of degree, and yet at the same time they are quite marked. Even in acute cases it has been shown by Tardieu that it is possible to distinguish three distinct forms, which have been termed common, nervous, and hemorrhagic, according as certain symptoms predominate. The lack of space forbids a consideration of these. Occasionally a patient will show a combination of all these types, the one following the other.

In what may be called for convenience a typical or normal case of poisoning (generally the result of matches), the victim first complains of pain in the throat. Usually, but not always, this pain extends downward with increasing severity, and is most marked in the epigastrium and abdomen. The tongue is enlarged and coated. Nausea in its most acute form sets in, followed later by vomiting of material of a mucous and bilious character. Very rarely at this stage is the vomit tinged with blood, but the ejected material is generally phosphorescent in the dark. There may be annoying eructations with an alliaceous odor and taste; the exhaled breath may even be luminous in the dark and give rise to a thin white vaper upon striking the air. Colic and diarrhœa set in at this stage, in about thirty per cent. of the cases. The pulse may for a short period be accelerated with an accompanying slight rise in temperature, but soon it becomes small, weak, slow, and often irregular. The temperature may fall as much as 3° or even 4° C. Respiration, which also suffered a slight acceleration, becomes slow, oppressed, and sometimes stertorous. This train of symptoms continues for from twenty-four to forty-eight hours when a remission often takes place; nausea and vomiting ceasing and the abdominal pain disappearing save for a few vague twinges. A period of apparent convalescence supervenes for two or three days; then suddenly, when all seems to be going well, the victim is stricken down with the most violent symptoms. Icterus appears, accompanied by hemorrhages, increasing in number and severity, in which practically all channels are affected. Vomiting and purging having again set in, the ejected matters are bloody in character and may at times consist almost wholly of blood; there is bleeding at the nose and even at the ears, and in women there is almost invariably more or less uterine hemorrhage. Up to the present time, in spite of the reputed aphrodisiac action of phosphorus, no venereal excitation has been observed in either sex in acute poisoning. The blood discharged is very thin and fluid. Hemorrhages have been known to continue for several months, the victim becoming weaker and weaker, and sinking into deeper and deeper apathy, being roused only by recurring nervous disturbances. Accompanying the hemorrhages is seen anæmic cachexia and urticaria, and a blotched skin. The eyes are icteric, blood shot, and prominent. Owing to paralysis of the sphincter muscles there may be, in the last stages of the disease, involuntary expulsion of urine and fæces. Prior to this, however, the urine is apt to be suppressed, and when discharged or drawn will be found to contain albumin, peptones, hæmoglobin, bile pigments, biliary acids, fibrin and hyaline cylinders, fatty droplets, often leucin and tyrosin, almost invariably sarcolactic acid, subnormal urea, and abnormal ammonium salts, phosphates, and sulphates. It is quite safe to assert that icterus is absent in exceedingly rapid death only. Death takes place in coma or syncope, occasionally in convulsions preceded by delirium.

In addition to the above-mentioned symptoms there is often quite marked paralysis of the voluntary muscles, especially those of the legs, preceded by coldness or numbness and accompanied by formication and twinges

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of pain. Occasionally there is anæsthesia of the lower extremities, but otherwise there seems to be no loss of sensation.

Recovery from severe acute phosphorus poisoning is rare and takes place only after a long time.

The symptoms seldom appear in less than one to three hours, more often in five to ten hours. There are exceptions, however; for example, Taylor cites a case of a young girl who swallowed a quantity of phosphorus paste, and who at first suffered from symptoms so slight that it was thought that but little poison had been ingested. It was not until the following day that she was taken ill, and on the second day had apparently recovered; on the third day she was stricken with symptoms of poisoning, but these were not violent until the fifth day. Death took place on the sixth day despite the efforts which were made during all this period to save her life.

At one time or another practically all the secretions and excretions have been observed to be luminous in the dark—the exhaled breath, vomited matter, stools, urine, perspiration, etc.

Phosphorus cannot be classed, as is very evident from the above, as a rapid or even moderately rapid poison; and, on the other hand, evidence is lacking which would justify its being credited with any truly latent action.

Acute Poisoning in Animals.—Typical symptoms, similar to those seen in man, are observed in dogs and swine. Horned cattle behave somewhat similarly, but horses and fowls are affected in an entirely different manner. Fowls are exceedingly sensitive to this poison, suffering chiefly from severe thirst, diarrhœa, and chorea. They die without having shown any characteristic symptoms save that they are apt to move with a peculiar hopping gait. Horses die suddenly in a few days, having shown practically no symptoms of poisoning. In cows a cessation of milk secretion is almost invariably observed. In animals, especially ruminants, the first symptoms appear after several hours. The shortest period of illness can be set at about ten to fifteen hours. Most animals die on the second or third day, or on the third to the fifth day. Sometimes death comes on very suddenly through paralysis of the heart following an apparent improvement.

Chronic Poisoning is almost invariably the result of breathing air containing vapors of phosphorus, and is therefore seen in workmen engaged in industries using phosphorus, such as the manufacture of "sulphur" matches, phosphor bronze, etc. In the manufacture of phosphorus chronic poisoning is very rare. Up to 1900, in the great Coignet factory in France, there had been only one case of maxillary necrosis in fifteen years. In the days of the extensive manufacture of sulphur matches chronic poisoning was so alarmingly frequent, especially among workmen in the "drying rooms," that several governments passed laws forbidding the manufacture of this kind of match. Since the introduction of parlor and safety matches chronic poisoning has become very rare.

This remarkable disease is characterized by bronchial catarrh, chronic gastro-enteritis, loss of appetite, constipation often followed by diarrhœa, exquisite toothache, chronic periostitis passing into necrosis of the maxillary bones, cachexia, and fever. In general, we have all the symptoms of acute poisoning, but in much less violent form and coming on slowly and insidiously.

The gums swell; there may be salivation; the teeth ache, decay, loosen, their dentine becomes exposed; there is persistent gingivitis; dental abscesses increase in number and the fistulæ discharge sequestra and fetid pus. The breath is horribly fetid. The victim suffers from pains in the joints and legs, rapidly weakens and wastes away. Hectic fever sets in, and death may occur in convulsions, more often in coma or syncope.

Usually it is the lower maxillary which is first attacked; less frequently and less seriously, at the outset, the upper jaw is affected. As the disease progresses both jaws become diseased. Sometimes the necrosis extends to the nasal bones and even to the base of the skull, when death from meningitis results. In the case of severe necrosis the mortality seems to range in the neighborhood of forty-five per cent. This disease has been incorrectly termed by some European physicians progressive necrosic osteoperiostitis. Following the necrosis there is marked thickening of the affected bones, and the cartilage becomes ossified. Workmen having carious teeth suffer most from maxillary necrosis. In fact, there is reason to believe that, in the absence of penetrating caries, necrosis of the jaw bones is rarely if ever met with. It has, therefore, become an established custom in all well conducted phosphorus industries to employ only men and women having sound teeth. Necrosis of the jaw develops after about six months' exposure to the vapors of phosphorus. Occasionally it may appear in a shorter period, or may fail to appear until after several years. This is only another instance of the remarkable variation in the action of this element.

Contrary to the facts observed with most other substances giving rise to chronic poisoning there are no records showing that the domestic animals frequenting the industries are afflicted with phosphorism.

Antidotes.—The most satisfactory chemical antidotes are copper sulphate, and oxidizing substances such as *old* turpentine, hydrogen peroxide, potassium permanganate, etc. In the case of acute poisoning administer copper sulphate, three grains every five minutes until the stomach has been sufficiently cleared. Follow this by one of the oxidizing agents, as, for example, old turpentine in emulsion in mucilage, one drachm every half-hour combined with the inhalation of turpentine vapor, or wash out the stomach with 0.2- or 0.3-per-cent. solution of potassium permanganate, or with a one- to three-per-cent. solution of peroxide of hydrogen. Magnesium sulphate may also be given to clear the bowels. The efficacy of copper sulphate depends upon its action as an emetic, and upon its property of reacting with phosphorus to form an insoluble copper phosphide and in part to oxidize the phosphorus, metallic copper and phosphoric acid resulting. With old (oxidized) turpentine a turpentine-phosphoric acid of low toxicity results, while with permanganate and peroxide the phosphorus is oxidized to non-poisonous phosphoric acid. Besides the administration of antidotes the patient must receive such treatment as the symptoms require. Administer ice and cold demulcent drinks. The paralysis and the sinking of blood pressure must be counteracted by excitants. All substances and foods containing fats or oils must be forbidden. Some practitioners bar the use of alkaline drinks on the ground that there is danger of the formation of phosphine; others insist upon their use as essential to maintain the alkalinity of the blood.

Prophylaxis.—In all industries using phosphorus, exceptionally good ventilation is imperative. There should be a constant circulation of fresh air in all the rooms. Exceedingly great care should be exercised under the supervision of a competent and conscientious foreman. Every workman should be required to wash and bathe frequently and thoroughly, and especially always to wash the hands before eating. Medical examinations should be made compulsory at stated intervals, and all cases of sore mouth, toothache, etc., should be at once excluded from the workrooms. Only men and women with sound teeth should be employed. A mouth wash containing boric acid, beta-naphthol, and eucalyptol has been found useful as a preventive against necrosis.

Post-mortem Appearances.—In typical cases the appearances after death are very striking and characteristic. Acute yellow atrophy and cirrhosis of the liver are practically the only diseases which yield lesions that can be confused with poisoning by phosphorus. The appearances are almost identical in each of these diseases, yet the symptoms and progress of the diseases are so different that there is little danger of error when the practitioner is in possession of the history of the case.

There is often corrosion and ulceration of the stomach and duodenum. The mucosa of the stomach is soft, swollen, mammillated, and degenerated.

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The most characteristic feature, however, is the remarkable icteric condition and fatty degeneration of the liver and kidneys in particular, but also of the heart, of the glands of the stomach and intestines, and even of the muscles. The alimentary canal as a whole is usually contracted. Multiple hemorrhages are found in the lungs, heart, and throughout the alimentary canal. Occasionally there is no corrosion nor ulceration of the mucosa of the œsophagus and stomach, but in such cases a hemorrhagic or ecchymosed condition is rarely absent. A similar condition obtains in the mesentery and the peritoneum.

The pleural and pericardial cavities contain bloody serum and the serous membranes are ecchymosed.

The liver will generally be found enormously enlarged, fatty, soft, pasty, and light or dark yellow in color, with the acini enlarged and prominent, while here and there are hemorrhagic spots. When the period of illness has been very prolonged, the liver may be found to be not only no longer enlarged, but even subnormal in size. It may be luminous in the dark.

Although slow poisoning by ammonia, alcohol, arsenic, antimony, cyanides, sulphocyanates, etc., also gives rise to fatty degeneration, the steatosis is seldom so extensive, so marked, nor of so rapid formation as in poisoning by phosphorus. Cases are recorded in which death from phosphorus took place in forty-eight hours, yet in this short period there was marked steatosis of the liver, kidneys, heart, and glands of the stomach.

Rarely death may take place and the autopsy will fail to reveal any noteworthy lesion or marked inflammation of the mucosa.

Mechanism of Action.—As regards this phase of the action of phosphorus, it is to be stated that at the present time no satisfactory theories have been formulated. Because of the lesions and remarkable effects of phosphorus, this substance has long been a most interesting and fruitful field of research for toxicologists and pharmacologists, yet in spite of the many investigations the mechanism of its action is still an *ignis fatuus.*

Phosphorus seems to be resorbed without change, and is carried by the blood either in colloidal solution, in the state of excessively fine emulsion, or the element is vaporized by the heat of the body and the vapor dissolved by the blood. It suffers, because of the high partial pressure of the oxygen in the blood, little or no immediate oxidation. The effects produced upon the tissues cannot be due to the action of hypophosphorous, phosphorous, or phosphoric acids, nor to any alkaline salts of these acids. The hypothesis that hydrides of phosphorus are formed and carried by the blood and are the primary cause of illness seems to be no more tenable than the oxidation theory.

It has been shown repeatedly that while from a chemical viewpoint phosphorus should not be able to exist as such for any length of time in arterial blood, not only is such the fact, but, as already stated, it suffers but little change.

All experiments go to show that phosphorus is to be classed as one of a group of poisons chiefly affecting the metabolism, of which group hydrocyanic acid, oxalic acid, and carbon monoxide are the other best-known types. Bauer has pointed out that the oxygen taken up and the carbon dioxide given off in acute poisoning is always abnormally low (eight to eleven per cent. CO_2 instead of twenty-four to twenty-seven per cent.), and that the respiration curve indicates a powerful disturbance of the metabolism. Moreover, this is further borne out by the fact that peptone-like digestion products are usually eliminated in the urine, that the urea is subnormal, and that the albumin of the food, and also to a certain extent of the organism, is decomposed, and goes to form fat, leucin, tyrosin, and probably sarcolactic acid. The decrease in the amount of urea has been explained on the theory that owing to the formation of acids (lactic acid?) a great part of the nitrogen, which would otherwise be converted into urea, goes to form ammonia to neutralize the acids. Because of this neutralizing action the alkalinity of the blood falls and probably countless blood corpuscles are destroyed; for this latter reason phosphorus is also classed, by some authorities, in the group of so-called "blood poisons." This whole question of action on the blood is very little understood. Cases are reported in which no destruction of blood corpuscles has been observed. In man there seems to be a transitory increase of erythrocytes and a decrease of leucocytes. In dogs the erythrocytes and hæmoglobin are not affected, but the leucocytes seem to be increased. In fowls there is undoubted dissolution of red corpuscles and an increase of leucocytes. Following the destruction of the red blood corpuscles—which, it is assumed, takes place at some stage in poisoning by phosphorus—an abnormal secretion of bile pigments takes place; at the same time the bile becomes thick and viscid and moves through the ducts slowly. To account for the direct cause of icterus several theories have been advanced: one ascribing it to catarrh of the duodenum and cutting off of the ductus choledochus; another to the compression of the tiny bile ducts by the swelling of the liver; still another that the mucosa of the biliary passages becomes diseased, and that there is finally a clogging of these passages through fatty degeneration and rupture of the walls of the vessels. It is likely that all these causes contribute to the retardation of the flow of the bile, and that this fluid overflows into the lymphatics. The cause of the polycholia is, however, not yet understood, but its results are apparent in cerebral disturbances, as shown by coma, etc.

As to what happens to the phosphorus in its long sojourn in the blood we know but little. Only one point is clear. Part unites with many as yet wholly unknown basic products of the metabolism to form toxic compounds. Selmi has succeeded in isolating some of these compounds from the urine, and has given them the name phosphoptomaïns, while Van den Corput has called them toxicomaïns. According to this latter investigator most of the ill-effects of phosphorus are due to the formation of these retention toxicoses. Besides these phosphorus bases in the urine and blood, Kunkel advances the hypothesis that part of the phosphorus is oxidized by the blood, and that the phosphoric acid thus produced is eliminated in the form of esters.

In the matter of the fatty degeneration of the liver the weight of evidence seems to be that we must regard it as the result of two causes: one, the formation of fat in the organ itself, and the other the transportation of preformed fat to this organ. Experiments on animals have shown that the microscope will demonstrate the beginning of fatty degeneration in the liver in as short a time as six to eight hours after the administration of the poison, and in about twelve hours in the kidneys and heart (Kobert).

No satisfactory explanation of the cause of the corrosion and ulceration of the mucosa of the alimentary canal has yet been found. It has been suggested that this may be the result of the nascent action of oxygen acids of phosphorus at the moment of their formation; but since the early formation of these acids is uncertain a better explanation is wanted.

As to phosphorus necrosis, little can be said save that it follows periostitis. It is not the mineral stroma which is attacked, but the cells of osseous tissue. Necrosis often follows an injury to the bones or periosteum, in illustration of which an interesting case, recorded by Wegner, may be cited. A boy working in a match factory rapidly developed periostitis and necrosis of the bone following the breaking of his leg. Wegner's investigations on the action of phosphorus on the bones are of great interest, although they shed but little light upon the mechanism of the action. He found that the administration of very small amounts of phosphorus daily, either internally by the mouth or as vapor, to young animals, caused an abnormally rapid development of osseous tissue, that the bones formed were more compact than usual, that the medullary cavities were much reduced in size, and that the abnormally developed bones did not differ in chemical composition from bones normally grown.

Investigations upon the action on the heart show that

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the beating is arrested in diastole in both warm- and cold-blooded animals, that the action is probably directly upon the heart muscles, that the automatic centres are first affected and then the muscles are greatly weakened, although they still respond to artificial stimuli.

Clinical Tests for Phosphorus.—Expose to the vapors given off from the warmed material to be tested two strips of filter paper, one of which has been moistened with silver-nitrate solution, the other with lead-acetate solution. If phosphorus is present, the silver paper blackens while the lead paper should remain unchanged. If both papers blacken, hydrogen sulphide is present and must first be removed before testing. In such an event add to the material to be tested sufficient lead acetate solution to precipitate all the hydrogen sulphide as lead sulphide, and test with the two papers as before. The blackening of the silver-nitrate paper is due to the formation of silver phosphide and metallic silver.

A less satisfactory test consists in boiling the material to be tested with a small piece of roll sulphur. After a few minutes the piece of sulphur, which has taken up most of the free phosphorus present, is removed, washed, and examined in a darkened room. On being gently warmed and rubbed with the finger the sulphur will shine with the peculiar glow of phosphorus, if this latter element is present.

If possible the suspected material should always be tested in the laboratory by the Mitscherlich distillation method.

There are reasons for believing that phosphorus can exist in the body in the free state for about eight weeks. After twelve weeks it can still be detected in the form of phosphorous acid, but after about fifteen weeks it is probable that all the elemental phosphorus has been eliminated or oxidized to phosphoric acid. As regards the detection of free phosphorus after death, it is safe to say that chemical tests usually fail after four weeks; but there are instances in which it has been possible to obtain undoubted proof fifteen weeks after burial.

Emile Monnin Chamot.

PHOTOMICROGRAPHY.—Definition.—The process of obtaining a macroscopic photograph of a microscopic object. It is sometimes incorrectly termed microphotography, which is the reduction by photography of landscapes, portraits, or other gross photographs to collodion positives of minute size, which are subsequently mounted beneath a small convex lens, in watch charms, paper knives, pencil handles, and the like. It is to be noted that this distinction is not universal on the continent of Europe. The above title in German is Mikrophotographie; in French, Photomicrographie.

History.—The first photomicrographs and probably also the first photographs were taken by Wedgewood and Davy. The record of their experiments, published in 1802, some time after the death of Wedgewood, show that they used a solar microscope and obtained images upon paper and leather which had been washed with a silver solution. They were, however, unable to fix the images so obtained and, when exposed to daylight, the entire surface became uniformly dark.

The Rev. J. B. Reade, of England, in 1837, with a solar microscope photographed entomological specimens and sections of vegetable tissues upon paper coated with nitrate of silver solution and fixed the images with an infusion of galls. In 1839, at a soirée given by the Mar-

Fig. 3805.—Installation for Photomicrography with Heliostat. The objects are arranged, from left to right, in the following order: camera, microscope, screens, shutter, and mirror; outside the window, on a levelling stand: heliostat and a second mirror.

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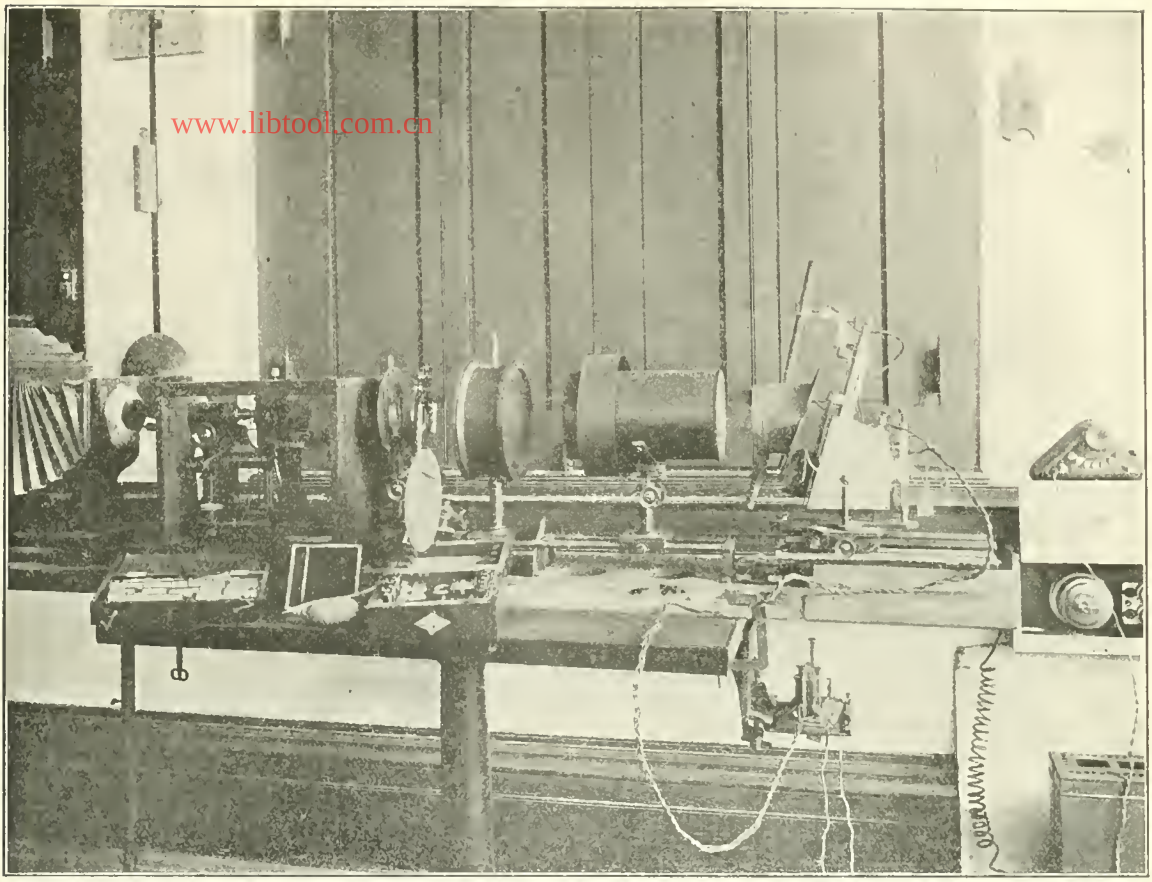

FIG. 3806.—The Optical Bench, Arranged for Photomicrography with the Electric Arc Lamp. The objects are arranged, from left to right, in the following order: end of camera, microscope, screens, shutter, water-bath, condenser system, arc lamp; on the table: battery of oculars and objectives, color screens and bulb of pneumatic release of shutter; under arc lamp—the adjustable shunt coil; at the extreme right, against the wall: switches and rheostat.

In practice a cloth is thrown over the frame which encloses the microscope, for the purpose of shutting out the rays of light from the eyes of the operator, while permitting at the same time all necessary manipulation. The screens, water-bath, condensers, and arc lamp are all enclosed in such a manner as to reduce to a minimum the escape of light into the room.

quis of Northampton, then president of the Royal Society, Mr. Reade exhibited more perfect results, and some of his photomicrographs were on sale at a bazaar in Leeds the same year. It was not until after Daguerre had announced his discovery before the Academy at Paris on the 19th of August, 1839, that attempts to use photography to obtain pictures through the microscope were generally undertaken. In 1840 Mr. Dancer, of England, photographed through a gas microscope upon silvered plates; he also by means of the solar microscope photographed wood sections and fossils on paper and glass plates. Dr. Donné, of Paris, in 1840, presented to the Academy of Sciences photomicrographs on daguerrotype plates; and in collaboration with M. Léon Foucault, in 1845, published an atlas on the study of the fluids of the body, illustrated by cuts from daguerrotypes. One of the first publications in England to use photomicrographs as illustrations was the *Quarterly Journal of the Microscopical Society*, which in 1852 contained prints from negatives by Mr. Joseph Delves. Since these early attempts the practice of photomicrography and its use for illustration have steadily grown. The list of those who have done notable work is a long one, and contains many well-known names.

The Apparatus.—The several parts comprising the apparatus for making photomicrographs are collectively called an installation. In its simplest form it may be a long bellows camera with a photographic lens on the front or on the front of a conical extension, as ordinarily used by photographers for making enlarged copies; such an arrangement is useful when the original object is of comparatively large size and the magnification slight, as the limit of a few diameters is very quickly reached by this method. For most photomicrographic work a microscope is a necessity, as are also the accessory apparatus on the optical bench and, in the present day of rapid dry plates, the camera. Sometimes, in the days when the slow, comparatively non-sensitive wet plates were in use, the room in which the optical bench and microscope were placed formed the camera; the source of illumination was outside the room, and enough diffuse light was admitted through yellow glass to enable the operator to work. Such an arrangement was used by Surgeon-General J. J. Woodward in making his now classical photomicrographs of difficult test diatoms, etc. At the present time, however, the rapid color-sensitive plate demands much greater care in the exclusion of all light not used in taking the picture, and many forms of photomicrographic apparatus have been devised. Some operators, in Europe especially, prefer to work with the vertical apparatus, subsequently enlarging the pictures so obtained; but most of the English and American photomicrographers use the horizontal apparatus, and with the long camera bellows obtain the desired magnification directly. The installation, then, may be described as consisting of the source of light, the optical bench with its accessories, the microscope, and the camera.

The Source of Light.—This may be an oil lamp of one

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or more burners, illuminating gas, a Welsbach burner, or an acetylene flame. All of these may be classified as illuminants of a low order, as when high powers are used their illumination becomes too feeble to enable satisfactory focussing of the image. The lime light in any of its modifications forms the next higher order of illuminant; magnesium ribbon or flashlight the next; then may be put the arc light; and, most powerful of all, the sun. When the sun is the source of light, it is necessary to use an heliostat to control the rays used for illumination, as after centring the light it should remain centred without appreciable variation; otherwise much time is wasted and many vexatious failures are inevitable. It is desirable that the heliostat be of comparatively simple construction in order that it may not easily get out of order. I have found that what is known as the Prazmowski heliostat is a very efficient form, being very easily adjusted and quite simple in construction. This instrument carries a single mirror on its axis which is caused to follow the sun by clockwork. The rays, being thrown at a convenient angle by adjustment when starting, are maintained in the same direction. A second mirror on an adjustable stand intercepts the rays reflected from the heliostat mirror and, if the installation is rightly placed, directs them through the microscope and camera. If, however, it is not convenient to have the installation so placed, a third mirror on the optical bench directs the rays in the desired direction (see Fig. 3805). All photomicrographers who have worked with sunlight know, however, how few are the perfect unclouded days when the work can be satisfactorily performed, as even the thinnest cloud passing across the sun's disc practically extinguishes the light with resulting delay and difficulty in making correct exposure; but notwithstanding the annoyances and difficulties attending the use of sunlight, until recent years those accustomed to it generally returned to its use after trying other methods of illumination. At the present time, however, with the electric current almost everywhere available, the use of the arc light frees photomicrography from many of the difficulties formerly obtaining. The essentials for illumination by the arc light are, the continuous current, a simple form of focussing lamp, a rheostat, and a shunt coil of simple form used outside the zone of heat radiated by the lamp, and capable of delicate adjustment. Many of the failures to obtain satisfaction from the arc lamp, aside from too delicate construction, have been due to the fact that the controlling coils were within the lamp body. Now, while such a lamp may work perfectly in the open where its heat is radiated away quickly, when we enclose it so that its light may not escape into the room to the annoyance of the operator, it soon begins to focus irregularly or not at all. The reason is simple: the actuating mechanism of the lamp is controlled by an electro-magnet; temperature has a decided influence on electro-magnets; with a given strength of current, the higher the temperature of the iron core the less will be the amount of magnetism developed therein. The remedy is also simple. A shunt coil with its armature balanced over a contact point and capable of close adjustment is inserted in the circuit anywhere between the lamp and its rheostat. It can thus be put where it will be unaffected by heat, and can be relied upon to perform its functions at all times. The normal current goes as usual by the two main wires to the lamp and back, but when the arc has reached such a length, determined by the adjustment at the shunt coil, that the resistance becomes too great, the current goes from the main wire by a small connecting wire through the shunt coil, actuates its electro-magnet, pulls down the armature, and through the contact mentioned above is shunted through a third wire, which enters the lamp by a separate binding screw and actuates the controlling mechanism. The lamp immediately focuses, and so delicately can the shunt coil be adjusted that the lamp will automatically adjust its focus every other second or two, each time moving the carbons together only a fraction of an inch, and keeping the crater of the positive carbon practically in the optical axis without flickering or change in the steadiness or intensity of the beam of light, the prime requisite of any illumination for photomicrography (see Fig. 3806).

The Optical Bench.—This consists of two parallel rails or V's or a slotted board fixed between the microscope and the radiant (the mirror reflecting the sunbeam, the crater of the positive carbon, or the flame of gas or lamp), and holding the condensers, water-bath to absorb the heat rays, diaphragm stands and screens for various purposes, and sometimes the shutter for the exposures. These are all arranged on stands so that they may be moved to and from the radiant. They should also be adjustable as to height as should the radiant itself.

The Microscope.—The microscope may be of the usual pattern; but for those using as low a power as a three-inch or four-inch lens, a microscope with a body tube of larger diameter and shorter length will be found most convenient. The long focus, low-power lenses can then be used inside the body tube, being held by a cone fitted to screw in place of the draw tube; beside the usual substage condenser there should be an achromatic substage condenser of about 1 N. A. adjustable for centring, a ring with screw thread to hold lenses sometimes used as condensers, and a simple low-power condenser for illuminating large objects when slight magnification is desired. There are also accessory pieces of apparatus, such as prisms, black ground stops, devices for oblique illumination, monochromatic illumination by means of the rays of the spectrum, etc., all fitted to the ring of the condenser carrier so as to be interchangeable. These latter are rarely used except for special lines of work. The stage of the microscope should be large and of the type known as mechanical, moving in any direction in its own plane. The aperture of the stage should be of such size that the high power condenser may be brought close to the object. The front of the stage may be fitted with a sliding carrier for roughly centring the object and a tilting carrier for special occasions. The battery of objectives may consist of any number desired; it will be found, however, that a large number is by no means necessary for widely differing magnifications, as by lengthening or shortening the distance between the microscope and the sensitive plate, various magnifications may be had with the same objective. An amplifier may be used for the same purpose, as also oculars of differing powers.

The Camera.—This may be of any usual make, the size adapted to the wants of the operator, or it may be a specially made long bellows camera. It may be firmly fixed to the same bench or plank that carries the microscope, optical bench, and radiant; or it may have a separate stand of its own and be capable of movement to and from the microscope. It is quite necessary that the connection between the microscope and camera, while excluding all light not used for illuminating the object, should be of such a nature that no vibrations may be transmitted to the microscope when adjusting the plate holder or withdrawing the dark slide. A cone front with cylindrical end is usually placed on the camera, and this may be connected with the microscope by a light-tight sleeve of fabric, or it may fit in, without touching, a double metal cylinder on the eye tube. When using a long bellows camera, some means of focussing both the coarse and the fine adjustments of the microscope from back of the camera must be added to the installation. Various methods of accomplishing this have been described by photomicrographers, each having its advantages. The essential points are that whatever method is used, it must not convey any jar or vibration to the microscope, or bring a strain upon the screws of either adjustment. It must of necessity work smoothly.

Procedure.—It is necessary when first setting up and adjusting the various parts of the apparatus to consider some one part as fixed and adjust all the other parts to it. Generally it will be found best to consider the microscope as the fixed part, and that imaginary line passing through the centres of objective and ocular and indefi-

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nitely prolonged, called the optical axis, as that line with which the centres of all the other parts from radiant to ground glass of camera must coincide. Suppose we have a long bellows camera, an arc lamp, an optical bench (with a large condenser, a water-bath, and supports for diaphragms or screens) and a microscope, and that we wish permanently to mount them upon a long narrow table or bench, two or three feet wide by about twelve feet long. At one end of our table we would place the lamp, next the optical bench, then the microscope turned to the horizontal position, and finally the camera. Upon the size of the ground-glass screen of the camera would depend the height above the table of the tube of the microscope. This having been determined, the base of the microscope is clamped firmly to the table in its proper position, so that the optical axis passes over a line drawn through the centre of the table in the direction of its length. The camera may now be placed behind the microscope and adjusted roughly as to the centring of ground glass with the optical axis. The same may be done with the optical bench in front of the microscope, and then with the lamp. A quick method of rough centring, which I have found practical, is to cross threads diagonally from corner to corner of the camera back, the ground-glass screen having been removed. This will give the centre of the ground glass screen. From this centre stretch a thread through the camera-tube of the microscope, through a pinhole diaphragm in the stage, and on through like diaphragms on the optical bench, fastening the thread at last to one of the carbons of the lamp. The various parts are now adjusted until the thread, being stretched taut, passes through the diaphragms without touching. The final centring is by the light. Removing the thread, putting a low-power objective in the microscope and starting the lamp, we focus the condensers so that the image of the crater, taken up by the objective, is thrown upon the centre of the ground-glass screen of the camera. After the centring is accomplished we are in readiness to take a picture. The object is fastened to the microscope stage and the low- or high-power substage condenser adjusted. The image may now be thrown upon white cardboard for adjustment, centring, etc., or by interposing ground glass and a color filter between the radiant and the substage condenser to render the light bearable to the eyes, the operator may view the image directly through the microscope in the ordinary way. The camera is then connected as above to the microscope and the final focussing done from back of the ground-glass screen, or, as some prefer, by means of a magnifying glass adjusted to the surface of a plate glass screen, which occupies the same position as the sensitive plate when the picture is taken.

We must now wait a few moments and then re-examine our image. If it is as sharp as we left it, we may proceed to photograph it; if, however, it is not so sharp as when we had finished focussing it, it will be necessary to find the cause and the remedy. The change of adjustment may be caused by jarring, by a worn thread on the micrometer screw, by too strong a spring in the micrometer movement, or by a change in the temperature of the room or parts of the apparatus. The microscope should be so mounted that no jar can be transmitted to it; worn parts should be replaced; and the temperature of the room should always be warm so that the starting of the lamp will not cause a noticeable increase in that temperature. It is always well to start the lamp a few minutes before one is ready to take the picture, and allow the different parts to adjust themselves to any changed conditions. The adjustment of focus, etc., being satisfactory, the exposing shutter is closed. The plate-holder containing the sensitive plate is placed in position and the exposure made. The subsequent operations of developing and printing are purely photographic, and are the same as in ordinary photography.

Special Forms of Apparatus.—Of special forms of apparatus and adaptations to special purposes there are many. Perhaps among the most useful to the laboratory worker in bacteriology, where a limited range of magnification (*i.e.*, from two hundred to one thousand diameters) is desired, is that of the Misses Foot and Strobell. Any of the small vertical cameras may be used and the microscope may be the same one used in ordinary research. The novelty consists in obtaining the focus directly by the eye, observing the image through the microscope with any one of a series of negative lenses placed on top of the eyepiece. The negative lenses used are those test sets furnished by opticians, and number from one to ten dioptries and their fractions. The use of this lens will of course cause the image to vanish and refocussing will be necessary. If the right minus lens has been chosen, upon its removal from over the eyepiece the image will be found thrown upon the ground glass of the camera above as a sharp picture. In each case the minus lens, best adapted to the end in view, must be found by trial. The method is faulty in that no provision is made for removing the negative lens from the eyepiece without some risk of disturbing the focus obtained. It has, however, the great advantage that any light can be used that one would ordinarily view objects through the microscope by, as ordinary diffused daylight. The exposure will of course run into the minutes with its attendant risk of change of focus or displacement. The preliminary wait, after obtaining the focus by this method to allow for change in focus, etc., is more important than with the horizontal apparatus; for the microscope being in the vertical we have the influence of gravity acting directly upon the focussing mechanism.

Photomicrography of Colored Objects.—In former years, when the wet collodion process was in general use, and when later the gelatin dry plates were introduced, the photomicrographer was limited in the selection of subjects to those that were nearly colorless, and was unable correctly to render those objects that contained mixtures of red, or yellow and blue. The chloride of silver of the wet plate and bromide of silver of the dry plate were alike sensitive to the light rays of short wave length (*i.e.*, the blue and violet) and comparatively insensitive to the rays of longer wave length (*i.e.*, the green, yellow, and red). The blue portions of an object would be fully impressed on the plate long before the green, yellow, or red portions made any impression at all; and if an attempt was made by prolonging the exposure to render the latter, the blue portion through over-exposure would be lost. It was not until Vogel announced his discovery that an ordinary gelatin dry plate, when bathed in a solution of an aniline dye, became more sensitive to the rays of longer wave length, that it became possible to represent by the light and shade of the photograph the brilliancy of the various colors as they affected the eye. It was not enough simply to dye the plate. The dye, while rendering the plate more sensitive than before to the yellow end of the spectrum, did not diminish its sensitiveness to the blue which was still in excess. The problem was solved by diminishing, or in some cases entirely cutting out the blue and violet rays by the use of fluids that absorbed them. Such fluids, termed color filters, had previously been in use for just the opposite purpose, *i.e.*, to allow only the rays of highest refrangibility to pass through the object, for the purpose of increasing the resolving power of the objective. It was afterward found that films stained with the proper dyes could be used in place of the fluids, a gain in convenience. Since then the color or colors of the object do not present much difficulty, provided, however, the object is not too thick nor too deeply stained in parts; nor, on the other hand, so lightly stained as not to afford sufficient contrast, as in certain thin pathological specimens where the diseased tissue will not take a good stain. It may be almost impossible to obtain a satisfactory photomicrograph of such objects. It is possible at the present time to go beyond the mere representation of colored objects in monochrome, as by the use of the proper color screens, as first demonstrated by the writer in 1895–96, three separate photomicrographs may be taken of a section stained in three or more stains; and by means of the commercial

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three color printing processes now in use, it can be quite faithfully reproduced in its original colors.

Preparation of Specimens.—The special preparation of specimens for photomicrography is not at present so necessary as before the introduction of the color-sensitive plate and the color filter. There are, however, certain requirements that have to be complied with if the best results are to be obtained, as, for instance, sections of tissue must be thin, evenly cut, and, above all, they should be flat. Many an otherwise good specimen cannot be used for photomicrography because sufficient care was not taken to get it perfectly flat upon its slide, and with its cover-glass down upon it. Now it must be remembered that the objective has no depths of focus; that is, only those objects or portions of the object in one plane at right angles to the optical axis can be in focus at one time. Any other plane of the object requires a separate focussing of the objective to render its image sharp; and therefore a section only slightly irregular, and which to the eye, (owing to its power of accommodation, which is involuntarily used) seems quite flat, upon being photographed will give a negative for the most part sharply defined, but containing spots or areas of various shapes which are quite blurred. The photomicrographer cannot by any means short of flattening such a specimen obtain from it a good result; for if he should, by stopping down the substage condenser or when possible the objective seek to render more than one plane of the specimen sharp, he would inevitably introduce errors of refraction which in themselves would spoil the result. Ridges or knife marks, due to the chattering of the knife blade of the microtome when cutting the section, will always show in the photograph. Special staining, as mentioned above, is not necessary, though it is always difficult to secure a good result from a section too deeply or too lightly stained; but in general any section stained so as to show well to the eye in the microscope will make a good photograph.

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Limitations.—To photomicrography, as to all other things, there are limitations. These are more especially evident when we seek very high magnifications. As we go beyond one thousand diameters, it becomes more difficult to obtain satisfactory images; and while it is possible to obtain sharp images of certain selected objects, such as a portion of the frustule of a diatom, up to five thousand diameters, it will be found that only such objects as lend themselves to the work can be so taken, and that, except as a *tour de force*, the results are all out of proportion to the labor and time expended. When much higher magnifications than one thousand are desired, the only practical way is first to photograph the object with as high a power as will give a good, sharply defined image (say up to three thousand diameters), and then to enlarge the negative. In this way it is possible to attain magnification of ten or twelve thousand diameters. But again we are limited in this method, as when we attempt to enlarge a gelatin negative more than three or four diameters, the grain of the gelatin begins to become disagreeably apparent and to interfere with the sharpness of outline of the image. It should always be remembered that the magnification of the objective is the only magnification that resolves the details of the object. What further enlargement we may get by oculars of high power, by increased length of camera bellows, or by enlarging the negative, does not add any detail to that resolved by the objective originally; it simply spreads the image as given by the objective over a larger surface. It follows then that to magnify any object further than to make its details clear to the unaided eye is useless and to be condemned. *Edward Leaming.*

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PHOTOTHERAPY. See *Roentgen Ray, etc.*

PHOTOXYLIN.—A nitro-cellulose, similar to pyroxylin, but prepared from wood pulp instead of cotton.

A three- to five-per-cent. solution in equal parts of alcohol and ether is recommended to replace collodion in plastic surgery and other conditions in which such an application is suggested. The solution forms a thick liquid, which upon evaporation leaves a firm, dense film, which is stronger than that of collodion. *Beaumont Small.*

PHRENIC NERVE.—ANATOMY.—The phrenic nerve, or the internal respiratory nerve of Bell, is the principal motor nerve of the diaphragm. The spinal origin in dogs and rabbits is located in the anterior horn of the spinal cord at the level of the fifth and sixth cervical vertebræ, and in man in the centre of the anterior horn, extending from the middle of the third to the sixth cervical segment. The superficial origin of the nerve is from the third, fourth, and fifth cervical nerves in the following proportions:

	Number of cases.	Fourth only.	Fourth and fifth.	Third, fourth, and fifth	Third and fourth.
Luschka	32	12	7	7	6
Brook	16	4	9	3	0
Green	52	9	21	13	9
Total	100	25–25%	37–37%	23–23%	15–15%

When there is a single root, it is always from the fourth nerve.

COURSE.—The course of the nerve is as described in the standard text-books, there being but few variations. Passing over the anterior surface of the scalenus anticus, diagonally downward and outward, it passes in front of the first part of the subclavian artery and behind the subclavian vein. In about four per cent. of cases, however, the nerve passes in front of the vein, and so lies immediately behind the clavicle. Two cases are on record in which the nerve passed through the vein. Passing into the thorax it lies, on the right side, external to and slightly behind the right innominate vein and the superior vena cava; on the left side, in front of the arch of the aorta. On both sides it passes between the pleura and the pericardium, anteriorly to the roots of the lungs; on the right side being in close contact with the root, and on the left side passing out and to the left, in order to pass around the heart. The right nerve has an almost vertical direction, and passes to the upper surface of the diaphragm, where it divides into from three to six branches, which pierce the diaphragm externally to and in front of the opening for the inferior vena cava. The left nerve has a more circuitous route, and generally divides in the substance of the diaphragm.

Branches. 1. Communicating: (1) From the upper ganglion of the cervical sympathetic gangliated cord. (2) Occasionally, from the loop formed by the descendens and communicans hypoglossi. (3) From the nerve to the subclavius. (4) The right nerve, at its termination, sends branches to the right semilunar ganglion of the solar plexus. (5) The left communicates with the sympathetic plexus to the œsophagus above the diaphragm.

2. Distribution: (1) On the right side, to the superior vena cava. (2) Pleural branches, from one to three in number. (3) Branches to the pericardium, usually three. (4) Luschka has described twigs to the right auricle. (5) Terminal branches to the diaphragm. This is the main distribution of the nerve. It supplies the entire diaphragm except an area along the costal margin, about 3 cm. in width, which is supplied by the lower six intercostal nerves, and an indeterminate area on the crura,

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probably supplied by the vagus. The exact area, supplied by the fibres from the various roots of origin, is as yet undetermined. A single case of a dog, in which Schroeder divided the upper roots of origin, and on post-mortem found degeneration of the anterior and middle portions of the muscular portion of the diaphragm, with the lateral and posterior portion intact, is the only case of the kind on record.

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Relations.—In the neck the nerve lies on the anterior surface of the scalenus anticus muscle, behind the great vessels and the sterno-cleido-mastoid muscle, the omo-hyoid muscle and the transversalis colli vein. In crossing the subclavian artery the nerve generally lies external to the origin of the internal mammary, but internal to the course of the artery in its course in the thorax. The other relations have been noted.

The physiological function of the nerve is that of the principal motor nerve supply to the diaphragm.

Pathology.—1. Paralysis of half of the diaphragm, as a result of inflammation or degeneration of the phrenic nerve, on the corresponding side, as a result of exposure, lead poisoning, or compression, may occasionally occur. The condition generally comes on slowly and is characterized by inversion of the type of respiration, which reduces intra-abdominal pressure, causing difficulty in defecation, etc. Respiration is usually affected only during exertion, when dyspnœa results.

2. Neuralgia. Some authorities describe a form of neuralgia characterized by pain in the lower and anterior part of the thorax, along the line of diaphragmatic attachment, extending up into the neck and along the inside of the arm, with painful areas at the points where the nerve becomes superficial. This condition is said to complicate angina pectoris, Graves' disease, and some forms of cardiac disease.

3. Surgical Pathology. Injury to or division of the nerve may occur in gunshot wounds or stab wounds, or in the course of surgical operations. This complication has generally been regarded as fatal, and the statement has been generally made in the surgical literature that it was necessarily so. A careful review of the literature, however, shows only six cases on record in which the nerve was injured. In all other cases, usually reported as injuries of the phrenic nerve, an examination of the original article shows that some other adjacent structure had been injured instead of the phrenic. Of the six cases of actual injury to the nerve, in the first four (those reported by Schurmayer, Beck, Bardeleben, and Erichsen) there was also injury to some other important structure, which was alone sufficient to cause death. Of the two cases of injury to the nerve alone, the first (reported by Mackenzie) was instantly fatal. The second (reported by Schroeder in 1902) ended in recovery, with paralysis of the corresponding half of the diaphragm. Mackenzie's case was that of an Indian coolie, who suddenly fell dead, and on post-mortem examination the reporter was unable to find any sufficient cause of death, except a rupture of the right phrenic nerve. It hardly follows, however, that the rupture of the nerve was the cause of death.

Schroeder's case, then, is the only one on record in which the phrenic was injured without injury to surrounding structures, and in which the exact extent of the injury was known. In removing a fibroma, which was attached to the borders of the foramen formed by the third and fourth cervical vertebræ, the upper root of the phrenic, coming from the third cervical, was found traversing the upper and outer part of the tumor, while the lower root came from below. As the tumor was thought to be malignant, an attempt was made to dissect the nerve from the tumor; but in doing so, the roots of the nerve were torn off. There was no material change in the patient except an increase of respirations to 32. The nerve was united by sutures, and on being pinched below the suture, the diaphragm responded. There was no cough or hiccough nor any other symptom, either during the operation or afterward, except that the respirations remained at 24 to 32 for four or five days, and then came down to 20. Examination after recovery showed the left half of the diaphragm stationary and two and one-half inches above its normal position. The patient left the hospital completely recovered, and resumed his former occupation.

Experimental Researches.—1. On the Human Being. In eighteen cases of tuberculous glands of the neck, the nerve was pinched during operation with the following results: Contraction of the corresponding half of the diaphragm, with sudden rising of the anterior abdominal surface below the costal arch. In ten cases the right nerve was pinched and the left in eight. In one case on each side there was some pain in the region of the diaphragm, but it subsided in forty-eight hours. The symptoms usually attributed to irritation of the diaphragm (*i.e.*, sneezing, coughing, and hiccoughing) were not observed in a single instance.

2. Experimental Researches on Dogs. In the course of an extended series of experiments on dogs, the following results were obtained: After resecting as much as possible of the cervical portion of the nerve, it was found that after resection of one nerve only, there was an increased thoracic expansion and a slight abdominal retraction, changes which were more evident on the divided side than on the normal side. In case of a double resection there occurred an inverted type of respiration, *i.e.*, decided retraction on inspiration and increased thoracic expansion, due to the action of the accessory respiratory muscles. In unilateral resection kymographic tracings showed that the normal half of the diaphragm rose half an inch on inspiration and fell the same distance on expiration, while the half of the diaphragm on the side on which the nerve had been resected moved only an eighth of an inch, as it was moved passively by the movements of the normal side. After division of the nerve, the diaphragm becomes relaxed and the muscle arches up into the thorax. The type of respiration becomes increasingly costal when one nerve is divided, and inverted when both nerves are cut. The accessory respiratory muscles become very active. There is no sneezing or coughing. In one case of double division the respiration became labored, but remained so for only a few days.

Post-mortem Findings.—In cases in which the dogs were killed in from seven to fourteen days after resection of the nerve, the atrophy of the diaphragm was not great and the color was reddish-yellow. When a longer time had elapsed, the atrophy was marked, the paralyzed part being thin and flabby, the color pale yellow, and in older cases translucent. In all cases there remained a margin from one-quarter to three-eighths of an inch in width at the costal border, which retained its normal color and thickness. This margin is supplied by the intercostal nerves.

Summary.—1. From clinical, experimental, and anatomical data it would seem that the diaphragm is not an essential muscle of respiration, and that the importance of injury to its principal nerve, the phrenic, has been exaggerated. Injury to the phrenic or division of one nerve is not necessarily fatal. It may, however, predispose to lung infection or be followed by diaphragmatic hernia.

2. While the diaphragm is supplied with branches from the lower six intercostal nerves, they are inferior to the phrenic in importance and unable to take the place of the phrenic after division of the latter.

[A full bibliographical list will be found in the February number, 1902, of the *American Journal of the Medical Sciences.*]

William E. Schroeder.
Frederick R. Green.

PHTHISIS PULMONALIS. See *Lungs, Tuberculosis of.*

PHYSICAL MEASUREMENTS. See *Naval Hygiene,* and *Recruits, Examination of.*

PICHI.—Fabiana. The dried leafy twigs of *Fabiana imbricata* R. et P. (fam. *Solanaceæ*).

This large evergreen, heather-like shrub is common upon high dry hills in Chile. It is rather closely related to the tobacco plant. Only the small twigs should be col-

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lected, though much of the drug of commerce includes the large woody branches, or even the trunks, several inches in diameter. The branchlets are slender and crowded with leaves. The bark is ashy gray and finely roughened by minute, short, sharp, thickly set longitudinal ridges and minute gland-like protuberances, both of which exhibit, under the lens, a peculiar resinous structure. The bark of the trunk and larger branches scales off in ragged strips. The bark is rich in the resinous constituent, which exists also, to a much smaller extent, in the young wood, but is practically wanting from the old wood. The leaves are broadly ovate and thick, about a line long, bluish or whitish green by reason of the resinous exudation, which is profusely deposited at their bases and edges. Toward the ends of the branches are numerous very short branchlets, each terminating in a persistent white or bluish flower, which is funnel shaped and from a third to a half-inch long. These flowers are rarely seen in the drug. Five unequal, included stamens are borne upon the constricted portion of the corolla. The style is slender, the stigma small and two-lobed. The fruit is a two-celled capsule, about one-fifth of an inch long, and contains several brown seeds.

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The important constituent of pichi is a large and variable amount of a bitter resin. Associated with this is a little volatile oil, the important constituent of which is *fabianol*, and to which the peculiar odor of the drug is due. A fractional amount of the alkaloid *fabianine* and a fluorescent glucoside, occurring in bitter crystals and resembling aesculin, also occur, together with gum, an inert crystalline resin, and ordinary plant constituents.

Pichi is a highly valued drug, both with the laity and with the profession, in Chile and other South American countries, and was introduced into use in the United States by the present writer (*Ther. Gaz.*, 1885, p. 810). Its special repute is for the treatment of vesical and renal troubles arising from the uric-acid diathesis and for the expulsion of gravel and small calculi. It also acts as a sedative to the irritable mucous membrane, modifying the secretion and subduing the pain. The following account of its action and uses, by Beaumont Small, in the preceding edition of this work, can scarcely be improved upon:

"Its use has been extended to all forms of acute and chronic inflammation of the urinary organs, and numerous reports of cases in which it has been employed tell of its beneficial action, not only in cystitis and vesical irritation due to simple causes, but also when these have arisen from gonorrhœal and prostatic disease. A special indication for its use is said to be the presence of pus in the urine. Dr. Reginald Harrison, after using the drug for four years in private and hospital practice, stated that he obtained considerable benefit from it, particularly under the following conditions: (1) In renal colic and the passing of calculi through the kidneys and along the ureters attended with hæmaturia; though not exercising any solvent power, it seems by its action on the tissues in some way to favor the escape of the stone, and thus to suppress the bleeding. (2) In the hemorrhage which frequently accompanies cancer of the bladder. (3) The sedative action of the drug on the mucous membrane of the bladder has proved beneficial in many instances of irritability connected with an enlarged prostate.

"In addition to its employment in urinary disorders, it is recommended for the relief of the headache, dyspepsia, and other symptoms arising from a condition of lithiasis, and has been used as an hepatic stimulant for jaundice and dropsy due to hepatic disease. Given in small doses, preceding the meal, it has been found to be an excellent stomachic.

"The drug is generally administered in the form of a decoction or fluid extract. The decoction is prepared by adding one ounce to twenty ounces of water, the whole to be given in four portions during the day. The dose of the fluid extract varies between ten minims and two drachms. The average dose is from half a drachm to one drachm. The effects of the drug are usually experienced after a few doses have been given. The extract is not miscible with water, and the appearance of the mixture is made more pleasant by rendering it alkaline. Glycerin is recommended as the best vehicle for its administration; it is a fairly good solvent, and maintains the drug in suspension in fine particles. Salines should not be combined with it, as they cause the separation of the resin in dense curds. Fluid extracts of hyoscyamus, hydrangea, buchu, and other remedies may be combined when they are indicated. A solid extract allows of its administration in powder in capsules. The dose is from two to ten grains." *Henry H. Rusby.*

PICRIC ACID.—(*Carbazotic Acid, Trinitrophenol*). $C_6H_2(NO_2)_3OH$. Picric acid may be formed by adding carbolic acid to fuming nitric acid and heating. It crystallizes in yellow, glistening, laminar or acicular scales. It is soluble in 95 parts of water, and in 16 parts of alcohol. It readily combines with alkalies to form salts, of which ammonium picrate is preferred as a therapeutic agent. Picric acid and its salts form powerful explosives, and many accidents have been due to their careless handling.

Ammonium picrate forms in yellow crystals, soluble in water and alcohol. It has a bitter taste, is odorless, and imparts a yellow color to everything with which it comes in contact.

Picric acid and its salts may produce toxic effects when administered internally, or when absorbed from the skin or abraded surface. It has caused weakness and depression, diarrhœa, colic, black urine, jaundice, convulsions, collapse, and death. It stains the tissues yellow and produces an alteration in the character of the blood. Many cases are reported in which it has given rise to unfavorable symptoms when applied externally in the treatment of burns and skin affections. It also discolors the skin and has produced a vesicular rash and an erythematous condition resembling scarlet fever.

Picric acid in the form of the ammoniate has been suggested as a substitute for quinine in the treatment of malaria and malarial neuralgias. It is given in doses of one-eighth to one and a half grains three or four times a day. Although it has been of service in the hands of some, it has not proved of sufficient value to warrant its continued use. On account of its property of staining the tissues it has also been suggested as a method of treating trichiniasis.

Picric acid is employed locally in the treatment of inflammatory affections of the skin, and for burns and scalds. In erysipelas the application of a saturated solution, which has a strength of nearly one per cent., has proved of value. It is to be applied from five to ten times a day and the solution allowed to dry upon the part. Its power of reducing the inflammation is supposed to be due to the fact that it penetrates the corneous cells of the skin, and by its astringent property acts as a protective to the Malpighian layer of cells; it also acts as a parisiticide upon the specific cause of the disease.

It is recommended in eczema when the inflammation is acute and superficial and accompanied by much itching. It is of less service in chronic forms accompanied by induration of the skin. A compress of the saturated solution is kept applied to the part for several days. It lessens the weeping and pain and promotes healing.

Of late years it has been particularly recommended for the treatment of burns and has been extensively employed for this purpose. It is most serviceable in burns of the first and second degree, as its special effect is to favor the growth of new epidermis. If there is a granulating surface it is of little value. A layer of absorbent cotton, saturated with the solution, is kept applied to the part. Under this treatment the heat and pains subside and the superficial lesions quickly heal. After which, if there are deeper burns and granulating surfaces, they may be treated by other means. Ointments of a strength up to five per cent. have been used, but it has been pointed out that where absorption and ill effects have occurred, these stronger preparations have been employed. The discoloration of the skin may be removed by washing with alcohol or with a solution of carbonate of lithium.

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Picric acid has also been used in genito-urinary disorders, urethritis, ear and eye diseases, and many other conditions, but has not met with much favor.

Beaumont Small.

PICROL—di-iodo-resorcin monosulfonate of potassium, $C_6H_2(OH)_2SO_3K$—is a white, odorless, bitter crystalline powder which contains fifty-two per cent. of iodine, and is soluble in water, glycerin, and ether. It is a soluble substitute for iodoform. *W. A. Bastedo.*

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PICROTOXIN.—*Picrotoxinum* (U. S. P.).—A neutral principle obtained from the seed of *Anamirta Cocculus* (L.) W. et A. (*Menispermum C.*, L.: *A. paniculata* Colebr. Fam. *Menispermaceæ*).

The origin of picrotoxin from fish-berries has been explained under *Cocculus Indicus.* The seed alone contains the active principle picrotoxin. This is extracted with boiling alcohol, the solution concentrated and cooled, the fat removed, and the residue treated with boiling water. The picrotoxin is crystallized out from the slightly acidulated decoction, and is afterward purified by the use of alcohol. Several associated alkaloids are liable to occur as impurities of picrotoxin. The substance is thus described by the Pharmacopœia:

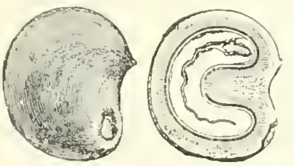

FIG. 3807.—Fruit of Cocculus Indicus. Whole and in section. (Baillon.)

Colorless, flexible, shining, prismatic crystals, or a micro-crystalline powder, odorless, and having a very bitter taste; permanent in the air.

Soluble, at 15° C. (59° F.), in 240 parts of water, and in 9 parts of alcohol; in 25 parts of boiling water, and in 3 parts of boiling alcohol; also soluble in solutions of the alkalies, and in acids. Very slightly soluble in ether or chloroform.

Picrotoxin is neutral to litmus paper.

When heated to 200° C. (392° F.) picrotoxin melts, forming a yellow liquid, and upon ignition it is consumed, leaving no residue.

Concentrated sulphuric acid dissolves picrotoxin with a golden-yellow color, very gradually changing to reddish-brown, and showing a brown fluorescence.

On mixing about 0.2 gm. of powdered sodium nitrate with three or four drops of sulphuric acid, in a small, flat-bottomed capsule, sprinkling a minute quantity of picrotoxin over it, and then adding, from a pipette, concentrated solution (1 in 4) of sodium hydrate, drop by drop, until it is in excess, the particles of picrotoxin will acquire a brick-red to deep red color which fades after some hours.

On diluting 2 c.c. of alkaline cupric tartrate V.S. with 10 c.c. of water, and adding a small portion of picrotoxin, red cuprous oxide will be separated within half an hour at ordinary temperatures, and much more rapidly upon the application of heat.

The aqueous solution of picrotoxin should remain unaffected by mercuric or platinic chloride T.S., tannic acid T.S., mercuric potassium iodide T.S., or other reagents for alkaloids (absence of *alkaloids*).

ACTION AND USES.—The most elaborate study of the action of picrotoxin was that made by Chirone and Testa, whose conclusions were as follows (*London Medical Record*): (1) Picrotoxin is capable of causing a true artificial epilepsy. (2) The epilepsy so induced is independent of the psychomotor centres, inasmuch as it is most intense after the removal of those centres. (3) Picrotoxin acts primarily on the bulb and on the commissural fibres between the cerebral and spinal centres, and secondarily on the spinal centres themselves. (4) It demonstrates the existence of a functional antagonism between the psychomotor and motor centres of the bulb and spinal cord. (5) The convulsive movements of the limbs induced by picrotoxin depend primarily upon the action of the drug on the bulb, which is thence propagated to the spinal marrow, and secondarily upon its direct action on the spinal centres. (6) In frogs the influence on the spinal functions is more marked than upon the cerebral, while in dogs and the higher animals the cerebral motor centres are the most acted upon. (7) By cinchonidine an epilepsy of cerebral, by picrotoxin an epilepsy of spinal origin, can be induced.

From the foregoing it is evident that the action of picrotoxin closely resembles that of strychnine. Besides the use of this substance for poisoning fish, it is said to be a constituent of some arrow poisons and to be employed for the poisoning of vermin. The flesh of fish poisoned by it is said to be dangerous unless early steps are taken to remove the poison from it.

The medicinal employment of picrotoxin is exceedingly limited. It has been recommended in paralysis, epilepsy, chorea, hystero-epilepsy, etc., but has not been very successful. As a retarder of the pulse it might be thought of, but we have already several safer remedies for this purpose. It has been used considerably for the prevention of the night sweats of phthisis; the hypodermic use of gr. $\frac{1}{100}$ to gr. $\frac{1}{50}$ proving very serviceable in many cases of this troublesome condition. It has been used locally in some cutaneous diseases, and as a parasiticide (in the form of an ointment); but it has no advantage for this purpose over less dangerous substances. "Convulsions and death have followed its application to the head" (Brunton); from one to two per cent. of picrotoxin in, say, petrolatum is of sufficient strength for pediculi, etc., if it is desired to use it. Dose, from 1 to 10 mgm. (gr. $\frac{1}{60}$ to gr. $\frac{1}{6}$). *Henry H. Rusby.*

PIEDMONT WHITE SULPHUR SPRINGS.—Alameda County, California. These springs are located three miles from Oakland, and have gained considerable local reputation in the treatment of rheumatism, jaundice, liver and kidney troubles, and disorders of the stomach. There is a well-kept hotel with pleasant grounds at the place, and its nearness to San Francisco makes it available for residents of that city as a day resort. The situation on the western slope of the Berkeley Hills commands a most picturesque view over San Francisco Bay and the Golden Gate The following analysis by Winslow Anderson shows the mineral ingredients of two of the springs:

ONE UNITED STATES GALLON CONTAINS:

Solids.	The Iron Spring. Grams.	The Sulphur Spring. Grams.
Sodium chloride	5.10	7.91
Sodium bicarbonate	11.70	9.40
Sodium carbonate	.52	6.20
Potassium carbonate	3.15	.76
Potassium iodide	Trace.	Trace.
Magnesium carbonate	6.37	3.17
Magnesium sulphate	1.03	17.80
Calcium carbonate	2.13	3.32
Calcium sulphate	1.60	7.09
Ferrous carbonate	1.73	Trace.
Alumina	.45	Trace.
Borates	5.23	1.90
Silicates	4.19	5.06
Organic matter	Trace.	Trace.
Total solids	43.20	62.61
Gases.	**Cubic inches.**	**Cubic inches.**
Carbonic acid gas	7.25	4.60
Sulphureted hydrogen	Trace.	9.25
Temperature of water	58°	60°

These analyses show that the waters are valuable as a tonic, antacid, diuretic, and aperient; they are useful in dyspepsia, constipation, anæmia, rheumatism, and liver and kidney troubles. *James K. Crook.*

PIEDRA.—(Synonym: Trichomycosis nodosa.)

This is a parasitic disease that occurs on the long hairs, especially those of the scalp. It may affect the beard,

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It was first described as occurring only in Cauca, one of the United States of Columbia. A few cases have been reported in Germany and one in this country. It is characterized by the appearance of from one to ten small, dark-colored, very hard and gritty nodes along a hair. When the hair affected by the disease is combed or shaken, the nodes rattle together like stones. This gave the disease its name, which in the Spanish language means stone. The hair itself is unaffected, the nodes being simply attached to it. Women are most commonly affected, men only exceptionally so, and then it is their beards.

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ETIOLOGY.—It occurs in warm countries and is a fungous growth. Microscopical examination shows that the nodes are composed of a mass of pigmented spore-like bodies arising from one cell that sends out columns radially in all directions.

DIAGNOSIS.—It differs from the other diseases of the hair in which nodes form, such as trichorrhexis nodosa, in that the hair itself is unaffected. Its nodes differ from the nits of pediculi in their dark color, and in their not being placed on one side of the hair.

TREATMENT.—The nodes can be readily removed by soaking them with a hot solution of bichloride of mercury 1 to 1,000. They can be combed off or pulled off when softened. *George T. Jackson.*

PIGMENT. (PATHOLOGICAL.)—The pigments found in the human body, either under normal or under pathological conditions, are formed either by the body cells themselves (*intrinsic or autochthonous pigment*), or are derived from the bile (*hepatogenous pigment*) or the blood (*hæmatogenous pigment*), or are foreign pigments which are deposited within the body from without (*extrinsic pigment*). The last named may enter the body through the respiratory or the gastro-intestinal tract, or through wounds; or, as in the case of malarial pigment, they may be formed inside the body by the activity of the cells of parasites.

Pigment.
- 1. Autochthonous .
  - Melanin.
  - Lipochrome.
  - Hæmofuscin.
- 2. Hepatogenous ..
  - Bilirubin.
- 3. Hæmatogenous .
  - Hæmatoidin.
  - Hæmosiderin.
- 4. Extrinsic ....
  - 1. Carbon.
  - 2. Silver.
  - 3. Lead.
  - 4. Tattoo.
  - 5. Malarial pigment.
  - 6. Various dusts.

1. AUTOCHTHONOUS PIGMENTS.—*Melanin* is found normally in the cells of the rete and in the choroid. It is believed by the majority of writers to be a product of specialized connective-tissue cells (chromatophores), which in the skin lie just beneath the cells of the rete, in the upper layers of the tissue of the dermis. These cells contain fine yellow or brownish granules of melanin, or their protoplasm may be diffusely stained with the pigment. Protoplasmic processes containing the pigment extend from the chromatophores into the epidermis, between the epithelial cells of the rete, and it is believed that the pigment is transferred to the epithelium by means of these processes. The chromatophores are most numerous normally in the skin of the flexor surfaces, about the nipples, external genitals, and anus. They are more abundant in dark-skinned individuals than in those having a light skin. The chemical nature of melanin is not known; it is a nitrogenous body rich in sulphur, and is believed to be a product of the combination of certain split products of albumin that contain sulphur. It does not give a reaction for iron. It is not a derivative of hæmoglobin, but is either built up by cell activity from the end products of albumins circulating in the blood or is formed by the cell from its own albumin.

A physiological increase of melanin occurs during pregnancy, particularly about the nipples, external genitals, and in the median line of the abdomen (linea fusca, chloasma uterinum). This pigmentation is especially pronounced in brunettes. In freckles, tan, lentigines, pigmented moles and warts, etc., the pigmentation is due to an increased formation of melanin by the chromatophores. In various cachexias, but particularly in Addison's disease, there is a greatly increased production of melanin, to such an extent that the individual may become very dark. Melanin may also be formed in excess in or about scars of the skin caused by various skin lesions or eruptions. From an abnormal proliferation of the chromatophores a pigmented sarcoma (melanotic sarcoma) may arise. The cells of these growths produce melanin in great excess, so that their color is usually brown or black. Their metastases, wherever produced, likewise form melanin. Such metastases occur most frequently in the liver; and they often overshadow the primary tumor, which may be of insignificant size, often originating in a small pigmented mole. The excessive production of melanin by sarcoma cells is of the nature of a degeneration; with the formation of the melanin the cells die.

Lipochrome is the coloring matter of fat tissue, corpora lutea, ganglion cells, epithelium of the seminal vesicles, and of the greenish-colored sarcomata known as chloromata. Its chemical nature is not known. It does not contain iron, and is colored black by osmic acid.

Hæmofuscin is the yellow or brownish granular pigment found in heart muscle, striped muscle, and in the unstriped muscle of the gastro-intestinal tract, vas deferens, seminal vesicles, etc. The pigment found in the cells of the glands of the stomach and intestine, as well as in the cells of the lachrymal, mucous, and sweat glands, is by some writers regarded as identical with hæmofuscin, by others as belonging to the melanin group. Its sulphur content favors the latter theory. Hæmofuscin does not give the iron reaction. In atrophic conditions of muscle particularly when following hypertrophy, the amount of hæmofuscin is either relatively or absolutely increased. The color of such muscle may become a deep brown. This is not infrequently seen in the case of atrophy of heart muscle in failure of compensation for valvular disease (brown atrophy of the heart). Microscopically, the pigment is found to consist of fine yellow granules arranged at the poles of the nuclei, in the form of a cone, the base of the cone toward the nucleus. In all cases the presence of a notable amount of hæmofuscin in muscle cells is to be taken as an evidence of degeneration (pigment atrophy).

HEPATOGENOUS PIGMENT.—*Bilirubin* is found as a pathological pigment in the tissues in icterus. As a result of the appearance of bile pigment in the blood, the skin, conjunctivæ, the internal organs, serous membranes, subcutaneous tissue, blood plasma, urine, etc., are stained yellow in mild or recent cases; but in jaundice of long standing the color may be an olive-green or a deep bronze. The bile pigment gains entrance to the circulation as a result of obstruction to the outflow of bile through the biliary vessels, or through changed conditions of the liver cells brought about by intoxication, infection, or through nerve influences, whereby the secretion of the liver cell, instead of passing into the bile capillaries, passes into the blood. Carried through the body by the circulating blood, the bilirubin gives to all of the tissues a diffuse yellow color. After a time granules of bilirubin collect in the lymph spaces and in the tissue cells themselves, and particularly in the lymph glands, spleen, and bone marrow. In the cells of the connective tissue, liver, and kidney, rhombic plates and needles of bilirubin may sometimes be found. In the kidneys the cells of the convoluted tubules are stained with bile pigment, and in the collecting tubules yellow, brown, or greenish casts are found. The presence of the casts is due to the degenerative processes set up in the cells secreting the bile pigment. In icterus there constantly occurs a deposit of hæmosiderin in connection with the bilirubin, as a result of the destruction of red blood cells by the bile acids.

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HÆMATOGENOUS PIGMENTS.—The pigments arising from the destruction of the red blood cells may be classed in two groups: one containing iron, *hæmosiderin*, and one not giving the iron reaction, *hæmatoidin*. The exact chemical nature of these pigments is not known, and the terms *hæmatoidin* and *hæmosiderin* represent groups of related pigments rather than individual pigments. The deposit of derivatives of blood pigment is known as *hæmachromatosis*, that of *hæmosiderin* alone, as *hæmosiderosis*. Hæmatoidin and hæmosiderin in all cases are derived from the destruction of hæmoglobin, either in extravasates or in the circulating blood. *Hæmatoidin* is regarded as identical with bilirubin. It is a ruby-red or reddish-yellow granular or crystalline pigment, soluble in absolute ether, chloroform and carbon disulphide, and insoluble in water and alcohol. With potassium ferrocyanide and hydrochloric acid it gives no reaction for iron. Hæmosiderin occurs in yellowish or brownish granules, which when treated with potassium ferrocyanide and hydrochloric acid give the Prussian blue reaction. With ammonium sulphide it forms a black sulphide of iron. After a time hæmosiderin may lose its iron reaction and become changed to hæmatoidin.

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Hæmatoidin is formed when the blood pigment is but little exposed to the action of living cells, as in the central portions of thrombi, or in large extravasates in the tissues, or in extravasates lying in the body cavities. It may be produced artificially by enclosing blood clots in capsules which admit the tissue juices but not the wandering cells, and by introducing such capsules into the peritoneal cavity or beneath the skin.

Hæmosiderin is formed in extravasates, in those portions exposed to the action of living cells, and is usually found around the periphery of thrombi and extravasates, in the area of organization. The pigment may lie free in the tissue, or may be contained within cells. The free pigment and that contained within phagocytes give rise to a pigmentation of the tissue about the extravasate, varying from a light yellow to a deep brown. After hemorrhage into the lung alveoli both hæmatoidin and hæmosiderin granules may be found in the sputum, either free or in phagocytes (pigment cells).

Both *hæmatoidin* and *hæmosiderin* may be carried from the seat of extravasation to the lymph glands and there deposited. Soluble blood pigment in the circulation is deposited partly as hæmatoidin and partly as hæmosiderin, in the spleen, bone marrow, lymph glands, liver cells, and kidney cells; and under certain conditions in the parenchymatous cells of various organs. The greater part of the pigment thus deposited gives the iron reaction, and therefore is to be classed with hæmosiderin. Such deposits of iron-containing pigment occur in pernicious anæmia and pernicious malaria, in poisoning with arsenic, toluylendiamin, potassium chlorate, mushrooms, etc., in overheating of the body, etc. As a result of the destruction of the red cells there occurs a hæmoglobinæmia; an increased amount of bile is formed, and there is an increased excretion of urinary pigment. In the kidneys the hæmosiderin is found chiefly in the cells of the convoluted tubules. In pernicious anæmia the hæmosiderin is found in greatest abundance in the liver cells of the peripheral portion of the liver lobules. Around the central vein the liver cells may contain hæmatoidin. The endothelial cells of the liver capillaries also contain the pigment; in the early stages of the process the pigment may be found only in these, later it is transferred to the liver cells.

If hæmosiderin comes into contact with hydrogen sulphide it becomes changed into a black hæmosiderin hydrogen sulphide. This condition is known as *pseudomelanosis*. It is usually seen after death in the intestinal canal, peritoneum, and suppurating wounds, but its production is dependent upon a formation of hæmosiderin in the tissues before death. It may take place in the living body as the result of hydrogen sulphide produced by bacteria. The green color seen in the early stages of the decomposition of the cadaver is due to a sulphur compound of methæmoglobin, produced by the action of H_2S on oxyhæmoglobin.

A peculiar brown or black pigmentation of cartilage, tendons, and the capsules of the joints occurs in old people, and occasionally in younger individuals. The condition is known as *ochronosis*. By some the pigment is regarded as allied to melanin, by others as a derivative of blood pigment. Neither its chemical nature nor its mode of formation is known. A similar pigmentation of cartilage may be produced by formalin.

EXTRINSIC PIGMENTS.—*Silver* taken into the body as a soluble salt (silver nitrate) is reduced by the cells of the blood-vessels and deposited as free silver or a low oxide in the connective tissue of the kidneys, intestine, skin, intima of large arteries, adventitia of the smaller ones, choroid plexus, etc. The epithelial structures and nervous tissue are alone spared. The pigment appears in the tissues in the form of fine black granules, lying in or between the connective-tissue cells. The condition is known as *argyria*. (See *Argyria*.) *Lead* may be deposited as a grayish-black discoloration of the gums, consisting of granules of sulphide of lead. *Iron* may be taken into the body in excess and deposited in the bone marrow, spleen, and lymph glands (*siderosis*), but this is rarely of a noticeable extent. In iron workers the lungs may acquire a reddish tinge from the deposit of iron-oxide dust. *Carbon* is the most common of the extrinsic pigments. It is usually taken into the body through the respiratory tract and deposited in the connective tissue of the lungs and in the peribronchial lymph glands (*anthracosis*). Under certain conditions, such as softening or tuberculous caseation of the bronchial glands, the carbon pigment gets into the general circulation and is deposited in the spleen, bone marrow, lymph glands, liver, etc. It occurs in the tissues as a deep grayish-black, coarsely granular pigment. *Colored dusts* from pottery clays, pigments, etc., may be found in the respiratory tract of individuals following certain trades. Various *pigments* may be introduced into the body in tattooing. Cinnabar and India ink are most commonly used. The pigment occurs in the connective tissue of the dermis as coarse black granules. The greater part of the pigment introduced into the wound of the skin is carried to the lymph glands, the remaining portion lies in the spaces of the scar tissue formed. As the pigment is constantly removed by wandering cells the outlines of tattoo marks slowly become indistinct. Carbon may enter the body through wounds of the skin: powder marks, cinders rubbed into cuts, etc. Silver particles may also enter the body through the skin or respiratory tract. *Malarial pigment* is a brownish-black pigment formed by the cell activity of the malarial plasmodium. It does not give an iron reaction. By some writers it is incorrectly called melanin. Its chemical nature is wholly unknown. It collects in the small capillaries of the body and is taken out of the circulation by the endothelium and also by wandering cells, and transferred to the tissue cells, chiefly in the spleen and bone marrow.

PATHOLOGICAL ABSENCE OF PIGMENT.—A failure of melanin production leads to the conditions known as *albinism* or *vitiligo*. The absence of pigment may be congenital or acquired. A lack of pigment throughout the skin of the entire body is known as *albinismus universalis*; in certain regions only as *albinismus partialis*. The hair may also be destitute of pigment (*leucotrichia*); and in universal albinism the pigment of the choroid and iris is also wanting. Acquired *vitiligo* is a condition characterized by a loss of pigment over certain portions of the skin, following scarlet fever, typhoid, or recurrent fever; or occurring as an epidemic disease without known cause. Idiopathic cases also occur. With the loss of the skin pigment may be associated a *leucotrichia acquisita*. Vitiligo appears to depend upon an atrophy of the chromatophores; its exact nature is unknown. It may depend upon a disturbance of adrenal function, or of the sympathetic system. A third form of absence of pigment follows infectious inflammations of the skin, leprosy, syphilis, etc.; and is known as *leucoderma*. The

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skin covering the scars produced by these diseases loses the power to produce pigment. This may be explained by a disappearance of the chromatophores, or by the inability of the epithelium to take up the pigment. The non-pigmented portions are not infrequently surrounded by a heavy pigmented border. See *Coloring Matter, Argyria, Vitiligo, etc.*) *Aldred Scott Warthin.*

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PILOCARPUS. See *Jaborandi.*

PINEHURST AND SOUTHERN PINES, N. C.—Pinehurst, six hundred and thirty feet above sea level, is situated in the "Pine Belt" of North Carolina, not far from the centre of the State, about seventy-five miles southwest of Raleigh. It is a comparatively recent creation, an attempt by one person to establish a model health resort in a favorable climate.

It embraces about five thousand acres, privately owned, and under the absolute control of the owner. Much labor and expense have been bestowed upon this enterprise; the grounds have been carefully laid out by landscape architects, and every attention has been paid to the sanitary conditions, sewerage, water supply, plumbing, etc., so that one is assured of finding here most wholesome hygienic surroundings and excellent accommodations. Consumptives, however, are not received, the desire evidently being to provide a winter resort for the large number of persons who, though not ill, desire to spend the winter in a comparatively mild and equable climate where they can remain for the greater part of the time out of doors.

Invalids are also received here, according to the writer's understanding, suffering from diseases other than tuberculosis. The soil of all this upland region is sandy, quite resembling the dry sand on the edge of the seashore, in which soil the long-leafed pine flourishes. Pines and sand comprise the scenery, but this lack of variety has its compensation in the abundant sunshine and bracing air. Moreover, the peacefulness of such surroundings must be restful to tired nerves.

The average winter temperature ranges from about 44° to 65° or 70° F., said to be about that of Southern France. In January, 1902, the maximum temperature was 72° and the minimum 20°, while in Philadelphia it was 54° and 15° respectively, and in Boston 54° and 4° F.

There is a large amount of sunshine, and one can generally spend most of the time out of doors. In the Piedmont Plateau which embraces this region, the annual average rainfall is 49.85 inches, and for the winter 12.28 inches. Snow is said to appear about once in two years, but remains only for a few hours. January is the coldest month; there may then be frosts at night and thin ice may coat the ponds. Spring begins by the middle of February. Protection is afforded from the cold northwest winds by the Apalachian range and by the pine forests. Naturally there is little to attract the visitor in this monotony of sand and silent, dark pines, but art has done much to make life attractive here. There are extensive golf links and a club house; shooting preserves for quail; horseback riding, tennis, croquet, etc. There are several hotels of varying prices, and furnished cottages for rent. The water is obtained from artesian wells and is pure and good. All the conditions of modern living are found here, and every attention seems to have been given to the maintenance of a high standard of sanitary excellence. Pinehurst has electric railroad connection with Southern Pines, six miles distant, which is on the Seaboard Air Line Railroad. It is a journey of eighteen hours from New York to Pinehurst.

Southern Pines, about six hundred feet above sea-level, is six miles distant from Pinehurst, and possesses similar conditions of climate, soil, and vegetation. It is situated upon a large sand bank, and is surrounded by the characteristic pine.

It is a comparatively new town of about one thousand inhabitants, and is essentially a winter health resort largely made up of Northern inhabitants or visitors. It has more of the features of a town than Pinehurst, there being several churches, shops, a graded school, library, electric lights, a trolley line, good water supply, and a sewerage system. There are several hotels of varying accommodations and prices, furnished cottages, apartments, and boarding-houses. Tuberculous patients are generally received here, although at the largest and most pretentious hotel, the "Piney Woods Inn," the statement is made that "confirmed consumptives will not be cared for."

Opportunities are afforded for various outdoor diversions, such as golf, tennis, driving, bicycling, and small-game shooting.

It is said that several thousand visitors frequent this resort during the winter season, and it can be recommended, especially for those of moderate means and requirements who desire to live with their families in one of the many small cottages which can be obtained at a moderate rental.

Several miles south of Southern Pines is Pinebluff, which is being developed as a health resort.

The air in all this pine-belt region is pure and dry, and impregnated with the balsamic emanations of the pines. It affords favorable conditions for many cases of tuberculosis and bronchitis, for convalescents from acute diseases, and for those suffering from chronic nephritis. This region is also a convenient halting place for those going to or returning from the lower South.

The season is from November to April.

Edward O. Otis.

PINE LAWN SPRING.—Bergen County, New Jersey.
—Post-Office.—Hohokus.

The Pine Lawn Spring water, recently introduced into the markets, is obtained from an artesian spring at Hohokus, twenty-three miles from New York City. The place is not used as a resort, but we are informed that residents of the neighborhood attach considerable medicinal value to the water and use it in large quantities. The following analysis was made in 1897 by Messrs. Smith and De Roode, chemists of New York:

One United States gallon contains: Potassium sulphate, gr. 0.06; sodium chloride, gr. 0.43; sodium sulphate, gr. 0.32; calcium sulphate, gr. 0.49; calcium nitrate, gr. 0.66; calcium carbonate, gr. 2.04; magnesium carbonate, gr. 0.72; alumina, a trace; silica, gr. 0.57. Total, 5.29 grains.

The water is exceptionally free from organic matter, and presents no evidence of surface pollution. It is clear, palatable, and sparkling, and well adapted for the table. *James K. Crook.*

PINGUECULA. See *Conjunctiva, etc.*

PINKROOT.—*Spigelia* (U. S. P.). The dried rhizome and roots of *Spigelia marilandica* L. (fam. *Loganiaceæ*).

This is a perennial herb, with a horizontal, twisted rhizome, and several erect, simple, somewhat quadrangular stems. Leaves opposite, sessile, ovate-lanceolate, smooth. Inflorescence terminal in a one-sided (scorpioid) spike, of half a dozen or more showy flowers. Calyx small, five-parted; corolla tubular, trumpet-shaped, with five acute, spreading lobes; bright scarlet outside, bright yellow within. Stamens five, inserted on the corolla; pistil single; ovary two-celled, several-seeded, superior. Pinkroot is a native of the Middle and Southern States, where large quantities are annually collected. Its medicinal properties have been known for upward of a century.

The description of the drug is as follows:

The rhizome is of oblique and sharply tortuous growth, somewhat branched, mostly 2.5–5 cm. (1–2 in.) long and 2–4 mm. ($\frac{1}{12}$–$\frac{1}{6}$ in.) thick, knotty from the approximate stem bases of the upper surface, which bear cup-shaped scars, dark brown or blackish, thickly clothed underneath and at the sides with long, rather coarse, finely branched, lighter brown roots, which are usually broken shortly, not leaving a long, bare, woody central portion; brittle, showing a whitish wood and a dark or decayed

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pith; somewhat aromatic; taste sweetish, bitter, and somewhat pungent.

The larger, lighter-colored rhizome of *Ruellia*, sp., with fewer coarse roots, from which the bark readily separates, is frequently substituted or admixed.

But little is known of the constituents of this drug. Starch, resin, gum, tannin, fat, volatile oil, and other ordinary plant substances exist, together with a small

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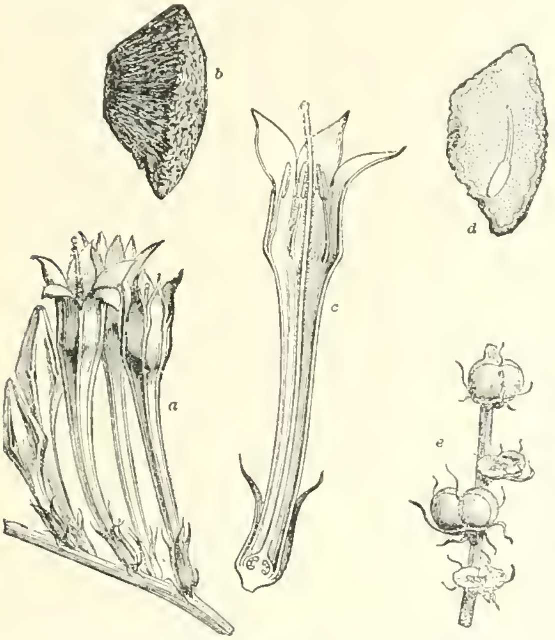

FIG. 3808.—Pinkroot. *a*, Twig with blossom; *b*, grain centre; *c*, section of flower; *d*, section of grain; *e*, fruit. (Baillon.)

amount of the volatile alkaloid *spigeline*, which is soluble in alcohol and water, and is probably the active constituent.

ACTION AND USE.—In overdoses spigelia is a narcotic poison. Quickening of the pulse, dryness of the throat, flushing and heat of the skin, uneasiness and delirium have followed its use. There is little doubt that in the cases in which it is most employed,—cases of *lumbrici* or round worms,—it is of considerable value. A fluid extract (*Extractum Spigeliæ Fluidum*, U. S. P.) is a good preparation, and the one generally prescribed. It is frequently combined with senna or some other cathartic. Dose of the fluid extract, for an adult, 2–8 c.c. (fl. ʒ ss.–ij.); for small children, from 1 to 4 c.c. (fl. ʒ ¼ to i.).

Allied Plants.—Another Spigelia, *S. anthelmia* L., growing in South America and the West Indies, has, as its name implies, similar properties and uses. Although used chiefly in its home, it has also been introduced into Europe. It is regarded, probably correctly, as more active than our own. *Henry H. Rusby.*

PINTA.—(Synonyms: Carat, Carate, Carathe, *Mal de los pintos.*)

Pinta is a parasitic disease characterized by the appearance on the skin of spots and patches of various sizes and colors.

Until recent times the disease had been observed only in Central America, Mexico, and South America, but lately reports have been published of its occurrence in Africa. It is said to be most common in the Mexican States of Tabasco and Chiapas, but it is also quite prevalent in Peru, Bolivia, and Brazil. In Venezuela and Colombia, along the low-lying banks of the rivers Zulia and Magdalena, the affection is quite in evidence. The half-breeds, mulattoes, and mestizos that make up the bulk of the laborers and crews of vessels plying these waters seem to have a peculiar susceptibility to the disease, or perhaps their skins offer less resistance to its inroads than the skins of the pure whites or pure negroes. I have often seen on these river boats as many as a half-dozen cases on a single vessel. So common is the trouble that it soon ceases to awaken interest in the average passenger.

The dorsal surfaces of the hands and feet, the anterior aspect of the legs, and the surface of the chest are the parts most often affected. The disease attacks both sexes and all ages, although it is seldom seen in children under six years of age. Like other diseases of a similar nature, it seems to have a preference for people of unclean habits, filth apparently having a direct bearing not only on the persistence but perhaps on the very existence of the affection. For this reason it is rare in the better class of mestizos and native whites.

The color of the patches may be red, blue, black, or white; hence the Spanish names rojo, azul, negro, blanca, etc. The size of the individual patches is quite variable. The disease first appears in one or two small spots which tend to increase along their periphery and merge into one another; it also extends by auto-inoculation in the act of scratching.

Some observers claim that the victims of this disease emit an offensive odor. One compares it to the odor exhaled by a mangy dog, another compares it to that of dirty linen. Personally I have never been able to detect this peculiar smell apart and distinct from the naturally offensive emanations from a body and clothes that have never been subjected to the action of soap and water.

SYMPTOMS.—The general health is not affected in this disease. Dr. Freites, of Venezuela, states that he has observed as prodromal symptoms chills, headache, anorexia, etc., but, so far as I know, no other observer has had a similar experience. The eruption appears suddenly as one or two small spots, at first slightly elevated above the surrounding surface. It progresses slowly and may even remain stationary for a variable period—the quiescent stage. This may be followed by a period of activity when the patches extend peripherally or appear on other parts of the surface, being the result of auto-inoculation, in the act of scratching. Pruritus may be excessive, even to the point of interference with sleep, or it may cause little or no annoyance. Desquamation is as a rule of a furfuraceous character, varying in quantity from almost *nil* in the white to a relative abundance in the red and black forms of the disease; in some cases of the latter variety it occurs in thick crusts. Suppuration and bleeding are due to the injuries inflicted by scratching. After a period of variable duration some of the spots merge into one another, giving the patient the characteristic piebald appearance.

The above symptoms are common to all forms of the disease. A few additional words regarding each variety of the disease would perhaps make the matter clearer.

White Form.—This looks very much like an ordinary leucodermic patch. The color is like that of yellowish-white wax, and the surface of the patch is smooth and shiny. When this form attacks the hairy portions of the body the hairs become thin, like lanugo, and lose their pigment.

Red Form.—This at first looks as if the surface had been scalded; later the affected portions become bright red and smooth. As the pruritus in this form is usually more intense, it is the one most liable to suppuration and other accidents due to traumatism.

Blue Form.—The eruption appears first as a group of small blue spots, like those made in tattooing; sooner or later these spots extend and merge into one another, the whole patch then having a peculiar blue color, which I would compare to the blue shell of a duck's egg. These patches are covered by a thin layer of dust-like grayish-blue scales.

Black Form.—In this form the spots are at first of a dirty gray color, which gradually becomes darker as the spots themselves grow older and larger. Eventually, the area affected resembles nothing so much as a surface

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spread with a layer of blue ointment. Another division that has been made recognizes a superficial form, including the blue and the black forms, and a deep form, embracing the white and the red varieties, in which there is destruction of the deeper underlying tissues. Several of these forms may and do occur together in the same individual.

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PATHOLOGY.—"The scales contain a white, highly refracting mycelium, and black spores which are round or oval in shape. The spores contain a yellow fluid in which abundant pigment is found. The mycelial filaments are short, non-branching, and taper from a broad base to a blunt point, by which each filament is attached to a single spore" (Manson).

DIAGNOSIS.—Pinta may be distinguished from anæsthetic leprosy by the facts that the sensibility of the patches is not impaired, and that the mucous membranes are not attacked; from acquired leucodermia or vitiligo by the fact that in the latter there are no changes of structure or of sensibility in the affected skin. From chromophytosis, ringworm, and erythrasma pinta may be distinguished by the history of the disease and the color and localization of the lesions.

PROGNOSIS.—As to life the prognosis is very good, but the disease is very rebellious to treatment; and in spite of all treatment it usually lasts a long time.

TREATMENT.—Absolute cleanliness and the local applications of chrysophanic acid, sulphur, iodine, the salts of mercury; in fact, all the stronger parasiticides are indicated.

N. J. Ponce de León.

PIPERAZIN (*Diethylene-Diamin. Ethlenimin*).—A synthetical compound primarily intended to replace spermin, but found to be a different body, both in chemical and in physiological characters. It is now utilized only as a solvent for uric-acid deposits in the place of lithia salts.

It is formed from the action of ammonia on ethylene bromide, which produces a mixture of compounds from which diethylene-diamin is separated by fractional distillation at a temperature between 130° and 180° C. When separated by a patented process it is supplied to the profession under the name of piperazin. It is a solid which melts at 104° to 107° C., and boils at 145°. It forms in bright, lustrous tables. When exposed to the air it absorbs water and carbonic acid gas, and becomes liquefied. It is very soluble in water, and forms a tasteless, alkaline solution without being in the least corrosive.

Experiments with solution of piperazin upon uric acid and upon calculi formed either of uric acid or of uric acid with phosphate of lime, prove that it exerts a powerful solvent action. When placed in a one-per-cent. solution at a temperature of 90° F., the stones are rapidly acted upon, the sharp edges are removed, and the surface becomes smooth and slippery; within twenty-four hours the mineral portion is dissolved and a soft mucoid skeleton only remains. All forms of urinary deposits are said to be more or less acted upon. Compared with carbonate of lithium it dissolves twelve times as much uric acid. Tests have been made of the relative solubility of fragments of a stone in one-per-cent. solutions of piperazin, lithia carbonate, borax, and sodium carbonate. In the piperazin solution the fragment was dissolved in six hours, the lithia solution did not dissolve the fragment until after forty-eight hours, the borax dissolved only a very small portion in forty-eight hours, and the sodium solution had no effect whatever after the lapse of the same period of time. In each case the residue was placed in the piperazin solution, when it entirely disappeared.

The action of the drug when administered to a person in health is perfectly harmless. It does not disturb the digestive, circulatory, or respiratory organs. After its administration and absorption it is not decomposed or acted upon, but passes through the system and is excreted by the kidneys unchanged. Piperazin may be detected in the urine two hours after its administration, and it continues to be excreted for a prolonged period. The urine is not rendered alkaline, nor in any way altered by its prolonged use.

Piperazin is theoretically a very valuable drug for the treatment of all conditions in which uric acid is formed in excess. Numerous cases are reported in which it has been used with very marked success—in gout in all its forms, in lithiasis, renal calculi, and vesical calculi, and in many forms of rheumatism of a gouty character. In these conditions it is supposed first to saturate the uric acid that remains dissolved in the organism, and then to attack all deposits of uric acid. The soluble urate of piperazin that is formed is readily excreted with the urine. The piperazin that is not neutralized in the system comes in contact with calculi and deposits in the kidney and bladder and there exerts its specific properties. On account of its freedom from any irritating action on the mucous membrane, it may be made to act directly upon the deposits in the bladder, by injecting a one-per-cent. solution, which assists in the decomposition of the larger calculi that would otherwise require operative treatment.

The results of its use have not always been so favorable. Prof. H. A. Hare reports having employed it in some cases of well-marked gout and in gouty rheumatism without any beneficial effects. He administered it internally and by hypodermic injection in the usual doses without relief. Sir William Roberts, in the "Croonian Lectures for 1892," on the treatment of the uric-acid diathesis, states that piperazin in blood serum or synovia had not the slightest effect in adding to the solvent powers of these media on sodium biurate, nor the slightest effect in retarding its precipitation from serum and synovia artificially impregnated with uric acid. He concludes that if piperazin has any beneficial action in gout it is not due to its solvent powers on the material of gouty concretions.

On account of its hygroscopic properties it must never be prescribed in powder or pill form. It is supplied in bottles containing 5 gm., which is sufficient for five days' use. This is to be dissolved in a definite quantity of water, and one-fifth given each day in divided doses. The quantity employed by all observers has been 1 gm. daily, in solution, well diluted. The effects of the drug are rapidly manifested. After the subsidence of the attacks a smaller dose of eight to fifteen grains may be given every third day, and continued for months. When administered hypodermically, fifteen minims of a ten-per-cent. solution may be used. The injections are to be made in the neighborhood of the affected joints. The drug is to be given internally at the same time. The effects of this method are reported to be very gratifying; the swelling and pain subside and the deposits are absorbed and greatly reduced in size. In some cases it is reported that deposits of gouty material in the pinnæ of the ears and in the eyelids were removed by two or three injections. The following solution is also prepared for local application to the affected joints: Piperazin, gr. xv.–xxx.; alcohol, ʒ v.; water, ℥ iiss.

Beaumont Small.

PIPERONAL—heliotropin, methylene ether, protocatechuic aldehyde, $C_6H_3COH.O_2CH_2$—occurs in small white crystals with a strong odor of heliotrope, and is soluble in alcohol and ether and insoluble in water. In dose of 0.5–1 gm. (gr. viij.–xv.) it is antiseptic and antipyretic. It is also used in perfumery.

W. A. Bastedo.

PIPSISSEWA. *Chimaphila. Bitter* or *False Wintergreen, Prince's Pine.* "The dried leaves of *Chimaphila umbellata* (L.) Nutt. (*Pyrola u.* L.; *C. corymbosa* Pursh. —fam. *Pyrolaceæ*)."

This very pretty little plant, native of dry woods throughout the cooler regions of almost the entire North Temperate Zone, is an herb-like undershrub, having an erect stem a few inches in height, arising from a short, prostrate portion. The leaves are crowded near the ground and the scape bears several very pretty, five-

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merous, wax-like, white, subpendulous flowers, about a half an inch broad. The leaves are from 2.5 to 5 cm. (1 to 2 in.) long and 1 to 1.5 cm. (⅜ to ⅝ in.) broad, oblanceolate, the lower half cuneate and entire, the upper coarsely and sharply serrate, acute or obtusish, thick and rigid, brittle, above dark-green or brownish-green, and slightly shining, the veins strongly impressed, underneath paler, the veins very prominent; odor very slight, tea-like; taste astringent and bitterish.

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Their constituents are almost identical (as are the properties and uses) with those of *Uva Ursi.* There is between four and five per cent. of tannin, arbutin, sugar, gum, etc., and a small amount of the yellow, crystalline, neutral substance, *Chimaphilin,* which is inodorous and tasteless, soluble in alcohol, ether, and chloroform, but only slightly soluble in water. For its mildly astringent and diuretic properties and uses, see *Uva Ursi.* The Pharmacopœia provides a fluid extract, the dose of which is 2 to 4 c.c. (fl. ʒ ss. to i.). *Henry H. Rusby.*

PITCH, BLACK.—Common pitch. See *Turpentine.*

PITCH, BURGUNDY.—*Pix Burgundica* (U. S. P., B. P.); *Poix de Bourgogne, Poix des Vosges, Poix jaune* (*Codex Med.*). This opaque resin is nominally, and properly, obtained in Europe from the Norway spruce, *Abies Abies* (L.) Rusby (*Pinus* A., L.: *P. Picea* Du Roi—fam. *Pinaceæ*), a magnificent evergreen with a pyramidal head reaching 40 metres or more in height, and having branches even down to the very ground. Its cones are large and pendent, its foliage is close, and of a brilliant green color. It is an abundant forest tree of Northern Europe and Asia, and a frequent ornamental one here.

Burgundy pitch is not an empyreumatic product like common black pitch, but a turpentine which has been exposed to hot water or steam, and has in consequence taken up enough of it to become opaque. It is collected by making rather deep incisions in the trunks of the trees, scraping off the resinous sap that flows out, boiling it in water, and straining it through cloths. The collection is carried on in Austria and Switzerland, but not to a very great extent, and is diminishing. In the place of this genuine article, the turpentine of other European Pinaceæ, prepared in the same way, is frequently substituted, and is sanctioned in most countries; and besides this, an entirely spurious preparation of common American rosin, mixed with oil or fat and water, is the common (false) Burgundy pitch of the market. That sold in this country is said to be almost never genuine. The following is the official description:

Hard, yet gradually taking the form of the vessel in which it is kept; brittle, with a shining, conchoidal fracture, opaque or translucent, reddish-brown or yellowish-brown; odor agreeably terebinthinate; taste aromatic, sweetish, not bitter.

It is almost entirely soluble in glacial acetic acid, or in boiling alcohol, and partly soluble in cold alcohol.

The principal portion of this substance—eighty per cent. or more—is *resin,* amorphous and opaque until the water is evaporated off, then clear; from three to five per cent. of *essential oils* is also present, and from five to ten of *water.*

It is a mildly stimulating substance when applied to the skin; taken internally it has the properties of common rosin, or, in a mild degree, those of turpentine; stimulating in small doses, irritating in large ones; but it is milder in its taste and action than common turpentine. Its very limited medicinal use is almost entirely confined to its presence in a few plasters, of which the following are official here: Burgundy pitch plaster (*Emplastrum Picis Burgundicæ,* U. S. P.). Burgundy pitch, 80 parts; yellow wax, 15 parts; olive oil, 5 parts, melted together. It may be used as it is, or as the basis for other more active medicaments. The pitch plaster with cantharides is more stimulating; it consists of: Burgundy pitch, 92 parts; cerate of cantharides (thirty-two per cent.), 8 parts, melted together after straining the cantharidal cerate through a very fine strainer. *W. P. Bolles.*

PITCH, HEMLOCK.—*Pix Canadensis* (U. S.), *Canada Pitch.* This is a product of the *Hemlock Spruce, Tsuga Canadensis* (L.) Carr. (*Pinus C.* L.: *Abies C.* Mx.—fam. *Pinaceæ*), collected and prepared in much the same way as the preceding. It appears often to have been boiled for a greater length of time, and is frequently very dark, almost black in consequence. It is described as follows: "Hard, yet gradually taking the form of the vessel in which it is kept; brittle, with a shining conchoidal fracture, opaque or translucent; dark reddish-brown; having a weak, somewhat terebinthinate odor." Canada pitch has essentially the same composition and properties as the preceding, and is used for the same purposes. A plaster is made of it in exactly the same way as the Burgundy pitch plaster (see above). *W. P. Bolles.*

PITUITARY GLAND.—(*Hypophysis Cerebri*: Ger., *Hypophyse*: Fr., *Gland* or *Corps Pituitaire*: Ital., *Glandula Pituitaria*; Span., *Ghiandola Pituitaria.*) Vesalius was the first to describe this organ, and in his "De Corporis Humani Fabrica" (1553) he calls it the "glans pituitam excipiens," due to the mistaken idea that this organ secreted the nasal mucus (pituita). Soemmering (1778) described it more fully and called it "hypophysis cerebri." Both thought that the pituitary was a gland, but as they could not find any duct, they considered it a part of the nervous system. Rathka (1838) pointed out the significant fact that the organ is developed from two *Anlagen,* one arising from that part of the fore-gut which later forms the pharynx, the other arising from the base of the third ventricle. These views were disputed for some time, but Mihalkovichs (1874) agreed with Rathka, and his proofs were so conclusive that but few have disputed them since that time. Pathological changes were noticed by many of the early observers. Wepfer, Bonnet (1679), and Morgagni found colloid cysts; Greding (1771) and Melcarne (cited by Mechel) found "enlargements of the pituitary gland"; and Wenzel claimed that diseases of the pituitary caused epilepsy. The physiology of this organ has been neglected much, and it is only recently that its physiological action has been given much attention.

Anatomy.—The pituitary body is an oval, glandular organ, consisting of two lobes and a connecting part. It rests in the sella turcica, and is enveloped by a layer of dense connective tissue, which is a prolongation of the basal dura. The average weight of the pituitary is 0.5 gm. In a series of one hundred cases Schönemann found that the average weight was 0.63 gm. between the ages of twenty and thirty, but that the weight diminished after that time until the average at fifty was 0.6 gm. Boyce and Beadles examined the pituitary glands from fifty female insane and found that the weight varied from 0.384 to 0.896 gm., the average being 0.6 gm. In fifty male insane the weight varied from 0.712 to 1.302, with an average of 0.453 gm. The ages of these cases varied from twenty-two to seventy-eight, none having presented symptoms referable to the pituitary. According to these authors the weight of the pituitary has no definite relation to that of the brain or to the age of the patient. The organ measures about 14 mm. in its lateral diameter, 7 mm. in its antero-posterior, and 6 to 7 mm. in thickness. The color of the pituitary is a dark brown or a bluish-red. The consistency of the organ is about that of the normal liver.

Histology.—The microscopical structures of the two lobes differ markedly, the anterior being made up of glandular elements, and the posterior of a tissue resembling, with ordinary stains, a modified glia. From the connective tissue surrounding the gland, fine trabeculæ carrying the blood-vessels run into the interior and separate the cords of epithelial cells. These epithelial cells are rather hexagonal in shape and are of two kinds. One contains a round or oval, deeply staining nucleus embedded in a large amount of granular protoplasm which stains deeply with eosin ("eosinophilic cells"). The other cells are somewhat smaller, more granular, and they do not stain with the acid dyes ("cyanophilic cells").

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The posterior lobe is enveloped by a capsule of connective tissue from which the fine septa carrying the blood-vessels enter the lobe. Immediately beneath the capsule are several layers of cells, which, according to Gemelli, react with certain stains like glio-epithelium. Beneath these is an indefinite layer of secretory cells of the epithelial type, which are often arranged into distinct alveoli separated by the fine connective-tissue septa. The central zone of this lobe contains small round, polygonal, and few pear-shaped cells together with a small amount of connective tissue. The pear shaped or nerve cells possess either one or two neuraxons. These cells are of two types, the large and the small pear-shaped cells. The large cells have many branching dendrites ending in feathery tufts. The neuraxons of these cells come off close to the cell bodies, have few collateral branches, and end by breaking up into fine threads, some of which are lost near the cell, while others end in networks among the epithelial cells along the border of the lobe. The other type of nerve cell or the small pear-shaped cell has dendrites, all of which are short, except one which is covered with hair-like processes. All the dendrites come off close to the cell body and terminate as clubbed ends.

The cells which possess more than one neuraxon are flask shaped. Each cell has three or four dendrites which gradually grow finer and terminate free, and from two to four neuraxons which apparently terminate about similar cells. Most of the neuraxons run toward the infundibulum, but Berkley, who has worked much on this subject, has been unable to trace them into the infundibulum. Gemelli has described nerve fibres in the pedicle; they enter the posterior lobe and branch in the shape of a fan under the glio-epithelium. From there he was unable to trace them to any cell in this lobe which he could call a nerve cell.

The infundibulum or the pedicle consists of a loose connective tissue which is composed of anastomosing stellate and spindle shaped cells, and which holds in its meshes blood vessels and nerve fibres and encloses small blind spaces lined by cubical epithelium, the remains of the neural central canal.

Embryology.—The pituitary gland is developed from two *Anlagen*, one coming from the midbrain ectoderm and the other from the entoderm of the posterior pharynx. At the angle formed by the pharynx and mouth a solid bud of cells is given off from the median area of the upper wall of the posterior pharynx. These cells grow out into the thin layer of mesoblast separating the brain from the pharynx, and the bud as a whole becomes hollowed out to form a duct like communication with the pharyngeal cavity. About the time when the pharyngeal bud begins to develop the brain sends another bud downward until the two *Anlagen* come to lie side by side. About this time the mesoblastic cells surrounding the *Anlage* from the pharynx grow into this hollow flask-shaped mass, and the wall of the once smooth cavity becomes folded inward upon itself. These papillæ become divided and interlaced to form the mature gland. While this has been taking place the canal communicating with the pharynx has become occluded and absorbed, and the base of the sella turcica has ossified.

When the *Anlage* for the posterior part of the gland is given off, it contains few embryonic ganglion cells, which are found as cells less developed than their corresponding cells in the base of the third ventricle. Along with these cells glia cells are found, some of which disappear and others remain as the cells described by Berkley.

Pathological Anatomy.—Because of the location of the pituitary body pathological conditions at the base of the brain are apt to cause secondary changes in it. These secondary changes may or may not be marked enough to produce symptoms. Usually before symptoms on the part of the pituitary appear, the primary condition at the base of the brain has produced its effects, which have either killed the patient or have masked the symptoms caused by the pituitary lesion.

Circulatory Disturbances.—General *congestion* of the brain, either active or passive, produces a similar condition in the pituitary. Anæmia of this organ occurs in general cachectic conditions such as result from malignant neoplasms, tuberculosis, general arteriosclerosis, etc.

Two instances of hemorrhage into the organ have been reported, one by Bailey, in which the lesion was due to endarteritis, and a second one by Anders and Cattell, which occurred in a case of pernicious anæmia.

Infarct of the pituitary has not been reported as yet.

Retrograde Changes.—Atrophy of the pituitary body results from the cachexias of malignant tumors, tuberculosis, syphilis, and pernicious anæmia. Senile atrophy occurs physiologically in every individual over fifty.

Necrosis. Necrosis of any form involving the whole organ has not been reported, but localized simple, liquefaction, and coagulation necrosis may be present under certain conditions. General infection may produce a simple necrosis of the gland cells of the anterior lobe of the pituitary body. Liquefaction necrosis may follow infection of the organ by the pus-producing germs, and coagulation necrosis may be present under similar conditions.

Degenerations.—General cloudy swelling and fatty degeneration may result from the general intoxications of infections or from inflammations of the tissues surrounding the pituitary. By far the most common retrograde change in the pituitary is colloid degeneration, which is, up to a certain degree, a physiological condition, similar to that of the thyroid. Accompanying an overproduction of colloid, there are often formed cysts, which are due to the inability of the organ to excrete the colloid. These cyst walls are lined by the cuboidal cells which are the remains of the parenchymatous cells.

Progressive Changes.—Hypertrophy. The most common progressive change, if not the most common change of any form, is hypertrophy. This change is confined usually to the glandular portion of the organ, and occurs in a large number of cases of acromegaly. The parenchymatous cells of the anterior lobe are increased both in size and in number, the connective tissue being relatively increased also.

Inflammations. Inflammation of the pituitary gland is usually secondary to a meningitis and, in pyæmia, secondary abscess may develop in the organ. Secondary inflammation may in rare cases result from an abscess of the pharyngeal vault.

Chronic Inflammations (Granulomata); Tuberculosis. In 1901 Baldwin reported tuberculosis of the pituitary gland in a case of general miliary tuberculosis; that this was a true case of tuberculosis cannot be doubted since the germs were found in stained sections. A careful study of the literature at that time failed to give another case of true tuberculosis of the pituitary. Weigert had reported a case of "tuberculous like granuloma" of the pituitary, but he was not positive as to its identity since he could find no germs in this granuloma, and he could find no tubercles in any other part of the body. Boyce and Beadles, and Wagner have reported cases similar to that of Weigert, but were unable to demonstrate germs.

Syphilis. Lancereaux says that the hypophysis may be enlarged in hereditary syphilis, such enlargement being due to increase of the connective tissue. Weigert, Barabacci, Birch Hirschfeld, Hunter, Sokoloff, Frasier, and Hektoen have reported gummata of this organ which resembled in structure gummata found elsewhere in the brain.

Tumors. The only mature connective-tissue tumors which have been reported are two cases of lipoma, and one of fibroma. The lipoma in both cases arose from the fat tissue about the organ, and not from the gland proper. Chiara published the case of a woman, aged sixty-three, in whom a fibroma the size of a bean was found in the pituitary.

Many of the tumors of the pituitary gland which have been reported have been called large, round-celled alveolar sarcoma or endothelioma, other varieties of the sarcomata being very uncommon. However, when the structure of the normal pituitary body is borne in mind, it is probable that many of the so-called round-cell sarcomata

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Pituitary Gland.

were adenomata. One case of lymphosarcoma of the pituitary, and another of spindle-cell sarcoma have been published, the former by Heusser and the latter by Hoffmann. Of the mixed sarcomata and those showing degenerations or deposits some of the large round-cell sarcomata have been alveolar and consequently mixed. To these may be added the angiosarcoma of Walton, the myxosarcoma reported by Whitwell, and the gliosarcoma of the posterior lobe published by von Graefe.

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Of the epithelial tumors various forms have been described. As stated before, small retention cysts are common in the anterior lobe and in the infundibulum of the pituitary. These may become very large and may replace the greater part of the organ. They may be lined by a single smooth layer of rather flattened cuboidal cells or the inner surface may be folded slightly. In every case these cysts contain a substance very similar to the colloid of thyroid, if not identical with it. Unless the retention cysts are classed as tumors, adenomata of the pituitary are the most common variety of epithelial tumor. It is possible, however, that many of the so-called adenomata have been examples of hypertrophy. In both hypertrophy of the pituitary and in adenomata the anterior lobe is the only part of the organ which is affected, and it becomes often a matter of personal opinion whether a given case represents a condition of hypertrophy or one of adenoma. In those cases which are genuine instances of adenoma all the elements of the anterior lobe are increased in number and many of the epithelial cells are enlarged. The lymph spaces between the cords of cells are broader and in many the colloid secretion may be slightly increased. These tumors are malignant only by position. Cases of carcinoma of the pituitary have been described.

The possibilities of inclusions of foreign embryonic cells into the *Anlage* of the pituitary and the subsequent formation of dermoid cysts from these cells are great. Nevertheless, very few of these tumors have been reported. Engel (1839), Rippermann (1864), Arnold (1875), Baart de la Faille (1875), Wasserthal (1875), Beck (1885), White (1885), Sanisburg (1886), and Beadles have described teratomata of the pituitary gland.

Most of these teratomata have been composed of small cysts containing semi-solid pultaceous material. The connective tissue surrounding these cysts contained small pieces of bone. Many of these tumors have been found accidentally at autopsy and have produced no symptoms during life. Others have been found in a fœtus, and these have shown a more complicated structure. Some have contained cortex, ganglion cells, liver, parts of the intestinal tract, hair, teeth, and bone, and they may have represented a parasite engrafted upon an autocyte; others of these teratomata have arisen from the remains of the pharyngeal diverticulum.

Of the parasites found in man Sömmering has reported a case of echinococcus cyst of the pituitary gland.

Physiology.—The physiology of the pituitary is not fully known. Before 1886 this organ was supposed to represent some evolutionary remains. In 1886 Marie found that it showed marked changes in so many cases of acromegaly that the old idea that it was non-functional was reconsidered.

Oliver and Shäfer have injected into animals intravenously a saline extract of the pituitary, and have found that it produced a rise in blood pressure. Howell confirmed this work, and found further that a second dose did not have so marked an effect as the first, unless considerable time had elapsed between the two injections. Shäfer and Vincent were able to extract from the pituitary one substance which depressed and one which increased the blood pressure. The substance which possessed the power of increasing the pressure was found to be soluble in salt solution and insoluble in absolute alcohol and ether. The other substance, however, was soluble in all three of these reagents. The experimenters injected the salt-solution extract and found that the blood pressure rose, but soon fell. They explained this by the fact that the depressive substance acted more slowly than the stimulating one. Osborne and Vincent extracted from the infundibular lobe a depressive substance which resembled that obtained from the cortex of the brain, and consequently they are not sure that the depression effects may not be due to the nerve elements of the infundibular lobe.

That the pituitary gland is similar in structure to the thyroid had been known for some time. Michel (1860) and Peremeschko (1866) were among the first if not the first to note the similarity and, in describing the pituitary gland, they compared it to the thyroid. It remained for Rogowitsch, in 1886, to prove that this supposed similarity was a fact. Since this time many workers have observed in diseases such as myxœdema, cachexia thyreopriva, and cretinismus, that the hypophysis is increased in size. The cells of the glandular lobe are larger than normal, and the amount of colloid material found in the organ is increased. Hence these writers have assumed that when the thyroid is diseased, the hypophysis attempts to assume the function of the thyroid. On the other hand, cases have been reported in which the hypophysis has been abnormal either in structure or in function, the thyroids and in some cases the parathyroids have been increased in size. In such cases it has been assumed that the thyroids and parathyroids attempt to compensate for the diseased pituitary bodies.

The experimental evidence on this subject is not uniform at present. Casseli has been able to produce a condition exactly analogous to cachexia thyreopriva by removal of the pituitary; and he states that arrest in development of the pituitary retards the growth of the organism as a whole. Freedmann and Maas removed the pituitary bodies from cats, and could not obtain the same results. Nevertheless, the great weight of clinical evidence and the larger part of the experimental study tend to show that the relation is very close between the pituitary body and the thyroid and the parathyroid glands.

Pathological Anatomy of Acromegaly.—In all the cases studied, Israel says (1901) that Virchow was able to find only five cases in which the pituitary was not enlarged. In sixty-nine cases which the writer has had the opportunity of analyzing the pituitary is found "not enlarged" in only one case. In all other cases this organ shows some pathological change.

The following shows the changes found as they were diagnosed:

Colloid degeneration and hemorrhage	2
Hypertrophy (anterior lobe)	22
Hypertrophy (posterior lobe)	1
Vascular hypertrophy	2
Fibrosis with atrophy of follicles	1
Tumor	4
Hypertrophy (?) or sarcoma (?)	1
Glioma	1
Glioma (?) sarcoma (?)	1
Neurogliomic sarcoma	1
Adenoma	10
Adenoma (?)	3
Sarcoma, round cell	19
Sarcoma (?) or lymphadenoma (?)	1
	69

In 29 of these cases the thyroid was examined, and in only 5 was this organ reported normal.

The conditions found in this organ are as follows

Normal	5
Atrophy	1
Atrophy with interstitial fibrosis	2
"Chalk-like" deposits	1
Colloid degeneration	3
Cystic degeneration	1
Hypertrophy	11
Hypertrophy with colloid cyst	2
Hypertrophy with interstitial fibrosis	2
Interstitial fibrosis	1
	29

In this connection it may be well to note that in 18 cases in which the thymus region was examined, the thymus was reported absent in 7; persistent in 7; both lobes were enlarged in 3, and in 1 case only the left lobe was enlarged.

The relations of the pituitary to the thyroid and thy-

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mus glands in acromegaly have not been demonstrated. That pathological changes of the pituitary occur in almost every case of acromegaly is true, but pathological changes are also found in this body in cases in which there has been no overgrowth of the bones or any other symptom or signs of acromegaly.

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Frederick A. Baldwin.

PITYRIASIS.—Pityriasis is an affection of the skin in which there is slight redness accompanied by a branny desquamation. The term was formerly used to describe many scaly conditions of the skin, but it is gradually passing out of use, as the conditions are now described under other headings.

Pityriasis of the scalp is described in the article on *Eczema;* it is the dry form of dandruff in which the scales do not adhere, but fall whenever the hair is brushed.

Pityriasis of the face and neck is usually found as ill-defined slightly scaly patches with very little redness. This condition is described by most authors under seborrhœa or seborrhœic eczema. (See article on *Seborrhœa.*)

Pityriasis rosea, Pityriasis rubra, Pityriasis rubra pilaris, and Pityriasis versicolor are described elsewhere. (See the articles on *Pityriasis Rosea, P. Rubra,* and *P. Rubra Pilaris,* in THE APPENDIX, and that on *Tinea* in Vol. VII.)

Howard Morrow.

PIXOL is a cheap substitute for lysol made by mixing one pound of green soap with three pounds of liquid tar (Pix liquida) and slowly adding a solution of three and one-half ounces of potash in three pints of water. The resulting liquid is miscible with water, and is used, in five-per-cent. dilution, for disinfecting the hands, linen, etc. It is claimed to be about as strong as carbolic acid.

W. A. Bastedo.

PLACENTA, ANATOMY OF.—The placenta (ὁ πλακοῦς, a cake) is a discoid, spongy body attached during pregnancy to a portion of the inner wall of the uterus. It is connected by means of the umbilical cord with the fœtus, and forms for it the organ of respiration, nutrition, and excretion. After the expulsion of the child, it becomes separated from its area of attachment, and together with the fœtal membranes is cast off as the so-

FIG. 3810.—Decidua Vera, Fourth Month. × 16. (From J. Whitridge Williams' "Text-book of Obstetrics," Appleton & Co., New York, 1903.)

called *after-birth* (Nachgeburt, l'arrière-faix). The portion of the placenta which is attached to the uterine wall is rough and irregular and is known as the maternal surface, while that facing the fœtus is smooth and covered by the thin glistening amnion, which overlies the smooth surface of the chorion and is closely applied to it.

The recently delivered placenta at term is smaller, but at the same time somewhat thicker than it is when in utero, the change resulting partially from the compression to which the organ has been subjected during labor, and partially from the escape of the greater part of the blood contained in its interior. The organ is spongy in consistence, and varies considerably in shape, size, and color. In single pregnancies,

FIG. 3809.—Maternal Surface of Mature Placenta, Showing Cotyledons; Membranes Turned Back. × 2/3. (From J. Whitridge Williams.)

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as a rule, it is more or less rounded, though it may be ovoid or oval, reniform, crescentic or lobulated. It measures from 15 to 20 cm. in diameter, and from 2 to 4 cm. in thickness, generally thinning gradually toward

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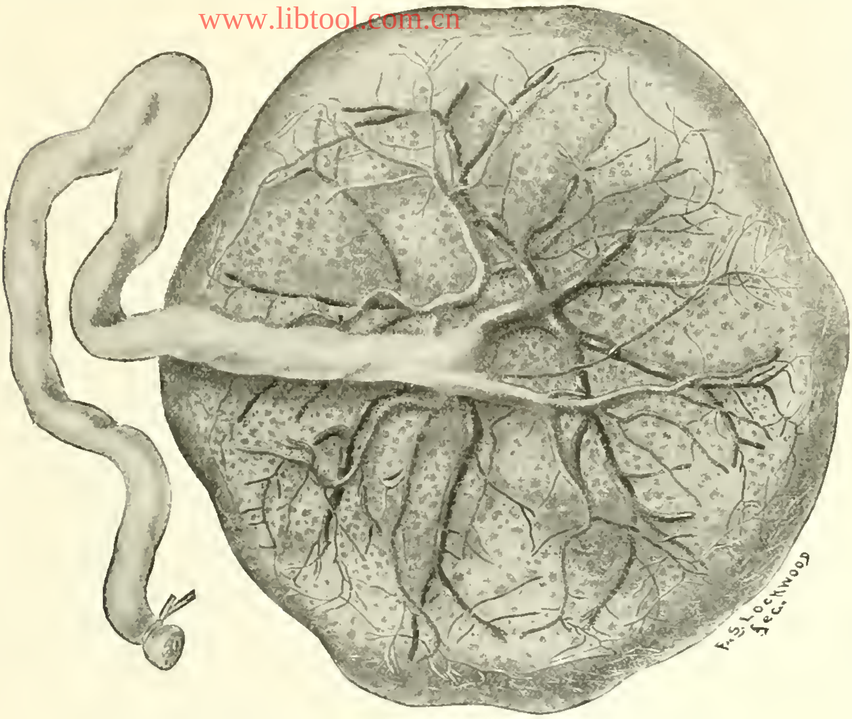

FIG. 3811.—Fœtal Surface of Mature Placenta. × ⅔. (From J. Whitridge Williams.)

the edges, which fade away into the thin fœtal membranes. Sometimes, however, the thickness is fairly uniform up to the very margin. Its weight varies from 500 to 600 gm., being usually about one-sixth of that of the child, though in syphilis, nephritis, and some other conditions it may be relatively heavier.

The placenta presents two surfaces for examination, the *maternal* and the *fœtal* (Figs. 3809 and 3811). The former varies considerably in appearance, but is usually dark red in color, varying according to the amount of blood contained in its substance and the density of its structure. It is divided into a number of irregularly shaped areas, the *cotyledons*, which are separated from one another by shallow fissures. They vary considerably in number, sometimes as many as thirty being observed, and may measure from 1 to 8 cm. in diameter. The cotyledons are not primary divisions of the placenta, but appear first at the fourth or fifth month (Minot). The outer layer of the entire maternal surface consists of a thin investment of *decidua*, which dips down to form the cotyledonary divisions, and at the edges of the placenta is continuous with the inner coating of the membranes. The decidua is transformed uterine mucosa; while the placenta is in utero, it constitutes the boundary between the chorionic villi of the placenta and the uterine muscle, and separates in the final stage of labor, so that its outer or compact portion is carried off as part of the placenta and membranes, the spongy or glandular portion remaining attached to the muscle wall (Figs. 3810 and 3816). Scattered over the maternal surface are numbers of minute yellowish-white patches of varying size. Some of these have undergone calcareous degeneration, and impart to the palpating finger a sensation as of coarse sand paper. Close inspection of this surface reveals the torn openings of many blood-vessels. Thus Klein was able to count one hundred and five of these on a single specimen, fifty-one being arteries and fifty-four veins.

As opposed to the rougher maternal surface, the fœtal side presents a smooth and glistening surface, and is of a purplish-gray color, mottled with minute yellowish patches, and marked by irregular yellowish-white areas of varying size (white infarcts) (Fig. 3811). It is covered by the thin glistening *amnion* which is loosely attached to it, but which may be separated as far as the insertion of the cord. Beneath the amnion lies the smooth *chorion*, from the lower surface of which the villi extend, giving rise to the mottled appearance of the surface.

The *umbilical cord* terminates upon the fœtal surface of the placenta, and presents a dull white translucent appearance. It varies from 1 to 2.5 cm. in diameter, and averages 55 cm. in length, the extreme variations being 0.5 and 198 cm. When unusually short it may give rise to dystocia at the time of labor. As the blood-vessels are usually longer than the cord, they grow in a spiral manner, and are frequently folded upon themselves, giving rise to projections which are termed *false knots*. On the other hand, *true knots* are sometimes noted. These may be most complicated in form, and are believed to be due to fœtal activity. Contrary to the usual statements, the cord is not enclosed in an amniotic sheath, but is covered by stratified epithelium,

FIG. 3812.—Umbilical Cord, Fœtal End. × 5½. *U.A.*, Umbilical artery; *U.S.*, remnant of umbilical stalk; *U.V.*, umbilical vein. (From J. Whitridge Williams.)

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which is continuous with that of the abdomen of the fœtus. Its interior is made up of mucoid connective tissue—*Whartonian jelly*, in which are embedded two arteries, a vein, the umbilical stalk, and a remnant of the allantois (Fig. 3812). The latter is seen only at the fœtal end. The cord is rarely inserted centrally, being usually somewhat eccentrically placed, although occasionally it may terminate at the margin of the placenta (*battledore placenta*). Less frequently the blood-vessels separate before reaching the fœtal surface, and make their way to the placenta in a fold of amnion—*velamentous insertion*. The arteries come down together from the cord, and are usually but not always connected by a transverse vessel, just before reaching the placenta. The vessels then spread in all directions in the superficial part of the chorion, each branch producing a ridge upon its surface, by which its course can easily be followed. The veins lie beneath the level of the arteries, are larger in calibre, and distended with blood. Both arteries and veins branch repeatedly, each set following in a general way the course of the other, but they do not anastomose upon the placental surface. Generally they can be traced in their ramifications until they disappear as fine branches, turning at right angles into the placental tissue,

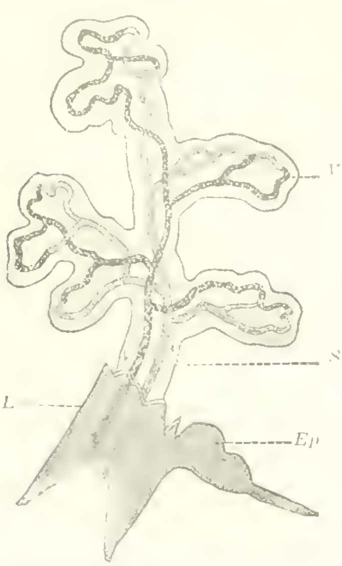

FIG. 3813. Chorionic Villus from Full-Term Placenta. Highly magnified. (After Kollmann.) *Ep*, Epithelial covering; *S*, stroma of villus; *V*, vascular loop.

in order to supply the chorionic villi. Occasionally, however, a large vessel, more often a vein, dips down abruptly. The greatest possible variation is noted in the arrangement of the placental vessels. When the cord is inserted near the margin they are arranged much more symmetrically than when the insertion is nearer the centre. There are no signs of a distinct cotyledonary circulation, but corrosion specimens of injected placentæ show that the terminal arteries communicate with veins by means of capillaries, at the free extremities of the chorionic villi.

In nearly all cases, as shown by Schultze, the *umbilical vesicle* and stalk may be found between the amnion and

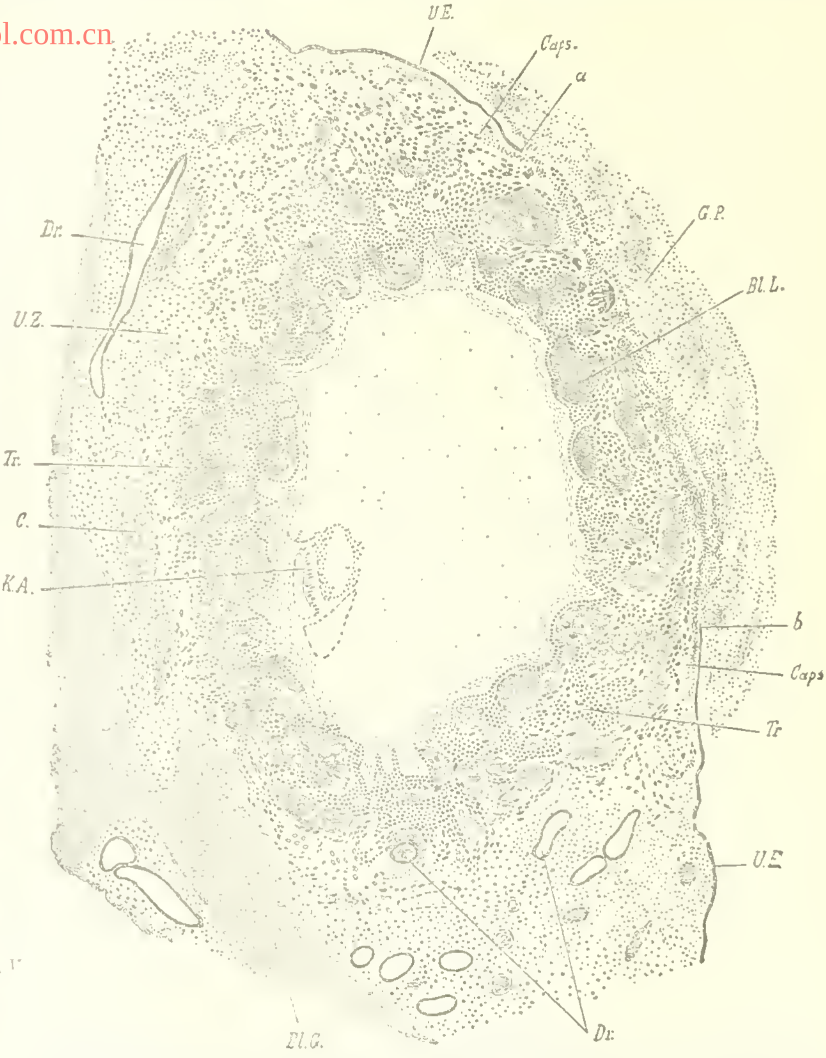

FIG. 3814.—Peters' Early Ovum. (From J. Whitridge Williams.) *U.E.*, Uterine epithelium; *Bl.L.*, lakes of blood; *Caps.*, decidua reflexa; *G.P.*, "Gewebspilz"; *Dr.*, uterine glands; *U.Z.*, decidua vera; *Tr.*, trophoblasts; *C.*, capillaries; *K.A.*, beginning embryo; *Bl.G.*, large blood-vessels; *a b*, point of entrance of ovum.

the chorion, and near the placental margin. When the membranes are separated it usually lies upon the inner surface of the amnion. The vesicle itself is a minute rounded sac 2–4 mm. in diameter, which usually contains in its interior a calcific point. It is attached to a thread-like stalk which extends to the cord, and frequently can be traced throughout its entire length. These may rarely be accompanied by omphalo-mesenteric vessels which have remained persistent.

The decidual and chorionic layers of the placenta are each less than a millimetre in thickness, save where the latter is thickened by blood-vessels or infarcts. On section the placenta presents a sponge-like structure, whose meshes are filled with blood, while the imperfect partition walls are formed by chorionic villi, which occupy the space enclosed between the decidual and the chorionic membranes. Some idea of the complexity of the villi may be obtained by floating a small piece of placenta in decinor-

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mal salt solution, and washing it free from blood, when one can distinguish a number of arborescent structures, consisting of a primary stalk, which divides and subdivides like the branches of a tree. The larger stalks arise from the maternal side of the chorionic membrane and extend a varying distance through the placenta, some ending freely, while others are firmly attached to the decidual portion. Under the microscope, the arborescent branching is readily appreciated, and it will be found that a great part of the interior of the terminal branches is occupied by blood-vessels, which break up into capillaries, just before reaching their free ends (Fig. 3813).

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Development of the Placenta.—All early human ova thus far described have presented, upon their outer or chorionic surface, branching villi each of which consists of a core of chorionic mesoderm covered by two layers of epithelial cells. For many years the origin of the latter has been a source of dispute, due in great part to the fact that much of our knowledge of human embryology is purely hypothetical, and is based upon observations made upon the lower mammals. During the last few years, however, considerable light has been thrown on this question by the study of the early human embryos of Peters, Leopold, and Spee, and by the work of Selenka upon the anthropoid apes, and of Hubrecht upon hedgehogs. Peters' specimen is the earliest human ovum thus far described, and was believed by him to be from three to four days old (Fig. 3814). Many writers, however, consider it to be somewhat older, probably at the end of the first week. The ovum was embedded in the depths of the endometrium, and was surrounded by a thin layer of mesoderm, surmounted by a capsule of many layers of fœtal ectoderm. To this latter Peters applied the term *trophoblasts.* He advocated the view that the trophoblasts proliferate rapidly, and invade the capillaries of the surrounding decidual tissue, with the consequent formation of pools of maternal blood of varying size. These are situated in the trophoblastic capsule, but are bounded externally by decidua, and represent the earliest stages in the formation of the *intervillous spaces.* As a result of the opening of the maternal vessels the trophoblasts soon present a sieve-like appearance, and the cells become compressed into masses of irregular form, some of which extend from the ovum to the surrounding tissue, while the majority never reach it. Into these the mesoderm soon makes its way, thus giving rise to the primary villi. Those reaching the decidua are known as *fastening,* or *anchoring villi,* and become firmly attached to it by the proliferation of the ectodermal cells at their extremities, giving rise to masses of cells, which may be seen throughout the first half of pregnancy and are designated as *cell nodes.*

FIG. 3815.—Reichert's Ovum. Magnified six times. (From J. Whitridge Williams.)

During the first weeks of pregnancy branching villi project from the entire periphery of the ovum (Fig. 3815), and come in contact not only with the decidua upon which it rests (serotina), but also with the layer which separates it from the uterine cavity (reflexa). During this period, the villi are devoid of blood-vessels,

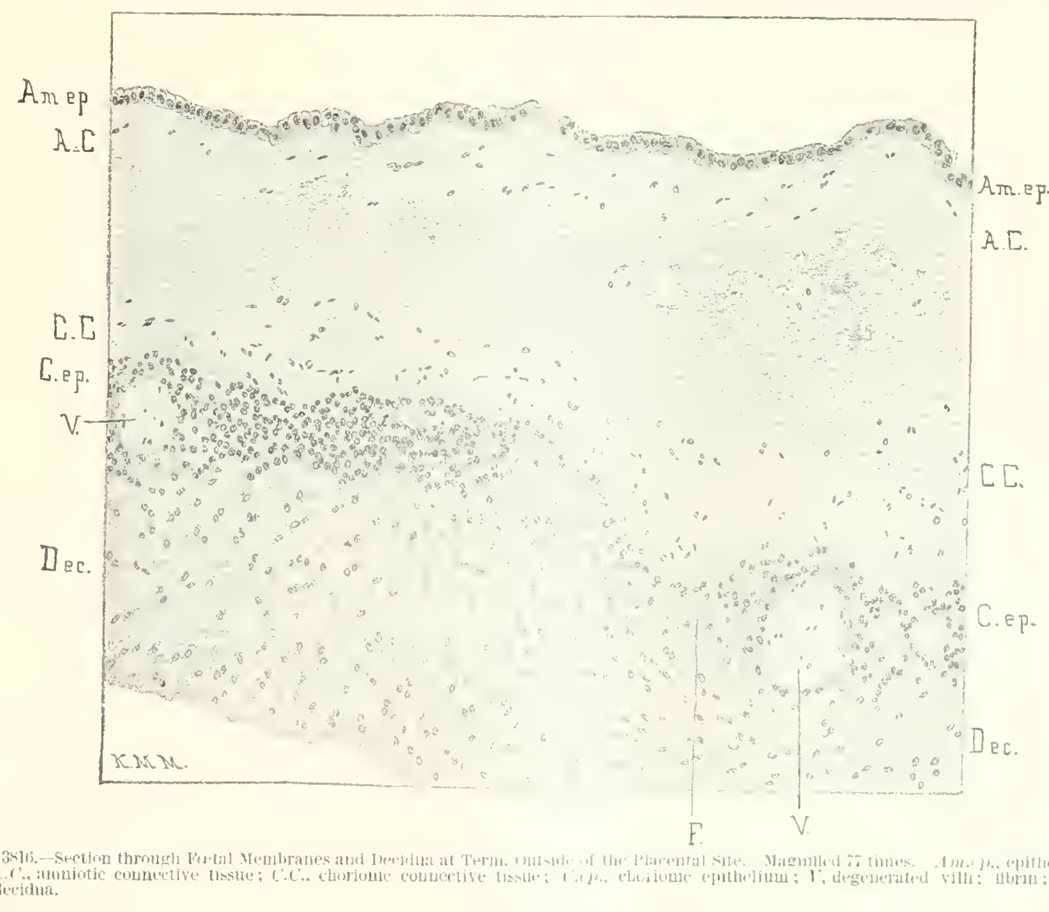

FIG. 3816.—Section through Fœtal Membranes and Decidua at Term, Outside of the Placental Site. Magnified 77 times. *Am.ep.*, epithelium; *A.C.*, amniotic connective tissue; *C.C.*, chorionic connective tissue; *C.ep.*, chorionic epithelium; *V*, degenerated villi; fibrin; *Dec.*, decidua.

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and the ovum is nourished by osmosis from the maternal blood. Probably as a result of contact with the maternal blood, the outermost cells of trophoblasts early undergo marked changes, becoming converted into a layer of

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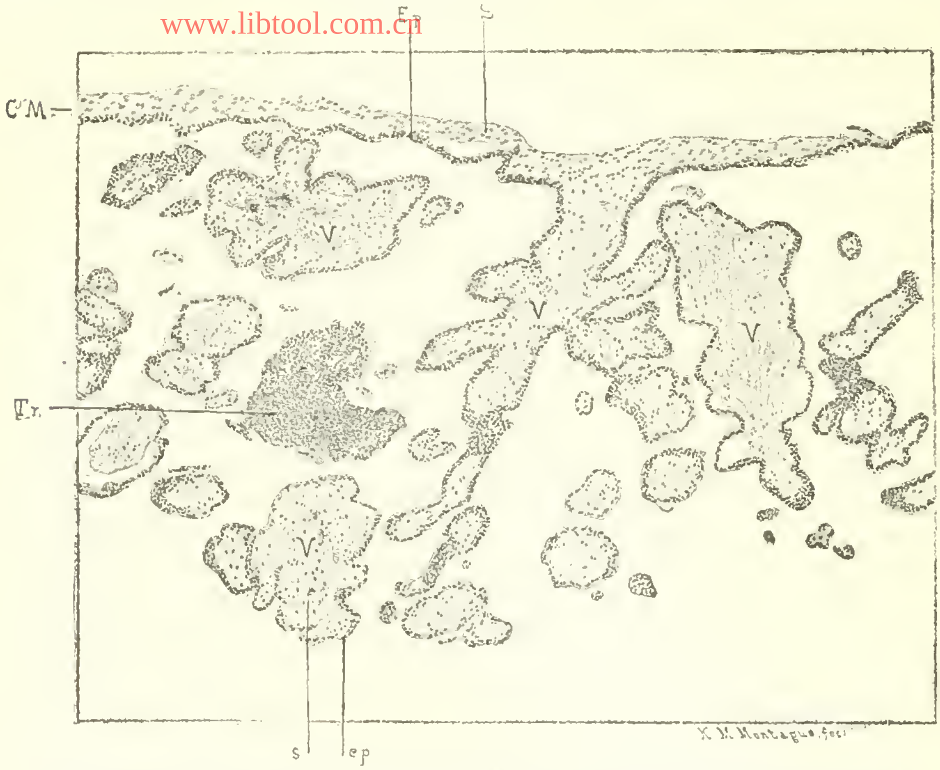

FIG. 3817.—Section through Chorionic Membrane and Villi of a Two-Weeks Ovum. Magnified 33 times. (From J. Whitridge Williams.) *C.M.*, chorionic membrane; *Ep*, epithelium of chorionic membrane; *S*, connective-tissue layer of chorionic membrane; *V*, villi; *s*, stroma of villus; *ep.*, epithelium of villus; *Tr*, decidual island (remnant of trophoblast).

coarsely granular, vacuolated protoplasm, with no sign of division into individual cells, and through it are scattered irregularly shaped, darkly staining nuclei. This tissue is known as *syncytium*, a term introduced in 1893 by Kossmann, although its characteristics had been recognized many years before by Kastschenko, who described it as plasmodium. Beneath the syncytium, and in contact with the chorionic connective tissue, develops a layer of sharply outlined, polygonal cells, with clear protoplasm and large vesicular nuclei, which is designated the *cell layer*, or *Zellschicht of Langhans*.

With the advance of pregnancy, the blood supply of the decidua serotina becomes more and more abundant, while that of the reflexa gradually disappears; as a consequence the villi in contact with the former are better nourished, and grow more rapidly than elsewhere, thus giving rise to the formation of the *chorion frondosum*. At the same time the villi covering the rest of the ovum develop less rapidly, and eventually undergo atrophic changes, so that this portion becomes known as the *chorion læve*. As the ovum increases in size, the intervillous spaces in the chorion læve diminish in size and gradually become obliterated, and by the fourth month, when the reflexa has come in contact with the decidua vera, the villi become atrophied, lose their epithelium, and eventually appear as round or oblong hyaline bodies. On the other hand, the villi of the chorion frondosum proliferate, and together with the decidua serotina form the placenta, which assumes its distinctive characteristics about the third or fourth month. It is probable that the primary villi do not increase in number with the advance of pregnancy, but their branches rapidly increase in complexity, so that their growth has been aptly compared to the development of a forest from a number of young trees.

Cross sections of chorionic villi differ markedly in appearance at the various periods of pregnancy, and De Loos has shown that their age may be roughly estimated according to their structure. Thus, in the early weeks, they consist of a more or less mucoid stroma with a few branching cells, the proliferation of which gives rise to the fibrillar structure observed in older villi. After the first few weeks the stroma is invaded by blood-vessels of fœtal origin, which come down by the cord, and which follow the villi in all their ramifications. The epithelial structures also differ in appearances according to the stage of development. During the first few months the distinction between the syncytium and Langhans' cell layer is sharply marked. As pregnancy advances, Langhans' layer gradually disappears, so that in the last months the villi are covered only by a thin layer of flattened syncytium.

Projecting from the surface of the villi are occasional buds of syncytium, which when cut across tangentially appear as *giant cells*, lying free in the intervillous blood spaces. They consist of a protoplasmic mass, which presents no distinct cellular division, and contain a large number of darkly staining nuclei. These represent the first stage in the development of new villous branches, and, as might be expected, when one bears in mind the development of villous processes, are seen less frequently in more mature placentæ.

Here and there, in the spaces between villi, may be seen masses of small clear cells with vesicular nuclei—*decidual islands*. These are usually surrounded by a layer of syncytium, rarely, if ever, contain blood-vessels, and appear to consist of decidual tissue, which frequently presents areas of degeneration. They are usually interpreted as cross sections through the so-called *decidual septa*, which are supposed to extend toward the chorionic membrane. Formerly they were regarded as being maternal in origin, but in the light of more recent investigation, it seems better to consider that they arise from fœtal tissue, and represent areas of trophoblasts that were not concerned in the formation of the chorionic villi.

The decidua is uterine mucosa which under the influence of pregnancy has been transformed to fit it for the reception and development of the ovum. It is composed of large branching cells of an epithelioid character, with round vesicular nuclei, containing a rather scanty chromatin network. In the upper portion of the decidua serotina is a thin layer of homogeneous tissue, staining deeply

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with eosin, and containing many vacuolated areas. This, the so-called *layer of canalized fibrin*, results from the degeneration of the trophoblastic cells forming the cell nodes. It was first described by Raissa Nitabuch, who showed distinctly that it marked the boundary between fœtal and maternal tissue; the cells which lie above it, in spite of their resemblance to decidual tissue, are of fœtal origin, and result from the proliferation of the trophoblasts, while those below it are of maternal origin and have developed from the stroma of the uterine mucosa. Interspersed between the latter are giant cells of syncytial origin, which invade the depths of the decidua serotina, and may even extend into the uterine muscle.

The intervillous spaces are lined throughout by syncytium, save where it has undergone degeneration in the decidua serotina and forms part of Nitabuch's fibrin layer. They contain maternal blood, as has been definitely proven by the work of Waldeyer, Farre, Turner, and others. The portion of the intervillous spaces which lies at the periphery of the placenta, between the edge of the decidua serotina and chorion, has been termed the circular sinus. It is not a continuous channel, although the villi here are less abundant than elsewhere. The blood gains access to the cavities by branches of the uterine arteries, which pursue a convoluted course through the decidua serotina, and after their walls have been reduced to a single layer of endothelium, open from the sides of the decidual septa. The blood escapes through widemouth veins upon the decidual surface, and makes its way to the large venous sinuses, underlying the placental site. It would consequently appear that the intervillous circulation is necessarily of a sluggish character, thereby facilitating the interchange of substances with the fœtal blood in the vessels of the chorionic villi.

FIG. 3818.—Section through a Three-Months Placenta, Showing Structure of Chorionic Villi. Magnified 110 times. (From J. Whitridge Williams' "Text-book of Obstetrics," Appleton & Co., New York, 1903.) *S*, Stroma of villus; *Sy*, syncytium; *Z*, Zellschicht; *S.B.*, syncytial bud; *G.C.*, so-called placental giant cells.

The villi are bathed on all sides of their syncytial covering by the maternal blood in the intervillous spaces, and

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contain branches of the umbilical arteries which break up into capillaries in the terminal ramifications. As direct communication between the fœtal and maternal circu-

FIG. 3819.—Cross Section of Seven-Months Placenta Showing Beginning Infarct Formation. (From J. Whitridge Williams.)

lation has been disproven, it is evident that the fœtus is nourished by substances derived from the maternal blood, by osmosis and by the selective power of the syncytium. These must traverse the layers of the chorionic villi which separate the two circulations. In the early and middle months of pregnancy there are four such layers—syncytium, Langhans' cell layer, the connective tissue of the villi, and the endothelium of the villous capillaries. Later, this number is reduced to three by the disappearance of the Langhans layer. These act as a barrier to the passage of formed substances. While the evidence concerning this question has been conflicting, it seems probable, in the light of recent investigations, that bacteria at least are not transmitted from the mother to the child unless the placenta presents definite lesions, which may constitute portals of entry.

The full-term placenta contains many infarcts, which if of moderate size cannot be regarded as a disease, but rather as a sign of senility of the placenta, analogous to the changes which are observed in the villi of the chorion læve at an earlier period of pregnancy. These begin as a rule in an obliterating endarteritis. At the same time changes may be seen in the portion of the villi which corresponds to the position occupied by Langhans' cell layer in the early months. This progresses and the tissue becomes converted by coagulation necrosis into canalized fibrin. If the process continues, numbers of villi become fused together and are eventually converted into a fibroid material, which in its final stages is indistinguishable from fibrin derived from the blood. Such structures are known as white infarcts, and are constantly present in varying size in every normal placenta, as has been shown by Ackermann, Eden, and Williams. The primary change in the production of infarcts occurs most frequently in the villi, although it may be initiated in the so-called decidual septa, which, as we have seen, are prone to degeneration, owing to the absence of blood-vessels. The frequency of infarcts has been emphasized by Williams, who found white surface infarcts of at least 1 cm. diameter in 243 of 500 placentæ, and marginal infarcts which extended throughout at least one-third of the placental periphery in 184 cases of the same series.

Anomalies in Form.—As already indicated, the placenta may present many varieties in size and form. We have seen that it becomes discoid in shape by atrophy of the villi of the chorion læve, and develops from the chorion frondosum, which is attached to the most highly vascularized portions of the decidua. Abnormalities in the blood supply of the decidua cause most of the anomalies of the placenta. If the vascularization, instead of being limited to the single area of the chorion frondosum, develops in several portions of the decidua, certain villi of the chorion læve, corresponding to the seat of vascularization, persist, and the resulting placenta may present one or more lobes, separated from each other by normal membranes. When it is incompletely divided into two lobes and the vessels extend from one to the other to form the umbilical cord, we term it *placenta dimidiata*, or *bipartita*. Ahlfeld noted this condition once in six hundred cases. If it consist of two separate lobes, the vessels of which are perfectly distinct, and do not unite until just before entering the cord, it is known as *placenta duplex*. The insertion of the cord in such cases is generally marginal, and at the periphery between the two lobes. Occasionally the organ may be made up of three distinct lobes—*placenta triplex*, while in very rare instances it may consist of a number of small lobes, Hyrtl having described as many as seven—*placenta septuplex*.

One or more accessory lobules are frequently noted in the membranes at some distance from the periphery of the main placenta. Ordinarily they are united to the latter by vascular connections and constitute the *placenta succenturiata*. When these are lacking and the accessory lobules are functionless, they constitute the *placenta spuria*.

Failure of the chorion læve to atrophy results in the formation of a thin placenta, which covers more or less of the entire inner surface of the uterus with functioning villi. This constitutes the *placenta membranacea*, which is frequently adherent, and may give rise to serious complications in the third stage of labor. Atrophy of the central primary villi of the chorion frondosum gives rise

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to the so-called *placenta fenestrata* in which there is an aperture of varying size in the central portion of the placenta, covered only by normal membranes. Other anomalies may occur, and as reported by Taurin the human placenta may be a broad annular organ which encircles the uterine cavity like those of the carnivorous animals.

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The outlines of the placentas in the case of twins varies accordingly as development occurs from the ova of two Graafian follicles (double-ovum twins), or from one ovum whose nucleus has undergone cell division (single-ovum twins). In the former instance there are two distinct placentas. In the latter, there is but one placenta, with a single chorion which contains two separate amnions, so that each child lies separated from the other by two amniotic walls. This septum may be ruptured by unusual pressure of the amniotic fluid or by excessive fœtal activity and atrophy of the partition may result.

The placenta in utero is generally attached either to the upper portion of the anterior or posterior wall, and extends for some distance upward and upon the fundus. If the insertion be low, it may cover the internal os of the cervix, which condition is known as *placenta prævia* and constitutes a most dangerous complication of pregnancy. Schroeder has drawn attention to the fact that the direction of the round ligaments may indicate whether the placenta is anteriorly or posteriorly placed. If the placenta develops upon the anterior uterine wall, the increased blood supply will cause a more rapid growth in this region and the resulting increased breadth of the uterus will cause the ligaments to run more or less parallel. If the placenta be posteriorly situated the reverse will be true, and the ligaments will be found to diverge in their course downward. The distance between the internal os and the edge of the placenta may be estimated by measuring the length of the membranes of the shed placenta from their point of rupture to the placental margin. As rupture occurs over the internal os, we can by this method frequently reconstruct the position of the placenta in utero, having first determined by palpation of the round ligaments as to whether the placenta was anteriorly or posteriorly placed.

Frank Worthington Lynch.

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PLACENTA, PATHOLOGY OF.—The chief part of the pathology of the placenta has been discussed under the heads of *Chorion, Pathology of the*, and *Decidua, Pathology of the*. This article will treat only of the general pathological conditions of the organ considered as a whole; namely, anomalies of development, size, and location, general disturbances of circulation, inflammation, etc.

Anomalies of Development.—These are of not infrequent occurrence. Instead of the usual round or oval form, the placenta may exhibit the greatest diversity of shape, such as crescentic, horseshoe, elliptical, etc. (*Pl. biloba, triloba, multiloba, reniformis, fenestrata, panduræformis, etc.*). Besides the main organ there may be found completely separated cotyledons appearing as smaller accessory placentas (*Pl. succenturiata*). The smaller accessory placentas owe their origin to a localized failure of placental development in certain areas corresponding to an endometritic thickening of the decidua with fibrin formation, leading to an obliteration of the intervillous sinuses at the point of separation between the main mass and the accessory cotyledons. Following the obliteration of the intervillous spaces the villi of the intervening areas undergo atrophy or fibroid change. Not infrequently the accessory placentas may suffer a similar change from obliteration of the intervillous spaces and appear in the mature placenta as thickened, bloodless areas separated from the main organ (*placenta spuria*). If the placenta becomes divided in similar manner by atrophy or non-development of a portion of the chorion, into two portions of approximately equal size, the phenomenon of an apparently double placenta with one child is presented (*Pl. duplex, dimidiata, bipartita*). Smaller accessory placentas may also be associated with this condition. The cord may be inserted marginally upon one half, or there may be a velamentous insertion between the two halves. It is also possible that a double placenta may be formed by the changes that occur in the placenta following the original implantation of the ovum in one of the uterine horns. Under such conditions the placenta finds proper nourishment for its development upon the anterior and posterior walls of the uterus, but not in the horn itself where the decidua is developed but slightly. As the result of the non-development of the chorion over the poorly developed

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decidua of the horn the portions of placenta developing on the anterior and posterior walls become separated from each other and appear as a double organ. According to some writers a double placenta may be formed through a secondary implantation of a placenta reflexa upon the opposite uterine wall; but by the majority of authorities this is considered doubtful. The peculiarities in development of the placenta mentioned above have been regarded as examples of an atavistic reversion to the placental type of some of the lower animals; but it is very likely that they represent the sequelæ of inflammatory conditions of the endometrium, or are secondary to a localized obliteration of the intervillous spaces and atrophy of the chorion analogous to infarct formation. Such atrophy may be due to the fact that the affected portions of the chorion do not find a favorable location for development. The various anomalies of development may have a practical importance, in that portions of the placenta may be retained after delivery; this is particularly likely to occur in the case of double placenta or when accessory placentas are present.

Placenta marginata. This term is applied to the placenta when the chorion læve is given off, not from the edge of the placenta, but from its surface, so that there is produced beyond the attachment of the fœtal membranes an edge or margin which does not stand in direct connection with the main mass of the chorion. From this margin the membranes are easily stripped; its surface is covered with a thick, firm, yellowish fibrin layer which is elevated 1–2 cm. above the general surface of the chorion. On microscopical examination the fibrin ring or margin is found to consist of atrophic and necrotic villi with obliterated blood spaces. Its structure is therefore the same as that of the placental infarct. If, on the inner side of the fibrin ring, there is developed a ring-formed elevation of the chorion, the variety known as the *placenta circumvallata* is produced. Both of these anomalies develop as the result of an abnormal proliferation of the *reflexa* with a subsequent infarction of the same and of the enclosed villi. In this way there is formed on the surface of the placenta a stiff and inelastic ring of fibrin at a time when the placenta has not yet attained its full size. The fibrin ring hinders the peripheral growth of the villi, but these are able to penetrate the decidua outside of the ring, where they give rise to masses of villi lying outside of the firm attachment of the membranes to the placenta. As the result of the formation of the placenta marginata, portions of the membranes are likely to be retained after delivery; and in those cases in which the condition develops very early the growth of the placenta may be so limited that the fœtus will probably be insufficiently nourished and abortion may occur.

The *placenta membranacea* is a rare form in which the organ is thin and flat, and extends over a large surface, either the whole or a large part of the chorion bearing permanent villi. It has been variously explained, but the most plausible theory is that the persistence of the villi over such a large part of the chorion is due to the fact that the villi penetrating the original serotina did not obtain sufficient nourishment. The *placenta membranacea* may give rise to clinical symptoms of *placenta prævia*, hemorrhages, retention, etc. Separation in the case of this form of placenta is much more serious than that of the normal form of organ.

Abnormalities of Site.—The *placenta prævia* is the most important form of abnormal location of the placenta. The placenta may completely cover the os (placenta prævia centralis), or extend into the lower uterine segment without reaching the inner os (placenta prævia lateralis). The etiology of the condition is obscure; and many theories have been offered in explanation. As a result of previous endometritis the cavity of the uterus may become so enlarged that its walls are no longer in contact with each other; so that when the ovum enters the uterus it drops downward and becomes attached to the lower portion of the uterus. In some cases the placenta prævia may be a normally situated placenta, which is so large that it extends into the lower uterine segment. It is also probable that the placenta prævia may owe its origin to a development of a portion of the chorionic villi in the decidua reflexa, instead of those implanted in the serotina. The clinical importance of placenta prævia lies in the fact that in the later months of pregnancy the enlargement of the lower pole of the uterus gives rise to detachment of the placenta with consequent hemorrhage.

Anomalies in the insertion of the cord are not infrequent; the usual attachment is the centre of the organ; not rarely it is eccentric, or even at the margin (*battledore placenta*). When the cord is inserted into the membranes some distance outside of the placental margin the condition is known as *velamentous insertion*. The vessels bifurcate at the point of insertion, their divisions running between the amnion and chorion to the placenta.

Circulatory Changes.—Œdema of the placenta occurs rarely. It is usually associated with general œdema of the fœtus; more rarely with maternal dropsy. Disturbances of fœtal circulation, thrombosis of umbilical or hypogastric arteries, antenatal closure of the foramen ovale, etc., have been regarded as the exciting causes. The placenta of acardiac monsters is usually œdematous. The number of leucocytes in the blood of the fœtus may show a great increase in these cases. The œdematous placenta is larger and heavier than normal, pale, friable, and soft. Microscopically the villi are found to be greatly enlarged and closely packed together; the intervillous spaces are reduced in size and contain but little blood. The stroma of the villi is separated by fluid, the cells being pushed far apart. The fœtus usually dies in utero as the result of the conditions causing the œdema.

Hemorrhage.—True apoplexies of the placenta are rare. They may occur either in the maternal or in the fœtal portion, and are usually the result of inflammatory changes. In the fœtal portion the mass of blood becomes encapsulated by a dense layer of fibrin. The neighboring villi are compressed and become atrophic or necrotic. The nutrition of the fœtus may be impaired and abortion result. Very rarely the hemorrhage may occur upon the surface beneath the amnion, or the blood may burst through the serotina and escape externally. In such cases the fœtus is usually born dead. In some of the reported cases the hemorrhage was regarded as due to a rupture of a branch of the umbilical vein or artery following thrombosis, twisting, or laceration. The causes of these hemorrhages are unknown and their pathology is doubtful. It is probable that some of the cases described were not true placental apoplexies. The small dark red areas frequently seen throughout the placenta, and regarded by many as interstitial hemorrhages, are not true hemorrhages, but represent local congestions of the intervillous spaces. Inasmuch as the blood is contained within the normal blood spaces the condition cannot be considered to be hemorrhage.

Hemorrhage into or from the placenta as the result of trauma or of attempts at abortion are of frequent occurrence. Hemorrhage from partial separation of the organ occurs in placenta prævia. In inflammatory conditions of the maternal portion of the placenta, degenerative changes in the serotina, etc., partial separations of the fœtal placenta may occur. Such hemorrhages are of frequent occurrence in the acute infections, syphilis, nephritis, Basedow's disease, chronic endometritis of gonorrhœal origin, etc. In all these cases the hemorrhage is from the maternal vessels and not from the fœtal. They represent decidual changes rather than placental. The escaped blood fills up the cavity caused by the separation of the chorion or outer layer of the decidua, or may break through the fœtal membranes or escape externally. The serotina may be completely destroyed and a large cavity formed between the muscle of the uterine wall and the placenta. The chorionic villi and fœtus may be compressed; the latter suffering from disturbances of nutrition may die, or may present abnormalities of development.

Retrograde Changes.—As has been mentioned in the articles treating of the pathology of the chorion and decidua, the retrograde changes which are constantly found

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in the mature placenta must be regarded as the expression of a physiological decay of the organ. The great majority of the older observations on inflammation, fatty degeneration, amyloid change, etc., were most probably nothing more at foundation than the various appearances produced by the physiological processes of infarction found constantly in the ripe placenta.

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Atrophy of the placenta may follow extensive hemorrhages, or inflammation, or atrophy of the decidua.

Necrosis.—Simple necrosis of the chorionic villi occurs in placental infarction. An abnormal degree of this change may be caused by nephritis of the mother, by syphilis, tuberculosis, etc.

Placental Infarction (see *Chorion, Pathology of*).

Fatty Degeneration.—The cases described in the literature by Barnes and others were undoubtedly placental infarcts. Fatty degeneration of the chorionic villi is extremely rare except as a sequela of other changes, retained placenta, placental infarction, etc. A small amount of fat is almost constantly present in the normal ripe placenta, and is to be regarded as physiological.

Calcification within certain limits is almost constantly found in the mature placenta, and is to be regarded as physiological. Only in marked degree is it of pathological significance. In the latter case it follows excessive infarction, fatty degeneration, etc., in nephritis, syphilis, acute infections, etc.

Amyloid has been described as occurring in the placenta; but the appearances taken for amyloid were probably those of infarcted areas.

Myxomatous degeneration of the stroma of the chorionic villi occurs in retained placentas and in hydatid moles.

Pigmentation.—Deposits of blood pigment may be found in both the normal and the diseased placenta, resulting from the disintegration of red blood cells contained in the clots found between the villi. Rarely this pigment may be taken up by the villi and be found deposited in the stroma of the latter.

Hyaline degeneration of the villi occurs to a certain extent in the ripe placenta as an evidence of physiological atrophy. When it occurs prematurely, or to a marked degree, it is to be regarded as of pathological significance. It may follow the changes produced in the villi by the acute infections and certain intoxications, but is most often due to syphilis.

Hypertrophy.—An enlargement of the placenta may be due to œdema or degenerative conditions of the villi. Fibrous hyperplasia occurs in syphilis, nephritis, etc. A true hypertrophy—that is, an enlargement of the organ with preservation of normal structure—is of rare occurrence in association with abnormal development of the fœtus.

Inflammation (see *Chorion, Pathology of*).

Tuberculosis of the placenta has been described but a few times (Lehmann, Schmorl, and Kockel, Auché and Chambrelente, Warthin). It is not improbable that the disease is of more frequent occurrence than the few published reports would indicate. Inasmuch as there are no gross changes in the placenta by which the condition can be recognized without microscopical examination, it is probable that cases escape diagnosis. In all cases of maternal tuberculosis of advanced degree, in miliary tuberculosis, and in all cases of maternal tuberculosis in which the tubercle bacilli gain entrance to the blood, the bacilli will undoubtedly be found in the blood contained within the intervillous spaces. The conditions would therefore favor the development of tubercles in this location. On the other hand, it may be argued that the syncytium and fœtal tissues possess a certain degree of immunity toward the tubercle bacillus. This view is supported by the fact that in placental tuberculosis large masses of fibrin containing great numbers of tubercle bacilli may be found resting upon an apparently normal syncytium; and in a case seen by the writer the syncytium had even grown around and enclosed such a fibrin mass containing tubercle bacilli.

Syphilis may affect either the fœtal or the maternal portion of the placenta. In both cases the changes are those of inflammation and premature degeneration. Gummatous proliferations have been observed in the serotina; but it is not improbable that some of the changes described as such were in reality fibrin masses and not gummata. The most characteristic and constant change in the placenta due to syphilis is that which occurs when the infection takes place at the time of conception or during the early stages of pregnancy. In such cases the chorionic villi not infrequently show a fibroblastic proliferation (interstitial placentitis) of the villus stroma with resulting obliteration of the chorionic vessels. If the fœtus survives, the affected villi undergo a fibroid change. In the great majority of cases, however, the condition results in abortion. Infection during the later months may produce little change in the placenta; or the physiological phenomena of obliteration of the chorionic vessels and infarction may be much more extensive than normally. The interstitial placentitis occurring in the early months of pregnancy is characteristic of syphilitic infection only in the involvement of large areas. A similar change is also found in the neighborhood of placental tubercles.

Gonorrhœal placentitis has been regarded clinically as a cause of abortion. Two cases have been reported in which the gonococcus was found; but neither the bacteriology nor the pathology was established beyond a doubt. The etiological rôle of the gonococcus has, however, been clearly shown in cases of interstitial decidual endometritis.

Placental adhesions with the uterine wall are of much more rare occurrence than is usually believed. In rare cases the serotina may fail of development and the chorionic villi penetrate directly into the uterine wall. In cases of decidual endometritis fibrous connective tissue may develop in the serotina and give rise to firm connections between uterus and placenta. As a result of such adhesions portions of the placenta may be retained, and this may lead to severe hemorrhages or to secondary infection. Putrefactive processes may take place in such retained placental tissue, as well as in that retained after abortion.

Detachments of the margin of the placenta of slight degree are relatively frequent, and possess no significance. Their occurrence is revealed by masses of fibrin or blood clot lying between the decidua vera and the reflexa. More extensive detachments may endanger the life of both mother and fœtus. Such detachments are usually associated with hemorrhage; the blood may collect in the space formed by separation of the placenta from the serotina or burrow between the layers of decidua and escape externally. In rare cases the blood may rupture into the amniotic cavity. Only exceptionally, when the detachment occurs in the central part of the placenta while the edges remain attached, is the hemorrhage unimportant. In such cases death of the fœtus occurs, however, as the result of disturbed nutrition. The detachment of the placenta during birth is of rare occurrence. Such premature loosening of the organ is due to sudden diminution in the volume of the uterus following the loss of large amounts of amniotic fluid. The weight of the placenta causes it to descend into the lower segment of the uterus, where it may present before the fœtus, and may be expelled first. In such cases the child is usually lost.

Changes in the Placenta after Intra-uterine Death of the Fœtus or Abortion.—After death of the fœtus in the early weeks of pregnancy the retained chorion may continue to grow. Hemorrhages occur repeatedly, forming thick layers of blood clot, which gradually loosen the placenta remains. These together with the blood clot are discharged as a *fibrin* or *fleshy mole*. A deposit of calcium salts in the fibrin mass gives rise to a *stone mole*; myxomatous or hydropic degeneration of the stroma of the villi to a *hydatid* or *grape mole* (see *Chorion, Pathology of*). Through continued growth of the villi with successive deposits of fibrin, polypoid tumors (*placental polyps*) may be formed. These may be discharged spontaneously or may become gangrenous or purulent as the result of in-

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fection. A penetration of the uterine wall by proliferating villi gives rise to the condition known as *malignant* or *destructive placental polyp* (see *Syncytioma*).

Placental Cysts.—Cystic formations have been frequently described as occurring in the placenta. The majority of these are probably degeneration cysts, arising either from a myxomatous or hydropic degeneration of the stroma of portions of the chorion, or from the liquefaction of areas of infarction. Less frequently small cysts may arise in the placenta as the result of the liquefaction of small encapsulated hemorrhages. The cysts arising from the degeneration of infarcted areas may reach a very large size, and in rare cases may be mistaken for a second amniotic sac. They are found usually on the fœtal side, beneath the connective tissue of the chorion. Their walls are lined by large epithelioid cells, in part syncytial and in part decidual. Small cysts lined with epithelial cells (so-called dermoids) have been observed in the placenta. These have been interpreted as representing remains of the allantois.

Tumors.—New growths of the placenta belonging to the connective-tissue group are extremely rare. Alin collected twenty-three cases from the literature, and twenty additional cases have been reported up to 1902. The diagnoses given were myxofibroma, fibroma, angioma, fibromyoma, and sarcoma. The majority of these cases are very doubtful. The so-called myxoma fibrosum is the most common form; it is found usually on the fœtal surface, and is rarely embedded in the placental mass, and still more rarely it reaches the maternal side. These growths present a varied appearance, but are usually encapsulated, firm, and homogeneous on section. Microscopically they show an alveolar structure, the tissue resembling that of the umbilical cord, sometimes very rich in cells, at other times containing but few. It is very doubtful indeed if these formations are to be regarded as true neoplasms.

Of much more frequent occurrence are the growths arising from the syncytium, the *benign chorio-epithelioma* or *hydatid mole*, and the malignant chorio-epithelioma (*syncytioma malignum*). (See *Syncytioma*, and *Chorion, Pathology of the*.) Such growths arise from retained chorion after abortion or delivery, usually after the former during the early weeks of pregnancy. From the decidual cells a sarcoma may arise (*sarcoma deciduocellulare*). Confusion, however, exists with regard to this variety; in many cases syncytioma has undoubtedly been regarded as a sarcoma of decidual origin. (See also *Chorion, Pathology of*, and *Decidua, Pathology of*; and *Syncytioma*.) *Aldred Scott Warthin.*

PLACENTA PRÆVIA. CLINICAL.—When the placenta is attached in whole or in part to that portion of the uterus which is dilated during labor for the passage of the child, it is called "prævia."

Dr. Robert Barnes, in a paper read by him in 1892 before the International Congress of Diseases of Women and Obstetrics in Brussels, divided the uterus into three zones—the fundal or superior zone, the equatorial zone, and the inferior zone. The inferior zone is separated from the equatorial by Barnes' boundary line, which has also been called the "internal os of Braune," the "ring of Bandl" and "Schroeder's contraction ring." It is this inferior zone which is dilated during labor for the passage of the child.

Varieties of Placenta Prævia.—Some writers make four divisions of placenta prævia:

1. Lateral, in which the placenta is attached toward the upper part of the inferior zone.

2. Marginal, in which the placental edge comes down to, but does not cover, the internal os.

3. Partial, in which the internal os is partially covered by the edge of the placenta. And

4. Complete, in which the internal os is completely covered by the placenta.

The nomenclature of Schroeder, Bodin, Parvin, and others who make but two divisions is more practical and less confusing. They condense the first three varieties under one head, lateral placenta prævia, which includes all cases not complete. Lateral placenta prævia occurs more frequently than complete, probably in the ratio of two or three to one.

Frequency.—Placenta prævia occurs about once in one thousand cases of labor, though the figures as to its relative frequency are widely divergent. Thus, Winckel gives 1 to 1,500; Kaltenbach, 1 to 1,500 or 1,600; Jewett, 1 to 1,000; while Townsend, at the Boston Lying-In Hospital, found 1 case in 239 labors, and White, at the New York Lying-In Hospital, reports a frequency of 1 to 322. These latter figures, however, are much higher than is usually found, as a great many abnormal cases are referred to lying-in hospitals by midwives and physicians.

Etiology.—The cause of the faulty attachment is still unknown. Predisposing causes are endometritis, relaxation of the uterine walls, anomalies of the uterus, as uterus bicornis and unicornis. Ingleby reported two cases in which there was a low opening of the oviducts. Webster says: "Three different sets of conditions explain the occurrence of placenta prævia: 1. Low implantation of the ovum. 2. Development of chorionic villi on the decidua reflexa, forming a reflexal placenta. 3. Low implantation of the ovum with a reflexal placenta."

Complications.—Faulty presentations are common, owing to the placenta filling the lower zone of the uterus which is usually occupied by the presenting part.

Anomalies of the placenta are frequently found in conjunction with the faulty attachment. It is usually thinner and spread out over a larger area than that occupied by the normally attached placenta; it is apt to be irregular in form, and "placenta succenturiata" is not uncommon. There are frequently abnormal adhesions between the placenta and the uterine wall.

Prognosis.—This is one of the gravest of the complications of pregnancy. The more nearly completely the internal os is covered and the earlier the hemorrhage the greater the danger to both mother and child. The prognosis is affected by the time at which the case is first seen and by the skill of the operator. The figures for maternal mortality range from five or ten per cent. (Winckel) to twenty-three per cent. From fifty to seventy per cent. of the children are lost. Lateral placenta prævia is less dangerous than complete.

Symptoms.—The cardinal symptom of placenta prævia is hemorrhage. This may occur at any time after the formation of the placenta, but is rare before the twenty-eighth week. In the complete variety it occurs earlier and is more profuse than in the lateral. Winckel states that the first hemorrhage in lateral placenta prævia occurs usually after the thirty-second week; in complete, between the twenty-eighth and the thirty-second. Hemorrhage occurring in the latter months of pregnancy without obvious cause is strong presumptive evidence of the presence of a prævial placenta. The diagnosis can be made certain only by feeling the placenta through the os with the examining finger. Before the os is sufficiently dilated to admit the passage of the finger, the failure to find the placenta by abdominal palpation, a faulty presentation of the fœtus, and on vaginal examination inability to recognize the presenting part through the vaginal vault and uterine wall, are suggestive symptoms.

The first hemorrhage, if it occurs before labor, comes on without warning. It may be profuse, or there may be only a slight flow which ceases spontaneously, to recur after a few hours or days. Rarely it is so profuse as to cause death. Sometimes there is constant oozing.

Treatment.—The treatment to be adopted depends on the period of pregnancy at which hemorrhage occurs, the extent of the bleeding, and the ability to control it by simple measures.

When the first hemorrhage occurs before the child is viable, when it is slight and controlled by rest in bed, if there are no contractions of the uterus, we are justified in temporizing, in the hope of getting a living child.

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Such a course being determined upon, the patient should be kept in bed and as quiet as possible until labor comes on spontaneously or is induced with the expectation of delivering a living child. She should be meanwhile on a nutritious and non-stimulating diet, and should be watched with unremitting care for a recurrence of the bleeding.

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Should, now, the hemorrhage be profuse, whether labor be present or not, there is no condition of pregnancy in which danger to life is more imminent or in which judicious interference is more essential. We have before us then the problem of how best (1) to check the hemorrhage, (2) to expedite labor. No single method of treatment can apply to all cases.

Should the hemorrhage occur first after the onset of labor, with lateral implantation of the placenta and a normal presentation, if the os is fully dilated or easily dilatable, simply rupturing the membranes and allowing the presenting part to engage will often stop the hemorrhage. Should this fail to check the bleeding, the head may be brought down with the forceps, or, if the breech present, a foot may be grasped and the os plugged with the thigh and buttocks. Should the presentation be a transverse one, podalic version is indicated.

When, on the other hand, we have a brisk hemorrhage coming on during pregnancy or labor, with a rigid os barely admitting one finger, rupture of the membranes would be a very doubtful procedure. In such a case most obstetricians advise the use of the tampon. To be of use, it must be applied with thoroughness and care, and, needless to say, with all aseptic precautions. The best material with which to tampon is gauze. It may be either sterile or medicated, and should be folded in strips about one inch wide and two or three yards long. A Sims speculum of large size facilitates its introduction. The patient should be placed on her side or in the lithotomy position. The cervix should first be plugged if possible, and then the vagina should be firmly packed throughout, the tighter the better. We accomplish two things by this procedure: check the hemorrhage and stimulate uterine contraction. The tampon may be left in place, provided there is no oozing through or alongside it, until the cervix is fully dilated or is easily dilatable. It should be remembered that the tampon is simply a preparatory measure. Its usefulness ceases with dilatation of the os. Some physicians allow it to remain until it is expelled by the advancing head. It is better not to allow it to remain for a longer time than ten or twelve hours, should no indication arise for its removal sooner. When it is removed, if the cervix is found to be dilated or nearly so, and the presenting part shows a tendency to engage, the membranes should be ruptured and the labor terminated by forceps or version. Should the cervix be partially dilated—two fingers or more—we have to choose between the use of some of the rubber dilators, such as Barnes' bags, the *ballon* of Champetier de Ribes, Braune's colpeurynter, etc., and version, either external, or the combined external and internal or bipolar version of Braxton Hicks.

Of the rubber dilators, the *ballon* of Champetier de Ribes is probably the best. Its conical form and moderate elasticity adapt it thoroughly to the purpose of a uterine dilator, and acting from within it closely simulates the action of the membranes in normal cases. It is urged against it that it sometimes fails to stop hemorrhage, that it adds to the danger of sepsis, and that it displaces the presenting part. It is applicable to the same class of cases as bipolar version, over which it has the advantages that it can be applied without anæsthesia and that it takes less time. But, like the tampon, its use is only a preparatory measure, and its expulsion or extraction must be followed in most cases by the use of the forceps or version.

External version is practicable only before the presenting part sinks into the pelvis and before rupture of the membranes occurs. As soon as it is accomplished the membranes should be ruptured, a foot brought down, and the os plugged with the thigh and buttocks. There is little danger of concealed hemorrhage, as the presenting breech makes firm pressure on the placental site.

The conditions necessary for the performance of bipolar version are: that the liquor amnii should be present, that the cervix should admit two fingers, and that the vagina should admit the rest of the hand if necessary. The operator should use, in the vagina, the hand corresponding to the position, *i.e.*, the left hand in left positions, and the right hand in right. Two fingers are slipped up through the cervix and push the head to that side upon which the dorsal plane lies, while with the other hand the breech is pushed to the opposite side. As soon as the head is pushed up out of the pelvis, the breech is crowded down with the outside hand upon the fingers inside the cervix, and a knee is grasped and brought down. The version is completed by drawing down the leg into the vagina, while the head goes up into the fundus, and the breech engages. The advantages of bipolar version over internal version are that it can be done earlier and that in bipolar version only two fingers enter the uterine cavity, thus causing less shock and less danger of sepsis.

Internal version, or ordinary podalic version, is one of the oldest and, when it is applicable, one of the best of the methods of treating placenta prævia. When there has been little blood lost in the earlier part of labor, when the os is fully dilated or is soft and sufficiently dilated to admit the hand, it is the most practical and direct method of effecting delivery. The hand and arm, during their introduction into the uterus, make pressure upon the bleeding surfaces, and thus check the hemorrhage, while, later on, the same office is performed by the thigh and breech of the child.

Whatever the method of version, after the foot is brought down and the os is plugged by the thigh, the further delivery may be left to the natural forces, provided there is no imperative indication for rapid extraction.

When the hemorrhage continues after the birth of the child, the placenta should be extracted manually at once, and the uterine cavity packed with sterile gauze, if necessary.

There is another class of cases in which the cervix is rigid and undilated, in which the tampon fails to stop the hemorrhage, or in which if the hemorrhage is checked the cervix fails to dilate and recurrence of the hemorrhage is imminent. In such a case, when the surroundings are not prohibitive, Cæsarean section would seem to offer much. With the improved technique of recent years, the mortality after this operation has steadily fallen, and as between it and "accouchement forcé"—by which is meant forcible manual dilatation of a rigid and oftentimes friable os, followed by internal version and delivery—Cæsarean section in competent hands should give a lesser mortality. *Richard Ewell Brown.*

PLAGUE, THE. See *Bubonic Plague*.

PLANTAIN—Codex Med. The flowering plant of *Plantago major* L., *P. media* L., and *P. lanceolata* L., three common European weeds, of which the first and last have made themselves pretty well at home in our fields and door-yards. They are very slightly acrid and bitter, somewhat astringent, and quite mucilaginous; containing a little of some sort of *tannin*, some *resin*, some "*bitter extractive*," and considerable *mucilage*, but no more active substances. They are almost obsolete as medicines, but were formerly esteemed as astringents, hæmostatics, and even antispasmodics, and were used locally in leucorrhœa, hemorrhoids, conjunctivitis, and scrofulous eruptions.

The order *Plantaginaceæ* is a large one of several hundred species, but none having active properties. The seeds of one, *P. Psyllium* L., have an abundant mucilage, like that of flaxseed, and are employed in the arts for sizing cloths, etc., and occasionally in medicine as collyria or demulcent washes. *W. P. Bolles.*

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PLASMA CELLS.—In 1891 Unna described the elements which he called "plasma cells," believing them to correspond with certain granular connective-tissue cells to which Waldeyer had previously given the same name. Later studies indicated that the two were not identical, and Waldeyer advised the restriction of the term "plasma cell" to that of Unna, thinking that the structures named by himself (Waldeyer) corresponded, at least in large part, with the "mast cells" of Ehrlich. Various papers on plasma cells have appeared since Unna's earlier publications, while their nature and properties have been the subject of numerous discussions, often lengthy and occasionally acrimonious. From this it appears that our knowledge of them is still far from definite. There is even some difference of opinion as to what a plasma cell is in fact. It has received its name on account of having *protoplasm* that may be stained by basic aniline dyes. This property is by no means peculiar to it, however, and is shared by several other varieties of cells; for instance, ganglion cells, lymphocytes, osteoblasts, certain giant cells, and mast cells. (In the case of mast cells, large granules contained in the body of the cell are the part stained, and they assume a different shade of color from that of the pure stain itself—metachromism.)

MORPHOLOGY.—With Unna's polychrome methylene blue (described hereafter) the protoplasm of the plasma cells is stained blue-violet, while the nuclei become blue. The outer part of the protoplasm stains more deeply than the inner part, leaving a pale zone around the nucleus. The nucleus is round or oval, and is usually placed eccentrically. Five to eight deeply stained masses of chromatin occur in the nucleus, chiefly around its border. Some observers have described a nucleolus. Two or more nuclei are occasionally present. In size the plasma cells vary from being of the dimensions of a leucocyte to objects of a much larger size—average diameters, 6 to 7 μ by 8 to 10 μ. In shape they are round, oval, roughly cubical, or elongated, according to whether or not they are confined by connective-tissue fibres or by the pressure of other cells. Evidences of both mitotic and amitotic division have been witnessed in plasma cells.

The above account is, in all essential respects, in accord with the views of von Marschalkó, which have been adopted by the majority of workers. It differs somewhat from the one originally given by Unna. According to Unna, the plasma cells have protoplasm that contains numerous granules capable of being stained. Such granules have not been seen by most other observers. It is not uncommon, however, to find plasma cells whose protoplasm is not homogeneous, but which contain small clumps and particles that stain unequally and irregularly. Cells having the metachromatic granules characteristic of mast cells, but otherwise like ordinary plasma cells, have been seen—plasma mast cells. These are unusual. Furthermore, according to Unna, the nuclei of plasma cells give up their stain much more easily than does the protoplasm, and in a preparation properly made the nuclei appear as unstained spots. Some have even maintained that two kinds of plasma cells exist, those of Unna and those of von Marschalkó. However, it is certain that the staining of the nucleus depends much on the technique employed.

OCCURRENCE.—Although they were at first supposed to belong only to pathological conditions, plasma cells have been reported as occurring in lymph nodes, in the lymphoid tissues of the spleen, and in the bone marrow, both in man and in the lower animals, in ligaments, in the framework of mucous glands of the tongue, and in the mucosa of the stomach and intestine in man. Information as to their distribution in normal tissues is not very full or exact.

On the other hand, so much has been written on their occurrence in diseased conditions that a mere enumeration of these conditions is impracticable. Unna's first accounts of plasma cells were based on sections of lupus. He directed attention to tumor-like collections of these cells. Such a collection he called a "plasmoma." It has since been learned that plasma cells are abundant in the lesions of tuberculosis wherever situated, in those of syphilis, leprosy, actinomycosis, and rhinoscleroma—*i.e.*, the so-called "infectious granulomata." They are also frequently seen in the stroma of carcinoma. In the main they are characteristic of rather chronic processes, where they constitute an important part of what is often termed round-cell infiltration. They are said to collect especially around small arteries. Their relations with the epithelioid cells of granulation tissue are in dispute. In acute inflammatory conditions, and especially in acute suppuration, they appear in smaller numbers. Plasma cells have, however, been demonstrated in acute inflammatory lesions, bacterial or otherwise, in keratitis in the rabbit, in recent granulating wounds in man and in the dog, in the lesions of typhoid fever, in the cell infiltration of acute interstitial nephritis, and in the stroma of the lung and even in the exudate late in lobar pneumonia. Further work is needed on their relations to the cells of sarcomata, and it may possibly yield information of use in diagnosis. The study of the plasma cells in diseases of the skin has been carried on by Unna with great energy; the results may be found in his "Histopathology of the Skin."

ORIGIN AND FUNCTIONS.—Unna held that the plasma cells were derived from connective-tissue cells, stating that he was able to detect all the necessary transitional forms between the two. This theory has obtained a few adherents. Most observers, however, believe that plasma cells are derived from the lymphocytes, and chiefly from the small lymphocytes. It is claimed by some, furthermore, that plasma cells may become connective-tissue cells and thus aid in the formation of fibrous tissue. This latter hypothesis would make the production of connective tissue from lymphocytes possible under certain circumstances, the plasma cells being an intermediate stage. It would modify existing ideas considerably and convincing proofs will be demanded before it can be accepted.

Some writers take a middle ground, believing that the plasma cells come in part from lymphocytes and in part from connective-tissue cells.

The functions of plasma cells in other respects are equally uncertain. It is to be noted that they are not distinctive of any particular disease or class of diseases. Their relative absence in acute suppuration is remarkable. According to Councilman and Mallory, they have the power of ameboid movement, they may occur inside the blood-vessels, and may be seen in the act of emigrating from the blood-vessels. It is doubtful if they possess phagocytic properties, and if so these are probably not energetic.

Other ideas that have been proposed as to their functions are purely speculative. It has been suggested that their peculiar staining property is the expression of diminished activity or degenerative changes, that it indicates an increase of activity, that it is due to their having taken up chromatin from other and degenerated cells, that they have some protective function, and that they serve to eliminate some unknown substance.

TECHNIQUE.—Fixation of tissues may be secured with alcohol, corrosive sublimate, Zenker's fluid, formaldehyde, or Müller-formol. Either paraffin or celloidin embedding may be used. Various methods for staining plasma cells have been proposed. Unna's alkaline or polychrome methylene blue gives satisfactory results; thionin or toluidin blue serves equally well. The plasma cells may sometimes be stained with hæmatoxylin. The following formula, which is one of many given by Unna, will be found serviceable: Methylene blue, 1 part; potassium carbonate, 1 part; distilled water, 100 parts. The solution must stand for periods varying from weeks to months before it is fit for use.

Stain in the methylene blue solution, which may or may not be diluted, fifteen minutes or longer. The sections will be overstained.

Rinse in water.

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Decolorize in water to which a few drops of "glycerin-ether" have been added, for a quarter of a minute or several minutes, as required, till differentiation of the structure begins to appear (one-per-cent. acetic acid, or alcohol alone serves nearly as well).

Rinse in water.

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Complete the decolorization with alcohol.

Clear in oil of bergamot or xylol.

By this process the plasma cells are stained blue-violet, their nuclei and other nuclei and bacteria blue, the granules of mast cells violet to red. Epithelial cells take the blue stain, sometimes intensely, especially the horny layers of the epidermis; giant cells are frequently stained as well: also the products of certain degenerations, as amyloid and mucoid, which may show varying degrees of metachromism. *Herbert U. Williams.*

The literature of this subject up to June, 1900, will be found in an article by the present writer in the American Journal of the Medical Sciences of the same date. The most important articles that have since appeared are the following:

Almkvist: Arch. f. Dermatol. and Syph., Bd. lviii., 1901.
Askanazy: Centralbl. f. allg. Path., etc., Bd. xiii., 1902.
Beattie: Journ. Pathol. and Bacteriol., vol. viii., p. 129.
Bosellini: Soc. Med. Chir., Bologna, December, 1901. Abs. Centralbl. f. allg. Path., etc., Bd. xiii., 1902, p. 331.
Enderlen and Justi: Deutsch. Zeitschr. f. Chir., Bd. lxii., 1901.
Friedländer: Arch. f. klin. Chirurg., Bd. lxvii., 1902.
Harris: Journ. Amer. Med. Assn., vol. xxxviii., 1902, p. 634.
Herbert: Journ. Pathol. and Bacteriol., vol. vii., p. 91.
Mallory: Journ. Exper. Med., vol. v., p. 1.
Pappenheim: Virchow's Arch., Bd. clxv., 1901, clxvi., 1901, clxix., 1902.
Schlesinger: Virchow's Arch., Bd. clxix., 1902.

PLASMODIUM MALARIÆ.—The protozoan parasite which Laveran discovered in 1880 was designated by Marchiafava and Celli Plasmodium malariæ. The organism which is classified with the sporozoa has little resemblance to the multinucleated amœboid bodies to which the term plasmodium has been given by zoologists; but even though unsuitable the binomial name, in virtue of its priority, is applicable to the species to which it was originally given. Observations inaugurated by Golgi have shown the existence of three readily distinguishable varieties of parasite, each of which is capable of producing malarial fever. The organism discovered by Laveran and later studied by Marchiafava and Celli is the æstivo-autumnal parasite which causes the most severe type of intermittent fever, characterized by irregular periodicity and occurring most commonly during the late summer and fall. That type of malarial fever which recurs at regular intervals of two days is caused by a closely related parasite which, nevertheless, presents such well-marked peculiarities that it is usually regarded as a distinct species. A third parasite causes the quartan type of malarial fever, distinguished by paroxysms recurring at intervals of three days. If, in accordance with the opinion of a few observers, it should be shown that the three parasites associated with these various types of fever are varieties of a single species, the name Plasmodium malariæ is applicable to this variable organism. In the present article, however, the organisms associated with tertian, quartan, and æstivo-autumnal malaria will be described as separate species.

The parasites of the malarial fevers multiply within the red blood corpuscles of their human host. Recent research has demonstrated that they are capable of development within the body of certain suctorial insects, which have fed upon the blood of an individual suffering with malarial fever. A second individual is infected by the bite of such an insect, which thus acts as an intermediary host.

Geographical Distribution of the Malarial Parasite.—The general and local conditions which favor the occurrence and spread of malaria are such as conduce to the extracorporeal existence of the parasite. The presence of mosquitos capable of transmitting the organism is essential to the endemic occurrence of the disease, so that the geographical distribution of malaria is in great part dependent upon factors which aid the multiplication of certain species of mosquitos.

In Africa, malaria prevails in its most pernicious form on the west coast, especially in the neighborhood of the Congo and Niger rivers. South of the Congo malarial fevers become infrequent and disappear in the most southern part of the continent. Upper Egypt is free from the disease, which occurs with great severity elsewhere upon the Mediterranean coast.

In Asia malaria is prevalent upon the coast of Asia Minor, Arabia, and near the Persian Gulf. Endemic malaria abounds not only in the basins of the Indus and of the Ganges, but upon the tableland of the Deccan. In many of the East India islands severe malaria prevails, but in the Philippine Islands, though the disease is widely distributed, it is not particularly severe. Pernicious malaria occurs in places near the coast and along the rivers of China, but in Japan the disease is mild and infrequent. Of interest is the almost complete immunity enjoyed by Australia, New Zealand, and the islands of the Pacific.

In Europe malaria prevails in the southern part of Russia, particularly upon the shores of the Black and of the Caspian seas, along the shores of the Danube, and upon the peninsulas bordering the Mediterranean Sea. In Italy well-known seats of endemic infection are the plains and marshes of the western coast, including the Roman Campagna and the Pontine marshes. Here the disease is so prevalent that it has been designated Roman fever, and its frequency and severity in Italy have stimulated much of the investigation which, since the discovery of the malarial parasites, has explained the complicated life history of these organisms. Northern Europe, including the British Isles, is in great part free from malaria, though there is evidence that at an earlier period, particularly in England and in Denmark, it has occurred with severity in regions where it is now almost wholly absent.

In the West Indies, along the northern and eastern coasts of tropical South America, and in Central America malaria exists in its worst form. The disease is common in the southern part of the United States near the Gulf of Mexico and along the Mississippi and its tributaries. It occurs near the Atlantic coast with gradually diminished severity as far north as New York. Elsewhere are a few scattered localities where the disease is of mild type.

Malaria is pre-eminently a disease of tropical and subtropical countries, but prevails with diminished severity in many parts of the temperate zone. It is endemic in certain localities, particularly near the mouths and along the banks of rivers. In such localities are found the pernicious types of fever caused by the æstivo-autumnal parasite, while where the disease is less prevalent milder types, the regularly intermittent tertian and quartan fevers, are more common.

Conditions which Favor the Occurrence of Malaria.—The influence of temperature upon the occurrence of the malarial fevers is well illustrated by the preceding account of its distribution. In the endemic foci of the tropical and subtropical countries where malaria occurs in its severest form the disease prevails throughout the year. In the temperate zone as the poles are approached its frequency and severity progressively diminish with the temperature, and, according to Hirsch, malarial fever does not occur in localities where the mean summer temperature is below 15° or 16° C. Even in tropical countries its prevalence increases during the summer and reaches a maximum about the beginning of autumn. In temperate regions the disease may be limited to the warmer months of the year. The incidence of the disease in Baltimore, as described by Thayer, illustrates this condition. During January and February malarial fevers are almost absent, but the gradually increasing number of cases which occur during the spring and early summer are of the milder tertian and quartan type. Double tertian and triple quartan infections occur later in the summer, and the æstivo-autumnal parasite makes its appearance. Cases of æstivo-autumnal infection now increasing in number form a very large proportion of those which occur during September and October, and then,

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gradually diminishing in number, finally disappear completely during the winter.

Conformation of the soil and its saturation with water have an importance little inferior to that of heat in determining the local incidence of malaria. Standing water associated with a warm climate is always suggestive of a malarious region, and the name paludal or marsh fever illustrates the well recognized relationship between the disease and marshy regions. The geological character of the soil does not influence directly the occurrence of malaria, but is of importance only in so far as it determines the saturation of the ground. Hence a clay soil is favorable to the disease, while a more porous, chalky, or sandy soil is less able to retain water; an impervious subsoil is especially capable of fulfilling this condition.

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Since saturation of the soil has such an important influence upon the existence of the disease, the most malarious regions are the low lying coasts and the marshy banks of rivers and lakes. Land which is submerged during a part of the year is believed to be particularly subject to endemic infection. The amount of rainfall has an important influence, and in tropical regions the disease usually reaches a maximum about the end of the rainy season.

Altitude, with its influence upon drainage and upon temperature, affects the local occurrence of malaria so that the severity of the disease tends to diminish as one ascends above the sea level. Nevertheless, severe malaria may be endemic upon high plateaus and even in mountainous regions, but here, according to Hirsch, it is the basin like depressions that are most markedly infected.

Cultivation and drainage of malarial regions have in numberless instances been followed by the disappearance of the disease, but occasionally an opposite result is produced and epidemics of severe malaria have followed the clearing of such lands. Moreover, outbreaks or exacerbations of the disease have followed extensive excavations of soil in making canals, railroads, and fortifications but careful examination of the attendant circumstances have not infrequently shown that such disturbances have in various ways interfered with surface drainage.

Recent observations having shown that the malarial parasites pass a part of their life within the body of the mosquito, it has become obvious that the previously described conditions under which the disease occurs are such as favor the multiplication of these insects. Since the development of the larval mosquito occurs in stagnant water, poorly drained lowlands and marshes afford most suitable conditions, and heat and abundant atmospheric moisture are favoring circumstances. No malarious region has been found to be free from these insects, but on the other hand it is not surprising that malaria does not always occur where mosquitos abound, for in the first place, as will be pointed out later, only mosquitos of the genus Anopheles have been found to transmit the disease; and in the second place, the malarial parasite may not have found its way into a locality where mosquitos of this genus prevail. A correspondence exists between the habits of the mosquito and the seasonal incidence of the disease in temperate climates. With the beginning of winter many mosquitos are killed while a few hibernate. In the spring those that survive lay their eggs upon stagnant ponds and continue to multiply during the warm season. Marchiafava and Bignami state that during the fall mosquitos, many of which are infected, seek shelter within the houses, thus explaining the frequency of infection at this time and the occasional occurrence of house epidemics.

Even should mosquitos of the genus Anopheles and malarial parasites coexist in the same locality, external conditions will determine the prevalence of the disease. Investigations of the Italian observers have shown that the parasites within the mosquito develop best at a temperature between 20° and 30° C., but at 14° to 15° C. development does not occur. This fact accords with the observation previously mentioned, that malarial fever does not occur as one passes from the equator beyond an isotherm at which the mean summer temperature is below 15° to 16° C. (59° to 60.8° Fahr.).

Method by which the Malarial Parasite Enters the Body.—Before the discovery of the malarial parasite, two theories explaining the mode of malarial infection were much discussed. It was believed that the contagium causing the disease entered by one of two possible paths; either (1) by the digestive tract, being ingested with water, in which the infectious agent was thought to have its natural habitat; or (2) by the respiratory tract, being breathed in with the air.

Clinical evidence has been adduced to show that the disease is a water-borne infection. Supporters of this theory cited instances in which, of two neighboring communities, each using a different water supply, one was subject to malarial fever while the other escaped. It was believed that boiling of drinking-water was an efficient prophylactic measure. Such claims are found to have been based upon insufficient evidence, and in individual instances the difficulties of diagnosis between typhoid and malarial fevers were not clearly recognized. In recent years Italian observers have attempted to infect individuals with drinking-water obtained from localities well known to be malarious. Celli failed to infect individuals in Rome by the repeated administration of water brought from the Pontine marshes, and Zeri obtained similar results in a considerable number of experiments in which water from malarious regions was administered in large quantity to healthy subjects.

Certain clinical facts favor the alternate theory of air infection; for example, the well-known danger of infection after exposure to the night air in a malarious district may be cited. The contagium was believed to have its home in the water and in the soil of marshy malarious districts, whence it found its way into the air and was inspired by those exposed. Since the discovery of the malarial parasites numerous efforts to discover some phase of these micro organisms in water or in the soil have proved futile, while the hypothetical means by which such bodies might reach the overlying air was difficult to conceive. Moreover, certain well-known facts are incompatible with this theory; for example, prevailing winds have little influence upon the spread of infection from an endemic focus, and the fact is frequently cited that upon vessels anchored off a malarial coast only those individuals become infected whose duties carry them ashore. This theory of air infection, unsupported by any convincing evidence, is now abandoned since accumulating evidence has demonstrated that the malarial parasite is transferred from one individual to another by a suctorial insect, within which the micro-organism passes one stage in its life history.

Manson, in 1878, showed that Filaria bancrofti is carried from one human host to a second by the mosquito; Theobald Smith has shown that Texas fever of cattle is inoculated by a species of tic. These important discoveries have pointed the way to a clear recognition of the method by which the malarial parasites enter the human body and have helped to explain its life history outside. The solution of these difficult problems has received much aid from the studies of parasites which, occurring within the red blood corpuscles of birds, are so closely related to the malarial parasites that by some observers they have been regarded, doubtless erroneously, as identical species.

The possibility that malaria might be transmitted by the mosquito had been suggested long before the malarial parasites were discovered and the fact had been recognized that localities and conditions favorable to the disease are such as further the multiplication of this insect. Manson, in 1896, brought this theory into prominence. Bignami subsequently published a considerable amount of evidence to show that malarial infection occurs under conditions which favor the attack of mosquitos. When the wind blows on the Roman Campagna, he says, mosquitos hide close to the ground or beneath the trees and are transported little if at all from the locality in which

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their larvæ develop. When the wind goes down at sunset, the insects rise in great numbers and attack men and beasts. The well-recognized danger of infection during the night is due to the nocturnal habits of the mosquito and is increased by sleeping in the open air. Many of the precautions which are taken by the inhabitants of malarious districts to ward off the fever are such as protect them from the attacks of insects. On the Pontine marshes relative protection is afforded by elevating dwellings on platforms six or eight feet high, for the insect tends to fly close to the ground.

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Ross, working in India, has shown that the parasite of birds which is closely related to the malarial organism undergoes a series of developmental changes within the body of the mosquito, and subsequently found that mosquitos which had bitten infected birds were capable of transmitting the parasite to others which repeated examination had proved to be healthy.

Grassi, in 1898, undertook a laborious investigation of the species of mosquitos found in malarious regions of Italy, and came to the conclusion that certain species are constantly present in districts of endemic infection. Where malaria prevails Anopheles claviger and other species of the genus Anopheles are abundant, while in non-malarial regions, though species of the genus Culex abound, he found the genus Anopheles unrepresented.

Direct proof of the agency of suctorial insects was finally brought by experiments of other Italian observers. Bignami brought to Rome mosquitos belonging to the genera Culex and Anopheles, obtained from a marshy region characterized by the severity of its malarial fever. An individual who had never suffered with malaria slept in the room in which these insects were liberated, and was exposed to their attack during more than a month. At the end of this time he became ill, suffered with chills and fever, and in his blood was found the parasite of æstivo-autumnal fever. In three subsequent experiments performed upon individuals who had never suffered with malaria, fever caused by the tertian or æstivo-autumnal parasite was produced by the sting of Anopheles claviger obtained from malarious districts. In every case recovery followed the administration of quinine.

In one of these experiments, insects, obtained, to be sure, from a malarious region, were allowed to sting a patient suffering with æstivo-autumnal fever. Subsequent examination of some of these mosquitos showed those developmental phases of the parasite which will be described later. Three such mosquitos, of which two were later found to be infected, were allowed to sting a healthy man. After an incubation period of from nine to twelve days, uncertainty being due to repeated exposure, fever of an irregular type ensued and the æstivo-autumnal parasite was demonstrated in the blood of the infected individual. It has been urged that these experiments were conducted in Rome, where malarial fevers are not uncommon. In order to meet this objection, Bignami sent to England where malaria rarely occurs, mosquitos infected with the parasite of tertian fever. P. Manson, Jr., who exposed himself to the sting of these insects, suffered a mild attack of tertian fever.

Demonstration that the parasites of malarial fever and the related organisms of birds undergo a peculiar process of development within the body of the mosquito, amplifies and confirms the experimental results just cited.

Parasites of the Malarial Fevers.—The micro-organisms which cause malarial fevers belong to the group of sporozoa known as Hæmosporidia. Recent observers have shown that they undergo two cycles of development: (1) One occurs within the human body where the organism, developing within the red blood corpuscles and multiplying by an asexual process, causes malarial fever; (2) parasites ingested by the mosquito when it attacks an individual suffering with the disease undergo a second cycle of development in the body of the insect. This second stage in the life history of the organism is preceded by a process of fertilization which occurs in the stomach of the insect and terminates by division of the parasite into a great number of reproductive bodies.

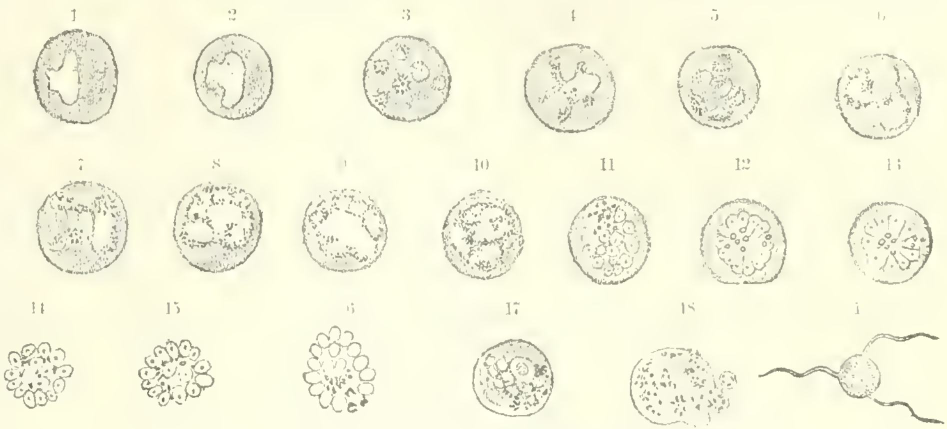

FIG. 3820.—Parasite of Tertian Fever. (After Marchiafava and Bignami.)

Golgi showed that the parasite which causes regularly intermittent fever of the quartan type differs morphologically from that associated with tertian fever. Both the tertian and the quartan organism within the human body develops in great groups, all members of which are at any given time in the same phase of development. The parasite of quartan fever completes its cycle in seventy-two hours, while the parasite of tertian fever repeats its cycle every forty-eight hours. It was subsequently shown that the organism present in those severer forms of malarial fever which prevail in the late summer and in the autumn months have distinctive peculiarities. In harmony with the irregularly intermittent course of the fever the parasite does not present the regular periodicity which characterizes the development of the other two varieties. Some observers have claimed that even among the parasites producing the irregular or æstivo-autumnal type of fever two varieties may be distinguished, but the distinctions which they emphasize are not sufficiently marked to establish the existence of more than one æstivo-autumnal parasite. Most observers recognize the existence of three distinct species of parasite; not only are differences observable within the human body, but during their development within the mosquito as well, morphological characteristics serve to identify the three varieties.

For the purpose of clinical diagnosis the malarial parasite is best observed in thin films of freshly drawn blood. Much attention has been given to the study of the parasite fixed and stained by a variety of methods, in great part modifications of that used by Romanowsky, who employed a mixture of eosin and methylene blue. The body of the organism stains blue, while its chromatin substance takes a lilac color. Wright has recently so modified this method that it may be used for the purpose of clinical diagnosis.

The Parasite of Tertian Fever.—The earliest phase of

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the parasite, Fig. 3820 (1 and 2), found within the red blood cell is represented by a minute clear body, often circular in outline, with a diameter about one-fourth that of the corpuscle. Active amœboid movements are readily observed, and the processes which are protruded often give the body a very irregular outline. The hyaline organism may temporarily assume the appearance of a ring. This phenomenon is apparently due to the fact that the centre of the disc-shaped body, becoming for a time thinner than the periphery, is lost to view.

As the organism becomes larger one or more particles of yellowish-brown pigment formed from the hæmoglobin of the containing corpuscle appear within its substance, Fig. 3820 (3 to 10). These granules, which have an active dancing movement, increase in number and size as the organism grows. At the end of twenty-four hours the parasite fills from one-third to one-half the red corpuscle, the latter showing certain changes as the result of its presence, being larger and paler than the neighboring unaffected corpuscles. The young forms exhibit active amœboid movements, which with further growth become less conspicuous. At the end of about forty-eight hours the organism has reached its full size, about that of a normal red corpuscle, and is ready to undergo the process of segmentation. The parasite, Fig. 3820 (12 and 13), having assumed a circular outline, the pigment granules collect into a clump, often a solid block, which usually lies in the centre of the body. The organism acquires a dense opaque appearance not observable in the amœboid stage. Refractive dots may be seen near the periphery, occasionally in the more central portion, and radial striations extending inward from corresponding indentations at the margin appear between the refractive points. The striations represent lines of separation which divide the body into segments corresponding in number with the refractive dots; very frequently there is formed a peripheral circle of segments, within which, nearer to the central pigment, is a second group. These bodies, numbering twelve to twenty or even thirty, assume a circular outline, the aggregation being still surrounded by a pale, very inconspicuous yellowish rim, the remains of the much-enlarged and decolorized corpuscle, Fig. 3820 (11). Finally, this ruptures and sets the bodies free in the plasma, Fig. 3820 (14 to 16).

As previously mentioned, all the members of a group segment at approximately the same time. During a period of about three hours before the chill, the temperature rises gradually and segmenting bodies can be found in the blood. During the chill and with the beginning of the hot stage, they are present in greatest number. It seems probable that a toxic material is set free when the parasite segments and that this toxin causes a febrile reaction. Occasionally two groups of parasites are present in the same blood and double tertian fever results. The two groups undergo segmentation on alternate days, and at any given time parasites in two phases of development are discoverable in the blood.

In addition to the full-grown parasites which undergo segmentation are even larger bodies situated within enlarged pale corpuscles. Since they do not divide to form reproductive segments, they were at one time regarded, in part at least, as degenerate forms. Some of them exhibit the remarkable phenomenon known as flagellation, Fig. 3820 (19), and their significance will be subsequently explained in describing this process.

FIG. 3821.—Parasite of Quartan Fever. (After Marchiafava and Bignami.)

Certain details of internal structure not observable in the living organism may be studied in stained specimens. In preparations treated with eosin and methylene blue according to the method of Romanowsky, the existence of nuclear material may be demonstrated. In such specimens young hyaline forms exhibit an external zone of blue color, the central part remaining unstained. Situated near the periphery of the body, at times encroaching upon the unstained area, more rarely wholly surrounded by it, is a compact round or oval body which takes a deep lilac stain. As the parasite grows the chromatin becomes less compact and, according to Ziemann, takes on the appearance of a collection of fine filaments. When the organism has attained its full growth, this mass of material divides to form a variable number of irregular chromatin bodies, and when division is complete each mass assumes a round compact outline and is surrounded by an achromatic zone. Changes now take place in the cell protoplasm and result in the separation of the body into a corresponding number of segments.

The Parasite of Quartan Fever.—The quartan, like the tertian parasite, pursuing its development in great groups, all members of which are in the same phase at any given time, repeats its cycle in seventy-two hours. As with the tertian organism, the malarial paroxysm is simultaneous with the process of segmentation, and, when the result of an infection with a single group, occurs every fourth day. When more than one group are present, they reach maturity on different days, the members of two groups never undergoing segmentation on the same day. When the blood is infected with three groups paroxysms occur daily.

The quartan parasite resembles closely the organism of tertian fever; nevertheless, certain differential peculiarities can be noted. The amœboid hyaline bodies Fig. 3821 (1 and 2) are indistinguishable from those of the tertian parasite, but with increase of size and the acquisition of pigment Fig. 3821 (3 to 9) the characteristic features become evident. The pigment of the quartan organism occurs in coarser granules having a deeper brown color. The body of the parasite has a more refractive appearance and its outline within the corpuscle is much more distinct; the amœboid movements are much less active, and as early as the second day they almost or completely cease. The changes produced in the containing red corpuscle differ from those caused by the tertian organism; the corpuscle is not swollen and decolorized, but becomes somewhat shrivelled and assumes a deeper color of a greenish copper-like hue. As the parasite increases in size the surrounding rim of the corpuscle becomes smaller, and at the beginning of segmentation, about ten hours before the paroxysm, though present, it is almost imperceptible. The pigment Fig. 3821 (10) collects toward the centre of the body, and in doing so usually assumes a radial arrangement not seen in the tertian organism. The segments are fewer in number, often not more than from six to ten, and are arranged regularly in a single row about the central pigment mass. In stained specimens the details of structure previously described for the tertian parasite are observed and the same division of the chromatin substance is found to precede segmentation.

The Parasite of Æstivo-autumnal Fever.—The severer forms of malarial infection, including those presenting pernicious symptoms, are caused by an organism which differs in several important particulars from those pre-

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viously described. Since, as already mentioned, its development, unlike that of the tertian and quartan parasites, does not take place in great groups, of which the members mature at approximately the same time, its cycle cannot be followed with the same readiness. And in accordance with this irregularity of development the symptoms of the disease do not present the same periodically paroxysmal character observed in the other two types. Moreover, the parasite of the irregular fever does not undergo its whole development within the circulating blood, and all stages of growth cannot be observed in specimens obtained in the ordinary way. In the blood from the peripheral circulation only the youngest forms are found, the subsequent development taking place in the internal organs. The more mature organisms tend to accumulate in the spleen and bone marrow, possibly because, as suggested by Bastianelli and Bignami, the red corpuscles being profoundly injured by the contained parasite act as foreign bodies and are taken up by the cells of these organs. The absence of definite groups and the difficulty of following in the peripheral circulation the process of maturation through all its stages have made it impossible to determine as yet the duration of the cycle of development. Certain observers believe that it lasts two or three days, or even longer.

The youngest intracorpuscular form of the parasite, Fig. 3822 (1 to 7), is represented by an amœboid organism resembling the hyaline bodies of tertian and quartan fever; it is, however, somewhat smaller and has a greater tendency to assume a ring-like form. Such a parasite may be seen to assume alternately a ring shape and an amœboid form. With further growth pigment granules are acquired, and occasionally one sees in the blood from the peripheral circulation a small body, one-fifth the diameter of the red corpuscle, containing one or two minute granules of dark brown pigment. Larger pigmented forms are only very rarely found in the peripheral circulation, so that the later stages have been studied mainly in specimens of blood aspirated from the spleen. As the parasite grows the pigment increases in amount, but does not become so abundant as in the tertian and quartan organisms. Indeed, Marchiafava and Celli have described instances in which the parasite attained its full growth and underwent segmentation without any formation of pigment. The invaded corpuscle takes on a greenish brassy color, and wrinkling and crenation may be observed in corpuscles containing even the smallest hyaline bodies. The full-grown forms, Fig. 3822 (17 to 19), vary considerably in size, often exceeding in diameter one-half that of the containing red cell. The pigment collects into a clump, Fig. 3822 (Fig. 21 to 23), and is finally caked into a solid block, usually situated near the centre of the body. The organism acquires a refractive waxy appearance and divides, in a manner similar to that exhibited by the tertian organism, into from eight to sixteen segments, Fig. 3822 (24), which are finally set free in the plasma by the rupture of the containing rim of the corpuscle. In stained specimens the existence of chromatin resembling that of a tertian parasite can be demonstrated; it undergoes the same division and arrangement previous to segmentation.

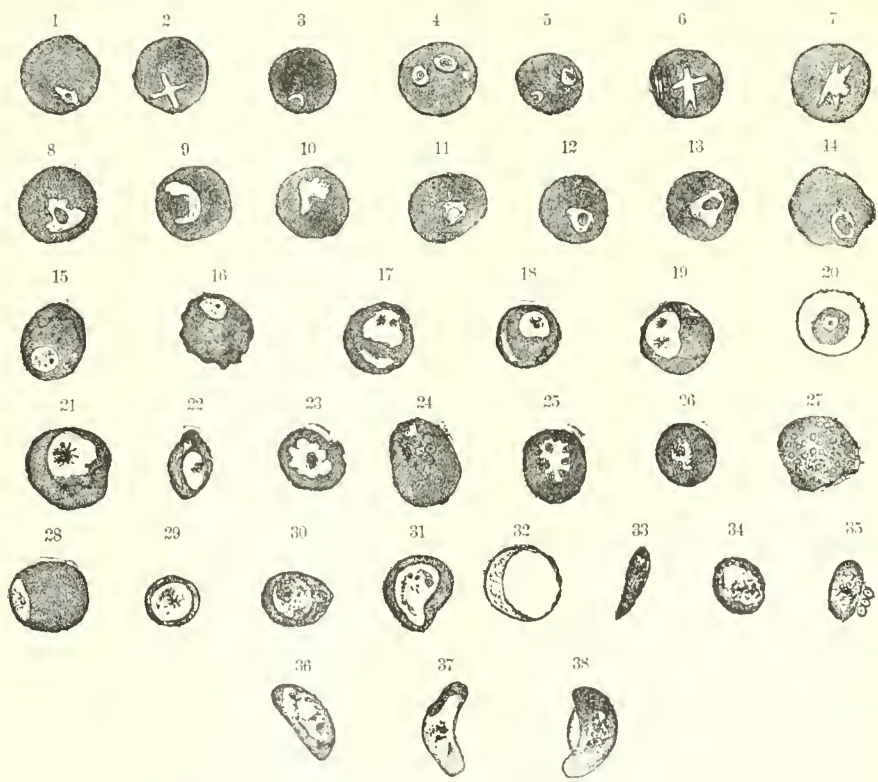

FIG. 3822.—Parasite of Æstivo-Autumnal Fever. (After Marchiafava and Bignami.)

In the blood of patients suffering with æstivo-autumnal malaria are found bodies not present with the regularly intermittent types—the crescents and ovoid bodies described by Laveran. The crescentic bodies, Fig. 3822 (36 to 38), present in the blood after the fever has lasted a week or more are longer than the red blood corpuscles, somewhat more than half their diameter across, and with very refractive protoplasm. A pale yellow rim projecting in bib-like form (38) from the concave side of the crescent surrounds the organism; this represents the remains of the corpuscle in which the body developed. Pigment, usually present in considerable quantity, is either distributed throughout or collected into a mass situated near the centre. The ovoid bodies, Fig. 3822 (34 and 35), differ from the crescents only in shape. Early stages, Fig. 3822 (28), in the formation of these bodies are found, and they represent transitions from the youngest forms of the ordinary cycle. Becoming fusiform, they develop in the red cells, and, as they exceed in length the diameter of the corpuscle, become bowed in order to accommodate themselves to its shape. Their significance has been much disputed, but, now understood, will be explained in describing the process of flagellation.

Flagellation.—The very remarkable phenomenon of flagellation is observable in freshly drawn blood. With tertian infection, within a week after onset of the disease, large spherical bodies, which do not segment, are present in the blood. The periphery of such a body in a specimen of fresh blood now unsurrounded by a rim of corpuscle is seen to undergo violent undulation, when suddenly there appear one or more thread-like filaments which lash about so actively that their outline is distin-

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guished with difficulty. Fig. 3820 (19). A flagellum with a club-like enlargement at one end not infrequently separates from the parent body and floats away in the plasma with an active undulatory motion. It has been shown that the flagella contain part of the chromatin substance. All the extracellular bodies observable in freshly drawn blood do not undergo [illegible]

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With the quartan infection a similar process is observable. Flagellate bodies, however are encountered with much less frequency than in cases of tertian fever.

In cases of æstivo-autumnal fever it is the crescents

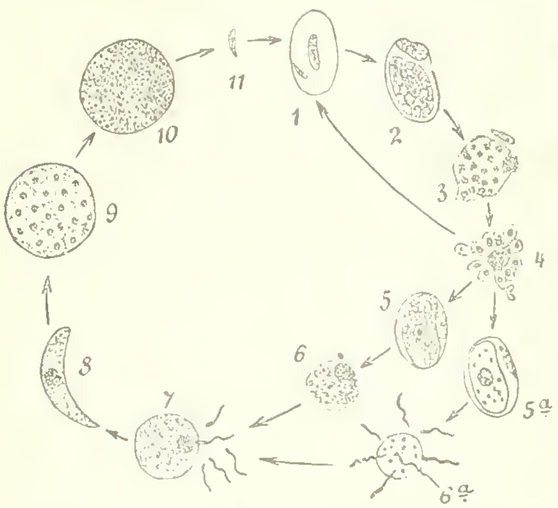

FIG. 3823. Diagram Showing the Life History of the Avian Parasite, Proteosoma. 1 to 4, Development of the parasite within the blood of the bird; 4, merozoites; 5 and 6, macrogamete; 5a and 6a, microgametocyte; 7, fertilization; 8 to 10, formation and maturation of oöcysts; 11, sporozoite. (After Grassi from Lühe, *Cent. f. Bakt.*, 1904, xxxvii.)

which undergo flagellation. In a specimen of fresh blood some of these bodies remain unchanged or merely assume a round or oval form; but others, after becoming spherical, extrude actively motile filaments which may become detached from the parent body.

The significance of this phenomenon has been explained by the study of a closely related parasite, Halteridium danilewsky, which occurs in the blood of many birds. This organism, which develops within the red blood corpuscles as a semilunar or halter shaped body curved alongside the nucleus of the containing corpuscle, like the malarial parasites forms pigment granules from the hæmoglobin. Opie showed that the parasite may assume two distinct forms, either of which when fully grown becomes free in the plasma after the blood is drawn. With one form the protoplasm is granular and stains deep blue by the method of Romanowsky; the nucleus is small. The other form, somewhat larger than the first, is characterized by the possession of a very large nucleus and scant protoplasm which stains with difficulty. The supposition that this form alone undergoes flagellation has been confirmed by MacCallum, who has demonstrated the occurrence of a remarkable phenomenon. Flagella break from the parent body and make their way to the granular bodies which have become extracellular. Several flagella may collect about such a body and beat against it with active lashing movements. One flagellum finally projects itself into the substance of the body, with which it becomes merged. The process is to be regarded as one of fertilization; the granular body with small nucleus is the female element, or, according to zoological nomenclature, the macrogamete, the flagellum is the male element, or microgamete, its parent body being designated by the term microgametocyte. The fertilized body remains quiescent for from fifteen to twenty minutes, when it assumes an elongated form and becomes capable of very active progressive movement, constituting the pseudo-vermiculus described by Danilewsky.

Flagella-formation observable with the three varieties of malarial parasite doubtless represents a similar process of fertilization, though only in the case of the æstivo-autumnal parasite has the phenomenon been actually observed. With both the tertian and the æstivo-autumnal forms morphological differences have been established between the microgametocyte from which arise flagella or microgametes and the macrogamete which undergoes fertilization. With the æstivo-autumnal parasite those crescents which do not flagellate, like the analogous macrogamete of the halteridium, stain more deeply and are granular. The formation of a body similar to the pseudo-vermiculus of birds has not been observed.

Life History of the Malarial Parasites in the Body of the Mosquito.—Study of the parasites in birds has here again pointed the way to an understanding of the life history of the malarial organisms outside the human body. Ross, working in India, directed his attention to the extracorporeal development of the avian parasite, Proteosoma grassi, because at the time cases of malarial fever were not available. Observations of Manson upon the development of filaria in the body of the mosquito suggested the agency of these insects. Ross proved that the mosquito can act as an intermediary host in transferring infection from one bird to another, and showed that the parasite develops within the body of the insect. The process of flagellation occurs with much activity in the middle intestine of an insect which has fed upon the blood of an infected bird. The flagellum or macrogamete unites with the microgamete, and the so-called pseudo-vermiculus which results, endowed with active motility, makes its way into the wall of the mosquito's intestine, where it becomes encapsulated and divides into a great number of minute bodies designated sporozoites. The latter, after rupture of the containing capsule, finally reach the salivary glands of the insect and hence may be injected into a second bird, there to undergo asexual multiplication.

In mosquitos which had fed upon the blood of individuals infected with tertian and æstivo-autumnal malaria, Ross found pigmented bodies similar to those which he had discovered in mosquitos. Bignami, Bastianelli, and Grassi have extended these observations and have shown that the tertian, quartan, and æstivo-autumnal parasites pass through similar changes within the body of mosquitos of the genus Anopheles.

An insect of this genus confined in glass test tubes is allowed to feed upon the blood of patients infected with malarial fever. The mosquito is so voracious that it stings when the mouth of the tube is applied to the skin of the patient. It is then kept confined in a larger vessel at a temperature of 20°–30° C., and is supplied with abundant moisture and vegetable matter for food. The parasite in the insect is studied after varying periods, in the intestinal wall and in the salivary glands, prepared by delicate teasing and examined in salt solution. Sections of the insect hardened and stained for microscopic examination give additional information.

With the tertian parasite fertilization of a macrogamete by a flagellum (microgamete) doubtless occurs, though the process has not been actually observed. During the second day after the insect has fed on malarial blood pigmented bodies can be found in the muscular walls of the intestine. Grown to twice the size of a red blood corpuscle, they are sharply outlined and possess homogeneous or vacuolated protoplasm. In stained specimens the chromatin substance is found to have increased in amount and may have undergone division into several small masses. Increasing in size, the parasite acquires a refractive capsule, and on the third day its contents have divided into a varying number of small bodies, each containing a part of the chromatin substance; between these lie the pigment and a small amount of undivided cytoplasm. This cyst-like body

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increases in size and within it is formed an increasing number of small bodies. Finally, on the sixth day, the parasite, which has grown to such size that it projects into the body cavity of the insect (compare Fig. 3825 showing Proteosoma of birds), contains a great number of slender bodies www.libtool.com.cn sporozoites, Fig. 3825 (*C*) each containing a particle of nuclear substance demonstrable only in stained specimens; they are arranged in groups side by side. The containing capsule ruptures and the sporozoites are set free in the body cavity, whence they make their way to the salivary glands of the insect. Should a mosquito so infected sting a human being, parasites are injected with the irritant fluid secreted by the gland. Developing within the red blood corpuscles, the organism now begins in its new human host the asexual cycle of development with which is associated tertian malarial fever.

A few observations have shown that the quartan parasite passes through a series of phases corresponding to those just described, but when mosquitos are allowed to sting patients suffering with quartan fever, in only a small proportion of the experiments are developmental stages of the parasite obtained. The small number of flagellate forms observable in the blood of patients suffering with quartan infection may explain this fact as well as the relative infrequency of this type of malarial fever.

The development of the æstivo-autumnal parasite in the mosquito may be readily observed. On the seventh day after the mosquito has stung a patient infected with the disease, cyst-like bodies project into the body cavity of the insect and are filled with sporozoites, which, though more numerous, resemble those of the tertian parasite. Even before sporozoites are formed, the æstivo-autumnal parasite is recognizable by the character of its pigment and by the high refraction of its cytoplasm.

Terms in general use by zoologists have been introduced to designate various phases of the asexual generation of the malarial parasite in man and of its sexual generation in the intermediate host, the mosquito. Some of these have been mentioned. The microgamete or flagellum, derived from the microgametocyte or flagellate body, unites with the more granular macrogamete, and as the result an oöcyst is formed within the stomach wall of the mosquito. Division of cytoplasm preceded by nuclear division gives rise to a great number of nucleated bodies known as sporozoites. The latter, injected by the mosquito, are capable of transmitting malarial infection, since they are capable of development within the red blood corpuscles of their human host. Reaching a certain size, the intracorpuscular parasites divide without preceding fertilization into a variable number of bodies, which may be termed merozoites, each capable of re-entering a red blood corpuscle and undergoing the same process of multiplication. A certain number of merozoites, however, are not destined to multiply by such asexual division, but give rise to macrogamete or microgametocyte as already described. By union of the male and female elements within the stomach of the mosquito is formed a body which is capable of development in the intermediary host. An analogous alternation of asexual and sexual generation occurs with other protozoan micro-organisms, notably those belonging to the order Coccidia. Asexual reproduction is the means by which a few parasites which have gained entrance multiply in the new host. In the case of the malarial parasite, relatively few organisms injected by the mosquito multiply to form the great number characteristic of the malarial fevers.

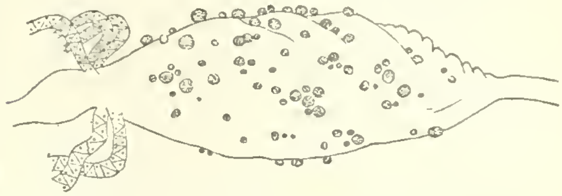
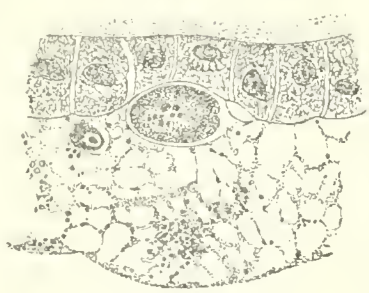


FIG. 3825.—Oöcysts of Proteosoma in the Wall of the Middle Intestine of the Mosquito. (After Ross from Lühe.)

Eugene L. Opie.



A.

B.

C.

FIG. 3824.—*A*, Parasite of Æstivo-autumnal Fever in the Wall of the Middle Intestine of Anopheles; *B*, formation of sporozoites within the oöcyst; *C*, ripe sporozoites. (After Grassi from Lühe.)

PLASMOLYSIS is the term used in a general sense to denote the disorganization of the achromatic part of the cell, in opposition to *karyolysis*, which is applied to the complete disorganization of the nucleus. *Achromatolysis* is, accordingly, used as a synonym for plasmolysis. The word plasmolysis, having been introduced by a number of investigators working along special lines, is frequently used in a more narrow sense to indicate the destruction or degeneration of the protoplasm of certain forms of cells. Thus, for example, plasmolysis is by a large number of writers applied only to such changes in the red blood cells, and is used interchangeably with *erythrocytolysis*. In this condition the soluble substances of the red cell escape into the plasma so that the red cells become smaller (microcytes) or come to consist only of the outer envelope (red cell shadows). Through the imbibition of fluids such cells may become swollen. Grawitz uses the term to indicate solution of the red blood cells and the production of hæmoglobinæmia. In the case of nerve cells, plasmolysis is applied to the simplest disorganizing changes in the achromatic part of the cell. In the case of bacteria, plasmolysis is used to indicate the formation of clear spaces beneath the capsule, due to the shrinking of the plasma, as may be observed in bacteria held in a salt solution. *Aldred Scott Warthin.*

PLASMORRHEXIS is the term applied to processes of disorganization in the protoplasm of the cell, in opposition to *karyorrhexis*, which is used to denote similar processes in the nucleus. By the majority of writers plasmorrhexis is applied to these changes as occurring in the red blood cells alone, and the word is used as a synonym for *erythrocytorrhexis*. The process is characterized by the formation of small granules or globules in the protoplasm of the red cell, and the escape of these from the cell; or the formation of minute prickles or globules over the surface of the cell, giving it an appearance of a gooseberry or mulberry; or the formation of variously shaped

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processes. Plasmorrhexis may be regarded as the stage immediately preceding plasmoschisis.

Aldred Scott Warthin.

PLASMOSCHISIS.—The partial or total disorganization of the cell through fragmentation or splitting of its protoplasm. It is characterized by the snaring off of the processes developed through plasmorrhexis, and the formation of round, oval, disc-like, angular, or thready bodies, which may be homogeneous or granular; or by the separation of the protoplasm from the nucleus. The term is used, particularly with reference to the disintegration of the red blood cells, as a synonym for *erythrocytoschisis*. It is believed by many investigators that the blood plates are nothing more than specially formed products of the plasmorrhexis and plasmoschisis of the red blood cells.

Aldred Scott Warthin.

PLASTIC SURGERY. See *Reparative Surgery*.

PLETHORA. See *Circulation, Pathology of*.

PLEURISY.—The pleura may be the seat of various forms of inflammation, some of which are only a part of a general inflammation involving the tissue of the lung, as in pneumonia, tuberculosis of the lung, and emphysema of the lungs, and some of which involve the pleura without disease of the lung.

A pleurisy may be primary, or it may be secondary to disease of the lung, or to some general disease, as chronic nephritis or rheumatism.

The different forms of pleurisy may be conveniently classified as follows:

1. Pleurisy with the production of fibrin, or acute pleurisy, or dry pleurisy.
2. Pleurisy with the production of fibrin and serum, or sero-fibrinous pleurisy, or pleurisy with effusion, or subacute pleurisy.
3. Pleurisy with an excessive production of fibrin.
4. Pleurisy with the production of fibrin, serum, and pus, or empyema, or suppurative pleurisy.
5. Chronic pleurisy with adhesions.
6. Tuberculous pleurisy.
7. Cancerous pleurisy.
8. Traumatic pleurisy.

Etiology.—Pleurisy occurs at all ages and in both sexes. Pleurisy may be *primary* or *secondary*, but there is at the present time considerable difference in opinion as to the relative frequency of true primary pleurisy, as well as to the frequency of tuberculous infection as the essential factor in the production of so-called primary pleurisies. Thus Strümpell states that we know positively of but two forms which may be regarded as primary, viz., the traumatic and the rheumatic; while others regard exposure to cold and wet and individual predisposition as frequent exciting causes. Of late years, under the lead of the French and German writers, the tendency of a large number of the profession has been to regard the majority, if not all, of acute and subacute pleurisies as tuberculous. There seems, however, good reason to reject so sweeping an assumption. That the tubercle bacillus is a frequent cause of pleurisy is, of course, well known, but many cases of pleurisy with effusion have been observed in which no tubercle bacilli have been found in the exudate, and in which tuberculosis has not subsequently developed. Moreover, an exactly similar pleurisy with effusion has been produced experimentally in the lower animals by chemical agents, as is shown by Delafield. By injecting a saturated solution of chloride of zinc with a hypodermic syringe into the pleural cavity of the dog he was enabled to excite a pleurisy exactly resembling that which is seen in the human subject. By varying the amount of fluid injected he was able to obtain pleurisies of different degrees of intensity, and with different amounts of products of inflammation.

Pleurisy may be secondary to changes in the lungs, notably tuberculosis of the lungs and lobar pneumonia, or to the infectious diseases, especially la grippe, to rheumatism, to peritonitis, to abscess of the liver, to carcinoma of the stomach, liver, or chest wall, or to nephritis.

Bacteriology.—Cultivations from the exudate give in the larger proportion of cases negative results, but, as stated by Netter, we may recognize three groups of acute or subacute pleurisy, caused by the tubercle bacillus, the pneumococcus, and the streptococcus respectively.

The tubercle bacillus is very difficult to find in the exudate. It has been demonstrated that a large amount of the exudate must be taken to make the test complete, either in cultures or in the inoculation of animals.

The pneumococcus pleurisy is almost always secondary to a focus of inflammation in the lung. It may, however, be primary. The exudate is usually purulent, but the prognosis of this form is very favorable. The streptococcus pleurisy is the typical septic form which may occur either from direct infection of the pleura through the lung in bronchopneumonia or in cases of streptococcus pneumonia; in other instances it follows infection of more distant parts. This is the most serious and fatal of all forms. The exudate is usually purulent.

These, then, are the important groups, but other bacteria have been found, as the staphylococcus, the typhoid bacillus, the bacillus coli communis, the gonococcus, the pneumobacillus of Friedländer, and the influenza bacillus.

Pleurisy with the Production of Fibrin (Dry Pleurisy).—*Morbid Anatomy.*—The inflammation may begin on the pulmonary, costal, or diaphragmatic pleura according to the cause which produces it. That beginning in the pulmonary pleura is always secondary to changes in the lungs. That which begins in the costal pleura is often independent of any inflammation of the lung. Usually only a circumscribed portion of the pulmonary, costal, mediastinal, or diaphragmatic pleura is involved, but the entire pleura of one side of the chest may be inflamed. The inflammation always extends to the portion of the pleura opposite to it. The inflamed pleura is coated with a more or less thick layer of fibrin, and bands of fibrin extend between the opposite pleural surfaces. As most persons recover from dry pleurisy, but little is known of its bacteriology.

This form of pleurisy is regularly seen with lobar pneumonia, less frequently with bronchopneumonia. It is very frequently associated with tuberculosis of the lungs, and may be the first or only sign of such tuberculosis. It is frequently found in connection with la grippe, and it may develop at any time in the course of this disease. It may develop simply from exposure to cold.

Symptoms.—The rational symptoms are usually few and not well marked. There may be more or less pain over the affected side, a slight dry cough, a little fever, and some malaise. Often these symptoms are absent. Though the pain is usually referred to the seat of inflammation, it must be remembered that this pain may be referred to a distant point, and thus the error may be made of regarding the case as one of lumbago or of appendicitis, of renal colic, or, in cases of diaphragmatic pleurisy, of peritonitis.

The physical signs are characteristic. Over the inflamed area are heard crepitant or subcrepitant râles. With these there may be a little dulness on percussion and some little diminution in the intensity of the breathing, but the essential sign is the presence of fine pleuritic râles. These râles may be scanty or very abundant. Sometimes they may be so faint as to be heard with the greatest difficulty. They are usually brought out best by causing the patient to cough. It must be remembered that these râles—contrary to the usual impression—are not necessarily constant; they may come and go in the same manner as a bronchial râle. If the pleurisy be diaphragmatic or mediastinal, no râles may be heard.

With acute or subacute miliary tuberculosis of the lung a dry pleurisy may either mark the invasion of the tuberculous inflammation of the lungs or it may be repeated from time to time as the tuberculosis goes on. Recent

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pleuritic râles, pain in the chest, and a rise of temperature regularly accompany these attacks.

So well is it recognized that fine pleuritic râles may be the only symptom of a beginning tuberculosis that such evidence of localized dry pleurisy, especially if primarily at the apex of the lung and attended with afternoon fever, is always a source of great anxiety to the physician, unless he can be sure that he has to do with an acute pleurisy due to other cause than tuberculosis, as, for example, one occurring in the course of an attack of influenza. In primary dry pleurisies involving the costal pleura there is a great variation in the extent of pleura involved. The inflammation may involve only a small area of the pleura; there are râles heard over a circumscribed area only, the patient has but little fever, and the pleurisy runs its course in a week. In other cases the pleuritic râles are heard all over the front or back of the chest, the pain is quite severe, there is considerable fever, and the patient may be confined to bed or to the house for two weeks.

The *prognosis* is good. Most cases end in recovery after a short time, but the patient is often left with permanent thickenings and adhesions of the pleura. Such adhesions may give no further trouble, or they may form the starting-point for a chronic pleurisy with adhesions, or the process may go further and cause chronic interstitial pneumonia and chronic bronchitis.

Rarely, dry pleurisy is succeeded after several days by a pleurisy with effusion.

In a moderate number of cases one or more attacks of dry pleurisy are followed by pulmonary tuberculosis.

Treatment.—Many of the milder cases are never seen by the physician and need no treatment, although it would seem wise to keep them in the house till the pleuritic râles have disappeared. The more severe cases should stay in the house or go to bed till the attack has run its course. There is no especial drug treatment. The pain in the chest may be relieved by poultices, strapping the chest, opium, phenacetin, or the like. Most physicians either paint the affected chest with iodine or employ wet or dry cups, but it is doubtful if anything is gained by these counter-irritants.

PLEURISY WITH THE PRODUCTION OF FIBRIN AND SERUM (PLEURISY WITH EFFUSION).—This is a much more serious form of pleurisy, and is the type which is most commonly seen by the general practitioner, since many persons with acute dry pleurisy never consult a physician.

Morbid Anatomy.—The essential lesion is the inflammation of the greater part of the costal and pulmonary pleuræ on one side, and the accumulation of a considerable or large amount of serous fluid in the pleural cavity. Sometimes, however, the extent of the inflamed pleura is small, and the serum is shut in by adhesions (sacculated pleurisy).

Rarely, the pleuræ of both sides of the chest are inflamed, and when this is the case there is apt to be *pericarditis* also.

The surface of the inflamed pleura is coated with fibrin, and bands of fibrin join together its opposed surfaces. In the pleural cavity is found clear or turbid serum of a straw or amber color, containing a few leucocytes. Red blood cells are so rarely found that a bloody effusion is usually regarded as a sign of a tuberculous or a cancerous pleurisy. The blood, however, may be due to an injury. There are, moreover, a few cases which do not differ from ordinary cases except that the fluid is bloody. Thus bloody fluid may be found in pleurisy in connection with cirrhosis of the liver and with infectious diseases. The quantity of fluid varies from a few ounces to a quantity sufficient completely to fill and distend the pleural cavity. The fluid is, of course, found in the most dependent part of the pleural cavity, unless shut in by adhesions, in which case it may be found anywhere, but most commonly at the base of the lung and in the neighborhood of the axillary region. If the effusion be of any considerable quantity the lung is compressed upward and backward against the vertebræ, the degree of compression of the lung depending upon the amount of fluid. In extreme and long-continued cases the lung is almost unaërated. If the amount of fluid be great the adjacent viscera may be displaced. After the inflammation has subsided the serum and fibrin are absorbed and the pleura is left thickened by connective tissue and with connective-tissue bands between the two layers. The compressed lung expands again either completely or partially; if the latter, more or less retraction of the affected side of the chest is left.

The causes of pleurisy with effusion have been already stated.

The behavior of the acute cases is such as to make it probable that infection by the pneumococcus is the cause of the inflammation; and this belief has been confirmed in a considerable number of cases, but, as before stated, in a large number of cases the fluid is found to be sterile.

The *diagnosis* is made by the symptoms and physical signs.

The essential symptoms are *pain* in the chest, *cough* with little or no expectoration, *dyspnœa*, and *fever*.

The essential physical signs are *absent*, or greatly diminished, *vocal fremitus*, *flatness* on percussion, *feeble* or *absent breathing*, *feeble* or *absent voice*.

With this combination of symptoms and physical signs the diagnosis is one of the simplest problems in medicine, but there are so many variations from these conditions of the problem that a more extensive discussion of the subject is advisable.

First, as regards the symptoms and course of the disease. We may conveniently divide the symptoms of pleurisy with effusion into three groups:

1. Pleurisy with an acute invasion.
2. Pleurisy with an insidious invasion.
3. Pleurisy with a subacute invasion.

In the first group the symptoms may very closely resemble the invasion of lobar pneumonia.

In the second group the pleurisy may be entirely overlooked by the unwary, and "malaria" or some equally indefinite diagnosis may be made.

In the third group the conditions are more regular and the diagnosis more simple.

First Group.—In pleurisy with an acute invasion the patient is suddenly taken ill with the symptoms of an acute infection. Sometimes there is an initial chill, as in pneumonia; more often there are chilly feelings, and then the patient is taken with a sudden pain in the chest, with a high fever, 103°–104° F., a dry cough and immediate prostration. The pulse is full, 100–120, and the face is flushed. In a few hours dyspnœa appears, and this may increase so greatly that the patient cannot lie down in bed. The breathing is from 28 to 35. The pain is apt to be very great and referred to the affected side, but it may be also felt throughout the muscles of the body. The pain, on the other hand, may be very slight over the inflamed pleura, but is referred to the opposite side of the chest, or to the abdomen. In the latter case, if it be on the right side, the rigidity of the abdominal muscles and the situation of the pain may lead to the erroneous diagnosis of appendicitis, an error which of course would be corrected by a proper physical examination of the chest. As the fluid accumulates in the pleural cavity this pain becomes much less.

While the constitutional symptoms are going on the fluid accumulates rapidly, and within two days it may fill the pleural cavity; but the quantity of fluid varies greatly in different cases.

The patient continues to have a high temperature and all the appearances of a severe illness for about two weeks; then the temperature subsides, leaving only a moderate afternoon fever, which continues as long as the fluid remains in the chest. These cases make us think of an infection of the pleura by the pneumococcus.

The prognosis is usually good, but sometimes death occurs, and some of these patients die suddenly.

In the *second group*, that of insidious invasion, we have a picture which is just the opposite. The disease begins so gradually that the patient hardly knows when

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he began to be ill. He has a little fever, he feels weak, has but little appetite, and he may feel short of breath on exertion, but the dyspnœa is not urgent. He may have no cough and no pain in the side, and he may go about his business for weeks suffering from fever and loss of flesh before the disease is recognized. For example, a gentleman coming from the South told me that he had suffered for three months from "malaria and an enlarged spleen." His dyspnœa was obvious to me at once, but he had hardly noticed it. His left chest was completely filled with fluid. The term "silent pleurisy" has been applied to this group of cases, and they are not infrequently tuberculous in their origin.

The duration depends entirely upon the length of time the fluid is left in the chest. If the fluid is removed recovery, as a rule, ensues at once—but tuberculosis of the lungs sometimes follows later; the interval may be weeks or months or years.

The *third group* is perhaps the most common. The invasion is of moderate severity; the temperature is about 101° F. in the morning and not usually above 103° F. in the afternoon; the respiration is about 30 and the pulse about 100; pain in the side, dry cough, and dyspnœa are prominent symptoms. The patients usually feel ill enough to go to bed, though they do not always do so. The fluid accumulates in the chest fairly quickly at first; then it continues to increase slowly, and if treatment is not instituted it will go on slowly increasing for several weeks.

The prognosis is good; these patients rarely die, and they usually make a perfect recovery.

The duration depends upon the treatment. Twenty years ago, when I was a hospital interne, the regular treatment was rest in bed, blisters to the chest and diuretics, and the regular duration was six weeks in bed and two months in hospital. Now the duration is often not more than two or three days in bed, and perhaps two weeks in hospital.

After recovery from this pleurisy changes in the chest may be left behind, which changes are in proportion to the quantity of fluid and the length of time it remains in the pleural cavity. The expansion of the lung may be complete, and no evidence of the former pleurisy remains. More often bands of connective-tissue adhesions are left between the opposing surfaces of the pleura, and the expansion of the lung is not complete. As a result there remains more or less retraction of the affected side of the chest, and the adhesions of the pleura may cause pain in the chest for several months; or, less frequently, these adhesions may be the starting-point of a chronic pleurisy with adhesions, of an interstitial pneumonia, or of a chronic bronchitis.

The *physical signs* of pleurisy with effusion depend largely upon the amount of the effusion and upon its situation. The rule is that we find the fluid in the lower part of the pleural cavity, and the lung more or less compressed upward and backward against the vertebral column. It is customary to describe the physical signs as in three groups, those above the level of the fluid, at the level of the fluid, and below the level of the fluid, but for the purposes of this article it will be sufficient to give the physical signs found above the level of the fluid and below the level of the fluid, as these are sufficient for all practical purposes.

Inspection may or may not show a fulness of the chest upon the affected side, and there is usually limitation of motion on the affected side. In children there may be bulging of the intercostal spaces below the level of the fluid. If the effusion be large there may be displacement of the heart or of the liver, but this displacement is not seen in cases of moderate effusion. There may be evident dyspnœa, and the patient usually lies upon the affected side.

The vocal fremitus is usually absent below the level of the fluid, but it may be only diminished even in large effusions.

Percussion, above the level of the fluid, may give exaggerated resonance, or skodaic resonance, or normal resonance. The percussion note over the opposite chest may be exaggerated or tympanitic. Below the level of the fluid the percussion note is usually absolutely flat, and this flatness together with the feeling of marked resistance to the finger used as a pleximeter is so constant a sign of fluid in the pleural cavity as to suggest at once the diagnosis without further physical signs, though it is not, of course, pathognomonic. In many cases, however, we do not get absolutely flatness, but only more or less marked dulness, even when the amount of fluid is considerable; this is notably the case in children. If the amount of fluid be small we get dulness on percussion of varying degrees of intensity.

Upon *auscultation* of the breathing, *above* the level of the fluid, the breathing is usually normal; it may be of a blowing character (cavernous or broncho-cavernous), or it may be feeble; *below* the level of the fluid it is generally stated that the breathing is *absent*, but this has not seemed to be the case to me. I should prefer to say that below the level of the fluid the breathing is quite feeble in most cases; exceptionally it is absent. There is another and most important exception to the character of the breathing heard all the way down the chest, below the level of the fluid, viz., distinctly *bronchial breathing*. This characteristic of the breathing in many cases of pleural effusion is now quite generally recognized, but it is necessary to emphasize it on account of the danger of mistaking this breathing for that of consolidation of the lung. It is usually noted in cases of large pleural effusion; but this condition is by no means essential.

If the effusion be slight, the breathing is only slightly diminished in intensity or is normal.

The *voice* above the level of the fluid is usually normal; it may be exaggerated or it may be slightly diminished in intensity. Below the level of the fluid the voice is very greatly diminished or absent. If there be bronchial breathing there is usually bronchial voice also, and this bronchial voice often seems distant from the ear. If the effusion be moderate in amount, there may be only slightly diminished voice or there may be ægophony.

Râles may be heard over the affected side if one see the case before the effusion of serum has taken place. After the two layers of the pleura are separated by the effusion it is only rarely that one hears râles below the level of the fluid. The important exception must, however, be noted that fine râles may be heard below the level of the fluid. This is not the place to speculate as to the explanation of this phenomenon, but it must be borne in mind that râles may be heard below the level of the fluid, or else the error of excluding pleurisy with effusion will inevitably be made.

Râles may, of course, be heard above the level of the fluid if there be fibrin on the pleura, or bands of adhesions at that point.

If the fluid be shut in by adhesions (sacculated), we get irregular physical signs, dulness or flatness, changes in the breathing and voice, and râles, corresponding to the situation of the fluid and the compression of the lung. In many cases there may be doubt as to the presence of fluid in the pleural cavity, and this applies to fluid free in the pleural cavity as well as to sacculated pleurisy. Here the diagnosis may be made by the introduction of an exploring needle attached to a hypodermic syringe. This little procedure is attended with such slight risk to the patient that its use is to be recommended in all cases of uncertainty of diagnosis. It must be remembered that a "dry tap" does not exclude the presence of fluid, which may be shut into numerous compartments by adhesions, and therefore introductions of the needle at several different points may be required before the fluid is found. Cases of sudden death *have* followed exploratory puncture, but fortunately these cases are rare.

As recovery takes place and the fluid is absorbed, the breathing and voice can be heard more and more distinctly, and lower and lower down, until recovery is complete. The flatness changes slowly into marked dulness, and this dulness persists for some time after all the fluid is removed. When there is doubt as to the exact height

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of the fluid which remains, the point at which the voice becomes distinctly muffled is the most reliable test.

The *treatment* of pleurisy with effusion is a matter of great importance both as regards the duration of the illness and as affecting the future of the patient. Personally I believe that there should be but one recognized form of treatment, and that is the mechanical removal of the fluid by aspiration of the chest, and that the sooner the fluid is removed the shorter the duration of the disease and the less the risk of the formation of permanent pleuritic adhesions. Aspiration, which was first advocated by Bowditch and Wyman many years ago, is now extensively adopted by physicians, but many still adhere to the practice of depending upon the lymphatics for the removal of the exudate, and wait two or more weeks before resorting to aspiration. There are many who seek to restrain the exudation by the use of the dry diet, and who give sodium chloride in considerable doses. If the effusion be at all considerable it has been an almost universal custom to administer diuretics, even though aspiration were resorted to quite early. After aspiration the use of diuretics is really unnecessary, and its use before aspiration is of doubtful value.

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The method I would advocate is that in the cases with high temperature and other symptoms of acute and severe invasion the patient be put to bed and on a fluid diet. His restlessness should be quieted by the use of some of the coal-tar antipyretics; and if the pain in the chest be severe, relief may be obtained by the application of poultices to the chest, or by the administration of morphine. After two or three days of this treatment, if the fluid has accumulated it should be removed at once by aspiration. The temperature usually falls on the day following aspiration, and the acute symptoms subside also, and in a few days the patient feels well enough to sit up. In the cases of insidious and of subacute invasion the removal of the fluid seems to be all the treatment necessary. The patient may be put on a normal diet at once, and may be gotten out of bed as soon as the fluid is removed. Before aspiration the skin of the chest should be disinfected, just as for a major surgical operation, and the aspirating needle and the operator's hands also rendered aseptic. With these precautions purulent infection of the pleura does not ensue.

The amount of fluid removed at one sitting varies. If the amount be not very great, it may be all removed at once; but if the chest be entirely filled, it is not safe to remove it all till the following day. In ordinary cases it is a good rule to remove all one can get, but to stop if the patient feels faint or if he begins to cough. If a little fluid be left it will usually take care of itself. In cases in which the fluid re-accumulates two or more aspirations may be required to effect a cure. The subacute cases in which removal of the fluid is not attended by a fall of temperature are apt to prove to be tuberculous. Sudden death has followed aspiration of the chest, but this is a very rare accident. It must be also borne in mind that when a chest is completely filled with fluid sudden death may occur if aspiration is delayed, and that it is imperative to remove a portion of the fluid as soon as possible.

The *differential diagnosis* of pleurisy with effusion must be made from empyema, pneumonia, pleurisy with excessive production of fibrin, pericarditis, abscess of the liver, or other enlargements of the liver, and new growths of the pleura. Of course the question of the fluid in the pleura being an hydrothorax, or of the pleurisy being a part of a tuberculous process in the lung, or of a lobar pneumonia, must also be considered. A due consideration of the associated symptoms will usually lead to a correct diagnosis, but where there is doubt the introduction of the exploring needle is the most important aid to diagnosis. It must also be remembered that the leucocytosis in all cases of inflammation of the pleura, except empyema, is usually moderate in amount, about ten to fourteen thousand per cubic millimetre, but the leucocytosis may be low in pneumonia or high in a pleurisy, so that the blood count is not a certain means of differentiation between these two diseases. Where there is the slightest element of doubt the importance of the introduction of the exploring needle cannot be too forcibly emphasized. Frequently pus will be found by the exploring needle when the physical signs would suggest consolidated lung or only a thickened pleura.

Among the infants which we see at Bellevue Hospital, many of whom are half starved or badly nourished, it is not so uncommon to find pus in the pleural cavity when the only reason for the introduction of the needle is a febrile condition and a little dulness over one chest.

Pleurisy with an Excessive Production of Fibrin is a much more uncommon condition. We find the pleura on one side, both costal and pulmonary, greatly thickened by a deposit of fibrin, which may be even an inch or more in thickness; there may be a little fluid in the pleural cavity or there may be none.

This pleurisy may be seen in connection with an acute articular rheumatism, or with tuberculosis of the lung, or with epidemic influenza, or without known cause.

The *symptoms* are very similar to those of pleurisy with effusion with acute invasion, or to those of lobar pneumonia.

The physical signs are usually diminished or absent vocal fremitus, flatness on percussion, distant bronchial breathing, distant bronchial voice, or, more commonly, ægophony, and abundant fine and coarse pleuritic râles. The physical signs may resemble those of a pneumonia or of pleurisy with effusion.

Exploration of the chest shows that little or no fluid is present, and the absence of the rusty sputum, of the high leucocytosis, and of the flushed cheeks, which are so characteristic of pneumonia, may point to the correct diagnosis.

Unless the inflammation is tuberculous the prognosis is good.

The *treatment* is symptomatic only.

Empyema.—The inflammation usually involves the whole of the pleura on one side of the chest; occasionally it involves a circumscribed portion of the pleura only.

When we examine the pleura we find two different conditions:

(1) We see that it is coated with fibrin and pus, and that the pleural cavity contains purulent serum. This form is most common in children.

(2) In other cases we find the conditions as above, and in addition the pleura itself is much changed. It is split up by a great number of new cells, so that it resembles granulation tissue. In old cases the pleura becomes much thickened and may be infiltrated with the salts of lime.

As in pleurisy with effusion the fluid usually accumulates in the lower part of the pleural cavity, or it may be sacculated in any part of the pleural cavity; or it may be sacculated between the lobes (interlobular empyema), and this is said to occur most commonly between the middle and the upper lobe of the right lung. The suppurative process may extend from the pulmonary pleura to the lung, and the pus will then escape at intervals from the bronchi, or the pus may escape through the chest wall, or the pus may travel down and simulate a psoas abscess. In a few cases the inflammatory products and the superficial layers of the pleura become gangrenous. The purulent fluid is either thin and consists of a considerable number of pus cells in an ordinary sero-fibrinous effusion, or it is thicker and contains a large number of pus cells, or it is a thick and creamy fluid, nearly all pus cells. This latter is usually pneumococcus empyema.

The micro-organisms found are either streptococci or pneumococci in the great majority of cases. In 109 cases of empyema examined by Netter, he found the streptococcus alone in 48 cases, the pneumococcus alone in 29 cases, the pneumococcus with streptococcus in 3 cases. Staphylococci were found in 2 cases. Of 12 tuberculous cases the tubercle bacillus was found in 6.

Of 15 cases of fœtid effusion saprophytic organisms were found in all.

Netter points out the much greater benignity of the

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pneumococcus, and explains by this fact the more frequent recovery of children; for of 28 cases in children the pneumococcus was present alone or with the other two cocci in 15—a ratio of 53 per cent., which is exactly that of the streptococcus in adults.

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The micro-organisms of infrequent occurrence are the typhoid bacillus, the colon bacillus, the gonococcus, and the influenza bacillus.

The inflammation may be primary or secondary. If primary it may follow exposure to cold or to heat, or be without discoverable cause, or it may be only a part of a general streptococcus or pneumococcus poisoning.

It may be secondary to an abscess in the wall of the thorax, in the liver, in the abdominal cavity, or in the lung, any of which may rupture into the pleural cavity.

Empyema not uncommonly follows a lobar pneumonia or a grippe pneumonia. It may follow a simple pleurisy with effusion, but it is a question if this does not depend upon the imperfect precautions taken in aspiration. In the primary cases the rational symptoms are the same as those of the first group of pleurisy with effusion, only they are much more severe. The temperature is higher and may be of the pus type; there are chills and sweating and marked prostration. The symptoms may continue acutely and the patient die in a short time, or they may subside and the inflammation pass into a chronic course. When empyema follows a pneumonia it regularly develops as the pneumonia is subsiding, or a few days after defervescence. The temperature rises again and the patient feels ill again. In the secondary cases the larger number pursue a subacute course, with afternoon exacerbations of fever, dyspnœa, cough, and gradual loss of flesh and strength.

Recovery with absorption or with perforation is very rare. But in some patients there is a partial recovery, most of the pus is absorbed, but there is set up an interstitial pneumonia, with more or less bronchitis, which goes on indefinitely.

The physical signs are essentially the same as those of pleurisy with effusion, and subject to the same modifications, the only exception being that sacculation and irregular and indefinite physical signs are more common in empyema. In many cases the diagnosis can be made only by the exploring needle.

The diseases from which differential diagnosis must be made are pleurisy with effusion, pneumonia, abscess of the liver, subphrenic abscess, tuberculosis of the lungs, and malignant endocarditis; the last two being thought of only where the physical signs in the lungs are unsatisfactory.

The duration of empyema, when no operation is performed, may be from a few days to many years, the patients in the latter case finally dying, emaciated and with waxy degeneration of liver, spleen, and kidneys.

The *prognosis* without operation is bad; with a proper surgical operation it is very good. Recovery is almost the rule.

Treatment.—The essential point in the treatment is to remember that we have to do with an abscess, and that we must follow the ordinary surgical rule, viz., to open the abscess and evacuate the pus. This should be done just as soon as the presence of the pus is shown by the exploring needle, and nothing but the removal of the pus should be thought of. No matter how weak the patient may be he will gain by the evacuation of the pus.

The method of procedure varies according as we have to do with children or with adults.

In children aspiration should first be resorted to, and in a majority of cases this will effect a cure. If the temperature does not fall, and the pus reaccumulates, then the chest may be opened and a drainage tube inserted.

In adults it is a waste of time to aspirate. The chest wall should be opened at once, under the strictest antiseptic precautions, and a drainage tube inserted.

There is some difference of opinion as to whether it is better to incise an intercostal space or to remove a portion of one or more ribs. Personally, I prefer to remove a large piece of one rib, as the indications are twofold: to make an opening large enough to permit of the insertion of the hand and the breaking up of pleuritic adhesions, so as to permit of thorough drainage, and to favor the closure of the abscess cavity by the collapse of the chest wall. It is not necessary to wash out the pleural cavity unless the contents be fœtid. A good-sized drainage tube is inserted, absorbent dressings are applied, and the whole chest is wrapped in bandages. The wound is dressed only when the discharge comes through the dressing. The patient is gotten out of bed as soon as possible, and at the end of a month, at the latest, the drainage tube should be removed. The principal danger after operation is that of reinfection of the pleura, and the success of the operation depends upon the antiseptic precautions taken during the operation and in the subsequent dressings.

If one can be sure that there is only a small sacculated collection of pus, as may be the case in an empyema following pneumonia, aspiration is all that is necessary to effect a cure.

Chronic Pleurisy with Adhesions is a condition which is of interest chiefly because of its resemblance to chronic miliary tuberculosis of the lungs, and of the importance of discriminating between the two diseases.

By chronic pleurisy with adhesions we mean a chronic productive inflammation of the pleura, and *not* the old adhesions which are found at so many autopsies.

It is an inflammation which is chronic from the beginning and results in the production of new connective tissue only. We find thickenings of the pleura and adhesions between the costal and pulmonary pleuræ. One pleura may be involved, or both, or only part of one pleura. The natural tendency is for the inflammation to extend, until finally both lungs are completely adherent to the walls of the chest. There develops more or less inflammation of the larger bronchi, and the heart becomes smaller.

The disease usually originates in the adhesions which have been left by previous attacks of dry or of subacute pleurisy, but sometimes no history of previous pleurisy can be obtained. It may be associated with emphysema or chronic phthisis.

The *symptoms* are slight or well marked, according to the extent of the lesion. There may be only some pain over the chest and a slight dry cough, or there may be considerable pain, cough with expectoration, dyspnœa, and loss of flesh and strength.

The physical signs depend upon the extent of the lesion. If this be slight there are only a little dulness over the affected chest and pleuritic râles. If the lesion be extensive, we have more marked physical signs. The chest is flattened or retracted, expansion is diminished over the affected area, vocal fremitus is sometimes normal, sometimes increased, and sometimes diminished. The latter is perhaps the most common condition. There is more or less well-marked dulness on percussion; the breathing is diminished, or it may be changed in character, resembling bronchial breathing or broncho-vesicular breathing; the voice is usually diminished, but it may be increased in intensity. Over the affected area are usually heard numerous pleuritic râles, some the creaking sounds of old adhesions, others the crepitant and subcrepitant sounds of more recent adhesions. It must be remembered that if the pleuræ are tightly adherent there will be no râles at all. These patients usually die from some intercurrent disease, but occasionally the pleurisy is the only discoverable cause of death.

The *treatment* is to expand the lungs as much as possible, and to live an outdoor life as much as possible. I am in the habit of advising such a patient to take the deepest possible breaths at each street crossing, and to practise mild chest gymnastics night and morning. The pneumatic cabinet is of service in these cases. Cod-liver oil and general tonics also help.

Tuberculous Pleurisy is usually secondary to tuberculous inflammation elsewhere in the body; most com-

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monly, for example, in the lungs, next in the bronchial lymph nodes, then in the peritoneum, bones, etc.; or the tuberculous pleurisy forms simply a part of a general miliary tuberculosis. In some cases, however, no tuberculous focus can be found elsewhere in the body, and these must be regarded as cases of primary tuberculosis of the pleura.

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The inflammation regularly involves the whole of the pleura on one side. It may be confined to the costal pleura or may involve also the diaphragmatic or pulmonary pleura.

There may be localized, or widely disseminated, miliary tubercles upon or beneath the pleural surfaces, either in direct association with lesions beneath the pulmonary pleura, or apart from them, or upon the costal pleura.

According to Delafield the gross appearance varies as follows:

1. The pleura is thickened, its surface is bare of fibrin, it is of a bright red color from the congestion of the blood-vessels, and this red surface is mottled with white dots—the miliary tubercles. In the pleural cavity is bloody serum.

2. The pleura is thickened, it is thickly coated with fibrin, no tubercles are visible to the naked eye; the pleural cavity contains clear serum.

3. The pleura is thickened and the pleural cavity contains purulent serum.

In all these cases the changes in the pleura itself are essentially the same—the thickened pleura is infiltrated with new connective-tissue cells. Scattered through its entire thickness are tubercle granula, either singly or joined together by diffuse tubercle tissue. The smaller blood-vessels show a growth of their endothelial cells.

In the serum of tuberculous pleurisy the tubercle bacillus may be occasionally demonstrated by staining, especially if the centrifugal machine is used, but it requires long and careful search, and often all one's efforts are unrewarded. The tubercle bacillus may be associated with other bacteria, most often with the staphylococcus pyogenes in the purulent exudate.

Many cases of pleurisy with sero-fibrinous exudate, giving no growth of bacteria on the ordinary culture media, are found to be tuberculous by the inoculation of guinea-pigs with the fluid.

The *symptoms* and physical signs are the same as those of pleurisy with effusion, or of empyema, or of pleurisy with an excessive production of fibrin. Of course the only positive diagnosis lies in the finding of the tubercle bacilli in fluid withdrawn from the pleura, but this is a procedure which is rarely successful. A fairly positive diagnosis can, however, be made in a majority of the cases by the consideration of associated conditions. Thus a bloody serum is more likely to indicate tuberculous pleurisy than anything else. A "silent pleurisy" is very apt to prove to be tuberculous. When the temperature remains high after the serum has been removed, and when the serum reaccumulates rapidly after each aspiration, the case is usually tuberculous. When the family history and the patient's history point to tuberculosis, the diagnosis can usually be correctly made. When there is empyema and the opening of the chest is followed by little or no improvement, the case is usually tuberculous. When the empyema is sterile it is usually tuberculous.

The *treatment* is unsatisfactory. We remove the fluid or we open the chest for the empyema; and then, if the diagnosis is certain and the patients are well enough, we treat them as we would any case of tuberculosis by out-of-door life, change of air, creosote and cod-liver oil, and good food.

Cancerous Pleurisy is rare; it may be primary or secondary. Fibroma, sarcoma, and endothelioma may occur as primary tumors of the pleura. Fibroma and lipoma formed in the subpleural tissue may encroach upon the pleural cavity.

Endothelioma usually occurs in the form of larger or smaller, flat or projecting, irregular nodular masses frequently most marked and extensive upon the costal pleura. Carcinoma may invade the pleura by extension, or sarcoma or carcinoma may be secondary to distant growths of the same nature. Small white, slightly projecting, often pigmented elevations of the pleura, either single or multiple, are common. These were formerly regarded as mostly miliary fibromata, but Hodenpyl has shown that they are mostly fibrous masses which replace or enclose miliary tubercles.

The tumors may be associated with an exudative pleuritis, and with either primary or secondary cancer of the pleura the exudate is frequently bloody. It must be remembered that though bloody fluid suggests either tuberculous pleurisy or cancerous pleurisy, and is due to one of these causes in the great majority of cases, it is possible to have a hemorrhagic pleurisy from other causes:

1. A perfectly simple pleurisy may be hemorrhagic.

2. A bloody fluid is met with in the pleurisy of the asthenic states, such as cancer, nephritis, and cirrhosis, in the malignant fevers, and in severe infections.

3. There may be a hæmatothorax due to the rupture of an aneurism, or to the pressure of a tumor on the thoracic veins.

4. The chest wall or the lung may be wounded by the aspirating needle, and blood in this way may get mixed with the sero-fibrinous exudate.

5. Wounds of the walls of the chest, fractures of the ribs, and blows on the chest may cause hemorrhagic pleurisy.

The *symptoms* of a cancerous pleurisy are those of the original new growth plus the signs of a pleuritis. If it be a primary new growth of the pleura, the diagnosis may present very great difficulties.

The subject of Traumatic Pleurisy need not detain us. If there be perforation of the costal or pulmonary pleura there will usually be a sero-fibrinous pleurisy, which may become purulent. Fracture of the ribs or blows upon the chest may cause a dry pleurisy or a sero-fibrinous pleurisy.

Pneumothorax.—By this we mean *air in the pleural cavity*, and also pyopneumothorax, *air and pus* in the pleural cavity, and hydropneumothorax, *air and serum* in the pleural cavity.

Air alone in the pleural cavity, a pure pneumothorax, is an extremely rare condition, for a pneumothorax usually becomes a pyopneumothorax, or, more rarely, an hydropneumothorax. We, therefore, speak of these three conditions under the term pneumothorax.

Pneumothorax occurs chiefly in adults, although we see it occasionally in very young children. It is more frequently met with in males than in females, and most commonly on the left side. It is caused by anything that perforates the pleura and allows air to enter the pleural cavity; but in ninety per cent. of the cases this cause is the rupture into the pleural cavity of a softened tuberculous nodule, or of a tuberculous cavity.

Other causes are: Perforating wounds of the chest; perforation of the diaphragmatic pleura from malignant disease of the stomach or colon, or ulcer of the stomach; perforation of the pleura by cancer of the œsophagus; perforation of the pleura, in the normal lung, from rupture of the air vesicles during straining; septic bronchopneumonia; gangrene of the lung; abscess of the lung; perforation of the lung from the pleural cavity by an empyema; the development, in a pleural exudate, of the gas bacillus (B. aërogenes capsulatus).

Osler has seen pneumothorax caused by the rupture into the pleura of an hemorrhagic infarct in chronic heart disease.

Pneumothorax has occasionally followed the introduction of an exploring needle into the lung. The number of cases of pneumothorax due to these exceptional causes is so small that practically pneumothorax is regarded as of tuberculous origin until it is proved that it is not.

Pathology.—If it be a pure pneumothorax we find the air in one of the pleural cavities under considerable pressure. The lung is compressed against the vertebral

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column, and it may be small, dense, and unaërated. If there be old pleuritic adhesions the lung may not be compressed against the vertebral column, but irregularly compressed, being held against the chest wall by the adhesions. The mediastinum and the pericardium are displaced, being www.libtool.com.cn side, and the liver or spleen may be displaced downward. If there be a pyopneumothorax, or an hydropneumothorax, there is in addition fluid in the pleural cavity, purulent or serous, and the pleura is inflamed.

Symptoms.—In the tuberculous cases we have first the ordinary history of tuberculosis of the lungs, then during some severe muscular exertion, or during a paroxysm of coughing, the rupture of the pleura suddenly takes place and the patient experiences a severe pain in the chest accompanied by intense dyspnœa and a feeling of weakness or faintness. He may even become completely unconscious, and he may die without recovering consciousness. If he does not die at once he rallies from the shock caused by the rupture of the lung, but he is much sicker than he was before. He has constant and very severe dyspnœa, and he is usually confined to his bed. He may remain in this condition for two or three weeks and then die, either with or without, though more commonly with, the development of pyopneumothorax, or he may grow stronger and be able to get out of bed and go about a little, but if pyopneumothorax has not already developed it usually supervenes. Then the symptoms of pyopneumothorax are developed, which are, of course, simply an intensification of the symptoms of tuberculosis of the lung with mixed infection. The patient loses flesh rapidly, he has a high fever at night, he sweats profusely, and he may expectorate a great deal of foul-smelling material—the pus from the pleural cavity. He finally dies of exhaustion. It must be remembered, however, that there may be no urgent symptoms of pneumothorax in cases of long standing tuberculosis of the lungs. There has been found post mortem a pneumothorax which was unsuspected during life. West states that even in healthy adults this latent pneumothorax may occasionally occur.

The *diagnosis* of pneumothorax is usually made with ease by the physical signs. The rule is that the affected side is larger than the other, and it moves but little with respiration. The heart is displaced, and the liver or spleen, or both, may be displaced downward. The vocal fremitus is usually absent.

Percussion gives tympanitic resonance or exaggerated resonance, or amphoric resonance. Auscultation gives amphoric breathing or absence of breathing. Auscultation of the voice gives amphoric whisper or very feeble voice.

If the lung be adherent to the chest wall, there may be pleuritic adhesion râles. There may be the metallic tinkle, even though no fluid be present.

The coin sound, Trousseau's "bruit d'airain," is characteristic. To obtain this sound the auscultator should put one ear on the back of the chest while an assistant taps one coin on another placed on the front of the chest. The metallic-echoing sound which is produced in this way is one of the most constant and characteristic signs of pneumothorax.

Certain exceptions to these physical signs must be noted:

1. There may be but little displacement of the viscera.
2. Vocal fremitus may persist.
3. Percussion may give nearly normal resonance, or *flatness*, or *dulness*, signs which may very well deceive us greatly.
4. The breathing may be normal over most of the chest, or it may be bronchial.

The physical signs of pyopneumothorax or hydropneumothorax are usually those of pneumothorax above the level of the fluid, and of pleurisy with effusion below the level of the fluid, to which is added the characteristic sign of air and fluid in the pleural cavity, viz., the *Hippocratic succussion*. This sign is obtained by placing the auscultator's ear upon the chest, and then shaking the patient's body. A splashing sound is produced which may be audible even at a distance. The patient can often feel and hear this fluid splashing in his chest.

Pneumothorax must be differentiated from large phthisical cavities; from total excavation of one lung; from diaphragmatic hernia following a crush or other accident; from pleurisy with effusion. In most cases the differential diagnosis does not present serious difficulties. The total excavation of one lung in which only a thin shred of lung tissue remains attached to the chest wall presents the physical condition which exactly resembles a pneumothorax and therefore presents unusual difficulties in diagnosis. This is, however, a very rare condition, and the patient does not develop a pyopneumothorax.

The *prognosis* is usually bad. According to West, the mortality is seventy per cent. The tuberculous cases usually end fatally within a few weeks. According to West, of thirty-nine patients, twenty-nine died within a fortnight, ten died on the first day, and two of these within twenty and thirty minutes, respectively, of the attack.

Pneumothorax developing in a healthy individual, it is said, often ends in recovery. There are tuberculous cases in which the pneumothorax, if occurring early, seems to arrest the progress of the tuberculosis.

The question of *treatment* is a difficult one to decide. As a rule, little can be done for the unfortunate victim. An operation for empyema does little good, since we have in the advanced tuberculosis of the lung the main cause of the inflammation of the pleura. In cases which develop early the fluid may, of course, be removed by aspiration, if serous, or a rib may be excised and permanent drainage obtained if the fluid be purulent. If the patient suffers from dyspnœa due to the pressure of the air, this may be relieved by the insertion of a fine trocar and allowing the air to escape. The aspirator should not be used. *Frank W. Jackson.*

PLEURISY ROOT.—*Asclepias* (U. S. P.). *Butterfly Weed.* "The root of *Asclepias tuberosa* L. (fam. *Asclepiadaceæ*)" (U. S. P.).

Asclepias L. is a genus of some sixty species, occurring chiefly in North America, a few in Central and South America, and in the tropics of the Old World. A number of these have been found to possess the composition and properties of the official one, and it is probable that the same properties are general in the genus.

The species in question is very abundant in sandy soil from New England southward and southwestward. It is a perennial, hairy herb, sending up a cluster of erect or ascending stems a foot or two long, as thick as a goose-quill, densely leafy, and bearing at the summit several branches terminating in handsome large umbels of orange-colored flowers. It is the only species of the northeastern United States with orange-colored flowers. The commercial root is irregularly or interruptedly fusiform, 10–20 cm. (4–8 in.) long, 1–5 cm. (½–2 in.), rarely more, in thickness, usually cut transversely or longitudinally into irregular pieces; externally light orange-brown, becoming gray on keeping, coarsely annular at the crown, bearing numerous fine longitudinal and transverse furrows, imparting a finely tuberculate appearance and feeling; fracture tough, uneven, granular, whitish, the thin bark yellowish in the outer layer, the wood bundles pale yellow; almost inodorous, taste bitterish, slightly acrid and nauseous.

Besides two resins, gum, and a large amount of starch, pleurisy root contains the bitter glucoside asclepiadin, to which its properties are chiefly due. Asclepiadin is a yellow amorphous substance, soluble in alcohol, ether, and hot water, becoming of a deeper yellow, then green, with concentrated sulphuric acid.

Pleurisy root is diaphoretic and expectorant, and in domestic and country practice it has been used extensively in lung affections and catarrh of the air passages. In large doses it is emetico-cathartic. If desired, it can be given in decoction. Dose from 1–3 gm. (gr. xv. to xlv.). The fluid extract is official. *Henry H. Rusby.*

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PLOMBIÈRES.—Plombières has been called, not without reason, "the Queen of Watering-places of the Vosges." It is charmingly situated, and its surroundings are so attractive that it is a favorite summer resort with many who have not been ordered there for a course of the waters. The little town has only about two thousand inhabitants. It is situated in a narrow valley, with mountains rising steeply up on either side. The climate is invigorating, and, while the days in summer are often hot, the nights are invariably cool.

ANALYSIS.—One thousand parts of the water contain in parts:

	Source Vauquelin.	Source No. 1, Du Thalweg.	Source Des Dames.	Source Du Crucifix.	Source No. 5, Savonneuse.
Temperature	158° F.	137° F.	124° F.	115° F.	68° F.
Carbonic acid (free)	0.00638	0.00879	0.1287	0.00825	0.00300
Silicic acid	.02155	.07539	.02731	.00739	.04589
Sulphate of soda	.13564	.07534	.00274	.10070	.04685
Sulphate of ammonia / Arseniate of soda	traces.	traces.	traces.	traces.	traces.
Silicate of soda	.12862	.07343	.05788	.10611	.04209
Silicate of lithia / Silicate of alumina	traces.	traces.	traces.	traces.	traces.
Bicarbonate of soda	.02288	.01426	.01133	.02092	.00818
Bicarbonate of potash	.01673	.00125	.00133	.00234	traces.
Bicarbonate of lime	.02778	.04965	.02868	.03639	.04451
Bicarbonate of magnesia	traces.	notable traces.	.00670	traces.	.01253
Chloride of sodium	.01044	.00794	.00927	.01005	.00651
Fluoride of calcium / Oxide of iron and manganese	traces.	traces.	traces.	traces.	traces.
Organic and azotyzed products	indications.	indications.	indications.	indications.	indications.
Total	0.37053	0.02295	0.25821	0.29823	0.19665

A special feature at Plombières is the long time (from half an hour to an hour and a half) during which patients remain in the water. Mr. Wolff ("The Watering-Places of the Vosges") says that only four springs out of the twenty-seven which are now in use at Plombières are drunk at all. The first is the chalybeate, which is very mild, and is employed mainly as a table water and as an adjunct to bathing in cases of anæmia and chlorosis. Another spring used for drinking, and also for bathing, the "Source Savonneuse," is mildly laxative. Besides these, the "Source des Dames" and the "Source du Crucifix" are employed for what little drinking there is. Apart from the chalybeate and the Savonneuse, the Plombières waters all belong to one category. Dr. Constantin James calls them alkaline; Dr. Bottentuit, "*arséniatées sodiques, sulfatées et silicatées sodiques*"; M. Jacquot, "*bicarbonatées sodiques silicatées*"; and Dr. Macpherson, "indifferent." The latter designation is most in keeping with their slight degree of mineralization.

The same author states that, "in addition to the baths, a very effective remedy in some cases applied at Plombières are the *étuves*, also called *étuves de l'Enfer*. These are hot vapor baths, for which the heat and vapor are supplied by the running springs. There are two such establishments, both of course underground, and both, at their hottest points, very hot indeed. But for people who cannot stand excessive heat, there is the convenient institution of *étuves en boîte*, which are taken in a closed box, with a hole left in the top for the head." Energetic massage is also much employed at this spa; so that the patient's time, what with drinking, bathing, walking, douching, massaging, and dieting, is quite fully occupied. Most of the visitors are women, although it is by no means an exclusively "female watering-place."

The place is rich in mineral springs, but the proportion of solids in the waters is rather insignificant. Over twenty-five springs are used at Plombières, and the water of most of them is collected into a single conduit and conveyed to the different thermal establishments. Only three of the latter are perfectly modern and satisfactory, viz., the *Nouveaux Thermes*, the *Bain Romain*, and the *Bain Stanislas*. Although so slightly mineralized, the varying temperature of the baths (65° to 160° F.) admits of a certain amount of variety in treatment. The waters are easily borne when taken internally, and do not produce any constitutional disturbance.

A course of Plombières is useful in many nervous states, especially those associated with hyperæsthesia, as well as in those depending upon lithæmia. Many symptomatic neuralgias and paretic conditions derive benefit from a course of treatment at Plombières. Stiff joints may be limbered up, lumbago cured, gouty manifestations alleviated, diseases of women improved. The place also has quite a reputation for the cure of sterility, though on what grounds does not specifically appear. The waters are also applicable to cases of gastralgia, dyspepsia, catarrhal conditions of the bowels, especially when accompanied by chronic diarrhœa. Some skin diseases, such as eczema and psoriasis, are likewise said to be greatly benefited by these waters. The chalybeate springs are, of course, useful in anæmia and chlorosis. In phthisis the place is said to be contraindicated.

Plombières is a decidedly international watering-place, although English and Americans form but a small contingent of the six thousand annual visitors of the spa. With reference to accommodation, Mr. Wolff is authority for the following: "The better hotels and villa-pensions seem intended for people altogether of the better classes. They are good, but dear. Of course, there are less pretentious ones, down to the lowest point of the scale; for the spa is much visited. The following are among the best: The Grands Hôtels, Hôtel de la Paix, Hôtel Stanislas, Villa Mocquard, Le Chalet Rose, and Maison Rossignol. There are as many as about a hundred private hotels, many of them with a regular table-d'hôte." Altogether, it is quite true that Plombières should be better known in our country than is now the case, especially as it is more convenient of access than Wildbad Gastein, Teplitz, and the other spas of that order, which Americans are wont to visit. *Edmund C. Wendt.*

PLYMOUTH ROCK MINERAL WELL.—Wayne County, Michigan. POST-OFFICE.—Plymouth.

Plymouth is a handsome village of about eighteen hundred inhabitants, twenty-three miles west of Detroit, from whence it is reached by both the Flint and Père Marquette and the Grand Rapids and Western railroads. The well is situated in a picturesque spot on the farm of Dr. M. V. B. Saunders. It was bored several years since, and the following analysis was made by Prof. John E. Clark, of Detroit, in 1893:

One United States gallon contains: Sodium chloride, gr. 14.38; sodium sulphate, gr. 0.37; sodium bicarbonate, gr. 5.27; potassium bicarbonate, gr. 1.73; calcium bicarbonate, gr. 5.47; magnesium carbonate, gr. 2.90; alumina and iron carbonate, gr. 1.73; silica, gr. 0.50; organic and volatile matter, gr. 1.29. Total, 33.64 grains. Lithium carbonate and carbonic-acid gas not estimated.

No accommodations have so far been prepared for visitors, but the water is widely sold. It is a good example of the alkaline-saline carbonated variety of water, and is useful in conditions to which this class is applicable. Its best effects have been observed in disordered states of the stomach, especially when accompanied by hyperacidity. It is also highly recommended in irritable states of the bladder and kidneys as a diuretic and diluent of the urine. It is said to have produced excellent results in gout, rheumatism, gravel, and other affections.

James K. Crook.

PNEUMATIC CABINET, THE.—The pneumatic cabinet, as distinguished from the pneumatic chamber of European countries, is an air-tight box of sufficient size to contain only a single patient.

By means of an attached bellows the contained air may be rarefied or compressed, and by means of a tube and stopcock in one wall of the cabinet the patient's lungs may be instantly connected with, or cut off from, the out-

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side air. The cabinet is designed for the application of differential atmospheric pressures, the differentiation being between the cutaneous and pulmonary circulations. Coincidently it may be advantageously employed in the administration of the various inhalations. It has no relation to, and is in no way comparable with altitude, but is properly classed with apparatus for the use of compressed and rarefied air. It differs, however, from all other apparatus of this class in that the differential pressure is applied to the systemic as well as the pulmonary circulation. As this differentiation is always negative, the effects upon vascular tension and blood flow are directly the opposite of those from compressed and rarefied air.

Physics.—The available variations of atmospheric pressure to which the patient may be subjected and under which respiration may take place are:

1. Diminished pressure on both cutaneous and pulmonary surfaces, the patient being in and breathing the rarefied air of the cabinet, called negative pressure.
2. Increased pressure on both surfaces, called positive pressure (rarely if ever used).
3. Barometric pressure on the pulmonary, with diminished pressure on the cutaneous surface, the patient being in rarefied air while breathing from without, called negative differentiation.
4. Barometric pressure on the pulmonary, with increased pressure on the cutaneous surface, called positive differentiation.

Respiration may be continuous under either of the above conditions or the differentiation may be shifted between inspiration and expiration, giving the following combinations:

COMBINATIONS.

Inspiration.	Combined with expiration.	Called.
Under No. 3	Under No. 1	Forced inspiration.
Under No. 3	Under No. 4	Forced respiration.
Under No. 2	Under No. 4	Forced expiration.
Under No. 4	Under No. 3	Obstructed respiration.

Clinical experience has shown that negative differentiation, and its combination with negative pressure in the form of forced inspiration, are the most effective and, essentially, the only desirable methods of application. The physical demonstration is, therefore, limited to these two motions.

Negative Differentiation.—In this motion respiration is carried on under a constant differential pressure, that upon the pulmonary circulation being barometric, and that upon the cutaneous and abdominal circulations being less by the amount of rarefaction in the cabinet. The mechanical effects are identical with those from compressed air aside from the circulation; but as they can be obtained in larger degree by forced inspiration with an increased instead of retarded circulation, this motion is never employed for the purpose of expanding and clearing the lung. Because the respiratory effort is shifted from inspiration to expiration, respiration under these conditions has been thought to be of benefit as a form of pulmonary gymnastics, and in developing the expiratory muscles. But the results are of little clinical value as it is the voluntary muscles which are increased, not the normal expiratory forces of pulmonary and thoracic elasticity.

The value of this form of pneumatic differentiation depends solely upon its action on the circulation. Respiration under negative differentiation results in:

1. Reduction of vascular tension in both the systemic and the pulmonary circulations.
2. Depletion of the pulmonary vessels with venous hyperæmia of the systemic circulation.
3. Slowing of the entire circulation, both systemic and pulmonary.
4. Mild anæmia of the cerebro-spinal vessels.

The manner in which these conditions are developed is obvious. While the barometric pressure of the respired air offers no increased resistance to the pulmonary circulation, and hence no impediment to right heart action, the lower pressure on the cutaneous surface becomes essentially a suction force influencing all the systemic circulation, save that of the brain and cord, which are protected by their bony envelope. As the result all the systemic vessels, and particularly the capillaries, are dilated, vascular tension is lowered, and for a moment the circulation is hastened as the blood is drawn from the lung. But with the continuance of the differentiation the contracting arteries gradually force a relative excess of blood into the veins, from whence it passes more slowly to the pulmonic vessels which are under the higher barometric pressure. The coincident slowing of circulation and pulmonary anæmia are such that a strong man can hardly breathe five minutes under a negative differentiation of one inch of mercury without marked dyspnœa. Clinically, therefore, this motion must be alternated with negative pressure, which increases the pulmonary circulation.

The pathic conditions to which negative differentiation is applicable are: (*a*) pulmonary hemorrhage. There is no measure at our command which so quickly arrests bronchial hemorrhages. It is an almost universal impression that pneumatic differentiation of necessity causes abnormal expansion of the lung, and is therefore dangerous in all cases of hemorrhage, or where there is softening of pulmonary tissue. Such is not the case, and negative differentiation may be applied with even less than normal expansion of the chest. It is, therefore, of value (*b*) in all forms of acute inflammatory hyperæmia of the lung or pleura. It affords immediate relief in (*c*) pulmonary congestion from any form of cardiac disease, except mitral obstruction, and is the proper motion with which to begin the treatment of any organic cardiac or arterial disease, with the above exception. In all of the above conditions after the acute processes have been relieved, negative differentiation should be supplemented or replaced by forced inspiration.

Forced Inspiration.—The effects of this motion are of two distinct forms, mechanical and circulatory. The pulmonary expansion, the opening and clearing of collapsed and plugged alveoli, and the stretching of pulmonary and pleuritic fibroses attained by means of the pneumatic cabinet do not differ in themselves from the corresponding effects of compressed air. The clinical results, however, are very greatly superior by reason of the coincident effect of the cabinet upon the attendant pathic processes through its control of the circulation. In this motion, during inspiration, which takes place under negative differentiation, the action upon the circulation is the same as with negative differentiation alone. It is greater in degree since a higher differentiation can be employed when the patient is to expire into rarefied air. With the decrease in cutaneous pressure the vessels are dilated and the blood is drawn from the lungs through the heart and arteries into the veins with a quickened flow and lowered tension. Before this action reaches the point of slowed circulation inspiration is ended and the differentiation instantly changed to negative pressure, under which, although the absolute pressure on the cutaneous and pulmonary circulations is the same, there is, nevertheless, a relative negative differentiation in favor of the pulmonary vessels due to their weaker anatomical protection and support. A pulmonary suction is thus developed which draws the blood from the hyperæmic veins into the depleted pulmonary vessels, again with quickened flow and under lowered tension. Thus during each respiratory cycle a double negative differentiation is developed alternately in favor of the systemic and the pulmonary circulations.

Continuance of this process results in increase of both circulations with all which that implies of increased absorption and improved nutrition, and this, too, under decreased vascular strain.

It is this power of the cabinet to hasten circulation and diminish arterial strain which distinguishes it from all

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other forms of apparatus for the use of pneumatic differentiation, and which renders it the most potential measure for the relief of very varied conditions. All the mechanical effects of compressed air may be attained by forced inspiration, with the addition of improved tissue nutrition. This motion is valuable in all forms of inflammatory pulmonary disease after the acute stage. All pulmonary and pleuritic fibroses are loosened and absorbed much more quickly than by any other means. The effect of forced inspiration upon all forms of organic heart disease, with the exception noted under negative differentiation, is more immediate, satisfactory, and prolonged than that from any other method of treatment. Cardiac angina and dyspnœa are speedily relieved, often within a few minutes, and in young subjects this relief often becomes permanent after a few treatments. Cases of aortic regurgitation give especially brilliant results.

In all conditions producing high arterial tension also, this measure affords very marked relief, the extent and duration of which depend, of course, upon the nature and continuance of the primary cause. The treatment does not cure Bright's disease, but it does relieve and delay the secondary arterial and tissue changes.

Charles E. Quimby.

PNEUMOGASTRIC NERVE, RESPIRATORY FUNCTION OF. See *Respiration*.

PNEUMONIA, BRONCHIAL.—(Synonyms: Bronchopneumonia, catarrhal pneumonia, lobular pneumonia, capillary bronchitis, etc.) The name bronchopneumonia is growing in favor, especially in this country, and is preferable. The condition is marked by the presence of bronchitis with areas of pneumonia. The latter are as a rule peribronchial, being confined to the immediate vicinity of the small bronchi, the bronchioles and their atria, the cells adjacent to which are filled with exudate.

Etiology.—The disease is most common in the extremes of life, that is, in the aged and in children under five years old. Of the cases occurring in children, about one-third are primary, the others being secondary most often to the diseases of childhood. Of these, measles is most frequently complicated by bronchopneumonia, and after this come pertussis, diphtheria, scarlet fever, influenza, and chickenpox. It will be noticed that these are diseases in which bronchitis is regularly present, or in which the upper air passages are involved in the morbid process. In older children and adults the disease may occur as a complication of any long-continued, severe illness, especially in those cases in which the mucous membrane of the mouth and pharynx becomes foul and the laryngeal reflexes are less effective than normally.

The predisposing causes in primary cases are old age or infancy, bad hygienic surroundings, the impure air of overcrowded, poorly ventilated rooms, bad feeding, and institutional life. We must also include among the predisposing causes the frequent presence of the diplococcus pneumoniæ and other pathogenic micro-organisms in the healthy air passages.

The exciting causes are sometimes difficult to discover. Exposure to cold and wet is one cause, and this accounts for the greater frequency of the disease in the cold months. The predisposing causes of secondary bronchopneumonia are the same as those of the primary form of the disease, plus dorsal decubitus and the weakened condition due to the original disease. The exciting causes are again hard to determine. Exposure is one, but there is a something in addition which favors the growth and multiplication of the micro-organisms usually present, even in health. In cases of deglutition-pneumonia the exciting cause is manifest.

The development of bronchopneumonia in old people is favored by the diminished powers of resistance and the less perfect expectoration.

Bacteriology.—In studying the flora of bronchopneumonia we have again to distinguish between primary and secondary cases. The micro-organisms most commonly found are the diplococcus pneumoniæ, streptococcus, staphylococcus aureus and albus, Friedländer's bacillus, and Loeffler's bacillus.

In nearly all of the primary cases the diplococcus pneumoniæ is present, and in about half of these it exists alone. When not alone, it is most often associated with the streptococcus and much less frequently with the staphylococcus and the other organisms just mentioned. Infrequently the streptococcus is found alone.

In secondary cases it is the rule to find a mixed infection. The diplococcus pneumoniæ appears in about seventy-five per cent. of the cases, but seems less potent in giving character to the disease than the streptococcus. The diplococcus pneumoniæ, the streptococcus, the staphylococcus, and Friedländer's bacillus may each be present alone, unassociated with other bacteria, but in the case of Friedländer's bacillus, at least, this happens only rarely. Although, generally speaking, the streptococcus plays the most important part in bronchopneumonia complicating measles, it is precisely in this form that the diplococcus pneumoniæ is more often found in pure culture than in other secondary cases.

Holt reports six tuberculous cases which were studied by Wollstein, and in all of which the diplococcus pneumoniæ was also found; indeed, this organism gave the character to the disease in these cases, as clinically they were indistinguishable from those of an ordinary bronchopneumonia, the post-mortem examination alone revealing their tuberculous nature.

Bronchopneumonia has in rare instances been found to be due to forms of streptothrix, and French investigators have reported the finding of the colon bacillus.

In deglutition-pneumonia the streptococcus and staphylococcus are most commonly found, and then, as a rule, in virulent form.

Pathological Anatomy.—In about eighty per cent. of the cases coming to autopsy, lesions have been found in both lungs. These lesions consist essentially of those of bronchitis and of pneumonia.

When the chest is opened the pleural cavities are seen usually to contain little or no excess of fluid. The parietal and pulmonary pleural surfaces may be normal or the seat of a fibrinous pleurisy. The lesions of the latter consist of patches of fibrin which vary considerably both in extent and in character. At times they are almost invisible lustreless spots, and then again they may be quite large and thick (as much as half a centimetre thick) and more or less discolored. Such patches correspond closely to areas of superficial pulmonary consolidation.

The lungs do not collapse as completely as they normally should, though crepitation is found quite generally when the lungs are handled in the search for nodules of consolidation. The latter are most often found in the lower lobes posteriorly. There may be found collapsed areas, bluish or bluish-brown in color, set in a lighter background. These are areas of simple atelectasis, and will yield to gentle inflation through a tube inserted in a bronchus. The bronchial nodes are invariably congested and enlarged. The heart—the right side more commonly—may be dilated.

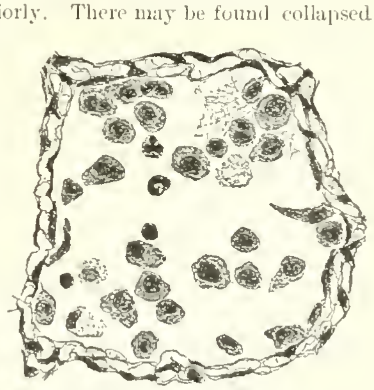

Fig. 3826.—Bronchopneumonia. Exudate in an air cell, consisting of exfoliated epithelium, a few pus cells, and a little fibrin. (From Delafield and Prudden.)

On section, the pneumonic areas stand out a little, are of a dark mahogany color, or more or less marbled with gray, smooth or finely granular, and moderately wet; only a small amount of dark blood escapes from the

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vessels. Such areas vary greatly in size, and may be close together or widely separated. Near the centre of each a bronchus is seen, white or gray, because of the exudate which it contains. The unconsolidated lung tissue may


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FIG. 3827.—Bronchopneumonia in a Child, Showing Single Lobular Pneumonic Area, with Bronchus in its Centre. The thickened wall of the latter merges into the surrounding zone of pneumonia. Near the corners the accompanying emphysema is shown. (From Delafield and Prudden.)

be normal, but more often it is congested and œdematous, particularly behind. An emphysema, usually vesicular, is often present, being most pronounced anteriorly. Upon section of the areas of atelectasis, dark fluid blood escapes; the cut surface is seen to be smooth, with occasional lobules projecting above it. Creamy pus can be pressed from the smallest bronchi; portions carefully removed are found to contain no air and they sink in water.

With the aid of the microscope we see that the exudate within the bronchi of the consolidated areas is composed of leucocytes, mucus, desquamated epithelium in various stages of disintegration, a few red blood cells, and the micro-organisms responsible for the condition. The walls of the bronchioles and bronchi are swollen and infiltrated with new small round cells with more or less indistinct contours and having large nuclei. (See Plate XLIX.)

Northrup mentions a mechanical dilatation of the smaller bronchi. These dilatations, which are for the most part fusiform in shape, are found with especial frequency in the lower lobes. They are associated, according to this authority, with three conditions: (1) Weakened bronchial walls; (2) abundant secretion within the bronchi; and (3) impermeable tissue surrounding them. The dilatation is due to the secretion being forced by each inspiratory impulse from larger to smaller bronchi. The process, which is observed in children between three and five years of age, occurs more often after the fifth day of the disease. The dilatations disappear entirely on the recovery of the patient.

As the walls of the bronchioles are swollen and infiltrated with new cells, so also are those of the atria and of the air sacs, including the partitions between the air cells. The capillaries are engorged with blood and small hemorrhages may be noted here and there. The air cells, air sacs, and atria are filled with leucocytes, swollen desquamated epithelium, occasionally a few red blood cells, and sometimes also a little fibrin.

In deglutition- or aspiration-bronchopneumonia the process is more intense, the infiltration with leucocytes often resulting in suppuration and gangrene.

In the areas of atelectasis the bronchi are seen to be filled with pus and swollen and detached epithelia, and the walls of the bronchioles are infiltrated; the air cells and sacs are partially collapsed, the diminished lumen being filled with swollen and proliferating epithelia and pus cells. The blood-vessels are tortuous and gorged with blood. Here and there are hepatized lobules. In some cases the emphysema is very marked (see Fig. 3828).

The bronchial lymph nodes may or may not show a cellular infiltration. They are always congested.

SYMPTOMS.—The symptoms may be most obscure, even misleading, making it almost impossible, for a period of several days, to reach a correct diagnosis.

Prodromal Symptoms.—In primary cases, as in acute bronchitis, the early signs are a general malaise with more or less anorexia, slight elevation of temperature, acceleration of pulse and respiration, and cough, dry or with mucous expectoration in patients old enough to perform that important act. The invasion may resemble that of lobar pneumonia, being marked by a chill or convulsion and by rapid rise of temperature to 103° or 104° F. or over; or the invasion may present no characteristic features, the symptoms resembling those of typhoid fever or meningitis. In the cerebral cases there may be repeated convulsions, apathy, photophobia, retraction of the head with rigidity of the neck, and an absence of physical signs of consolidation.

In *secondary* cases, the prodromal symptoms and the invasion are masked by the symptoms of the primary disease. The invasion is gradual, seldom marked by a chill or convulsion, the child becomes restless, the temperature rises, and the pulse-respiration ratio diminishes. If there was a cough before, it becomes worse, or one develops if there was none previously. If there is any expectoration it is muco-purulent in character. An early symptom may be the cough,—painful, frequent, and hacking,—and it often continues after resolution has taken place.

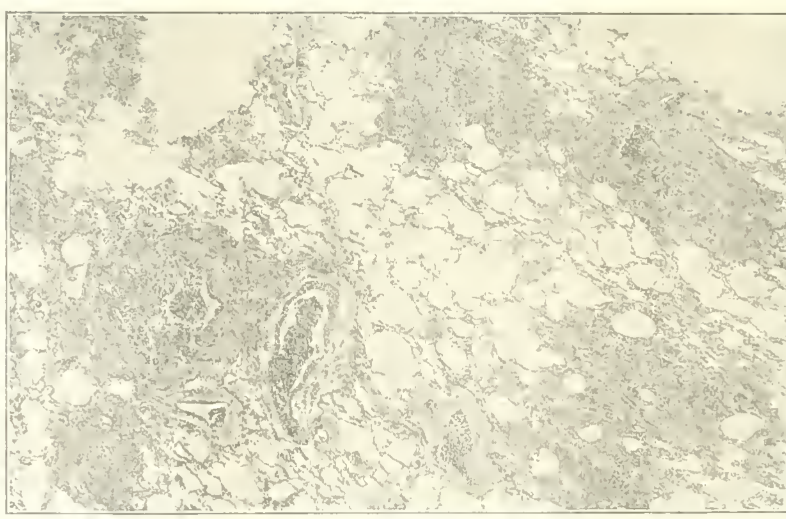

FIG. 3828.—Bronchopneumonia in an Adult, Showing Several Areas of Consolidation, with the Central Bronchus Filled with Exudate. Marked emphysema may also be seen in parts of the section. (From Delafield and Prudden.)

The temperature varies according to the extent of the

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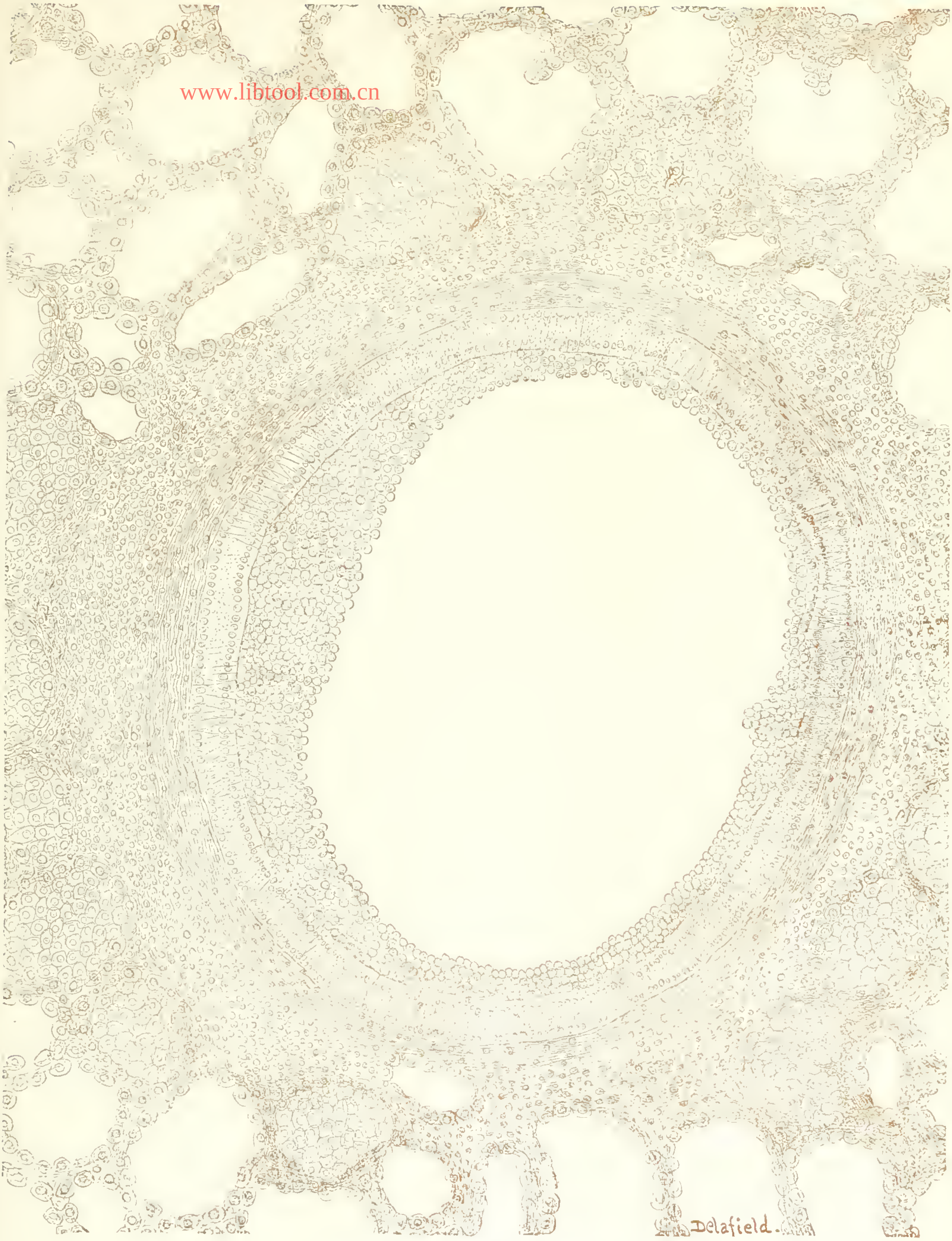

ACUTE BRONCHO-PNEUMONIA

(COPIED, BY PERMISSION, FROM DELAFIELD'S STUDIES IN PATHOLOGICAL ANATOMY.)

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lesions, the virulence of the infection, and the general condition of the patient; apparently also it is influenced by the variety of micro-organism present. It may rise slowly or very suddenly, as a rule to 103° or 104° F., and it averages moderately high, with sharp elevations, most often in the afternoon, but at times in the early morning. The variations in the temperature curve gradually become less and less; in favorable cases the general trend is downward, restoration to the normal being by lysis. In unfavorable cases the trend of the curve is constantly upward, the temperature sometimes going as high as 107° F. The temperature may be of a high, continued type, this usually portending a fatal issue. On the other hand, in greatly debilitated subjects the temperature may rise little if at all above 100° F. The usual termination of such cases also is death.

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Pain is not a constant symptom, and as a rule it occasions little trouble.

Cyanosis is quite common, but there is little or no dyspnœa. When it is caused by atelectasis the temperature remains unaffected or falls a little. The skin is often cold and clammy. These symptoms disappear upon the removal of the cause of the atelectasis, and the patient is then about as well as before the attack. If the cyanosis persists for more than a day or two, however, the result is a fatal one.

In well-marked cases, the respiratory rhythm is changed. Instead of the inspiratory murmur being nearly continuous with the expiratory, the pause which in health was after expiration and before inspiration, is now transferred and is after inspiration and before expiration. The child quickly draws its breath, holds it, then with an explosive grunting sound expires and without pause inspires. The expiration is prolonged and loud. There may be Cheyne-Stokes respiration.

Gastro-enteric symptoms, such as loose green stools without vomiting, are frequent in infancy. The urine may become scanty, high colored, and with a trace of albumin, but casts are rare.

In cases ending in recovery amelioration of all symptoms may occur at any time from the fourth day to the third or fourth week. In mild cases it is looked for from the fourth to the eighth day.

Resolution takes from seven to fourteen days in favorable cases. Relapses are common.

Physical Signs.—It may be that for days no signs at all can be discovered within the chest, and it frequently happens that no signs of consolidation are found at any time during the course of the disease. In primary cases the first signs are due to congestion and bronchitis; they are either localized in one or more areas, or are generally distributed. The results of percussion may be negative, or there may be slight dulness. On auscultation we detect feeble breathing, which later has a higher pitch over the affected areas, and is associated with fine sibilant and coarse sonorous râles of the same or of wider distribution. These râles may disappear when the patient coughs. A little later, very fine moist râles are heard, as a rule, only over one or more areas, usually in the lower lobes behind. The vocal fremitus is unaltered. In such cases the pneumonic areas are deeply seated, small, and scattered.

The signs of consolidation, when present, vary according to the degree of consolidation, the area involved, and its proximity to the chest wall. In well-marked cases percussion reveals the existence of dulness in varying degree, associated at times with a sense of resistance. The vocal fremitus is increased only over areas of fairly complete consolidation. Auscultation reveals the presence of the râles above mentioned, only they are more marked and apparently closer to the examining ear; the breathing is bronchovesicular or diminished; the voice sounds approach the bronchial in character. In the cases in which there is a considerable area of complete consolidation, the signs more nearly approach those of lobar pneumonia, a disease which occurs in young children more often than was formerly believed. The dulness and vocal fremitus, however, are less than one would expect to find with voice and breathing of such a bronchial character. The signs of bronchitis are rarely general, and are most numerous in and near the edges of the consolidated areas. Friction sounds are infrequently present, usually only in cases of complete consolidation extending to the pleura.

It may be necessary to make the patient cough in order to develop the sounds of bronchitis, or crying may bring out, in an area of diminished voice and breathing, a marked bronchial quality. In extreme cases the breathing becomes shallow and very rapid, 80 or more to the minute, with retraction of the xiphoid and ribs and playing of the alæ nasi. The right ventricle of the heart may be found increased in size.

When resolution begins the signs of consolidation, which were the last to come, are the first to go. They may disappear very rapidly or they may persist for days or weeks. The signs of bronchitis subside less rapidly, often being found as late as from two to four weeks after resolution has begun. The blood count, as a rule, reveals a decided leucocytosis; in influenza pneumonia, however, it is only in exceptional cases high.

Complications.—We rarely find any pleurisy, except when there is marked pulmonary consolidation that reaches to the pleura. The simple fibrinous pleurisy is the most common.

The possibility of empyema must always be borne in mind. Abscess of the lung complicating bronchopneumonia is found in about seven per cent. of the cases that come to autopsy; these abscesses are usually minute and multiple, and not clinically discoverable. Gangrene is less frequent. Tuberculosis may complicate any bronchopneumonia, and in fatal cases cannot be diagnosed before death.

As in lobar pneumonia, so in bronchopneumonia, a purulent meningitis may occur, and may mask the symptoms of the primary disease.

Pericarditis is found at times, almost always in cases in which there is marked consolidation in the left lung. The rarity of endocarditis makes it hardly worth mentioning.

It is common to find functional derangement of the gastro-intestinal tract, as shown by vomiting and diarrhœa, which are serious, not in themselves, but in that they reduce the patient's chances of recovery in the other fight.

Nephritis is not a common complication, and when it does occur it is usually of an acute exudative type and does not much affect the course of the original disease.

Diagnosis.—The diagnosis of primary bronchopneumonia from lobar pneumonia is at times very difficult. It must be made on the age, history, and mode of invasion, on the character of the temperature, on the sputum (when there is any), and on the physical signs; the latter alone furnish positive evidence.

The diagnosis from pleurisy with effusion or from empyema must be settled by an exploratory puncture, several dry taps with a large-calibre needle being necessary to establish the absence of fluid.

As an aid to diagnosis in uncertain cases, in children two years of age or under, Northrup gives the three following points:

1. The pulse-respiration ratio tends to depart from the normal, which is as four is to one, and approximates or exceeds three to one. For instance, instead of being 80 to 20, it approximates the ratio of 120 to 40.

2. Fever; persistent elevated temperature, whether remittent, intermittent, or uniform.

3. Râles; subcrepitant and crepitant over a circumscribed area or areas, and especially if these râles are found on one side only.

Malaria is excluded by the absence of malarial organisms, by normal spleen, and by no history of exposure in malarious regions; the presence of leucocytosis also argues against malaria.

Treatment.—No treatment directly influences the pneumonic process. Much, however, can be done to prevent the development of the disease and to help

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the patient pass safely through it, when once it is established.

I would outline the treatment under the following heads: (1) Prophylaxis. (2) General management of the disease. (3) Diet and feeding. (4) Special treatment: (*a*) by drugs; (*b*) by serum therapy. (5) Symptomatic treatment: (*a*) ... (*b*) to lower the temperature and moderate the nervous symptoms; (*c*) to stimulate the heart, in order to prevent cardiac failure or to overcome it if present; (*d*) to stimulate respiration.

Prophylactic treatment is very important. Care must be taken to see that children are sufficiently clothed yet not overclothed; that they are much out of doors, and that while indoors they are in well-ventilated rooms, with a temperature not over 68° or 70° F. during the day and a few degrees lower at night. Children ill with any diseases, particularly those that are most likely to be complicated by bronchopneumonia, should be turned often in bed, now on one side, then on the other, now on the back and then on the abdomen. Bronchitis in an infant should be most carefully treated, as such cases, especially if neglected, are very prone to develop bronchopneumonia. In all cases the mouth should be carefully washed at least once daily, preferably with some alkaline antiseptic solution; and antiseptic nasal sprays are advisable as preventive measures.

General Treatment.—Infants are better for being much held in the nurse's arms; older patients are to be put to bed at once and the bowels moved by calomel, in doses of one tenth of a grain every half hour or every hour for ten doses, or until the desired effect is obtained. The sick room should be large, light, and well aired; there should be a steady renewal of the supply of fresh air, and—if it is deemed advisable—additional moisture should be imparted to it. A change of rooms several times in the twenty-four hours is the best arrangement, provided all of the windows of the one which the patient leaves be opened wide so that it may be in the best condition upon his return. An open fireplace is an excellent ventilator. When the patient's temperature is high the temperature of the room may be at from 65° to 68° F.; when the patient's temperature is normal, the room temperature should be 70° F. The chest had better be protected by an oiled-silk jacket throughout the attack, and the skin of the chest may advantageously be kept red by some light application of mustard. Thick hot poultices should not be used.

It is well to establish a more or less strict isolation, and to disinfect the patient's rooms and their contents before they are used by another person. Especially should this be done in secondary cases.

Great care should be exercised in the management of the diet, as the turning of the tide one way or the other often depends upon it. Plenty of cool water, not iced, should be at hand, and the patient should be encouraged to drink it.

Special Treatment.—Drugs can often be given to advantage by inhalation. The child should be placed under a tent and some kind of a vaporizer employed. A variety of drugs may be added to the water or it may be used by itself. The addition of creosote gives particularly good results. Turpentine, compound tincture of benzoin, and terebene may also do good service when exhibited in this way. The inhalations should be given for from eight to fifteen minutes at a time, every two to six hours. The cough is often greatly relieved by such inhalations. The administration of drugs which, it is believed, can make the blood a less favorable medium for bacterial life, is not to be considered in the case of infants and young children.

For accomplishing this purpose we must look to the better preparation and use of serum therapy, which is now only in its incipiency.

Symptomatic Treatment.—Pain severe enough to demand the administration of some form of opium is unusual. When such a condition does exist, small doses of Dover's powder are quite efficient. Ordinary temperatures, say those under 104° F. rectal, do not in themselves call for special treatment. However, it may be advisable to apply cold, when this degree of temperature is reached, in order to control the nervous symptoms, such as sleeplessness, restlessness, or delirium. In some cases Holt gives for this purpose one grain of phenacetin every two hours to an infant of six months.

The cold is best applied by cool or tepid sponging, or by packs. The spongings are to be frequently repeated until the symptoms for which they are given are controlled. Both cardiac and respiratory stimulants may be needed. Of the first class we will mention alcohol in the form of brandy or whiskey, strychnine, nitroglycerin, and caffeine. None of these is to be administered as a routine treatment. As a matter of fact, however, very many, indeed nearly all, patients with secondary bronchopneumonia need cardiac stimulation, the chief indication for such being a weak, rapid, irregular pulse. The physician should determine how much alcohol it is desirable to give in the twenty-four hours and have it administered in small divided doses, well diluted with at least from six to eight times its bulk of water. A child one year old may need only half an ounce of brandy during the day, or he may need as much as two ounces. The dose, whatever it is, should be reduced as soon as possible, and the alcohol should not be continued for too long a time. Nitroglycerin may be used to help the heart over a particularly hard strain. To a child of the age mentioned above, gr. $\frac{1}{600}$–$\frac{1}{300}$ can be given every hour for several doses, say five or six. Strychnine is not to be given so frequently as alcohol or nitroglycerin. To a child of the age mentioned gr. $\frac{1}{400}$ to gr. $\frac{1}{300}$ of strychnine may be given every three or four hours. It is often best to use two of these drugs, giving them alternately. The effect of caffeine is less certain and the drug is not so much used as the others for its effects upon the heart; as a respiratory stimulant it is better.

The seat of the disease being in the lungs, it is very natural that respiratory stimulants should be called for. Strychnine helps here just as it does in cases of cardiac failure, and in addition to it we can use atropine, caffeine, and oxygen, all of which may be necessary in cases of respiratory failure. We should not wait until the patient is *in extremis* before giving oxygen; when administered it should be considerably diluted with air.

After an attack of bronchopneumonia general tonics are indicated, and it is especially advisable for the patient to have a change of air, preferably to a warm, dry climate, where he should remain for several weeks.

PROGNOSIS.—This must always be guarded, for bronchopneumonia is a dangerous disease. The mortality of all cases, considered together, is between sixty and seventy per cent.

The mortality of primary cases varies greatly, viz., from ten to fifty per cent., depending upon the previous condition of the patient, upon the virulence of the infection, and upon whether the child is an inmate of an institution or not. In private practice the maximum mortality is about thirty per cent.

In secondary institutional cases the mortality of infants under one year of age is appalling. In certain diseases it reaches and stays at one hundred per cent. for months at a time.

The prognosis depends upon the child's age, surroundings, and previous condition, and upon the nature of the infection. Rachitic children developing bronchopneumonia are almost sure to succumb. Bronchopneumonia is most fatal when associated with pertussis, next with measles, and then with diphtheria. This order, however, is a matter about which statistics differ.

Holt says the shortest cases are the most fatal; that the only termination under ninety-six hours is a fatal one, and he says further that, in cases of over two weeks' duration, the prognosis grows worse with each day of continued temperature.

Patients having a low temperature, little or not at all above 100° F., are usually in a condition of low vitality, and consequently about seventy-five per cent. of them die. The mortality of cases in which the temperature

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reaches 106° F. or over is about eighty-five per cent. The most favorable prognosis is in cases with a fairly even temperature curve, one that does not run to either extreme, and does not vary much one way or the other from 103° or 104° F., during the period of activity of the infection.

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A steeple chart with great rises and correspondingly great drops of temperature, simulating a pus temperature, usually indicates a mixed or a streptococcus infection, and the prognosis is worse than in the cases with a more even curve.

A convulsion or two at the onset of bronchopneumonia does not affect the prognosis unfavorably, but when convulsions come later in the course of the disease they do affect it, and that decidedly for the worse.

Bronchopneumonia may terminate in resolution, suppuration, gangrene, chronic bronchopneumonia, or death.

Henry E. Hale.

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PNEUMONIA, CHRONIC.—(Synonyms: Interstitial Cirrhosis of the Lungs, Chronic Interstitial Pneumonia, Pulmonary Fibrosis, Fibroid Phthisis.)

Chronic pneumonia is not an independent morbid entity, but occurs as a sequel of one or more previous or coexisting pathological conditions of the lungs or pleura. It is a chronic productive inflammation which may occur wherever connective tissue is found. It is encountered in two chief forms, circumscribed and diffuse. The circumscribed form is associated with tuberculosis, gummata, tumors, infarctions, hemorrhages, abscesses, and every morbid growth, and really is the attempt of the part to wall off the pathological condition.

The diffuse variety is secondary to incompletely resolved lobar pneumonia or to acute or subacute bronchopneumonia and chronic bronchitis, spreading mostly from the bronchial walls. It may also be a result of pleurisy, and is then called by Charcot pleurogenous.

Interstitial pneumonia may invade the lung in great bands, which develop in the normal septa. A potent cause of interstitial pneumonia is the inhalation, for a considerable length of time, of dust, as necessitated by certain occupations; for example, coal-mining, stone-cutting, and some kinds of work in iron. Zenker calls this form pneumonokoniosis.

In general arteriosclerosis inflammation of the connective tissue of the arterial walls extends to that of the lung itself and results in a diffuse interstitial pneumonia.

Chronic pneumonia is, as a rule, unilateral, but in pneumonokoniosis it is always bilateral. The circumscribed variety is, as a matter of course, distributed according to the distribution of the lesions with which it is associated. When these lesions are close to the pleura this membrane becomes involved, its two layers being thickened and adherent. The zones of new connective tissue about the original lesion contain blood-vessels at first, but later these become more or less obliterated, although there is not the same tendency to death of tissue as is found in tuberculous lesions. About these zones there is usually present a certain amount of emphysema.

In well-marked cases of the diffuse variety more or less of the pleura is adherent and greatly thickened, and the affected lung is smaller than normal and cannot be separated from the chest wall without tearing. The lung feels firm and leathery. The heart may be drawn to the affected side, and its right half may be hypertrophied.

On section the pleura is seen to be tough, fibrous, and of a grayish color. There is often a creaking sound as the lung is cut. The cut surface is firm, shiny, and of a dull red or bluish color or marbled. Much pigment is often present throughout the lung tissue and in the bronchial nodes. The walls of the small bronchi are increased in thickness and in many places dilated. Some of the dilatations are large and often contain varying amounts of pus. The microscope shows the new tissue to be connective tissue of the small-celled variety; most of the cells are round, but some are fusiform. There are at first blood-vessels in this new tissue, but they tend to disappear later; there is, however, as before mentioned, but little tendency to tissue necrosis. The walls of the atria, air sacs, and air cells are infiltrated with the new connective-tissue cells, and the air cells may contain organized exudate.

In the unilateral cases the unaffected lung is enlarged because of the compensatory emphysema present.

SYMPTOMS.—In looking for the symptoms of chronic pneumonia we first get a history of one or more of the diseases which it follows, especially chronic bronchitis or protracted bronchopneumonia. In the early stages the patient may feel fairly well, complaining only of cough with sero- or muco-purulent expectoration. The cough is worse in the morning, and is paroxysmal when there is an accumulation of secretion in the lower lobes. As the process advances there is dyspnœa on exertion. Lying on the unaffected side may cause dyspnœa, as it restricts the action of the functioning lung; consequently patients with unilateral chronic pneumonia lie on the affected side. With the onset of ulceration a new order of symptoms is noted, all of them being worse during the winter season. The sputum changes its character and becomes a thin muco-purulent fluid, of a gray or black color and is often fetid. On standing it separates into layers; the lowest contains solid particles and is yellowish in color; the next above is a greenish fluid; and the top layer is thin and frothy and contains mucus and fat. Cavities are formed, allowing of accumulations of pus, and these in some instances are emptied by change of position. Fever, of a hectic type, and night sweats may be looked for early, and small, frequent hæmoptyses are common occurrences. With the conditions present giving such symptoms, it is no wonder that the patient's general condition becomes rapidly worse. The whole aspect of the case is that of chronic pulmonary tuberculosis, excepting that no tubercle bacilli can be found.

There is no elevation of temperature except during exacerbations of the bronchitis and after ulceration has begun, as noted above. Pain is by no means a constant symptom. It is present only when the pleura is involved, and then the diminution of respiratory movement on that side usually keeps it from being very severe.

For months we may be able to discover only the physical signs of previous or coexisting disease. Gradually there develop signs due to diminution of aërating surface, thickening of pleura, contraction of the new tissue giving lessened or absent respiratory movement, deformity of the chest, spinal curvature, and displacement of the heart. The cardiac pulsations are sometimes abnormally visible. The dilatations of the bronchi, with or without contained fluid, also give rise to special symptoms. In unilateral cases the unaffected side is increased in size, has increased respiratory movements, and shows the signs of compensatory emphysema.

TREATMENT.—In the management of these cases prophylaxis is of the utmost importance. All patients with persistent bronchitis, or with protracted or unresolved pneumonias, and those who have had several attacks of bronchopneumonia, should receive the very best tonic treatment with respiratory exercises; and above all, they should find the climate in which they do best and should, if possible, live there. When the trouble is due to the occupation, this must be abandoned. No treatment directly affects chronic pneumonia when once it is estab-

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lished. The therapeutic endeavor is then to control the cough, overcome the fetor of the sputum, and keep up the general tone of the individual. The patients must avoid exposure to cold and wet. They must spend their winters, at least, in the South, and are better for living the year around in a dry, warm, equable climate. Moderate daily outdoor exercise and the best of food are very important.

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Diagnosis.—In aiming at a diagnosis of chronic pneumonia, we have to consider the possibility of pleurisy, cancer of the lung, pneumothorax, and pulmonary tuberculosis.

Prognosis.—The outlook for the future comfort and happiness of these patients depends largely upon their dispositions and their ability to get to a suitable climate. No hope of cure can be held out to them. The disease, however, is seldom in itself a cause of death. Some intercurrent malady usually terminates the scene.

Harry E. Hale.

PNEUMONIA, LOBAR.—(Synonyms: Croupous Pneumonia, Fibrinous Pneumonia, Pneumonitis, Lung Fever.) The lung differs from all other structures in having two separate circulations—the nutrient, supplied from the left side of the heart through the bronchial arteries, and the functional, supplied from the right side of the heart through the pulmonary artery. This double circulation underlies all the phenomena of pneumonia, and must be recognized in any definition of the disease, as without it the disease itself could not exist.

Definition.—Lobar pneumonia is an acute disease in which a specific parasite invades the air cells of one or more pulmonary lobes, where it grows in a fibrinous medium exuded from the functional capillaries, and generates a toxin that infects the system at large.

The local process causes consolidation of the affected area by filling the air cells with the effused material, which material is afterward removed, leaving the structure of the lung intact. The general infection is marked by fever, which in a typical case begins with a chill, and after a duration of from four to nine days ends abruptly by crisis.

In most cases a local dry pleurisy is excited, the phenomena of which are added to those of the pneumonia proper.

Death may take place from the virulence of the infection, from loss of respiratory surface, from exhaustion of the right heart, from consecutive asthenia, or from a combination of two or more of these causes.

Symptoms and Clinical Course.—The attack may be preceded by prodromes,[1] such as malaise, headache, anorexia, pain in the limbs and back, etc. But, as a rule, the first complaint of the patient is of pain in the chest, usually in the mammary region. This is sudden in its onset and often very severe, and by restricting the movements of the ribs renders the respiration superficial and rapid. In most cases a chill follows, or, it may be, precedes the pain. The chill varies from a mere creeping sensation to a heavy and prolonged rigor, as severe as in a case of intermittent fever. With the chill there is a rise of temperature. The thermometer shows from 3° to 4° F. of fever during the first twelve hours, rapidly rising until the temperature reaches from 103° to 105° F. or even more. Then there is a period during which the temperature is maintained with slight variations until from the fifth to the eighth day, when a crisis occurs and the temperature becomes normal, or often subnormal. Cough is an early symptom, but it is repressed as much as possible to avoid the severe pain which it causes. The expectoration is apt to be frothy at first and mixed with florid blood; later it becomes viscid and very tenacious, so that it is spat out with difficulty and adheres like thick mucilage to the vessel containing it. Its color at this stage varies in different cases. It may be a light yellow, a pale green, or a chocolate-brown, or a mixture of these colors. It is often likened to prune juice. Sputa of this kind may be considered pathognomonic. As resolution progresses the expectoration becomes less colored, less sticky in consistence, and more catarrhal or purulent in its character, and the quantity gradually diminishes until it ceases altogether.

The respirations are early increased in frequency, and this quite out of proportion to the pulse rate and temperature. In nearly every severe case the respirations will go up to 40 or 50 or more to the minute, and they not infrequently reach 60 or more when the consolidation is extensive, or pulmonary œdema takes place. This disproportionate frequency of respiration is very significant. The pulse is full and strong in the early stages, running from 90 to 100 when the temperature is 103° to 104° F., and becoming weaker and more frequent as the disease advances. When the respiration is greatly embarrassed the pulse is apt to be small and creeping.

The skin is hot and dry at first, later there is a tendency to perspiration, which may be profuse. The face is pale, with often a dusky red patch on each cheek. The lips are inclined to a bluish hue in proportion to the degree of pulmonary implication. They are often the seat of an herpetic eruption.

After the first forty-eight hours the chlorides in the urine are greatly diminished, or entirely absent. In severe cases a moderate degree of albuminuria is common during the height of the disease.

The physical signs begin to be appreciable, as a rule, within from twelve to twenty-four hours after the initial chill. Usually the first to be noticed is a fine crepitant râle, heard only with inspiration, though in some cases this is preceded by a diminished clearness of the respiratory murmur. Dulness on percussion succeeds, increasing in intensity as the consolidation becomes more complete. Ultimately the respiratory murmur is wholly replaced by a peculiar whiffling sound heard most distinctly toward the close of expiration, the so-called tubular breathing. If the pleura is involved there may be a rubbing or creaking sound in addition. There are increased vocal resonance and vocal fremitus. At the crisis, while the temperature falls and the pulse and respiration become less frequent, there is no immediate change in the physical signs, showing that the condition of the affected area remains the same.

In a large proportion of cases of pneumonia there is decided leucocytosis, the white cells numbering 20,000, 30,000, 40,000 or more to the cubic millimetre.

Variations from the above course are common. The pain may be entirely absent, or it may be felt at a point outside the chest, as for instance in the abdomen. The chill is absent in about one-third of all cases. The subsequent severity of the attack seems to be in some degree proportioned to that of the chill, but this rule has many exceptions, especially in advanced age. The temperature begins to rise from the moment of the attack, and increases with slight fluctuations until the maximum is reached. In cases that pass the crisis the highest point is usually a few hours before the decided fall takes place. When death takes place before the crisis, the highest point often immediately precedes dissolution, when it may reach 107°, 108°, or even 109° F.

When defervescence occurs by crisis, which is usually from the fifth to the eighth day, the temperature falls within a few hours almost or quite to normal. This is apt to occur during the night, and it often happens that the patient is left at the evening visit with no sign of an approaching decline of temperature, yet the next morning is found in an almost afebrile condition.

Within a day or two after the crisis the temperature very often becomes subnormal.

In a considerable proportion of cases instead of crisis there is a gradual fall of temperature until the normal line is reached. This defervescence by lysis may be complete at any time between the third and the fifteenth or twentieth day.

Delirium.—As the pyrexia increases, delirium is pretty frequently observed. Occurring early, and in persons having a tendency to cerebral disturbance in the presence of fever, it may have but little significance, but in other cases it is due directly to the infection, and it then points

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to a condition of considerable gravity. Old persons are especially liable to a quiet delirium resembling that of typhoid fever.

Sleeplessness is not at all uncommon, and should always suggest an inquiry into the habits of the patient,

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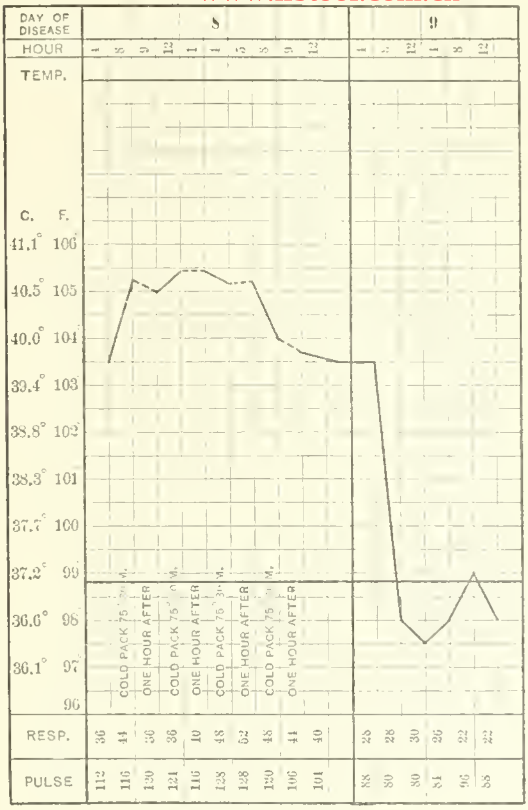

FIG. 3829.—Defervescence by Crisis.

for while it is not confined to those with alcoholic antecedents, it is much more frequent in such persons, and in the absence of delirium the key to the problem might be overlooked. In non-alcoholics the condition seems to be one of cerebral irritation at first, and later, perhaps, of cerebral exhaustion.

In children often, and very rarely in adults, convulsions take the place of the initial chill.

Causes of Death.—Death may occur in a variety of ways. The patient may be overwhelmed by the intense virulence of the infection, death occurring within from thirty-six to forty-eight hours after the chill. Apparently all the vital functions are overpowered by the toxæmia. There is extreme muscular and nervous prostration, the heart's action becomes rapid and feeble, digestion is suspended, the kidneys act imperfectly, delirium and coma supervene, and death occurs from acute asthenia.

In other cases death is caused by exhaustion of the right heart. The muscle, already enfeebled by the action of the poison, tires out from overwork, dilatation and over-distention follow, and finally, failure to contract.

Still another cause of death is loss of respiratory surface. This is rarely the result of simple pneumonic consolidation, but there are added to this, congestion and œdema of other portions of the lung. The lung fills up more and more, and death by asphyxia takes place.

Not infrequently death comes from exhaustion of the vital powers after a protracted struggle which the system is no longer able to endure. This is common in feeble and aged persons, and occurs usually after the febrile period.

Lastly, death may be caused by one or more of the complications of the disease.

In addition to the foregoing, sudden death may occur at any stage of the disease in a manner which, with our present knowledge, cannot be accounted for, and for which there is no anatomical explanation.

PATHOLOGY.—*Autopsical Findings.*—These correspond to a process extending from simple hyperæmia through extreme engorgement, fibrinous and cellular exudation into the air cells, complete consolidation, fatty degeneration of the exudate, and removal of the latter by absorption and expectoration. All of these stages may be represented at the same time in different portions of the lung.

The earliest lesion is simple congestion. When the chest is opened a portion of the lung may be found in this condition. It is not so fully collapsed as the surrounding normal lung, and to the touch it is slightly more resistant. On section the surfaces are bright red, and exude a bloody frothy serum. The physical sign corresponding to this condition is a slight localized feebleness of respiration, with more or less abundant moist râles. A few hours later the hyperæmia has passed into an extreme degree of vascular engorgement. The diseased part shrinks but little when the chest is opened. The pleural surface is of a deep red color, veiled by more or less of fibrinous exudate, which peels off readily in flakes. The resistance to touch is markedly increased,

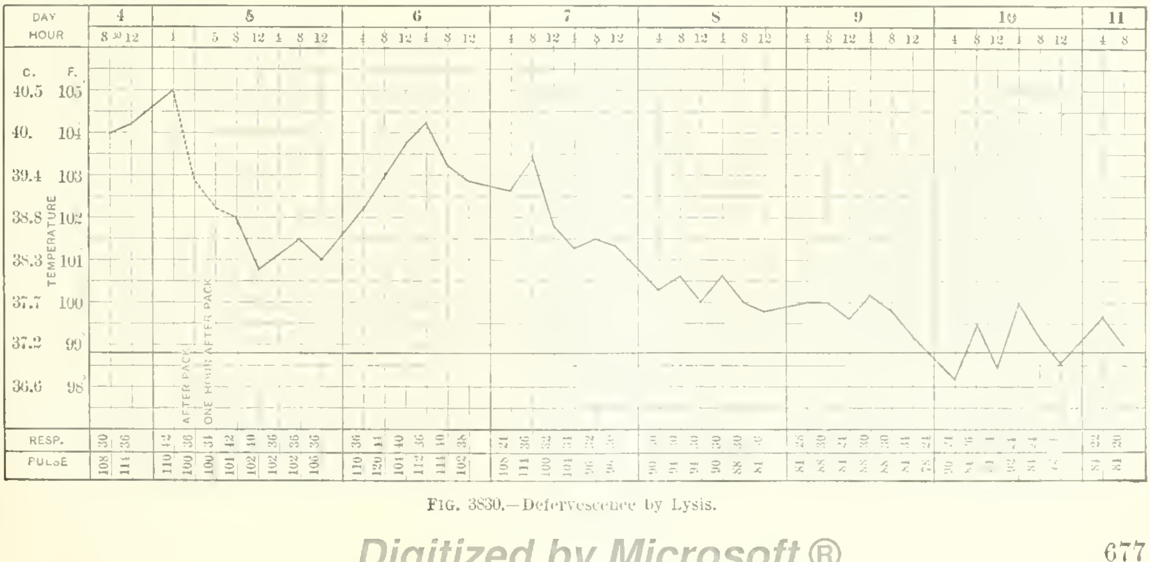

FIG. 3830.—Defervescence by Lysis.

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and on section the tissue is more readily divided than in healthy lung. The cut surfaces are dark red, and dark blood mingled with air follows the knife. The appearance resembles closely that of an incised spleen, and the term splenization is applied to this stage of the local disease. Microscopically, the pulmonary capillaries are found distended with blood, more or less fluid occupying the air cells. But the lung still crepitates between the thumb and finger, and can be squeezed dry without breaking down. A piece of it thrown into water floats.

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The corresponding physical signs are diminished resonance on percussion, broncho-vesicular respiration, crepitant râles, and slightly increased vocal resonance. A pleural friction sound also is often present.

In the next stage the air cells are filled with a fibrinous exudate, by which the parenchyma is completely solidified. If a considerable area is involved, the lung is increased in volume, and pushes out into the intercostal spaces, so that furrows are imprinted on its surface by the ribs. The lung is usually covered by a dense layer of fibrin, which, if removed, shows a deep mottled red or purple color beneath. This layer is adherent to the costal pleura also, and the separation leaves both surfaces rough and irregular. When cut into, the solidified mass has much the consistence of liver, and is dark red or brownish-red in color, and for this reason the condition is known as *red hepatization*. A piece of lung in this condition will sink in water. The infiltrated tissue does not crepitate on pressure, is friable, and can be torn much more readily than normal lung structure. During this stage the weight of the lung may reach 2,500 or 3,000 gm., instead of 600 gm. which is the normal average.

Microscopically the contents of the alveoli consist

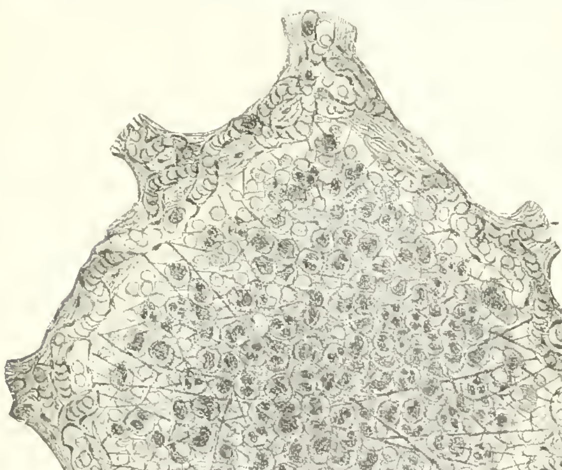

Fig. 3831. Air Cell Filled with Pneumonic Exudate. (Drawn by Dr. Louise Cordes from a specimen in the laboratory of the Presbyterian Hospital, New York.)

chiefly of fibrin in the form of a delicate mesh, red blood corpuscles, leucocytes, epithelial cells, and numerous diplococci pneumoniæ. Other organisms, such as streptococci, staphylococci, etc., are often found associated with the specific microbe.

In this stage the capillaries derived from the pulmonary artery are occluded, and the resulting thrombosis extends back into the larger vessels. The septa between the air cells are but little changed. The nutrient vessels remain pervious.

The physical signs of hepatization are dulness approaching to flatness, and increased resistance on percussion, with tubular breathing, or perhaps entire absence of respiratory sound and increase of vocal resonance and of vocal fremitus.

Succeeding the stage of red is that of *gray hepatization*. Much of the red coloring matter has been removed by absorption, white corpuscles have been added in great numbers, and the formed elements in the contents of the air cells have degenerated into a fatty, granular material. Hence the change in color. The tissue is softer than in the previous stages, so that the finger can be thrust into it, and the pit thus made fills with a dirty puriform fluid.

As resolution progresses, the infiltrated material is gradually removed, partly by absorption, partly by expectoration, and little by little the air regains access to the alveoli. It is several days, however, before the physical signs get to be entirely normal.

Often, besides the specific pneumonic lesion limited to a certain area, there is congestion in other parts of the same lung, and perhaps in its fellow. This may be so intense, and the resulting secretion so abundant, as to leave insufficient breathing surface, and thus be the immediate cause of death. The congestion may be hypostatic, when it will be limited to the dependent portion of the lung, or it may be due to cardiac weakness and affect all parts. Very frequently more or less pulmonary œdema is present.

Abscess of the lung as an event of pneumonia occurs in between one and two per cent. of all cases. The abscesses vary in size from that of a pea to the dimensions of the entire lobe.

After death from pneumonia the left cavities of the heart are usually found nearly or quite empty, while the right are distended by firm coagula that often extend into the branches of the pulmonary artery. The spleen is often enlarged and the liver congested. The cells of the renal tubes may be in the condition of cloudy swelling, and in a small proportion of cases there is fully developed "nephritis."

Pathology.—It is now very generally conceded that the essential phenomena of pneumonia are due to the action of one or more forms of bacilli. In nearly every case the diplococcus of Fränkel is found in the exudate. With this are sometimes associated other micro-organisms in such number as to suggest that they may play an important though subsidiary part in both the local process and the general infection.

As to the relation of the specific organism to the disease as a whole, we may note:

First, that no amount of traumatism inflicted upon the lung, be the methods ever so varied, produces pneumonia. We may cut, bruise, burn, or scald the lung; we may introduce mechanical or chemical irritants into the air passages, and while we get a certain kind of reaction as the result, we do not get pneumonia.

Second, we may have pneumococcic infection in several serous and synovial cavities at the same time, resulting in suppuration in each, and not have pneumonia.

Third, we may introduce the pneumococcus into any portion of the body save the lungs, and even into the blood itself, and not get pneumonia.

Fourth, but if we introduce active pneumococci into the parenchyma of the lung we get pneumonia as the result.

Fifth, in probably every case of pneumonia coming to autopsy during the active stage, if the search is properly conducted, the presence of pneumococci in the lung can be demonstrated.

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The inference from these facts is that the one thing necessary for the development of pneumonia is the presence in the alveoli of pneumococci in a condition of active multiplication.

It is known that pneumococci exist in the upper air passages of a considerable proportion of persons in absolute health. It is necessary only that favoring conditions should result in the translation of some of these into the alveoli in order that pneumonia occur. Once in the air cell the specific organism produces its specific irritation, causing effusion of the specific exudate. In this exudate as in a culture medium the coccus grows and separates its specific toxin, which in turn is absorbed into the blood, and gives rise to the fever and other manifestations of toxæmia.

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So long as fresh supplies of toxin are being formed, or in other words, so long as the consolidation is spreading, so long the toxæmia will be maintained. But here again, as in artificial cultures, there is a limit beyond which the process cannot extend. A given quantity of culture medium can maintain the life of a given number of germs only for a certain time, beyond which the changes produced in it unfit it as a soil for the further growth of the organisms, and the death of the latter puts an end to the process. With the supply of toxin cut off, the temperature falls.

This does not exclude the theory of an antitoxin. Indeed, numerous observations, and especially those of the Klemperer brothers, go to show that a transient immunity is created by an attack of pneumonia, and that this immunity may be transferred to another subject by serum inoculation. This could scarcely be explained except on the theory of an antitoxin, and I can see no obstacle to accepting both theories in explanation of the phenomena in question.

The specific organism of lobar pneumonia is the *pneumococcus lanceolatus.* Discovered in 1880 by Sternberg, its causal relation to pneumonia was demonstrated by him a few years later. It is generally seen in pairs of oval or lancet-shaped elements surrounded by a capsule. In cultures, short chains of three or four members are common. Like other micrococci, it is non-motile. It grows in faintly alkaline media, and by transplanting every third or fourth day the growth may be continued indefinitely.

This organism is found, in all but a very small percentage of cases, in the expectorated material. Failure to find it is probably due to defective technique. When a pure culture is injected into the substance of the lung typical croupous pneumonia results.

When in a dry state the pneumococcus retains its virulence for long periods, especially when protected by being mixed with dried sputum. The disease has been communicated to newcomers in houses that had been closed for months.

Recent researches show that in fatal cases of pneumonia the specific diplococcus is quite commonly present in the blood, while in cases ending in recovery it is only exceptionally encountered.

Diagnosis.—A typical case of pneumonia seen from the beginning can scarcely be mistaken for any other disease. The abrupt onset, the pain, the chill, the fever, the respiration accelerated out of proportion to the temperature, pulse, and respiration, and, finally, the peculiar expectoration, will suffice to establish the diagnosis even without the aid of the physical signs. But when the latter are added, and we have fine crepitation with inspiration and a little later a blowing sound with expiration, while the vocal resonance and the vocal fremitus are exaggerated, and the percussion note becomes constantly duller until it approaches flatness, there is presented a picture which for vividness and individuality can hardly be surpassed.

But not all cases of pneumonia run a typical course. There is scarcely one of the classical symptoms or signs that may not sometimes be wanting. In about twenty per cent. of all cases the chill is absent. Pain is not a marked feature unless the pleura is involved, and in central pneumonia it is often not severe enough to excite complaint. In feeble or elderly persons the fever may be slight; indeed, even apart from these conditions, some of the worst cases that we meet show but a moderate temperature throughout. The pulse may not correspond with the temperature; and the respiration, usually the most characteristic of the symptoms, is sometimes not strikingly frequent. Cough and expectoration may be entirely absent, or the cough may bring up only a little frothy mucus from the bronchial tubes. Apart from the above, the diagnosis involves differentiation from quite a range of affections, such as bronchopneumonia, pulmonary œdema, pleurisy with effusion, pulmonary phthisis, cancer of the lung, atelectasis, engorgement in fever, typhoid fever, for which the reader is referred to the articles in which these affections are discussed.

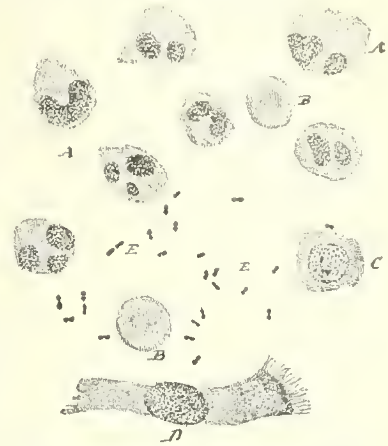

Fig. 3832.—The Micrococcus Lanceolatus in Pneumonia Sputum. *A A*, Leucocytes; *B B*, red blood cells; *C*, epithelial cell; *D*, ciliated epithelium; *E E*, pneumococci. × 1000.

Complications.—There are several affections that so often appear with pneumonia as to make it reasonably certain that there is a common influence at work, and this influence can often be found in the presence of the pneumococcus in the locality in question. The following tables show the complications observed at the Presbyterian Hospital, New York:

Complications of Pneumonia.

Out of 488 Cases.

	Number of cases.	Recovered.	Died.
Pleurisy with effusion	20	17	3
Pericarditis (acute)	6	1	5
Otitis media	6	6	
Thrombosis of femoral vein	3	3	
Bronchitis	13	9	4
Jaundice	2	1	1

Out of 304 Cases.

	Number of cases.	Recovered.	Died.
Gangrene of leg	1	1	
Delayed resolution	7	7	
Relapse	2	2	
Delirium tremens	11	5	6
Pyæmia	2	..	2
Abscess of lung	1	1	
Laryngitis	1	1	
Erysipelas	2	2	
Persistent bronchopneumonia	1	1	
Acute nephritis	3	2	1
Œdema of lungs	6	1	5
Empyema	10		

Prognosis.—This is modified by a number of preexisting conditions, the principal of which are sex, age, season of the year, habit as to the use of alcohol, and the presence or absence of certain chronic diseases.

While pneumonia is more frequent in men, it is more fatal in women. Of 223 patients in the Presbyterian Hospital 170 were males, with a mortality of 28.8 per cent., and 53 were females, with a mortality of 31.2 per cent. The mortality in reference to age is shown by the

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following table taken also from the records of the Presbyterian Hospital:

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Pneumonia—434 Cases.

Relation to age.	Died.	Percentage dying.	Recovered.	Percentage recovered.
Below 5 years	0	0	13	100
Between 5 and 10 years	0	0	18	100
Between 10 and 15 years	1	9	11	91
Between 15 and 20 years	7	23 +	23	76 +
Between 20 and 30 years	28	22 +	95	77 —
Between 30 and 40 years	37	37 +	62	62 +
Between 40 and 50 years	31	42 +	42	57 +
Between 50 and 60 years	16	47 +	18	52 +
Between 60 and 70 years	16	66 +	8	33 +
Over 70 years	5	62 +	3	37 +
	141	32 +	293	67 +

As to seasons of the year, the spring months give the lowest mortality, the summer shows a slight increase, while in the autumn and winter the percentage of deaths is greatest.

The habitual abuse of alcohol unfits the system to bear up against pneumonia, as is shown by the following table:

Pneumonia—428 Cases.

Relation to alcoholism.	Died.	Percentage dying.	Recovered.	Percentage recovered.
Markedly alcoholic	36	70	15	29
Moderately alcoholic	52	32	109	67
Non-alcoholic	45	20	171	79

Among pre-existing conditions a rheumatic habit, diabetes, and chronic renal insufficiency, especially if associated with cardio-vascular changes, render the prognosis much more serious. The presence of advanced valvular disease leaves but little chance for recovery. Of the conditions arising in the course of the disease and affecting the prognosis, the first is the initial chill. This occurred in 144 out of a series of 223 cases, with a mortality of thirty-four per cent., while the remaining 79 cases in which the chill was absent gave a mortality of only nineteen per cent.

The prognosis depends largely upon the extent of the pneumonia. When both lungs are involved not half of the patients recover. Pneumonia occupying the whole of a lung is more dangerous than when only a part is involved. The right lung is more frequently implicated, and also gives a higher mortality.

A feeble pulse that is frequent in relation to the respiration and temperature is a disquieting element, as is also a very frequent respiration, especially when it occurs with a moderate temperature.

Up to 105° F. the danger does not seem to increase materially with the rise of the thermometer. A higher temperature, however, tells immediately upon the death rate.

A physical sign that has an important prognostic significance is accentuation of the pulmonary second sound. This is the result of increased tension in the pulmonary artery, and is a measure of the obstruction in the lung on the one hand, and of the power of the right ventricle on the other. If this accentuation becomes less marked it is either because the obstruction is diminished, which is a favorable sign, or because the right ventricle is becoming weaker, with all that this implies. Which of these two conditions is present is easily determined by the general symptoms.

A considerable increase in the number of the white blood cells is, as a rule, a favorable indication, while a low count is unfavorable. In anything like a severe case the prognosis is alarming if the leucocytosis remains below 12,000 or 14,000. On the other hand, a high leucocytosis persisting after the temperature falls indicates further trouble in store, probably some complication.

It is generally believed that the presence of herpes labialis is of good augury. If there is an absence of expectoration in the second and third stages, or if the expectoration becomes scanty and difficult, the outlook is grave. A sudden cessation of expectoration, if accompanied by tracheal râles, indicates the near approach of death. Late delirium is an unfavorable sign, as are also apathy and somnolence.

The mortality in pneumonia differs enormously under different conditions. It is much greater in hospitals than in private practice, and in civil than in military hospitals. In civil hospitals it runs from twenty-five to thirty per cent., while in private practice it is scarcely half so great. The death rate is much higher in some years and in some localities than in other years and in other places.

Etiology.—While the essential cause of pneumonia is the development of a specific germ in the pulmonary alveoli, there must be a contributing cause that in some way opens the system to attack. Among the predisposing causes are the following:

Sex. Males are more liable to attack than females.

Age. If the total number of persons living at any given age be considered, it is probable that the ratio of cases in successive decades is fairly uniform except during the most active period of life when exposure is greatest.

Race. In America, the negro race is decidedly more liable to pneumonia than the white.

Former Attacks. A person who has passed through one attack is more liable to another.

Unsanitary Living. Pneumonia occurs more frequently in dark, crowded, and ill ventilated dwellings than where the supply of light and air is ample.

The principal exciting causes include exposure to cold, exhaustion, the presence of some other infectious disease, and operations under the use of an anæsthetic.

Although not readily communicable, pneumonia may undoubtedly be transmitted from person to person. Indeed, it quite frequently assumes the form of a veritable epidemic. In addition to this, certain houses have been observed to furnish, year after year, an undue proportion of cases, which seems to indicate that the infecting principle lurked in the apartments.

As to the etiology of pneumonia in general, we are obliged to admit that in a large proportion of cases the attack appears to come on spontaneously.

Treatment.—A correct treatment of pneumonia must recognize that the disease is essentially a germ culture going on in the air cells of the affected part. The causal indication, therefore, is to inhibit this culture. The debatable question is whether such inhibition is practicable by any safe means within our reach. The writer is firmly convinced that it is; and observations sustaining this view are rapidly accumulating from many sources. The problem requires that we rid ourselves of the conception of an "inflammatory" process carrying on an independent work of its own, over and above the response of tissue to the irritation of the micro-organism. This irritation depends upon a specific vital property of the pneumococcus, as is shown by the fact that no other irritant whatsoever will produce a like result. If, therefore, we can so modify the bacterium that it loses its specific irritant property, the essentially pneumonic changes in the lung will be arrested. This then is the first indication for treatment, and it is as unwise to defer action upon it until the case becomes severe, as it would be to defer opening an abscess until the signs of pyæmia should appear.

It is clear that the material exuded into the air cells must contain its share of any substance circulating in the blood from which the exudate is derived. This makes it possible to impregnate the exudate with any desired medicament, including one inimical to the pneumococcus. It is not necessary to kill the germ; it is enough to inhibit its growth, a very much easier thing to do.

A considerable number of drugs seem to be capable of producing this effect. The salicylate of sodium or am-

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monium has, up to the present time, been the most efficacious. It is given in doses of ten or fifteen grains every two hours. In a large proportion of cases, especially if given early, it will affect the temperature at the end of

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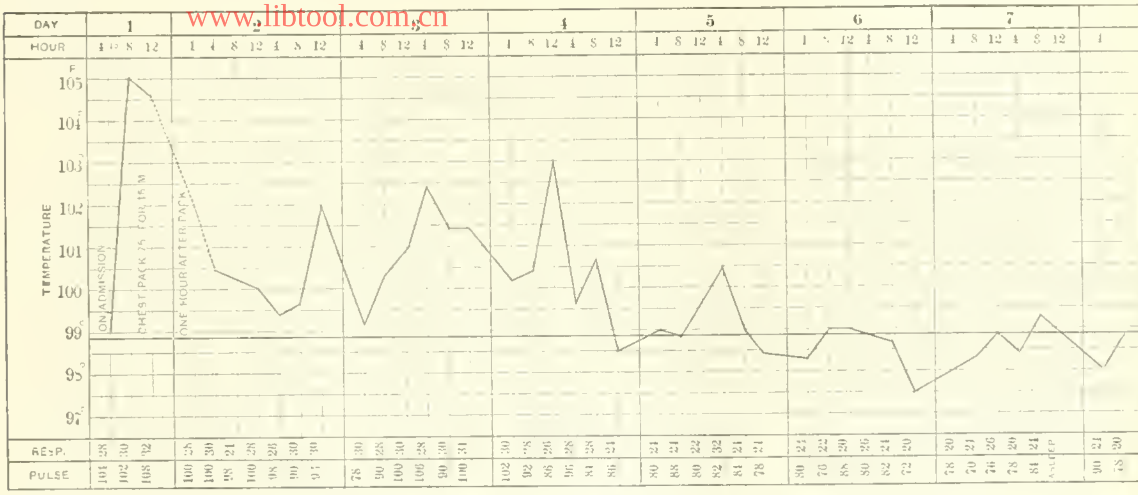

FIG. 3833.—Case Treated with Ammonium Salicylate. Patient was admitted immediately upon the occurrence of the chill, and twenty grains of the drug were administered every four hours. Temperature reached the normal on the fourth day.

twenty-four hours, and bring about a defervescence by lysis in the course of the two or three days following. Recently Dr. George Peabody has substituted aspirin in doses of fifteen grains four times a day. Of twelve cases treated in this way all ended in recovery, and in every case defervescence was by lysis.

Creosote and its carbonate have also been employed successfully in a very considerable number of cases. Of the carbonate ten or fifteen minims are given every two hours, either in emulsion or in capsules.

The substitution of lysis for crisis in a large majority

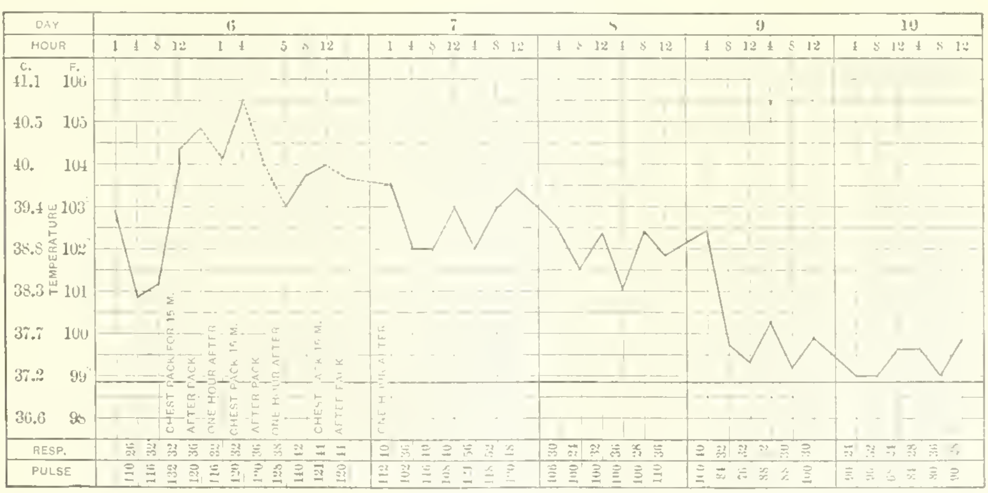

FIG. 3834.—Patient having Double Pneumonia who was Treated with Sodium Salicylate. Entered hospital on the third day of the disease with pneumonia of the lower right lobe. On the sixth day the left lower lobe became involved. Cold applied to the chest for temperature above 103.5° F., and twenty grains of sodium salicylate administered every four hours. Defervescence by lysis. Normal temperature on the tenth day.

of cases is a very remarkable result of remedies of this class, and demonstrates the power they possess to modify the usual course of the disease.

Specific medication of this kind is more efficient the earlier it is resorted to, but it is not without value at any stage of the disease. Many remedies besides those mentioned above have been employed with more or less success for their anti-bacterial effect, but have nothing especially to recommend them.

Aside from specific measures, the treatment of pneumonia will be in accordance with the following indications: Stimulation of the emunctories to throw off the poison as it forms; sustaining the vital powers and particularly the heart; relieving the pulmonary circulation; compensation for loss of respiratory surface by the inhalation of oxygen; reduction of excessive temperature; relief of incidental symptoms.

It is well at the outset to relieve the bowels by an efficient cathartic, and for this purpose nothing answers so well as calomel. Its operation is often followed by a considerable fall of temperature which may be permanent. If the urine is scanty a diuretic is called for, and the best of all is an abundance of cold soft water.

The vital powers must be sustained, and at the first evidence of flagging strychnine, strophanthus, caffeine, or other heart tonic is called for. Much harm is done by a routine use of digitalis. This drug increases the periph-

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eral resistance and thus adds to the labor of the heart, while at the same time it favors venous congestion by lessening the capacity of the arterial system. Its use is admissible when cardiac arrhythmia is present, but it should always be guarded by an arterial dilator. Alcoholic stimulation may be required almost from the first, particularly in those patients who are addicted to its use. It is indicated when the pulse is small and thready, or when there is persistent delirium in an alcoholic subject. When under its use the temperature shows a reduction, and the pulse loses in frequency and gains in volume, we may be sure that the alcohol is doing good. It should not, however, be given in such quantity that its odor remains persistently in the breath.

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The pulmonary circulation may require to be relieved by dividing the blood more equally between the arteries and the veins. This is accomplished by the use of arterial dilators. Of these sodium nitrite in doses of two grains every two hours gives the most satisfactory and even result. It can be supplemented by nitroglycerin as occasion demands. The indication for arterial dilators is found in a small and creeping pulse with failing pulmonary second sound and a tendency to cyanosis. In cases presenting these conditions in an extreme degree venesection followed by saline infusion will sometimes prove singularly beneficial.

Compensation for loss of respiratory surface may be secured to some extent by inhalations of oxygen. These should be resorted to whenever the respirations exceed forty per minute, and they may be made continuous if the condition persists.

For the reduction of excessive temperature cold sponging and an ice-cap to the head are the most available means. When the fever produces extreme jactitation, tending to nervous exhaustion, the coal-tar preparations may be employed very cautiously and for brief periods.

For the relief of pain hypodermic injections of morphine are by far the best means at our command. They are efficient, and at the same time, by slowing and deepening the respiration, they improve the circulation in the affected part. They are to be used with care, however, and their frequent repetition is to be avoided. Hot poultices on the one hand, and ice bags on the other, are preferred by many, and are fairly efficient. In mild cases dry cups or sinapisms may suffice.

The feeding of the patient requires close attention. The tendency is to feed too highly. The conditions present are very unfavorable to digestion, and undigested food in the alimentary canal gives rise to flatulent distention and greater embarrassment of respiration, besides being a burden rather than a help to the vital power already overtaxed.

A concentrated fluid food that will not readily ferment is to be given, but in no greater quantity than can be easily digested and assimilated.

An abundance of fresh air from first to last is indispensable, and anxiety lest this should cause the patient to take cold should be dismissed. "Antiseptic precautions" should be adopted.

Serum therapy has not yet established its claim to be adopted, though the prospect for the future is somewhat encouraging. *Andrew Heermance Smith.*

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PNEUMONIA OF INFANTS.—The acute pneumonia of infants may assume one of two distinct types—either that of an acute lobar pneumonia or that of an acute bronchopneumonia or lobular pneumonia. The former type, which is less common than the other, is caused by the pneumococcus, develops as a primary disease, has an acute onset, runs a short course, is characterized by a continuous high temperature, ends by crisis, and allows a good prognosis. The other type of pneumonia is the most common disease of infancy, is usually secondary, may be caused by one of several micro-organisms, is variable in onset, runs an indefinite course with irregular temperature, ends by lysis, and allows a less favorable prognosis—that is, one which depends largely on the disease to which it is secondary.

LOBAR PNEUMONIA.

Infantile lobar pneumonia—croupous pneumonia: Fr., *La pneumonie franche;* Ger., *Primäre genuine Pneumonie*—corresponds in some measure to the lobar pneumonia of adults, but it allows a more favorable prognosis. Lobar pneumonia is an acute disease of short duration, characterized by inflammation and hepatization of a certain area of lung tissue, and is caused by the pneumococcus.

ETIOLOGY.—The disease is almost always primary. Although it is less common before the third year, it may occur in early infancy. In fact, cases have been reported in which the disease developed before the birth of the child.

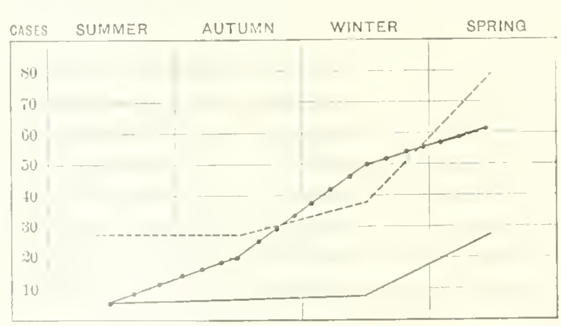

FIG. 3835. Chart Showing the Frequency of Lobar Pneumonia in Infants and Children at Different Seasons. - - - - - -, Cases reported by Dr. Comby; •—•—•, cases reported by Dr. Holt; ———, cases reported by Drs. Northrup and Freeman.

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All statistics seem to agree that boys are more frequently affected with the disease than girls, the general ratio being 60 per cent. boys and 40 per cent. girls. Comby reports that in 172 cases seen by him 105 were in boys and 67 in girls. Of 44 cases reported by Henoch 24 were in boys and 20 in girls. Holt reports 60 per cent. of his cases as occurring in boys. Rilliet and Barthez, out of 408 cases, report 221 in boys and 187 in girls. Of 42 cases at the Foundling and Nursery and Child's hospitals in New York 25 were in boys and 17 in girls, or 60 per cent. in boys and 40 per cent. in girls.

Season.—This disease is seen most often in the spring. The accompanying chart (Fig. 3835), constructed from data by Comby and Holt and the authors of this paper, shows the frequency of lobar pneumonia, in children, in New York and Paris at different seasons. Exposure to cold, traumatism, contagion, and previous poor health have been mentioned as occasional etiological factors; but if they do play any part in the production of this disease, except by lowering the resistance, this must be true only in rare instances.

The micro-organism regularly found in the sputum and in the lesion, and occasionally in the blood, is the micrococcus lanceolatus or pneumococcus of Fränkel. Various other bacteria may be associated with the pneumococcus.

Pathology.—The focus of the disease may be located in various parts of the lung, but certain lobes are more often affected than others. Holt finds that the left lower lobe is the one most often affected, the next in order being the right upper and the right lower. Comby, on the other hand, finds that the right upper lobe is much more frequently affected, the next in order being the left upper and the left lower. Monti, who has had a large experience with the disease in Vienna, considers that the right upper lobe is much more often involved than the left, and the left lower much more often than the right. The cases collected by the present writers show that the right upper, the right lower, and the left lower lobes are about equally often affected, while the left upper lobe is the least apt to be involved. The exact figures of relative frequency are as follows:

	Right upper.	Right lower.	Left upper.	Left lower.
Holt	2	3	..	1
Comby	1	..	2	3
Ashby	2	..	..	1
Northrup and Freeman	2	3	..	1

So far as its general characters are concerned, the lesion of lobar pneumonia in children corresponds to that in adults. It will therefore not be necessary to describe them here in detail (see article on *Pneumonia, Lobar*, by Dr. A. H. Smith). The disease is an acute exudative inflammation of the lung, in the course of which the air spaces become filled with red and white blood cells, serum, and fibrin. At the same time there is developed a toxæmia from the absorption of the poisons which are produced in the lungs. The lesions are not usually in the same state of development in all parts of the involved lung tissue at the same time, for while one area is in the condition of red hepatization, a neighboring area may show gray hepatization.

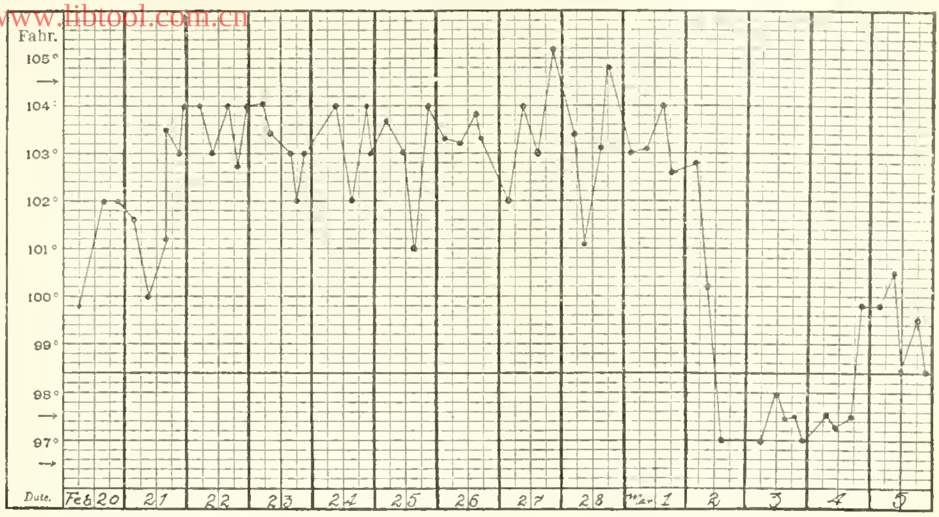

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Fig. 3836.—Temperature Chart of a Case of Lobar Pneumonia in a Baby of Nine Months.

Resolution does not always take place. The products may persist and become organized, or they may break down and form an abscess, or, finally, a necrotic process may ensue and gangrene manifest itself. In the lobar pneumonia of infants, however, these terminations are less often observed than they are in adults.

Pleurisy, with the development of fibrin only, or with a plastic exudate, or with pus, may accompany the pneumonia. A bronchitis is usually present. Pericarditis, endocarditis, and meningitis occasionally occur.

No sputum is, as a rule, expectorated by infants, all that is coughed up is swallowed. We have found that the sputum may best be obtained for microscopic examination by washing out the stomach half an hour after the child awakes and before food is given. Where this fails sometimes titillating the pharynx causes cough and ejection of small masses of muco-pus.

A leucocytosis appears at the beginning of the disease, and increases in intensity, disappearing as the temperature drops.

Symptoms.—There is no incubation stage in the lobar pneumonia of infancy. The baby becomes suddenly very severely ill. It usually vomits and has a rapid rise of temperature. Convulsions may occur with the onset, especially in infants that have rachitis. Chills are rarely seen with the onset of the pneumonia of infancy. The child becomes dull and apathetic. With the rise of temperature the pulse rate is increased, while the respiration is increased out of proportion to the pulse rate. Thus the ratio of respiration to pulse, which normally should be one to four, approximates that of one to three. The child develops a short dry cough, and is apt to have an expiratory grunt. The alæ nasi expand with each inspiration. The child's face is usually flushed and the skin dry. The severity of the attack may usually be judged from the degree of elevation of the temperature. Cerebral symptoms often accompany the disease. Convulsions are occasionally seen, while stiffness of the back of the neck, stupor, and delirium are often present.

The typical temperature chart of the lobar pneumonia of infancy shows a rapid rise of temperature to about 104° F., slight morning remissions and evening exacerbations continuing for less than a week, and the disease ending by crisis. Such a chart is shown in Fig. 3836; it

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represents the variations in temperature observed in a child nine months old while passing through an attack of lobar pneumonia. In other cases the remissions are more pronounced, the charts resembling more nearly those of bronchopneumonia, but differing in the fact that the disease now under consideration runs a short course and ends by crisis. The temperature continues to be elevated for about a week, and then usually falls somewhere between the fifth and the tenth days. It may fall on the second day or may persist for fully two weeks.

The pulse, which is at first full and strong, varying from 120 to 160 beats per minute, later becomes weaker, more rapid, and sometimes irregular or intermittent. The respirations are also increased in rapidity, even more so than the pulse; they may reach as high a rate as 40 or 60 or even 80 per minute. Usually, however, they bear to the pulse a ratio of one to three or at times one of even one to two and one half. The inspirations are short and the expirations long and accompanied often by a characteristic grunt or groan.

Physical Signs.—The physical signs of lobar pneumonia in infancy differ so materially from those usually found in adults that they should be especially emphasized. These physical signs are usually late in appearing and are less regular and well defined, while in some cases no physical signs at all can be elicited until after the temperature has dropped.

Many cases show, at the beginning of the attack, evidences of congestion; these being recognizable in the form of slight dulness on percussion and diminished respiratory murmur, at times quite pronounced. In many of the cases neither of these signs is present, but on carefully going over the chest there will be found a small area where subcrepitant or crepitant râles will appear at the end of a deep inspiration. In other cases the first sign will be a small area of high-pitched breathing, which may or may not have the true bronchial character. In whichever of these manners the signs first appear, other of the usual signs of lobar pneumonia in the adult are gradually added, so that in most cases, before the end of the week, the chest will present, in some particular area, a group of characteristic signs, the most important of which are dulness on percussion, bronchial breathing and bronchial voice sounds, and increased vocal fremitus. In some cases the disease manifests the characteristic onset and range of temperature, the ratio of the respiration to the pulse is as one to three, the alæ nasi are dilated, and the expiration groan is present, and yet no signs of consolidation can be made out in the chest. However, the signs in the chest are not essential for the establishment of the diagnosis in any given case provided there be present the group of symptoms just enumerated. In some cases the chest signs will first make their appearance at the time when the temperature falls. Again, in other cases, while there may be no definite signs of consolidation, percussion over the area situated below the clavicle may elicit an exaggerated or tympanitic percussion note, a sign which is believed by Comby to be of great value as indicating an involvement of the pleura or lung on that side.

Complications.—The most frequent complication is a general bronchitis, which may be the result of an infection with other micro-organisms than the pneumococcus. This complication may cause a greater daily variation in the temperature than is usually seen.

Next in point of frequency are the pleural lesions. At autopsies of these cases a dry pleurisy over the consolidated area—indicated by a lack of lustre in the pleural surface—is usually seen. In six or eight per cent. of these cases some exudate of a fluid or plastic character may form in the pleural cavity. When this is marked it forms a thick layer of fibro-purulent exudate of a yellowish color and shaggy appearance, accompanied by more or less purulent fluid. The character of this exudate in children is important, for in some cases it is thrown out in considerable amount, and yet only a small portion of it is free fluid. This small quantity, however, is sufficient to yield the physical signs of the presence of fluid in the pleural cavity and consequently to justify puncturing the chest wall with a needle. But the operation, under these circumstances, is very apt to prove unsuccessful, owing to the fact that the needle becomes occluded by the thick exudate.

Meningitis caused by the pneumococcus may occur as a complication, as may also pericarditis.

Diagnosis.—The diagnosis should be based on the history of an acute onset in the midst of good health, on the ratio which the respirations bear to the pulse rate, on the prolonged expiration, on the expiratory grunt, and on the dilatation of the alæ nasi. If the diagnosis can be confirmed by physical signs on examination so much the better, but the absence of these signs need not invalidate the diagnosis.

Prognosis.—The prognosis in primary uncomplicated lobar pneumonia in previously healthy infants is good, the mortality varying from three to five per cent. The prognosis is graver in children that have not been robust. The presence of only a slight leucocytosis is believed by Monti to render the prognosis worse.

Treatment.—On account of the possibility of communicating pneumonia to others, and for the good of the patient as well, a large, well-lighted and ventilated and quiet room should be obtained. But one person should be allowed in the room at a time. The number of cases which have presented at the onset the symptoms and physical signs of lobar pneumonia, but which have promptly recovered, is sufficiently large to warrant the belief that it is sometimes possible to abort the disease provided the efforts directed to the attainment of this object are made sufficiently early. Such treatment should consist in the administration of a single fairly large dose of calomel, the use of active counter-irritation by mustard paste, applied either over the whole thorax or simply over the suspected area, and the stimulation of the patient with strychnine. If no amelioration occurs within twenty-four hours after this treatment is begun, one may assume that the disease will run its course.

The medication, after the disease has once become established, should, as a rule, be directed either to the gastro-enteric tract or to the heart. Expectorants are rarely indicated. The tendency to constipation and tympanites, which is apt to embarrass the patient by interfering with the descent of the diaphragm, may usually be best treated by rhubarb or by a combination of rhubarb and soda. Heart stimulants are usually indicated early, and of these strychnine is the most valuable; it should be given in rather large doses, gr. $\frac{1}{100}$ to gr. $\frac{1}{50}$ every three or four hours. When the extremities are cold nitroglycerin is useful. Alcoholic stimulants should be reserved as a later resource. Among the antipyretics the use of water will be found to be most effective. Sponging with equal parts of alcohol and water has a moderate antipyretic action, and later, if it should be found necessary, a cold pack or a cool bath may be given. Of the antipyretic drugs only phenacetin should be given. In order to secure a sedative effect a very small dose (0.15 gm or gr. $\frac{1}{4}$) of codeine or from five to ten drops of paregoric may be administered. Oxygen (by inhalation) is one of the most valuable stimulants, especially in the treatment of very young babies who take medicine badly by the stomach.

Bronchopneumonia.

Bronchopneumonia—Lobular pneumonia; Capillary bronchitis; Fr., *Broncho-pneumonie*; Ger., *Bronchopneumonie*—is an acute disease of indefinite duration, which is characterized by a capillary bronchitis and by peribronchial areas of consolidation, and which may be caused by one or more of several micro-organisms.

Etiology.—This disease is the form of primary pneumonia most commonly found during the first two years of life, and at the same time it is the ordinary form of secondary pneumonia encountered throughout childhood. It is very common in infancy and early childhood; and at the autopsies in the New York Foundling Hospital it is a rare event not to find the evidences of more or less

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bronchopneumonia. The disease occurs most frequently during the first year of life and much less frequently with each succeeding year up to the fifth. After this age it is not a common disease. In the majority of cases the disease develops during the winter season; but this statement is more true of bronchopneumonia than of the lobar variety, for cases of the former disease in infants are seen also at other seasons of the year. Another important fact is, that bronchopneumonia rarely attacks infants who have previously been in good health. It often occurs in those who have had a preceding acute attack of chronic gastric or intestinal disorder. Rickets and hereditary syphilis predispose to the disease. The following acute diseases which are apt to precede bronchopneumonia are arranged in the order of frequency: measles, whooping-cough, diphtheria, influenza, ileocolitis, and scarlet fever. Furthermore, the environment has a good deal to do with the frequency of this disease. Thus, for example, it occurs with special frequency among the occupants of the tenements and hospitals, and among those who live in the crowded and poor sections of the cities, as has been well shown, so far as Boston is concerned, by Morrill.[8] Finally, exposure to cold, which is by the laity considered all-important, is undoubtedly occasionally an active factor, but the history of a sufficient exposure of this sort is rarely elicited. Experimental researches in the lower animals have shown that cooling of the body does predispose to infection with the pneumococcus.[2]

So far as the bacteriology of the disease is concerned, it has been distinctly determined that there are several varieties of micro-organisms which may be actively concerned in the production of bronchopneumonia. These bacteria are also often found in the upper air passages of healthy persons, and become active agents in the production of bronchopneumonia when the organism has become depressed by a previous disorder or by a severe exposure to cold or fatigue. One or several varieties of these bacteria may be present. The pneumococcus is the organism most frequently found, while the streptococcus and the staphylococcus are often present. Darrier,[3] in 1885, found in four cases of bronchopneumonia complicating diphtheria the streptococcus either alone or associated with the Loeffler bacillus. Prudden and Northrup,[4] in 1889, after an extensive study of the bronchopneumonia of diphtheria in infants, also found that the streptococcus was the usual cause. Netter[5] studied bacteriologically 42 cases of bronchopneumonia. In 25 only one organism was found, and in 17 more than one. As regards the 25 with only one variety of micro-organism, it was found that the pneumococcus was present in 10 cases, the streptococcus in 8 cases, the staphylococcus in 5 cases, and Friedländer's bacillus in 2 cases. As regards the 17 with more than one variety, it was found that the pneumococcus and the staphylococcus were present in 1 case; the pneumococcus and streptococcus in 3 cases; the pneumococcus, streptococcus, and staphylococcus in 2 cases; the streptococcus and staphylococcus in 5 cases; the streptococcus and Friedländer's bacillus in 3 cases; the pneumococcus, streptococcus, and staphylococcus in 2 cases; and the pneumococcus and Friedländer's bacillus in one case. Munier[6] in 10 cases, without any diagnostic signs of influenza, found the Pfeiffer bacillus alone or associated with other organisms. In 5 cases he found Pfeiffer's bacillus alone; in 2 cases with the pneumococcus; and in 3 cases with other undetermined organisms. Wollstein,[7] quoted by Holt, studied 33 cases, 19 of which were primary and 14 secondary. She found the pneumococcus alone in 17 of the primary cases, with the streptococcus in 7, and with the staphylococcus in 1. Holt found the streptococcus alone in 1, and the staphylococcus alone in 1. He found that the pneumococcus was present in 11 out of the 14 secondary cases. It was alone in two cases; it was associated with the streptococcus in 1 case; with the staphylococcus in 2 cases; with the tubercle bacillus in 2 cases; with the tubercle bacillus and the streptococcus in 2 cases; and with the tubercle bacillus and the staphylococcus in 2 cases. The streptococcus was alone in 1 case; it was associated with the staphylococcus in 1 case, and with the tubercle bacillus in 1 case.

Anatomical Characteristics of the Lung in Infancy.—Before we consider the pathology of the bronchopneumonia of infancy, it may be well to speak briefly of the anatomy of the lung in infancy, for this is undoubtedly a determining factor in the preponderance of the bronchial form of pneumonia at this age.

In infants the bronchi are larger and more numerous and thus form a much larger proportion of the lung tissue than is the case in adults. In infants, therefore, the alveoli represent a much smaller proportion of the lung as a whole. This is particularly marked during the first two years of life. The connective tissue is present in greater abundance and binds the different elements together very loosely. As a result the blood-vessels are loosely held and easily become distended and encroach on the alveoli. These characteristics of the lung of infancy persist to some extent until the fifth year, after which period it may be considered to have assumed the adult type.

Pathology.—The lesions of the bronchopneumonia of infancy are to be found most often in the posterior portions of both lungs, generally of the lower lobes, but extending frequently to the posterior portions of the upper lobes. In bronchopneumonia we have usually a tracheitis, a bronchitis, a capillary bronchitis, and a pneumonitis, the inflammation starting in the upper air passages and travelling downward until the lung tissue is involved. The inflammation may extend downward slowly, several days elapsing before the pneumonia is developed; or, in severe infections in subjects with little resistance, the disease may extend so rapidly that signs of pneumonia are noticed simultaneously with the indications of inflammation of the upper air passages. Upon examining, at the autopsy, the lungs of an infant who has had bronchopneumonia, one often finds evidence of some pleurisy over the pneumonic area; perhaps only a dull, lustreless appearance, or a little exudate on the surface, and, in rarer cases, a fibro-purulent exudate. On section of the lung, if it be an early case, the involved area will be found, usually in both lungs, to be dark red in color and resistant to the touch. Other areas of congestion will show the dark red color, but will offer little resistance. The cut surfaces will also have for the most part a dark red color. Small white areas, of the size of a pin's head, are due to the filling of small bronchi with muco-purulent material which may be pressed out. The larger white areas which are found at a later period of the disease, are due to lobules undergoing gray hepatization. In a section of a lung of a child where the bronchopneumonia has advanced still farther in its course, one often finds all stages of the process in different adjacent lobules, so that instead of having a general condition of red or gray hepatization one notices a mottled appearance. The exudate which forms the consolidation consists of serum, epithelial cells, red blood cells, fibrin, and polymorphonuclear leucocytes. There is, however, as a rule, less fibrin, and the leucocytes are fewer than in lobar pneumonia.

Among the other lesions which are sometimes observed in these cases may be mentioned the following: atelectasis, hemorrhages, emphysema, and gangrene. Atelectasis may occur in areas supplied by bronchi which have become plugged with mucus that forms a valve, allowing the air to pass out but not to enter. Hemorrhages may occur in other areas, so that, on examination with the microscope, the air passages are found filled with red blood corpuscles. A vesicular emphysema may also occur, especially in the anterior portions of the lungs. Both vesicular and interstitial pneumonia are frequently found associated with the bronchopneumonia of whooping-cough. Finally, gangrene of a portion of the involved lung is occasionally found at autopsy.

In addition to the pulmonary lesions already described, the bronchial lymph nodes are commonly found to be enlarged from cellular hyperplasia. Occasionally, on

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cutting such nodes, tuberculous lobules are discovered, although no tuberculosis is found elsewhere.

TERMINATIONS OF THE DISEASE.—Resolution may take place by cell degeneration and absorption at any stage in the process. This, however, takes place irregularly, and, while certain lobules may be undergoing resolution, others may show an advancing lesion. In the place of complete resolution, chronic bronchopneumonia may establish itself, especially in feeble babies, who will thus be left with patches of marked bronchopneumonia which may persist for weeks or months. These areas undergo interstitial changes with dilatation of the bronchi, and sometimes with the formation of cavities which are filled with muco-purulent material. At times these cavities represent veritable abscesses. Finally, death may occur at any stage of the bronchopneumonia.

SYMPTOMS.—In the bronchopneumonia of infants both the symptoms and the course vary greatly, as might be expected when the conditions are considered; for the term bronchopneumonia is applied to a disease that may be caused by any one or more of several micro-organisms, and that may develop either as a primary affection or as a secondary phenomenon in the course of some other severe disease. If, in addition, we take into consideration the varying resistance of the subjects, the extreme irregularity of the course of this disease will appear perfectly natural.

Of the different symptoms which accompany a bronchopneumonia *fever* is one of the earliest noticed, and it is very rarely preceded by a chill. This fever usually rises to 102° and sometimes to 104° F. and then falls, rising again as high as or higher than the highest point previously reached. Thus it continues with exacerbations, followed by marked remissions usually of from two to four degrees. The exacerbation of temperature usually occurs in the afternoon or evening. The temperature lasts one, two, or three weeks, or longer. Only twenty-five per cent. of the cases defervesce within the first week. When the disease runs a long course, there are often observed intervals during which the temperature, for a day or two, will run much lower, rising again with the invasion of new lung tissue. The fever usually ends by lysis.

A *cough* is commonly present from the first. It is ordinarily a dry, short, hacking cough, but at times it is paroxysmal in character and may be almost incessant. Later in the disease the cough may disappear, owing to a loss of reflex activity in the air passages. The cough often persists after the other symptoms of the pneumonia have disappeared. Inasmuch as babies swallow all the material which they cough up, we cannot examine the sputum unless we take special measures for obtaining it.

As the disease advances the *respirations* become rapid, rising usually to from 40 to 80 a minute, and sometimes higher. Respirations above 30 should make one suspicious of pulmonary complication, but usually they are over 40. They vary from 40 to 60 ordinarily, but may reach 100 or more in severe cases. The rhythm of the respiration is also disturbed. The pause, which normally takes place after expiration is completed, is done away with and a pause takes place after inspiration. The child quickly draws its breath, holds it and then with an explosive grunting sound, expires, and without pause again inspires. The expiration is prolonged and loud. The expiratory grunt is a very characteristic symptom of pneumonia in infancy. Another disturbance of rhythm is that known as Cheyne-Stokes respiration; this disturbance occurs in severe cases. Temporary suspension of respiration also occurs in the very sick. It may last as long as two minutes and be spontaneously resumed. Evidence of respiratory embarrassment is also found in the sinking in of the intercostal spaces and the dilatation of the alæ nasi with each inspiration, in severe capillary bronchitis. Cyanosis is another symptom which often develops in severe cases of capillary bronchitis.

The *pulse* is accelerated with the onset of the disease, and in an ordinary case will soon reach the rate of 150 a minute. It is usually full at first, but later, and especially in the severe cases, it becomes more rapid and weak.

A most important diagnostic sign of bronchopneumonia is to be found in the *ratio which the respirations bear to the pulse*. This is usually altered from the normal ratio of one to four to a ratio approximating one to three; that is, in an ordinary case the respirations will number about 40 or 50 and the pulse beats from 120 to 150 to the minute. Such a respiration-pulse ratio should at once direct attention to the thorax, which should be very carefully examined for evidence of pulmonary disease.

Pain is not a symptom of any importance in the bronchopneumonia of infancy. There is usually some soreness in the chest, but these little patients do not, commonly, suffer from acute pain.

So far as *cerebral symptoms* are concerned, the onset of bronchopneumonia in infancy is usually characterized by a condition of apathy. The patients are said to be "dopey"; they are markedly prostrated, indifferent to their surroundings, and want only to be left undisturbed. Convulsions at the onset are rare; they occur only in very severe cases, in children with marked rachitis, and in those of poor previous condition. Delirium and stupor often develop. The *tache cérébrale* and Kernig's sign may sometimes be elicited.

Various *gastro-enteric symptoms* are commonly associated with a bronchopneumonia. Thus, for example, anorexia usually occurs at the onset of the attack, while thirst may supervene at a later stage. The tongue is sure to become coated, and in a certain number of cases the disease begins with marked gastro-enteric symptoms, vomiting, abdominal pain, diarrhœa, and tympanites—symptoms which may lead to a false diagnosis, or at least to overlooking the pulmonary condition.

PHYSICAL SIGNS.—The physical signs vary as much as do the symptoms. Some cases, which in other respects are following a typical course, may at no time give physical signs; that is, the disease fails to produce marked changes in any part of the lungs adjacent to the thoracic wall. In other cases local physical signs will be elicited only when the temperature falls, while in still other cases one gets marked signs of consolidation from the beginning of the disease.

Inspection reveals the fact that the respiration is rapid, irregular, and variable in its rhythm; it also perhaps shows the existence of a certain degree of cyanosis.

Palpation is of less value in infants than it is in adults, owing in part to the fact that the lesion usually is bilateral and in part to the fact that it often fails to yield good evidence of the existence of consolidation.

Percussion also gives valuable information less often in infants than it does in adults. It must be practised with care and with the employment of very little force; one finger will suffice for the actual percussing, and the examiner should make a light, sharp stroke by quickly withdrawing the finger. The revelation, by means of percussion, of a very slight dulness, especially if it is associated with a sense of resistance, points to congestion and consolidation, while a marked degree of dulness should raise a suspicion that fluid is present, and this conjecture should lead to the employment of auscultation as a means of differentiating between these conditions.

It is by *auscultation* that the first evidence of local pulmonary involvement is usually elicited, and it is upon auscultation that one must especially rely for locating the bronchopneumonia in infancy. In these little subjects the ear should not be relied on alone, but a stethoscope with a small opening should also be used. If the baby is emaciated, a flexible rubber chest-piece may be necessary. Auscultation gives information as to the presence of râles, the duration of the expiration as compared with the inspiration, and the pitch of the breathing. Since in bronchopneumonia there is an inflammation of both large and small bronchi, and often a pleuritic inflammation as well, all varieties of râles may be heard. The coarse, low-pitched, sonorous râles, which have their origin in the large bronchi, are usually present.

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Areas of subcrepitant or crepitant râles, audible at the end of an inspiratory effort, are carefully to be looked for, since they are usually the first physical sign found by which one can locate the bronchopneumonia in infancy. It is not sufficient to listen carefully over the chest of a sleeping or quiet child, for an effort must be made to secure deep inspiration. If the child cough, the coughing will be followed by satisfactory inspiration, but often it is necessary to make the baby cry. It is during crying that the most satisfactory examination of the baby's chest may be made, for it elicits both deep inspiration and voice sounds which may be difficult to get by other means. If the pneumonia is sufficiently developed one may get a prolongation of expiration, and high-pitched or bronchial breathing.

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In some cases the first local physical sign will be diminished breathing, which may be associated with dulness over the same area. Dulness and diminished breathing, although often due to congestion, should always suggest the possibility of fluid being present. If these signs are due to congestion, they should soon change to high-pitched breathing with râles; if they are due to fluid, they should persist and become more marked.

The location of the heart apex should always be definitely made out, as a displaced apex often determines the presence of fluid in cases in which other signs would seem to point to consolidation of the lungs.

Course of the Disease.—The bronchopneumonia of infancy usually begins with an abrupt onset, characterized by considerable fever and a condition of apathy. The child is evidently seriously ill. It coughs, breathes rapidly, and with each expiration is apt to groan or grunt. Dyspnœa develops, and sometimes cyanosis. The alæ nasi dilate with inspiration. The fever persists for from one to three weeks, finally ending by lysis. As the disease progresses, the prostration becomes more marked, the pulse more rapid, and the extremities, nose, and ears often become cold. The respirations become very rapid, and delirium or stupor may develop; gastric or intestinal symptoms also often occur.

The disease may manifest itself under one or the other of three different types: the acute congestive type (or capillary bronchitis), the latent type, and the persistent type. The first of these, *the acute congestive type*, may be primary or secondary, and occurs most often in young infants. They become suddenly severely ill, and breathe with great difficulty and very rapidly (70 to 80); there is high fever (104° to 106° F.); and the pulse is rapid (180 to 200). Death often occurs in from twelve hours to three days. Some of these cases will end in recovery in the course of a few days. By the expression *latent type* is meant a bronchopneumonia which is found in cachectic and marasmic infants, who may have neither fever, nor cough, nor dyspnœa. It is a hypostatic pneumonia, which gives little evidence of its presence during life, and is often first discovered at autopsy. The *persistent type* of bronchopneumonia is seen in children who are in poor condition at the time when they are taken ill; it also often develops after whooping-cough. In these cases the disease usually runs a moderately severe course for from two to three weeks, and then, instead of defervescing and undergoing resolution, it continues for some time to manifest a moderate degree of feverishness and the physical signs of persisting consolidation. These patients are apt gradually to become weaker and die, although some of them may recover after a long period.

In addition to the three types briefly outlined above, it is permissible to establish—in accordance with certain characteristics that belong to the secondary bronchopneumonias following the different acute infectious diseases—other less important groups. For example, one group may comprise those cases in which a *bronchopneumonia develops in the course of an attack of measles or scarlet fever*. In this group the pneumonia begins either when the eruption is at its height or not until after the temperature has fallen to normal. In the latter event the temperature does not remain at this low point but soon rises several degrees, and evidences of the pneumonia begin to manifest themselves. But whether the pulmonary complication develops at this later stage of the original disease or whether it develops at the time when the eruption is at its height, the prevailing character of the pneumonia is in either case likely to be severe; indeed, the disease often assumes a congestive character. *The bronchopneumonia of whooping-cough* constitutes another group. This develops usually during or at the end of the paroxysmal period. The onset is more gradual and less severe than it is in the preceding group, and the fever usually is moderate. The disease develops in children who are much depleted by the whooping-cough, and it runs a long, subacute course. Finally, in the third group may be placed *the bronchopneumonia of diphtheria*. In this group of cases the disease again manifests itself commonly in a severe form like that which characterizes the bronchopneumonia of measles and scarlet fever. It usually develops early in the attack of diphtheria.

Bronchopneumonia also develops in connection with other diseases. Thus, for example, it sometimes occurs in a fairly severe form in the course of an *influenza*. When it occurs in connection with an *ileo-colitis* it usually develops at a time when the baby has been much weakened by the primary disease, and it then assumes a type similar to that seen in whooping-cough.

Complications.—The one very common complication of bronchopneumonia—the one for which diligent search should be made daily, in order that it may not be overlooked—is *empyema*. This occurs in a considerable number of cases, and requires a prompt evacuation of the fluid whenever the baby suffers severely from its presence. Evidence of fluid is usually first found behind or in the post-axillary line; less frequently it is found in front. Diminished breathing sounds and marked dulness on percussion are usually the first local signs. Another occasional complication is *purulent meningitis*, which is caused by the same micro-organism that produces the lung consolidation. *Pericarditis* is also sometimes encountered, but usually in connection with empyema. On the other hand, in all the cases of bronchopneumonia which have been seen by the writers in the New York Foundling Hospital, the complication of an *endocarditis*, except when associated with pericarditis, has not once been observed. Finally, in a certain number of cases, *tuberculosis* may constitute a complication of the bronchopneumonia. In these cases the trouble may sometimes be attributed to the breaking down of an old cheesy bronchial lymph node.

Diagnosis.—The early diagnostic signs are the abrupt onset, the presence of fever and of a certain degree of apathy, the disturbed respiration-pulse ratio, and the discovery, by auscultation, of the existence of râles in the chest. To these signs may be added, at least for some of the cases, the following: some dulness on percussion, a high-pitched respiratory murmur, and broncho-vesicular respiration. Many of these signs may be absent, especially in the subacute form of the disease as it occurs in weak infants or as a complication of whooping-cough.

The differential diagnosis from lobar pneumonia is based on the following points: Most of the cases of bronchopneumonia are secondary, and when the disease is primary in its nature it occurs usually in infants under two years of age. The signs develop more gradually in this disease than in lobar pneumonia. Furthermore, the remissions of temperature are more marked than they are in the latter disease, and the return to normal takes place by lysis rather than by crisis. Finally, the course of the disease, unlike that of lobar pneumonia, is very irregular. In order to distinguish the disease from fluid in the chest, when there are signs pointing to the latter condition, it often becomes necessary to resort to an exploratory puncture in order to determine the truth. In making such a puncture it must be remembered that the fluid is often thick, so that a negative result from the use of a small needle means nothing. A large needle should always be introduced in an aseptic manner.

Prognosis.—The prognosis in the lobular form of pneumonia in infancy is always very serious. It is mod-

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ified by several factors. In the first place, the younger the child the more serious the outlook. Pneumonia in an infant under one year justifies a very serious prognosis. The condition of the child's health before the attack is another important factor. The better the health of the baby when taken ill with the bronchopneumonia the better the prognosis. The environment of the child also modifies the prognosis. Usually cases do much better under good surroundings, with isolation, quiet, and plenty of air—*i.e.*, under such conditions as may be found among the wealthy classes—than they do in the tenements and hospitals.

Primary bronchopneumonia usually allows a much better prognosis than does that which develops in the course of some severe disease; for the outlook in secondary pneumonia varies with the disease which it complicates. Thus, in many of the cases of pneumonia complicating diphtheria the patients die, and the mortality of the disease, when it develops in the course of whooping-cough, is always very high (fifty to one hundred per cent.). The bronchopneumonia of measles is usually of a severe form, but, notwithstanding this fact, the mortality is somewhat lower than it is in the secondary pneumonias of diphtheria and whooping-cough (thirty-three to one hundred per cent.). In the influenza cases the mortality is more favorable.

TREATMENT.—A study of this disease emphasizes the importance of watching very carefully all children who are affected with colds, influenza, bronchitis, and the other primary diseases which bronchopneumonia is apt to complicate. Of still more importance is the careful watching of the digestion of babies and the prompt modification of the diet when necessary.

The direct treatment is entirely symptomatic, and the general hygiene, nursing, and feeding are usually of far more importance than the medicinal treatment. A baby with bronchopneumonia should be placed in a large quiet room with plenty of light and a southern exposure. The room should be ventilated from out of doors and not from other rooms in the house. Some moisture in the room will make the patient more comfortable, and this may be obtained by boiling water in a kettle. But one person should be allowed in the room at a time, and the same care should be observed to avoid disturbing the patient that is exercised in the case of a nervous adult.

The diet should consist of milk or modified milk, or milk with barley water, or oatmeal gruel. If the milk is not well digested, it may be given only after it has first been peptonized. If but little is taken at a time, the feeding may be done at intervals of one or two hours. With the onset three modes of treatment should be actively tried in an effort to abort the disease. These are: purgation, counter-irritation, and stimulation. For the attainment of the first of these objects, calomel is altogether the most satisfactory drug. For a baby under one year of age one-tenth of a grain may be given every half-hour until from four to ten doses shall have been given. If this medication fails to move the bowels, castor oil, in doses of one or two drachms, should be administered. Counter-irritation over the affected area, or, if this cannot be determined, over the whole chest in front and behind, may be made with mustard paste. The operation should be repeated at intervals until a marked redness of the skin is produced. Stimulation with strychnine in fairly large doses (from gr. $\frac{1}{100}$ to gr. $\frac{1}{60}$) every four to eight hours, according to the age of the child, may be resorted to temporarily. This treatment, which may be kept up until the physiological effects of the drug are obtained, will aid the organism in its effort to overcome the disease. Afterward the remedy may be administered with advantage in smaller doses throughout the entire course of the disease. The counter-irritation may also be repeated with benefit from time to time. Stimulation should be used when needed. Nitroglycerin is of especial value when the extremities become cold, and it should be given in a dose of gr. $\frac{1}{400}$ every four hours. At the same time hot-water bags should be applied to the feet. The administration of alcohol internally may usually be reserved for severe cases, since it is a drug that is often badly borne by babies. It may be given in the form of whiskey diluted with from eight to ten parts of water and sweetened; champagne and sweet wine may also be administered. Oxygen is a most valuable aid in the treatment of this disease, and it may be given at frequent intervals or constantly, and should be delivered from the pipe held close to the child's mouth.

The gastro-enteric tract must be carefully watched, as marked tympanites, which interferes with respiration by restricting the descent of the diaphragm, is a frequent and very serious complication in many cases. A mixture of rhubarb and soda, or of rhubarb and soda with bismuth, or an occasional dose of castor oil, will often relieve this symptom, but at times the introduction of a stomach tube or rectal tube is needed for evacuating the gas. Counter-irritation and hot fomentations applied to the abdomen are also useful. The employment of pneumonia jackets and of poultices, as a routine treatment of the bronchopneumonia of children, has been given up. Both of these tend to increase the temperature of a child already suffering from fever, and they limit the expansion of the chest. A woollen shirt provides a sufficient protection to the chest.

Antipyretic treatment is needed in the severe cases, and should be resorted to if the child is bearing the fever badly, even if the latter is not very high. Stupor, delirium, or great restlessness calls for antipyretic treatment. A temperature of over 103° F. is usually an indication for antipyretic treatment. There is no disease in which the thermometer is of so little service as a guide as it is in infantile bronchopneumonia. It is the child's general condition that furnishes the best indications for treatment.

Bathing furnishes the best means at our disposal for reducing temperature. Sponging with equal parts of warm water and alcohol may be used for slight fever and restlessness, but the most efficient and simplest method is to place the infant in a bath. The bath may have a temperature of from 80° to 90° F., and the baby may be kept in it for five or ten minutes. It is usually well to stimulate the baby before putting it in the bath. The bath may be repeated as often as indicated by the temperature.

The coal-tar derivatives should never be used as antipyretics for infants. Expectorants are very rarely needed in the treatment of this disease. Ipecac is probably the most efficient, but, if used, it should be given in small doses. Of sedatives, a warm bath is usually the only one needed. If the cough is constant and interferes with rest, and if it is not relieved by a bath, five-drop doses of paregoric may be given every three or four hours.

In protracted cases and during convalescence, the internal administration of creosote, or guaiacol and cod-liver oil, or of some iron preparation may be of advantage, while counter-irritation may be made by painting the chest with Churchill's tincture of iodine, or by the use of the Paquelin cautery. *William P. Northrup.*

Rowland Godfrey Freeman.

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PNEUMOPERICARDIUM. See *Pericardium, Diseases of.*

PODOPHYLLUM.—U. S. P., *Mandrake, May-apple.* The dried rhizome of *Podophyllum peltatum* L. (fam. *Berberidaceæ*).

This striking and beautiful plant is found in the greatest abundance in rich soil throughout the eastern and central portions of North America, except the far north.

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The drug is mostly collected in the Ohio valley and the mountains southward. The very long and much branched rhizomes form a network a few inches beneath the surface of the soil, and produce large beds of the very peculiar foliage of the plant, which is herbaceous, about a foot high, and of the appearance shown in the accompanying illustration. The leaves are thin and somewhat shining, about a foot broad, the flower beautifully white and waxy, and about two inches broad. The sterile stems terminate in a circular, centrally attached leaf, which is similarly lobed, and presents the appearance of an umbrella, whence the plant is often called umbrella plant, whereas the form of those of the flowering stems have given it the name of duck's foot. The fruit is a yellow, sweet, and edible berry, about as large as a pigeon's egg, and is known as May, hog, Devil's, or Indian apple, also as wild or ground lemon.

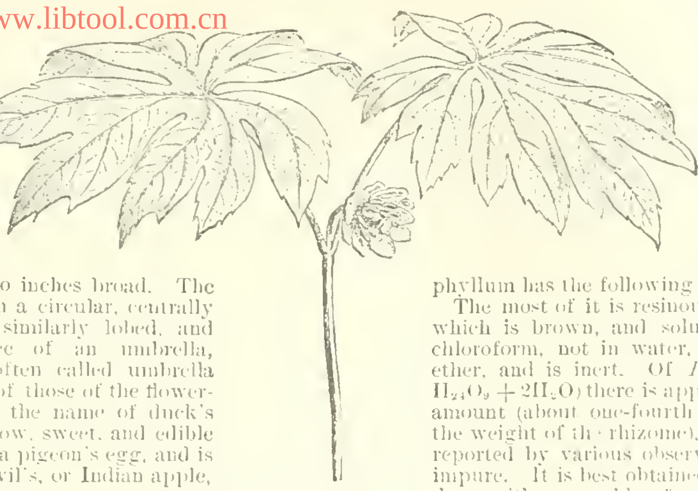

FIG. 3837.—Podophyllum: Flowering Plant. (Baillon.)

The younger portions of the rhizome, after being dried, are dark-colored, thin, and shrivelled, and are deficient in medicinal property. The drug is thus described:

Of horizontal growth and indefinite length, occurring in irregular pieces; cylindraceous, flattened from above, consisting of joints about 5–10 cm. (2–4 in.) long, the internodes 2–8 mm. ($\frac{1}{12}$–$\frac{1}{3}$ in.) thick, the nodes about twice as broad; yellowish brown to dark brown, the darker pieces usually longitudinally wrinkled, the lighter ones nearly smooth, the nodes marked above by broad cup-shaped scars and underneath by whitish, short stumps of the brittle roots; fracture short and sharp, whitish to pale brown, resinous in the best drug, marked by a loose circle of very short yellow wood wedges surrounding a large pith; nearly inodorous; taste sweetish and bitter, becoming acrid.

The active portion of the drug resides in its three to five per cent. of resinous matter, which is associated with much starch, a very little gallic acid, and small amounts of fixed oil, gum, etc. The resin is a somewhat complex mixture, but is an official substance and is very largely employed under the name *Podophyllin*. It is highly subject to adulteration, more than fifty per cent. of adulterant having been reported in it; hence, the official description should receive close attention. It is prepared by exhausting the powdered drug with alcohol, concentrating the filtrate by evaporation, and pouring it into water acidulated with a little hydrochloric acid, when the resin is precipitated. It is afterward dried and powdered. The resin is described as follows in the pharmacopœia:

"An amorphous powder, varying in color from grayish-white to pale greenish-yellow or yellowish-green, turning darker when exposed to a heat over 35° C. (95° F.); having a slight, peculiar odor, and a peculiar, faintly bitter taste. Permanent in the air."

FIG. 3838.—Rhizome and Bases of Roots of Podophyllum.

Its alcoholic solution has a faintly acid reaction.

Soluble in alcohol in all proportions; ether dissolves fifteen to twenty per cent. of it; boiling water dissolves about eighty per cent., and deposits most of it again on cooling, the remaining, clear aqueous solution having a bitter taste, and turning brown on the addition of ferric chloride T.S.

Resin of podophyllum is also soluble in potassium or sodium hydrate T.S., forming a deep yellow liquid which gradually becomes darker, and from which the resin is reprecipitated by acids.

It should yield not more than 0.5 per cent. of ash.

Resin of podophyllum has the following composition:

The most of it is resinous *Podophyllic Acid*, which is brown, and soluble in alcohol and chloroform, not in water, ether, or petroleum ether, and is inert. Of *Podophyllotoxin* ($C_{23}H_{24}O_9 + 2H_2O$) there is apparently a very small amount (about one-fourth of one per cent. of the weight of the rhizome), the larger amounts reported by various observers being probably impure. It is best obtained by extracting the drug with pure chloroform, and this extract with pure ether, then precipitating with petroleum benzin. Pure podophyllotoxin usually occurs as a white, amorphous, bitter, slightly acid powder, or in crystals soluble in ether, chloroform, hot water, and diluted alcohol. This pure substance is very difficult to obtain, being usually contaminated with the isomeric *Picropodophyllin*, which is readily formed from podophyllotoxin by the action of alkalies, and is much less active than the latter. Picropodophyllin occurs in bitter crystals, soluble in alcohol, not in water. Podophyllotoxin is also very apt to be contaminated with podophyllic acid, with the yellow coloring matter *podophylloquercetin*, and with fat.

ACTION AND USE.—Podophyllum or its resin is locally irritant, the dust occasioned by powdering the drug causing redness and smarting of the skin and inflammation of the conjunctivæ. It has also been known to produce, upon the perspiring skin, ulcers which have been mistaken for chancroids. It is an irritant cathartic, whether introduced into the bowels or stomach, given subcutaneously, or absorbed from a raw surface. It is a very slow-acting medicine, requiring from twelve to fifteen hours before its effects begin, but it is also rather persistent and thorough, and in full doses is followed by numerous watery stools. Griping pains are frequent accompaniments, and vomiting and persistent diarrhœa may follow if the dose is very large. After poisonous amounts the above symptoms are exaggerated, and inflammation and ulceration of the intestines, bloody stools, great prostration, stupor, and death may follow. The action upon man and the lower animals is essentially the same. It is supposed to stimulate the liver, and is very extensively given with a view to this effect, in the digestive disturbances called popularly "biliousness," but probably, as we now know of nearly all so-called cholagogues, it does not increase the production of bile, but merely favors its dejection.

Moderate doses of podophyllotoxin given to man produce the same effects as podophyllum itself, with perhaps less pain and less tendency to vomiting. Picropodophyllin acts like the above, but less violently, in consequence,

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as is supposed, of its complete insolubility in water. Podophyllum and its preparations are, then, useful cathartics where action upon the whole intestine, or at least the small one, is desired and when the expulsion of bile is desirable. They are frequent ingredients of "antibilious" pills, both in regular and irregular practice, and are frequently given, too, in small doses in "after-dinner" and other mildly laxative pills.

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ADMINISTRATION.—The powdered crude drug may be given; dose from 0.5 to 1.5 gm. (gr. x. ad xx.). But, in view of the great compactness of the precipitated "resin" (*Resina Podophylli*, U. S. P., etc.), this is to be preferred. The following preparations are in the Pharmacopœia: Extract (*Extractum Podophylli*), strength about $\frac{1}{4}$; fluid extract (*Extractum Podophylli Fluidum*), strength 1, and the before-mentioned resin, strength about 3^{0}, dose from 1 to 3 cgm. (gr. $\frac{1}{6}$ ad $\frac{1}{2}$). Of these preparations only the latter need be remembered or used. *Podophyllotoxin* can be had in the larger cities, and should be more uniform than either of the above, though very commonly it is not.

The dose of the ordinary commercial article is about one-third that of the resin, but of the pure substance this would be about five times too much.

"Mandrake" of the ancients was *Mandragora officinarum* L., a solanaceous plant, containing mydriatic alkaloids of the atropine type. It is now obsolete as a medicine.

Henry H. Rusby.

POISONING, LEGAL ASPECTS OF.

—This paper does not discuss the general principles of toxicology. The reader's knowledge of these is taken for granted. The nature of poisons, the distinguishing characteristics of the various kinds, the different modes in which they may be administered and will operate, the appropriate methods of detection—these and other branches of the subject are elsewhere treated. The present purpose is to state very briefly those peculiar duties of the practitioner which are connected with the use or misuse of poisons.

LEGAL DEFINITION.—For the purpose of what may be called legal toxicology, there is little need of establishing a precise definition of the term "poison." Medical authorities on the subject agree that the word is one very difficult (some say impossible) of precise definition. The law, in general, either leaves the question "What is a poison?" to be determined by judges or juries, under the counsel of medical men and experts, in view of the particular case which brings it forward for decision; or relieves the doubts and obscurity which hang over the word by associating others with it which may enlarge its scope. Thus an English statute passed early in Queen Victoria's reign (1 Vic. c. 85, § 2), says that whoever shall administer, etc., to any person "any poison or other destructive thing" with intent to commit murder, shall be guilty of felony. A trial under such a statute as this would not call for any lengthy discussion of the meaning of "poison"; testimony of experts, that the thing administered was adapted, when administered in the way proved, to destroy life, would be sufficient on that point to sustain a conviction. On the other hand, if the experts doubted or disagreed, the judge would instruct the jury to give the accused the benefit of the doubt. Early American statutes use the simple word "poison," leaving the courts and juries to fix the meaning on the principles above stated. Thus in New York there are laws of long standing, punishing every person convicted of having "administered any poison to any human being," and every person who shall "wilfully poison any spring"; and every person who shall "wilfully administer any poison to cattle," etc., or shall "wilfully expose any poisonous substance to be taken by cattle"; etc. The actual administration of even such laws as these does not turn on chemical or medical discussions of the precise meaning of "poison" nor vary materially with changes in the exact idea attached to it by men of science. Statutes passed in recent years specify what are deemed poisons; thus the Act of Congress regulating sales of poisons in the District of Columbia names in two schedules the particular drugs intended; and of course, to sustain a conviction under such laws, there must be proof that one of the designated drugs was sold. Or, to put the idea in other words, the vital question in a trial at common law, as it is called, is not poisoning, but murder; did the accused kill the deceased by the drugs, etc., described in the indictment? In a prosecution under a statute punishing a particular form of poisoning the question is, Did the accused do the act prohibited by the language of the statute, in the manner alleged in the indictment? Experts called in cases involving poisoning are sometimes pressed to state by way of general definition, "What is a poison?" Such questions are unreasonable, except perhaps when put to test the witness' general knowledge and qualifications as an expert. The legitimate inquiry involved in the issue is this: Is the particular article or drug administered one within the class prohibited by the statute or rule of law on which the accusation is founded, as that is commonly understood? A physician may not be able to give an exact definition, or to enumerate all known poisons, yet be perfectly qualified to give an opinion on a question of poisoning by arsenic, by strychnine, by laudanum, etc., and such are the questions involved in all ordinary cases. Again, there is no important legal difference between the meaning of "poison" and that of "deadly poison." Drugs which prove speedily fatal when taken in small doses are characterized as deadly, but this is a mere matter of convenient classification. There is, however, a class of cases in which a general definition of "poison" may be important; they are such as arise under a statute which uses only "poison" to define the crime, without adding "destructive thing" or any similar term of enlargement; but the thing administered is not a poison in any correct sense, such as pins or needles, bits of sponge or wood, tufts of hair, orange seeds or peel, cherry stones, raw rice, pounded glass, boiling water, all of which have been effectively used with suicidal or murderous intent. In these cases, the objection that the accused had not administered a "poison" would prevail; at least the question of the extension of that term would be legitimately involved. And generally, in inquiries as to criminal poisoning, the intent with which the noxious substance was administered is quite as important an element as is the nature of the substance.

ADVERTISEMENT AND SALE OF POISONS.—The dissemination of advertisements of so-called remedies for procurement of abortion, framed in obscure, deceptive phraseology, has grown during the present generation to be a serious evil, and deserves to be mentioned as connected with the general subject of poisons. The regulation of the issuing of advertisements and circulars announcing such things rests wholly with the State legislatures and police. Congress has no power over that branch of the subject. Several of the States have enacted laws which, however, are not, as a general thing, very stringent or very efficiently enforced. The repression of the circulation of either the advertisements and the circulars, or the remedies themselves, devolves on Congress. The postal law, as in force at the beginning of September, 1887, and which operates, of course, over the whole country, excludes from the mails all poisons and every article or thing intended for the prevention of conception or procuring of abortion, or for any indecent or immoral use, and every written or printed card, circular, etc., advertisement or notice of any kind, giving information when or how such things can be obtained or made; and punishes by fine and imprisonment any person who shall deposit such things in the mails, or take them from the mails for the purpose of giving them circulation (Rev. Stat., § 3878, § 3893, as amended July 12th, 1876, 19 Stat., 90). The duty laws forbid and punish the importation from abroad (a matter wholly within the power of Congress) of all kinds of abortives, and advertisements of them (Rev. Stat. § 2491, as amended March 3d, 1883, 22 Stat., 489).

The selling of poisons, as distinguished from the mere advertisement of them as being for sale, does not belong to Congress (except as respects the Territories and the

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District of Columbia), but to the States. The laws are quite numerous and are varied in their provisions, but the general character of them is that they do not forbid, nor indeed restrain, the sale of poisons (in ordinary course of business of dealers), but prescribe a manner in which the vial or package containing a poisonous substance shall be labelled, and record made of the date of sale, name, residence, etc., of the purchaser. Independently of restrictions or penalties imposed by special statutes, the courts throughout the country hold dealers in drugs to a strict responsibility for sales of poisons made by mistake. A druggist who negligently sells a poison labelled as a harmless drug, and thereby causes the purchaser's death, is chargeable with manslaughter. That the error was merely carelessness is no justification; dealers in deadly drugs are held to a strict accountability for their sales. They must take the highest degree of care known among practical men, and are held to responsibility in dealing with poisons corresponding to the degree of knowledge required in the business. They are under a general implied obligation that what they sell is genuine, commercially pure, and fit for the use designed. A Kentucky druggist kept a mill for grinding drugs, and one day had need to grind some Spanish flies in it for a blister, and did so, not cleansing the mill properly afterward. Next day a customer brought a prescription calling for Peruvian bark, and the careless apothecary passed the bark through the same mill. It thus became mixed with a modicum of the dust of Spanish flies, and the unfortunate patient was made very sick. He recovered damages for the suffering and peril to which he had been exposed. The court said an apothecary is bound to know what he sells; and if Peruvian bark alone is called for, he must not sell bark mixed with cantharides (13 B. Mon., 219). More recently, another Kentucky druggist sold croton oil instead of linseed oil for a patient, who died in consequence of the mistake, whereupon his widow was adjudged to have a right to full damages (11 Bush, 380). And there is a memorable case in New York State in which some manufacturing druggists put up belladonna in jars labelled, through mistake, "extract of dandelion." These jars were sold to retailers at random, and one of them, a druggist in Cazenovia, filled a prescription calling for extract of dandelion from this belladonna jar. The patient, a married lady, was nearly killed. As the Cazenovia apothecary acted innocently he was not prosecuted; but the husband sued the manufacturers, and recovered (6 N. Y., 397).

Poisoning in Reference to the Distinction of Degrees in Murder.—In the legislation of many of the leading States during recent years murder has been divided into two degrees, the general purpose being to class the more aggravated, deliberate forms of homicide, in the first degree, and make them punishable with death; while those exhibiting an instantaneous intent only shall incur imprisonment for life. Murder by poisoning is eminently deliberate; in the statutes of several of the States—of Pennsylvania and New Hampshire, for instance—killing by poisoning is expressly declared murder in the first degree; under other statutes it falls into that class by force of general terms employed to define the class, such as "wilful, deliberate, and premeditated killing." Under such statutes there have been one or two convictions for the second degree, where poison was unquestionably the means used for the homicide; but such convictions do not imply that poisoning is not in the view of the law deliberate; they rather show a compromise among the jurors; those who hesitated to join in a conviction which would be capital induced the others to unite in a verdict of the second degree rather than have a disagreement. The intent to kill is, however, essential under all accusations of murder by poisoning. In an Indiana case the accused administered a dose of cantharides to a woman, not meaning to kill her, but to excite her passions, so as to induce her to consent to sexual intercourse; but the dose was excessive, and caused her death. The decision was that, for lack of intent to kill, the crime was not murder.

The Importance and Difficulty of the Physician's Duties in cases involving poisoning can scarcely be overstated. His task involves intimate knowledge of chemistry, and often of law, as well as of practical medicine. The recovery of the patient if alive, the honor of the dead in cases of suicide, the reputation of the living in cases of suspected murder, may depend on the acuteness and energy, or on the prudence and reserve, of his measures. He must work, not only with friends and nurses, but often with persons shuddering or smarting under suspicion, and with jealous detectives, and with suspicious police. If he is called while the sufferer is yet living, his duties are complicated by the primary effort to effect a cure. If death has taken place, he may probably be the first person to detect any fleeting indications that crime has been committed, and is above all others best fitted to register and preserve the evanescent evidences. Moreover, with the progress of chemical science, the list of means at the command of the well-instructed poisoner is constantly extending, while the rapidity with which the methods of detection at the command of the practitioner are increased in number and complexity renders his task steadily more difficult and responsible. Moreover, the number and variety of symptoms which poisons produce, many of which closely resemble those characteristic of natural disease and are easily mistaken for them, complicate and embarrass the examination. There are several diseases whose course and termination resemble the action of certain poisons. In short, of all crimes that of poisoning requires the most learning, acuteness, skill, and promptitude for its detection. The importance of the physician's part in the work is equalled only by its difficulty. In the capacity of medical jurist he needs a thorough knowledge of the physiological, therapeutical, and toxical actions of poisons and of the lesions which they may cause. As legal chemist he needs that wide knowledge of the kinds of poisons and of their distinguishing characteristics, and that practical experience and skill in chemical analysis and manipulation, which will enable him not only to detect a poison with certainty if it exists, but also to avoid all risk of obtaining evidence of it, or of confounding things similar but innocent.

Classification of Poisons for Legal Uses.—Dr Pugnet suggests ("Med.-Leg. Papers," 2d ser., rev. ed.) that the division of poisons into the organic and the inorganic, though acceptable to the chemist, is insufficient for the needs of the medical jurist. He suggests the following:

I. Corrosives.	*Strong Mineral Acids*		Sulphuric acid. Nitric acid. Muriatic acid.
	Vegetable Acid		Oxalic acid.
	Alkalies		Strong alkalies. Alkaline carbonates, etc.
II. Simple Irritants			The above diluted. Lime. Zinc. Silver, etc.
III. Specific Irritants			Arsenic. Mercury. Antimony. Phosphorus. Iodine.
IV. Neurotics.	*Narcotics*		Opium and its active principles.
	Sedatives	*Cerebro-spinal*	Hyoscyamus. Belladonna. Stramonium. Calabar bean.
		Spinal	Digitalis. Aconite. Prussic acid. Tobacco. Hemlock.
		Vaso-motor	Hellebores.
		Anæsthetics	Chloroform. Chloral. Bichloride of methylene. Ether. Nitrous oxide. Amylene.
	Convulsives.		Nux Vomica, Brucine, Strychnine.
V. Asphyxiants			Noxious gases.
VI. Abortives			Ergot, Savine, etc.

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The corrosives destroy the tissues with which they come in contact by chemical action, and are characterized by causing intense pain with a burning. The simple irritants cause primarily irritation; secondarily, inflammation, which may prove fatal. The specific irritants act primarily as local irritants but have a secondary specific action. These are the poisons with which the physician is most frequently called to deal in this country. In acute cases they cause lesions of the alimentary canal; but in cases of slow poisoning these are wanting. Of the neurotics, Dr. Pugnet says that they have not as yet occupied a prominent place in toxicology, but the day is not distant when the practitioner may be called upon to investigate cases of criminal poisoning by means of them.

The above classification is the most complete which the writer has seen. Others which have received wide approval are those of Orfila, Taylor, and Tardieu (the leading features of which are given in 2 Wharton and Stillé's "Med. Jur.," 4th ed.). What recommends it to the toxicologist is that the various poisons are classified according to their distinctive physiological action upon the living organism, and not upon their chemical organization and differences. Classifications by Christison and Foderé are also widely quoted.

Counsels and Cautions Relative to a Legal Inquiry.—The various works that discuss toxicology in its chemical and medical aspects contain numerous counsels and cautions to the practitioner as to the manner of carrying forward the scientific investigation necessary in cases of supposed poisoning. This paper will select and mention such as are particularly applicable where a suspicion of crime arises.

Remember that poisons may enter the system with fatal effect, not only by swallowing, but also by inhalation, by absorption through the skin, including the accessible mucous membranes, and by injection, subcutaneous or per anum. Swallowing is the mode best adapted for administering them with murderous intent, but in cases in which the symptoms are obscure and not explainable by a suspicion of a poison swallowed, the medical jurisprudent will do well to consider the possibility that one or the other modes may have been employed.

In particular persons, substances ordinarily poisonous may be rendered inert, or those not ordinarily unwholesome may be rendered poisonous, by some idiosyncrasy of the individual, by a habit of taking them, or by a condition of disease.

A poisonous compound may, by possibility, be formed within the body by two medicines innocently prescribed or taken, either of which alone would have been innocuous.

An organ may, by possibility, become impregnated with a poison after death, either accidentally, as where it has been laid in a soil in which are poisonous elements, or where such elements are introduced in the process of embalming; or feloniously, as where an attempt is made to introduce a poison in order to give ground for charging an innocent person with murder. The presence of substances introduced after death is scientifically distinguishable, no doubt, from those taken in life; but the two may be confounded if the distinction is forgotten.

The narrative of the symptoms attending the last illness is of less service than is usually supposed in determining the criminal character of the case. Modern experience is, that death cannot be safely attributed to poisoning from the symptoms alone; too many diseases resemble the action of poisons to allow of dispensing with an autopsy and a chemical examination, when poisoning is suspected. And still less light is thrown by the mere symptoms upon the question fundamental in the legal aspects of the subject—whether the poison was taken accidentally or ignorantly, or was taken with suicidal purpose, or was administered with felonious intent this question must be decided from the general attendant circumstances of the case.

The physician should never allow moral circumstances to prejudice his mind, neither should he neglect them. Indeed, he is the best judge concerning them. Let him ascertain whether an enmity exists between the sick person and any one who attends or visits him; whether any poisonous substances have lately been purchased; whether these are still in the house; whether the alarming circumstances came on immediately after taking a drink or any other substance of an innocent nature; and particularly, in case of a sick person, let him ascertain whether anything has been given without the orders of the physician or by a person ignorant of drugs; and then he should draw a comparison between the symptoms present and those that ordinarily accompany the supposed disease.

He should carefully examine and preserve samples of every article of a suspicious nature, such as vials, boxes or papers containing powders, remains of food or drink, linen, sponges, cooking utensils, etc., in use about the patient; and he may (if assured of the support of the persons interested to promote justice) safely exercise a good deal of assumed authority in taking such precautions as against anybody who may object or oppose. Often a careful search of the premises and of the dead body will bring to light some article which, coupled with peculiar circumstances, warrants suspicion.

To decide between the relative probability of suicide and murder is a difficult question. The following facts are considered to indicate suicide: that the deceased had recently met with great losses or disappointments, or was suffering under disgrace, or under some form of insanity or delirium; that the mode of poisoning was cunningly devised to avoid a suspicion of suicide while yet the deceased held a life insurance policy; that he left any recent writing expressing his last wishes. If death has not occurred, the circumstance that the patient does not complain, but declines medical aid and remedies, confirms a suspicion of suicide. On the other hand, such suspicion is partially excluded when the circumstances favor the presumption that the deceased was in the enjoyment of a prosperous and happy life; when the drug employed is rare and procurable only with great difficulty, or is one which needs the co-operation of a second person for its administration, or is known to be productive of long and severe suffering. Considerations like these, and the results of a skilful toxicological investigation, in which the means afforded by anatomical and microscopic science, chemistry, and spectral analysis are useful to be employed, are more important in determining that the death is attributable to poison, and that this may probably have been criminally administered than are the mere symptoms.

The examiners should observe perfect cleanliness at every step of their work; the organs removed from the cadaver for chemical examination should not be placed, for example, upon boards or in receptacles which have been cleaned with disinfecting solutions which may have had poisonous constituents, but should be placed in glass or porcelain-lined dishes previously cleansed. The prudent and judicious advice given by Wharton and Stillé (2 "Med. Jur.," § 11) is that whenever, in a case involving a suspicion of murder, "a chemical analysis for poison is to be made of any of the organs, these organs should be placed by the physician himself in perfectly clean glass jars; glass preserve jars with a glass or porcelain-lined cover are suitable for the purpose, and can always be obtained in the country or city. Each organ should be placed in a jar by itself—for instance, the stomach in one jar, its contents in another, the intestines in another, contents of intestines in a fourth, the liver in a fifth, the kidneys in a sixth, the brain in a seventh, etc. The organs which should be saved for chemical analysis are in order of their importance, as follows: stomach, contents of stomach, liver, intestines, contents of intestines, kidneys, brain, heart, spleen, and urine if there be any; in some cases, it is important to save portions of the muscular tissue, and in others a part of the lungs. In some cases it is wise for the physician making the examination to divide each of these substances into approximately two equal parts, each part to be kept in separate

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jars, one to be given to one chemist for preliminary analysis, and the other to be retained by the physician himself, in case it may be necessary to have the analysis confirmed by another chemist, as is usually the case in trials for murder by poison. These jars containing the organs should be closed and sealed by the physician himself, the seal to be stamped with a private stamp. They should then be locked up until they are to be delivered to the chemist. It is better that the organs be placed under double lock, one key to be taken by one person and the other by another, so that neither one alone has access to the organs; this is, of course, not necessary if one person possesses the key and another has possession of the stamp with which the seals have been stamped. When the jars are to be sent to a chemist, they should be sent by messenger, preferably by two messengers, since, in the event of the investigation resulting in a trial for murder, the identity of the organs cannot be lost by the death of the messenger. The organs should never be sent by express since it is in that case impossible to preserve with absolute certainty the identity of the organs."

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Sending the organs or their contents to the chemist is often not enough, especially when crime is suspected. Thus, the reason why no poisonous substance is found in the stomach may be that all which was not absorbed was vomited; therefore all vomited matter which can be procured, including clothing, or carpet, or surface of floor which has received it, should have chemical examination. The vessel in which vomited matter has been contained will often furnish valuable evidence, since heavy mineral poisons fall to the bottom, adhere to the sides, or leave a sediment. The offender may have had the intelligence and opportunity to empty the basin, etc., but not have thought, or not have been able, to attend to the dress or the floor.

Formerly it was the practice to confine the analysis to the stomach and its contents. Experience has, however, shown that most if not all the viscera, including the bladder and urine, are required before anything like a satisfactory conclusion can be drawn as to the existence of poison.

The stomach, with its contents, should always be received by the analyst in its entire state, and not, as was formerly usual, sent to him slit, and the contents mixed in a jar with other fluids and organs—a practice which is highly objectionable, as it may lead to the ends of justice being defeated by the complication involved. A slight incision may suffice to inform those who perform the autopsy of the state of the organ and the nature of its contents, when it should be tied and handed to the analyst. If, in case of accident or dispute, a necessity arises to preserve a portion of the stomach and other organs, together with any fluids or solids, in bottles or otherwise, for further reference and confirmation, this may be done, but they should all be properly labelled and dated and kept in a cool place.

Besides receiving the matter to be analyzed or examined, the analyst should be thoroughly informed upon the history of the case, and the symptoms and effects, as a knowledge of these will aid his examination, enable him to avoid useless searches, and prevent his overlooking suspicious facts. He should even be informed of the exact time of the death, which is important in reference to the length of time usually taken for a fatal operation of the poison suspected; of the attitude of the body, etc., especially if there were any dying struggle; as certain poisons cause characteristic writhings or convulsions.

The analyst should never leave the vessel containing the suspected fluid in an exposed situation. He should keep it under lock and key, and, if interrupted in the course of the experiments, should restore it to such a place that he can positively affirm that no one could have meddled with it.

The notes of an autopsy or chemical examination should be promptly reduced to an orderly report; and greater care than is usually taken is desirable to avoid the use of medical or chemical terms, such as are not easily understood by judges and jurors.

When the chemist has completed his analysis, if he finds that the poisoning has been committed with an inorganic poison, such as arsenic, antimony, etc., he should bring the metal into court and present it to the jury; and there should be a sufficient quantity of it in order to submit it to all the tests necessary for its identification. With the organic poisons, the legal chemist would find this almost an impossibility, as the organic poisons are much more active, and are fatal in smaller doses. Their presence can be proved by various tests which are reliable; but their very nature would tend to prevent their complete isolation in sufficient quantities for presentation to the jury.

Benjamin Vaughan Abbott.

POISONOUS PLANTS.—It is generally agreed in toxicology that the term "poison" should not be applied to any substance which produces its injury through mechanical means. Following this terminology, we exclude from consideration in this article all such substances as cowhage, which produces intestinal injury chiefly by the piercing quality of its hairs, the sharp awns of the many grasses so fatal to grazing animals, the prickles and thorns of thistles, brambles, cactuses, and similar plants, which act mechanically, at least chiefly, notwithstanding that their presence often produces abscesses from which blood poisoning may result. From this article are excluded also all the ordinary disease germs. Although, strictly speaking, such diseases are the results of poisoning by these minute plants, growing within the system, their proper treatment pertains to bacteriology and pathology.

Since most of the more important poisonous plants are, by virtue of their activity, available for medicinal purposes, they are discussed elsewhere in that connection. Not only are their poisonous effects and the treatment there considered, but descriptions ample for their identification, in the condition of drugs, are provided. In many cases such drug descriptions have been supplemented by others, pertaining to the plants themselves, often with illustrations, in order to provide for their identification in cases of poisoning by the fresh material. The present article is intended to supplement the above by considering important poisonous plants not used as drugs. At the same time many of the latter will be referred to at the proper points in this system, and the other articles upon them will be duly cited.

General Recognition.—The question is frequently propounded, "Is there any general rule by which a poisonous plant can be recognized at sight?" To this question an emphatic negative must be returned. There are certain characteristics which frequently accompany poisonous properties, but this is not true in all cases; and, on the other hand, these characters may exist in the absence of such poisonous properties. Of such characters are the peculiar lurid purple color seen upon the stems of the castor oil, cicuta, conium, pokeberry, dogbane, and many other plants, though shown also by the harmless angelica. A narcotic odor is common to many of the most poisonous plants, but is wanting in many others. An acrid taste is probably the most common characteristic, and constitutes the best safeguard which we possess, since it is likely, especially in the fresh article, to furnish a warning before a dangerous quantity has been consumed. Thus the potato, though ordinarily quite bland, imparts, when poisonous, a peculiar bitter, nauseous, and slightly acrid taste. Even this taste-guide, however, fails in many notably poisonous substances. It may be added that milky-juiced plants are usually to be regarded with suspicion.

Principal Poisonous Families.

Of the two hundred and eighty or more families of plants, a number are recognized as being specially rich in poisonous species; but not all of the species of any family are poisonous, and important food plants are usually found closely related, in the same family, to violent

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poisons. Thus the family *Solanaceæ* contains the deadly nightshade, stramonium, and henbane, yet yields the potato, the egg plant, and the tomato, and even the potato itself may at times be poisonous. In the *Euphorbiaceæ* we find the manchineel, croton, and euphorbium, together with the cassava; and we have indeed poisonous varieties of the latter. Many similar illustrations might be cited. It is, therefore, not deemed feasible to essay a classification based upon botanical or any other general relationship, although, as a matter of convenience, the characteristics of several highly poisonous families are given below. While only a practical botanist can be expected to utilize this method of recognition to the fullest extent, yet surgeons in the army and navy and other travellers may gain great assistance by recognizing suspected plants as pertaining to the following families:

Apocynaceæ (the Dogbane Family).—This large family, of more than a thousand species, chiefly tropical, is probably, all things considered, the most commonly and powerfully poisonous. Its members are mostly heart poisons, well illustrated by apocynum, strophanthus, and oleander. Its poisonous constituents are bitter and chiefly glucosidal, though many alkaloids are contained, and a number of them, or the extracts containing them, enter into the manufacture of arrow poisons, especially in the Old-World tropics. Poisoning accidents by members of this family are rather common in tropical regions, sometimes occurring through the use of the stems for spitting meat, stirring food, or in similar culinary operations. The botanical characters are as follows: Juice usually milky; leaves (in the poisonous species) opposite, simple, exstipulate. Flowers regular, perfect, 5-merous; calyx inferior, persistent, imbricated; corolla tubular, the limb usually rotate, convolute; stamens five, borne upon the corolla and alternating with its lobes, the anthers two-celled; pistil dicarpellary, the carpels distinct or united; the ovary 2-celled or with two parietal placentæ; styles united or divided up to the simple stigma; fruit usually of two follicles, occasionally drupaceous; seeds frequently plumose.

Araceæ (the Arum Family).—This monocotyledonous family is well illustrated by the calla and calamus. Its members are chiefly tropical, and produce thick, somewhat succulent stems, frequently climbing tree trunks, and usually large, somewhat succulent, cordate leaves similar to those of the calla. A great many species produce bulbous or tuberous stem bases, commonly regarded as roots. Some of these, as the taro (*Colocasia esculenta*), are important foods. Others would be so but for their poisonous constituents. In a few cases, where these poisonous properties are mild, they are destroyed by thorough cooking, while in others this method fails and attempts thus to use them may result disastrously. The injurious principles fall into three classes: First, as in the seeds of peltandra and skunk's cabbage, needle-shaped raphides of calcium oxalate, occurring in great abundance, and irritating mechanically; second, as in our common wild turnip, acrid juices which are partly destroyed by drying; third, powerful alkaloids, some of them, or the extracts containing them, used in the manufacture of arrow poisons. The flowers of the aroids occur densely massed upon a cylindrical (as in calla) or a globular (as in skunk's cabbage) spadix, enclosed or subtended by a spathe (the white portion of the calla), though this is sometimes obscure. The plants are diœcious, or the staminate flowers are on the upper, the pistillate on the lower portion of the spadix. Rarely the flowers are perfect. There is usually no perigone, though sometimes this exists in the form of a number of scales. The filaments are very short, their anthers two-celled, the cells separated by a broad connective and opening dorsally. The ovary is variable in structure, the stigma terminal, small, sessile, or on a very short style. Fruit usually a berry, occasionally inflated.

Cactaceæ (the Cactus Family). Beyond remarking that many leafless and spiny or succulent plants which do not pertain to this family are frequently mistaken for cactuses, little need be said of its characters. The juice is bland and never milky, the flowers are showy, polypetulous and polyandrous, and the inferior fruit is a many-seeded berry. In desert regions, in the absence of food, and more especially of drink, the flesh and juice of cactuses are often utilized. In such cases it should be borne in mind that while the spiny species are usually innocent, those which are unarmed, or nearly so, like the night-blooming cereus and the anhaloniums, are often narcotic or cardiac poisons.

Campanulaceæ (the Harebell Family), including *Lobeliaceæ* (the Lobelia Family).—The two divisions of this family here named have been regarded by many botanists as distinct families. Certainly there is a marked distinction between their properties, the former yielding roots rich in inulin and sometimes edible, whereas the Lobeliaceæ contend with the Apocynaceæ for first rank among poisonous families. The nature of the constituents and the character of the poisoning are pretty uniform and have been sufficiently detailed under Lobelia. Since the poisonous species are very widely distributed throughout both temperate and tropical regions and are quite showy and attractive, their recognition is unusually important; fortunately it is also quite easy. The juice is acrid and almost always milky; leaves alternate, exstipulate, simple, and commonly abundant; flowers perfect, mostly showy, usually 5-merous; calyx tube adherent, the limb mostly regular and persistent; corolla tubular, epigynous, irregular and oblique or two-lipped, its tube fissured on the upper side; stamens five, inserted upon or with the base of the corolla and alternate with its lobes, the filaments coherent for the most of their length, as well as the anthers.

Cucurbitaceæ (the Cucumber Family).—Notwithstanding that this family is rich in edible fruits, like the pumpkins, melons, and cucumbers, yet it contains also a very large number of poisonous species. The poisonous properties pertain usually to the roots or the fruits. The former class is typified in bryonia, and has been sufficiently considered under that title. The latter is illustrated in our accounts of colocynth and elaterium, and need not be further considered. No difficulty need be experienced in the identification of the *Cucurbitaceæ*, which are tendril-bearing vines, usually herbaceous, and the flowers of which are invariably constructed like those of the plants named above, though they are occasionally small or even minute.

Euphorbiaceæ (the Spurge Family).—The general and poisonous properties of this family have been considered in Vol. IV. The plants are readily recognized by their milky juices, in connection with the unisexual flowers, which are themselves inconspicuous, though often surrounded by showy modified leaves resembling a flower circle. The perigone and andrœcium are so extremely variable as to be difficult of any brief characterization. The ovary and fruit are almost uniformly three-celled and the latter few-seeded.

Iridaceæ (the Iris Family).—This monocotyledonous family almost uniformly contains irritant poisonous oleoresins, well illustrated by that of the official *Iris*. Owing to their acrid properties they are not very likely to cause poisoning, except through their medicinal employment. Nevertheless, owing to the fleshy and obviously nutritive character of their rhizomes or tubers, they are not infrequently resorted to as famine foods in some countries, and disastrous results have sometimes thus occurred. These plants are perennial herbs with narrow, distichous, often succulent leaves. The flowers are perfect, with an adherent six-parted convolute and marcescent perigone. The stamens are three and adherent to the outer perigone segments. The ovary and seed pod are commonly three-celled, with a three-parted style, and the ovules and anatropous albuminous seeds are numerous.

Leguminosæ (the Bean Family).—This family has already been briefly considered in Vol. V. as to the general nature and properties of its poisonous constituents. As poisons, its members present peculiar dangers, which, upon the whole, are not equalled by those of any other family. These dangers lie in the fact that, while the poi-

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sonous constituents are very widely and irregularly distributed, and extremely subtle and uncertain, the family is at the same time the most highly nutritious as to albuminoid constituents in the vegetable kingdom. Even such edible articles as peas and beans are not entirely free from poisonous properties, which become apparent when they are fed in large quantities as stock foods. Although the poisonous properties pertain to all three of the sub-families, they are most common and conspicuous in the Papilionaceæ. The members of this family are rather easily recognized by their almost uniform habit of producing a legume for a fruit, and by their highly developed exalbuminous seeds. In the Papilionaceæ the leaves are alternate, stipulate, and usually compound, the flowers papilionaceous and nearly always perfect, the calyx more or less gamosepalous, the five or ten stamens almost always more or less coherent. In the two other sub-families the flowers, though often irregular, are not papilionaceous, and the stamens are commonly wholly or nearly distinct.

Liliaceæ (the Lily Family).—This very large monocotyledonous group is now, with good reason, divided into the Smilaceæ, Melanthaceæ, and Convallariaceæ as distinct families. Nevertheless, since they agree, excepting the Smilaceæ, as to their poisonous properties, the entire group is here considered. The plants are mostly herbs, growing from bulbs or fleshy rhizomes. The juices are usually bland, though sometimes, as in the onions, acrid. Indeed, the poisonous species have mostly acrid juices. The leaves are parallel-veined and usually sheathing at the base. The flowers are regular and possess a six-parted perigone in two circles. The family is distinguished from the *Iridaceæ* by its six stamens, which are usually free, or nearly so, and distinct. The ovary is three-celled and usually superior, the styles distinct or united. The pod is three-celled, the seeds are numerous and highly albuminous. This family, like the *Iridaceæ*, is very liable to cause poisoning accidents, owing to the succulent and nutritious properties of its underground portions and even of its herbage. The nature of its poisonous constituents, both chemically and physiologically, is too varied for any general description.

Loganiaceæ (the Nux Vomica Family).—This is here referred to as being a small family, closely related to *Apocynaceæ* and almost equally poisonous. It is closely similar to that family in its structural characters, but lacks the milky juice and the annular stigma. Accidental poisoning is scarcely likely to occur from its members, except through their medicinal employment, and those subjects are fully treated elsewhere.

Oxalidaceæ (the Oxalis Family).—This small family, for a long time regarded as part of the *Geraniaceæ*, is readily recognized by the close similarity of all its members in foliage and flower structure to the genus Oxalis, represented by the wood sorrel, the sheep or lady's sorrels, common garden weeds, and by many species cultivated in the conservatory. The herbage of these plants contains oxalic acid and, like the meadow, field, or kitchen sorrel (*Rumex Acetosella* L.) has, when eaten in excess, caused serious or even fatal results, both to children and to adults.

Papaveraceæ (the Opium Family).—This small family is almost uniformly narcotic-poisonous, very many of its species being also irritant. Its constituents are pre-eminently alkaloidal, and these alkaloids are very numerous and varied in their mode of action. Owing to their commonly irritant properties these plants are not likely to cause poisoning, except through their medicinal use. They have commonly milky or colored juices, mostly compound or lobed leaves, perfect flowers (usually regular), their parts free and, except as to the carpels, distinct. The seeds are numerous and small.

Pinaceæ or *Coniferæ* (the Pine Family).—The large family of cone-bearing evergreens is too well known to require description. Its constituents and properties have been sufficiently indicated in our accounts of *Juniper*, *Savin*, *Turpentine*, etc. Similar constituents exist generally throughout the family. Poisoning is not likely to occur, owing to the acrid and excessively disagreeable character of the tissues.

Ranunculaceæ (the Buttercup Family).—This large family is distinguished by its alternate, exstipulate leaves, flowers which show neither adhesion nor cohesion in any of their parts, innate anthers, anatropous ovules, and the small embryo in fleshy albumen, taken in connection with the acrid juices. These acrid juices are commonly cutaneous and internal irritant poisons. Attempts to utilize them for blistering purposes have been made, but the blister is not readily controlled. A great number of the species contain, in addition, principles which, upon absorption, act as cardiac paralyzants, of which aconitine may be taken as the type.

Simarubaceæ (the Quassia Family).—The constituents and properties of these plants have been sufficiently discussed in connection with quassia and simaruba. Their consumption so as to cause poisoning is almost impossible, owing to their very bitter taste. A curious case of poisoning by Ailanthus is recorded below under "Poisonous Leaves."

Solanaceæ (the Potato Family).—A description of the characters of this highly narcotic family is not called for, since pretty much all of the species likely to cause poisoning have been already considered in connection with the drugs, Belladonna, Henbane, Stramonium, etc., or below in connection with Solanum.

Umbelliferæ (the Parsley Family.)—This very large family, although it yields many important edible products (carrot, parsnip, parsley, celery, angelica, etc.), contributes also such violent poisons as conium, cicuta, and œnanthe. Its species are very readily identified. They usually possess, especially as to the poisonous species, hollow stems, petioles which are dilated and sheathing at the base, leaves pinnately compound, usually decompound, as seen in celery and parsely, flowers in (usually compound) umbels, these flowers usually minute, with five superior calyx teeth, five epigynous petals and stamens and fruits having the general structure of the well-known conium, anise, coriander, fennel, etc.

Violaceæ (the Violet Family).—Although not at all likely to be consumed in poisonous quantities, except as overdoses of medicine, the violets should be remembered as containing one or more emetico-cathartic poisonous constituents, very similar to emetine, and long mistaken for it. The violets are so well known that no description of them appears called for.

Local Cutaneous Poisons.

Poisonous plants can be conveniently divided into those locally poisonous to the skin and those internally poisonous. The first-mentioned class will be first considered.

They represent all grades of irritation, from a mild and brief itching to a severe corrosion or a dangerous or even fatal inflammation. The milder of these groups can be accorded but the briefest mention. A large number of them produce no effect upon most persons, but have been at times recorded as irritating to certain individuals with a highly sensitive skin, or who are subjects of idiosyncrasy. Illustrations of this class are seen in the fresh herbage of *Veratrum*, in various species of *Cypripedium*, *Catalpa*, *Rhododendron*, and *Kalmia*, and in *Vanilla*. In a number of cases the nature of the poison has not been ascertained, and it is possible that it is due to the presence of animal or vegetable parasites, or other foreign bodies. Others, like the various nettles (*Urtica*, *Urticastrum* [*Laportea*] *Urera*, etc.) are regularly irritating, but the irritation is temporary, though often very painful, and unless complicated does not call for treatment. In the last-mentioned genus of tropical American shrubs the stinging hairs of the ordinary nettle are magnified into needle-like prickles, several inches in length, intensely poisonous, and causing severe inflammation when contact with them is extensive and violent. The nature of this poison and its treatment have not been investigated, though doubtless much the same as in the nettles. Very similar to the nettles are the stinging hairs upon the various

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Poisonous Plants.

species of *Jatropha*, *Tragia*, and others of the *Euphorbiaceæ*, *Sicyos* in the *Cucurbitaceæ*, *Echium*, and others in the *Boraginaceæ*. Those of the *Euphorbiaceæ* have also tropical relatives (*Hura*, etc.), in which the hairs are magnified into spines, the effects of which are severe.

The important poisonous plants, those requiring our attention, pertain chiefly to the families *Anacardiaceæ* and *Euphorbiaceæ*.

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The poisonous members of the *Anacardiaceæ* are numerous, and their effects are of extremely common occurrence and very severe. The poisonous constituents, their mode of action, symptoms, and treatment are in all cases either identical or so closely similar that they can be readily considered under the one subject of Rhus poisoning, the further consideration of the respective individuals being confined chiefly to their description and recognition.

Rhus Poisoning.—The principal agent concerned in this accident is the herbage of *Rhus radicans* L., the common Poison ivy or oak, Climbing or Three leaved ivy or sumach, Mercury, or Black mercury. There is considerable difference of opinion as to whether Linné's *R. toxicodendron* is identical with his *R. radicans*, but the title, as here used, includes both. The plant is a slender North American shrub, and occurs wild to some extent in Europe, where it has been introduced. It may lie prostrate upon the ground, though it prefers to climb shrubbery or trees, in sunny locations, or upon fences or walls, to which it clings by false or non-absorbing roots. Sometimes, especially southward, it grows with an erect, self-supporting stem. Having thus attained a support, its branches spread or droop outward to a considerable distance, being thus very apt to brush against the faces of those walking along country roadsides. Flower and fruit habit are well displayed in the accompanying cut (Fig. 3839). The trifoliolate, or occasionally quinquefoliolate leaves sometimes reach a foot and a half or even two feet, including the petiole, in length. The leaflets are very thin and present a peculiar satiny lustrous appearance. Although usually apparently smooth (sometimes conspicuously hairy on the lower surface), they in reality bear an infinite number of extremely fine and short hairs. The flowers are of a greenish-yellow and are followed by small drupaceous, pale green, smooth fruits, borne in loose bunches, quite unlike those of the ordinary red sumac.

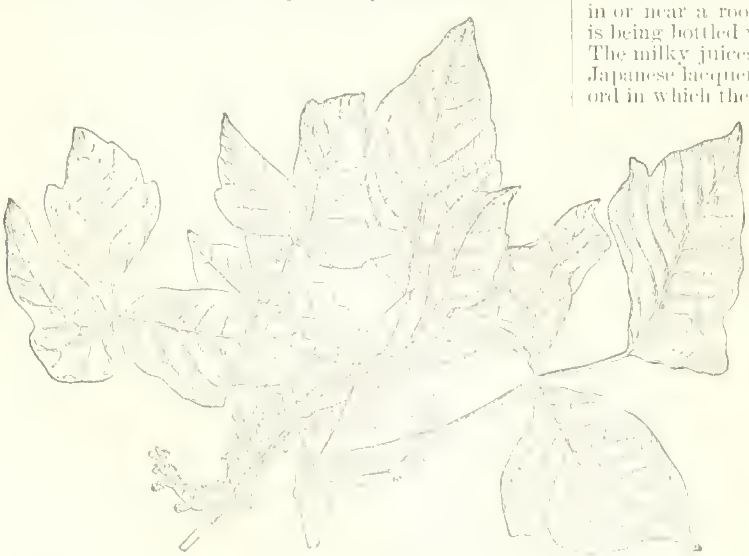

Fig. 3839. Rhus radicans. (Two-thirds natural size.)

Some of the conditions by which poisoning can occur from this plant are in dispute. On theoretical grounds, if what is known of the nature of the poisonous constituent be taken into consideration, actual contact in some form appears to be requisite; yet innumerable and well-authenticated experiences render this view quite untenable. There is the widest difference in the susceptibility of different individuals, some being apparently incapable of being poisoned by it under any circumstances. Others, who have been exposed to it frequently for many years without result may suddenly become severely poisoned. Others again are extremely sensitive to its action, the most serious, or even fatal, results ensuing from even a moderate contact. Finally, cases are of common occurrence in which poisoning occurs apparently without any contact whatever, a strong wind blowing over the plant from a short distance constituting a sufficient occasion. It has been suggested that in such cases the pollen grains constitute a medium of transportation, but such occurrences take place when no pollen grains are present. It seems hardly credible that the almost microscopical hairs can be active in these cases, notwithstanding that experiment has demonstrated their power, in very small number, to effect slight poisoning when directly applied to the skin of sensitive persons, under specially favorable conditions.

Much speculation has existed, and many conflicting statements have been published, as to the nature of the active constituent, but the laborious researches of Pfaff have gone far toward clearing up this subject. He has located the poison in the fat or fixed oil which exists in fractional percentage, and which has been called *toxicodendrol*. This is an alcohol-soluble fat, in which character it resembles croton oil and its relatives. Its chemical nature is very incompletely known. Reasoning by analogy, we should assume that the oil is not poisonous in its own form, but only through its freed fat acid. If, as originally claimed by Maisch, who called it *toxicodendric acid*, this decomposition product be volatile and active, all of the inconsistencies regarding its action would be removed. The same or similar fat existing underneath the bark acts similarly, and here again it is notable that many cases of poisoning have been recorded as occurring by contact with the smoke emanating from a smothered fire of the wood of the plant. It is also stated that certain very sensitive persons cannot remain in or near a room where the tincture of the fresh drug is being bottled without the certainty of being poisoned. The milky juices of other species of Rhus, especially the Japanese lacquer tree, act similarly, and a case is on record in which the emanations from a bottle of this lacquer poisoned the faces of those smelling it, though there was no contact. Poisoning did not result where the substance came into contact with the mucous membranes of the mouth and nose.

There exist in the leaves, besides toxicodendrol, a small amount of resin, some tannin, wax, and other unimportant constituents.

Poison ivy has been highly recommended by the homœopaths as a medicinal agent, purely upon the dogmatic assertion *similia similibus curantur*, and it has even found its way into the United States Pharmacopœia, though it is to be dropped from the forthcoming edition. Making the most liberal allowance, we are obliged to conclude from the evidence at our command that its medicinal activity is practically *nil*.

Ivy poisoning first appears as minute, clustered, itching papules, which soon become surrounded by a bright erythema, in part produced by the inevitable scratching. The papules have by the next day become minute, deep seated, eczematous blisters. For several days this appearance is not much changed, nor are the burning and itching diminished. Then the surface of the blisters gets rubbed

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off, the watery exudation moistens the surface affected, and often spreads the disease to other parts. The blisters finally become pustular, and then crusts and scabs cover the surface. The first appearance is always local, and if contracted in any of the usual ways is on either the hands or wrists or the face. In the latter situation the swelling is always great, the eyelids generally becoming completely closed by it. From the hands it easily extends to the breasts or male genitals, on the latter of which the burning is exceedingly hard to bear; occasionally it becomes general. The course of the affection in a single spot covers usually five or six days, but it may often spread over twice that time when different parts of the body are successively invaded. It heals without a scar, but is a little apt to return on successive summers.

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FIG. 3840.—Rhus vernix. (Two-fifths natural size.)

There is rarely any difficulty in establishing a diagnosis. The symptoms present some superficial resemblances to those of erysipelas, but in the latter disease the underlying tissues are swollen and hard, whereas in ivy poisoning the effects are superficial and the surface is soft and somewhat fluctuating.

Numerous remedies and specifics are in use against Rhus poisoning; still its course, when fairly begun, is not often really aborted. The measures for its treatment may be divided into the following classes: (1) The destruction of the poisonous constituent; (2) the prevention of friction due to scratching the affected surface, and the prevention of the spreading of the poisonous matter; (3) the relief or prevention of itching and pain from atmospheric irritation.

The first of these results can be fairly well accomplished if measures are taken very promptly after exposure and before the symptoms of poisoning have fairly presented themselves. Ordinary washing is inadequate, unless very thorough indeed; and it is, in fact, liable to spread the poisonous substance over a wider surface. Washing with a great abundance of common cheap laundry soap, or even the application of a thick layer of this soap to the surface, has yielded good results. Washing with a strong solution of sugar of lead is a favorite method with some, and lime water, black wash, and other alkaline applications are useful. The discovery of the fatty nature of the poison serves to explain to some extent the principles of this line of treatment, the alkali probably saponifying the fat and destroying its activity. The second-named object is attained by the use of vaseline or some similar application, and this also accomplishes part of the third object, protection against the effects of the atmosphere. These applications should be made as lightly as possible, though thickly, and not by means of plasters or similar coverings. Excellent results have been attained by applying the fluid extracts of Grindelia, Eriodictyon, and similar resinous substances, as well as collodion. In these cases the effect is probably due to the deposit upon the surface of a thin protective coating resulting from the evaporation of the alcohol. Relief of the irritation is to be obtained by the application of carbolic acid. An excellent method is the use of the official lime liniment to which from one to five per cent. of carbolic acid has been added. To any small areas which exhibit a specially irritable condition, a solution containing ten per cent. of the acid may be applied. Great care should be taken, however, that no large area, and especially that no extremity, be covered up by even the weaker solution. A saturated solution of oxalic acid is highly recommended by some practitioners. As the eczema dries away, zinc ointment may profitably be applied to take the place of the other applications. The Cheyenne Indians are said to employ with great success an infusion or decoction made from the herbage of *Astragalus nitidus* Pursh., a near relative of the famous loco weed (*A. mollissimus* Presl.). This infusion is applied just when the eruption takes on its "watery" character. Since the constituents of this plant are entirely unknown, the principle involved in its employment cannot be stated. The fresh juice of the wild or great celandine, or jewel weed (*Impatiens fulva*) is said to have been used with excellent results.

Almost precisely similar in action to poison ivy is the Poison dogwood or elder or Swamp or Poison sumac (*R. vernix* L.; *R. venenata* D.C.) (see Fig. 3840). This species is an erect-branching shrub or small tree with a smooth ashy-gray bark, of swamp lands, throughout Eastern and Central North America. The habit of the leaves and inflorescence is indicated in the accompanying cut. The leaves are very characteristic, on account of their deep red petioles. The leaves sometimes reach a length of one and a half to two feet, are nearly smooth, and green on both surfaces. Flowers and fruit are very similar to those of the poison ivy.

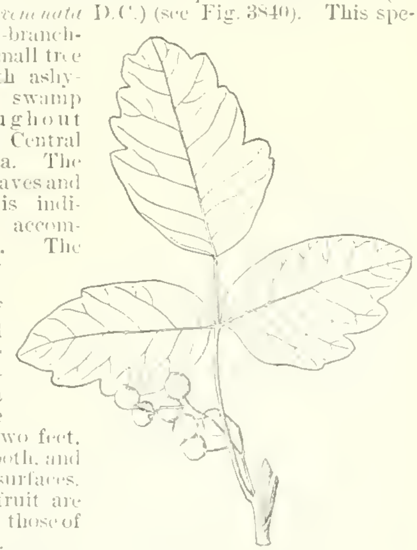

FIG. 3841.—Rhus diversiloba. (One-half natural size.)

The two species of Rhus above described pertain to the section *Venenatæ*, characterized by smooth fruits, and most, if not all, of the species of which are poisonous. The Japanese lacquer tree (*R. vernicifera* DC. or *R. vernix* Thunb.) has been already referred to. The lacquer is prepared from its milk juice, which frequently pro-

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duces severe poisoning, as does the herbage. The tree closely resembles our *R. vernix* L. Species which quite closely resemble *R. radicans* are *R. microcarpa* (Mx.)

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FIG. 3842.—Metopium. (One-half natural size.)

Steud. (*R. Toxicodendron microcarpa* Mx.) of our North Central States, *R. Michauxii* Sargent (*R. pumila* Mx.) of the Eastern United States, and, in the West, *R. Rydbergii* Small and *R. diversiloba* T. et G. (*R. lobata* Hook.), the

FIG. 3843. Comocladia. (Reduced one-half.) *A*, Leaflet of *C. glabra*; *B*, base of leaf and fruit cluster of *C. dentata*; *C*, upper portion of leaf of *C. ilicifolia*; *D*, leaf of *C. platyphylla*.

Californian or *Pacific Poison Oak* (see Fig. 3841). The celebrated *Coral Sumac, Mountain Manchineel* or *Bumwood* of Florida and tropical America, has been referred to this genus as *R. metopium* L. or *R. oxymetopium* (Griseb., but is now called *Metopium Linnæi* Engl. (see Fig. 3842). Its close relative in Cuba, *M. venosum* (Griseb.) Engl. has similar poisonous properties. These are small trees or large shrubs, and their fruits are reddish instead of greenish-white like the others named.

FIG. 3844.—Lithræa caustica. (Two-thirds natural size.)

The genus *Comocladia* P. Browne (*Dodonæa* Plum.) represents shrubs and trees of the central portion of tropical America, including the West Indies, which are violently poisonous. Several species are known as *Guao*, and a number are here illustrated (see Fig. 3843). Poisoning by these species has been successfully treated with an application of collodion. The following possess, in their respective localities, histories of poisoning similar to those of the *Venenata* and *Comocladia* described above: in Chili the *Llithi* (*Lithræa caustica* Miers (*Rhus c.* Hook.) (see Fig. 3844); in Mexico, the *Copaljiote, Cuajiote* or *C. Blanco, Guajilote* or *Stinking Wood* (*Pseudosmodingium perniciosum* (H. B. K.) Engl. (*Rhus p.* H. B. K.); in Eastern Asia, *Melanorrhœa laccifera* Pierre; in the East Indies, *Holigarna ferruginea* March.; in Southeastern Asia, *Gluta Renghas* L.

The fixed oil of the cashew or caju nut, the ripened ovary of *Anacardium occidentale* L., a small tree, native of tropical America and largely cultivated and naturalized in other tropical countries, yields the vesicating principle *cardol*, evidently very similar to the poisonous element of Rhus. This substance exists in specially large amount in the middle layer of the pericarp, and the fatty substance thence exuding frequently causes poisoning. Cardol ($C_{21}H_{30}O_2$) is soluble in alcohol and ether. In the crude condition it varies from yellow to reddish or brownish, but can be decolorized. Poisoning

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Poisonous Plants.

by it, and its treatment, are practically identical with those pertaining to Rhus.

The only other cutaneous poisons important enough to require consideration here are certain acrid juices of the Euphorbiaceæ. Types of this class are *Aleurites* and *Euphorbium* (which see). Others are referred to in our article on *Euphorbiaceæ*. In most of these cases the poisoning agent appears to be resinous. In croton oil and some others they are apparently fat acids. In the former class the saponification treatment offers little promise. In both cases protective and soothing applications are equally efficacious as in Rhus poisoning. Manchineel is the large tropical American (chiefly West Indian) tree *Hippomane Mancinella* L. It bears large, thick, ovate, acute, finely serrate leaves and an apple-like fruit containing several silvery seeds. Its milky juice is abundant and is the poisoning agent, its active constituent being apparently volatile. Treatment is much like that applicable to Rhus poisoning.

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Internal Poisons.

In considering the poisonous plants which act through the entrance of their constituents into the circulation or into the alimentary canal, the primary requirement appears to be their identification. This, in a majority of cases, is most readily effected by reference to the objects themselves, rather than to the symptoms as in cases of poisoning by chemical substances. This fact has determined the following classification of these objects as plant parts.

To discuss all poisonous plants would require a large volume, and it has been deemed wise to treat the subject from the standpoint of a North American work, considering all plants of importance, or likely to become so, as poisoning agents in our own region, and including, from outside of this region, only such as are of primary importance. Moreover, no attempt is made to enumerate all those known to possess poisonous properties, since it is clear that many of them are not at all likely to be eaten. A still further restriction of the subject is made by omitting, except by mere mention, those poisonous plants or plant parts which become effective only through their medicinal employment, these having been sufficiently treated in the materia medica portion of our work.

Fruits and Seeds.

These products are placed first because of their greater liability to being eaten. Contrary to popular ideas, the

Fig. 3845.—Belladonna. Branch reduced one-half; fruit natural size.

number of poisonous fruits and seeds in North America is small. Even in country districts, where correct knowledge of this subject should be found, many perfectly innocent substances are commonly regarded as poisons.

Belladonna (fam. *Solanaceæ*).—Undoubtedly this is our most important poisonous fruit, its seeds containing the active constituents pertaining to the roots and leaves. The plant is rare in a wild state in this country, though very common in Southern and Central Europe. Its scarcity, however, renders it on some accounts the more dangerous, since it is thus not well known. It is a highly attractive, purple-black, shining, juicy berry, as indicated by one of its common names, "black cherry," and has been often eaten by children in the regions where it abounds. The accompanying illustration (see Fig. 3845) is ample for identification. The plant is a tall, widely spreading, smooth perennial herb, somewhat resembling the pokeberry plant, though not so large and wanting the strong purple stem coloration of the latter. All matters pertaining to the symptoms and treatment of poisoning by it will be found under *Belladonna*.

Bittersweet, True and False.—Rather closely related to belladonna is the true Bittersweet (*Solanum Dulcamara* L., fam. *Solanaceæ*). Leaf, flower, and fruit forms are shown on page 763, Vol. I., and the plant is there described. It is found both in Europe and in America, and grows commonly in the edges of swamps and along streams, especially where the water is stagnant, or where the ground is subject to overflow. Occasionally also it grows in other localities, as about shaded stone walls and fence rows. The branches are long, slender, sprawling, and widely spreading over bushes, and the fruits are pendulous. Nothing more attractive than these fruits can be imagined. They are of a ruby-red color, smooth, shining, and somewhat translucent, and children are very apt indeed to eat them. Their poisonous properties are rather mild unless large numbers are eaten. The seeds appear to be the poisonous portion. The properties are partly those of the drug Dulcamara, but more intense, and the poisonous constituent appears to be solanine.

False Bittersweet (*Celastrus scandens* L., fam. *Celastraceæ*) has been considered in the same connection. Its fruits are also attractive, but possess an acrid taste; hence they are not likely to be eaten in quantity. Their poisonous properties, due probably to a small amount of saponin, are comparatively slight.

Potato Fruits.—The small berries which develop upon potato plants are mildly poisonous, especially when unripe, in the same way as are the berries of true bittersweet. They have a nauseous, acrid, and disagreeable taste, and are not at all likely to be consumed.

Black Nightshade.—The fruits of black nightshade (*Solanum nigrum* L., fam. *Solanaceæ*) may be dismissed with the same remarks which have been applied to potato fruits. This plant grows like a tall, slender, and erect potato plant, in similar situations to those of bittersweet, though usually in dryer ground and more in the vicinity of barns and waste places. It is not very abundant, though somewhat common in the United States, as indeed in almost all other parts of the world. Its fruits are a little larger than large peas, and are of a greenish-black color. The fruits of many tropical species of Solanum are similarly, some violently, poisonous.

Other North American berry-like or fleshy fruits requiring consideration in this connection are the baneberries, or cohoshes, red and white, pertaining to the genus *Actæa* and the fruit of the yew.

Actæa (fam. *Ranunculaceæ*) is a genus of several species, probably more numerous than generally admitted by systematic botanists, distributed from Japan across Asia and the most of Europe, and in North America from ocean to ocean. According to ancient, and to one very recent authority, the half-score species of Cimicifuga are also included; but to most botanists familiar with the plants in a state of nature, an absurdity is involved in this association. The red and white berries have been recorded as poisonous, the medical botanist Lindley saying of them that they produce death with violent delirium, emesis, and catharsis (see Fig. 3846). The active constituents of the baneberries have not been investi-

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gated, but are in all probability similar to those of larkspur seeds and stavesacre. Not enough is known of their action to suggest anything more than rational treatment, consisting of prompt evacuation, followed by alleviation

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FIG. 3846.—Actaea. A, A. rubra; B, A. alba. (Two-thirds natural size.)

of the painful symptoms, and support to the circulation, which is depressed as in poisoning by hellebore.

Yew Berries (fam. *Taxaceæ*).—It was for a long time supposed that the American creeping yew was a mere variety of the European, which latter is recorded as having produced various poisoning accidents. Now, however, it is recognized that they represent distinct species. The foliage and fruits are here illustrated. The plant is an evergreen and the fruit is of a beautiful bright scarlet, frequently with a somewhat glaucous surface (see Fig. 3847). The poisonous constituent, present in the seed and foliage, is the alkaloid *taxine* (C[illegible]H[illegible]NO[illegible]), which is bitter, readily soluble, in its free state, in alcohol and ether, but not in water and is precipitated by silver nitrate. Its action is very imperfectly understood though it is compared in a general way with that of digitalis. The following symptoms have been recorded: nausea and retching without much vomiting, dilated pupil, convulsions interrupting a semi-comatose condition, a cold and clammy skin, and difficult respiration. No cases of poisoning by the American plant have been recorded, though it doubtless acts similarly.

Phytolacca or *pokeberry* has already been considered as a drug. The so-called berries are in reality stone-fruits. They are of a beautiful and tempting appearance, being of a dark purple-black, shining and juicy, and are not rarely eaten by children (see Fig. 3848). After a little time the taste becomes acrid, so that large quantities are not usually consumed. The seed, which is the poisonous portion, is enclosed in a crustaceous endocarp, which is usually not crushed in eating, so that the seed is protected for some time against the digestive juices. Meantime the pulp itself is somewhat laxative, so that the dejection of the pyrenes in an entire condition is to be anticipated. Treatment should consist in prompt emesis and catharsis, followed, if irritant symptoms should appear, by that applicable to poisoning by pokeroot.

Other fleshy fruits.—In this connection brief reference may be made to the fact that although the common May apple or mandrake berry is commonly and freely eaten, yet two cases are recorded of poisoning by it, one resulting fatally. The symptoms were those of poisoning by podophyllin, although narcosis came on very early.

Such seeds as those of the cherry, plum, and peach are in all respects similar to bitter almond, and are capable, when eaten in excess, of causing prussic-acid poisoning. Two cases are reported in which intestinal impaction of wild cherry stones, followed by the freeing of the seeds by maceration, resulted in poisoning, one of the cases proving fatal. Excessive indulgence in eating the sweetish fruits of any species of juniper may result in poisoning similar to that by the ordinary medicinal juniper.

The fruit of *Tamus communis* L., the Black bryony (fam. *Dioscoreaceæ*) grows upon a tendril-bearing vine of Northern Africa, Southern Asia, and Southern and Central Europe. It (see Fig. 3849) is an active emetico-cathartic poison, producing powerful diuresis, and apparently acting much after the manner of squill.

In Southern and Central Europe, as well as in cultivation for lawn ornament, occur the peculiar fruits of *Daphne mezereum* L., which are quite actively emetico-cathartic and diuretic; they are used for fish poisoning, and sometimes poison children. They contain the glucoside *daphnin* ($C_{15}H_{16}O_9.2H_2O$) which is neutral, soluble in hot

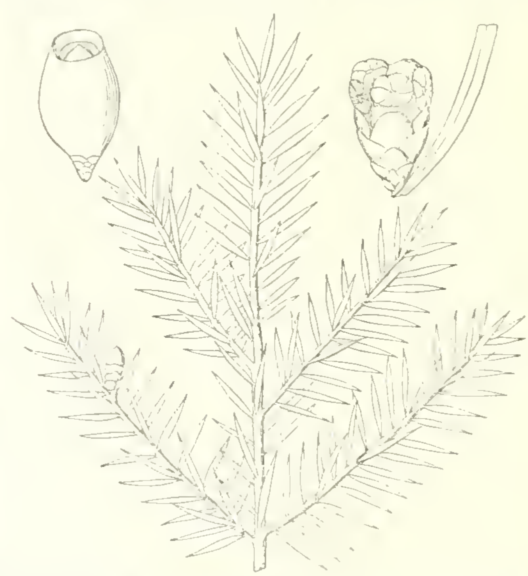

FIG. 3847.—Taxus. Branch slightly reduced; ament and fruit × 2. (After Britton and Brown.)

water and not alcohol; also the amaroid daphnetin, which is a feebly acid and astringent principle, similarly soluble. We here figure also the fruits of *Hedera helix*, the common ivy, which are discussed under the title *Ivy*, and those of *Ligustrum vulgare*, or privet, considered under the title *Privet*.

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Poisonous Plants.

Finally, reference may be made to the fact that mild narcotic properties pertain to the common elderberry, notwithstanding the freedom with which this fruit is eaten. Small animals, like barnyard fowls, have been

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Fig. 3848.—Phytolacca. (One-half natural size.)

recorded as suffering from intoxication from eating them. Cooking or fermentation appears to destroy these properties.

Stramonium.—Among the non-fleshy fruits and seeds, probably the most important poisoning agent is Datura or stramonium, the common thorn apple. An examination of our illustration (see *Stramonium*) will show that the fruit is large and conspicuous, and very likely to attract the attention of the curious or hungry. Growing as it does in waste places in cities, whose inhabitants are not accustomed to observing vegetation, it not infrequently happens that its seeds, which are contained in abundance, are eaten, especially by young people. It is also stated that in India and other Oriental countries where this plant abounds its seeds are often eaten by starving people in times of famine, with widespread fatal effects. The Thugs were said to use them freely for the purpose of stupefying their intended victims. Such assassins were called *Dhaturias.* The symptoms are identical with those described under *Stramonium*, as is the treatment.

Henbane.—Closely related in every way to stramonium is henbane. The plant is similarly a large, coarse, widely spreading herb, with clammy foliage and heavy narcotic disagreeable odor. Its capsules are not more than half so large as those of stramonium, and they discharge by the separation of a terminal lid. Poisoning by these seeds is not common.

Cicuta.—Small fruits, usually spoken of as seeds, are those of conium and cicuta. The former has been sufficiently considered under that title. Poisoning by the latter, except as part of the plant itself, which subject will be considered under roots, is not at all likely to occur. The same may be said of the seed-like fruits of our wild parsnip, which are said to be somewhat poisonous, the action being partly acrid-irritant and partly narcotic. No authenticated cases of poisoning are recorded. The fresh juice is said to blister and the root is regarded with suspicion.

To be classed with ergot, as poisonous constituents of grain, are the darnel, the cockle, and perhaps the seeds of other species of plants in the pink family.

Lolium, Darnel, Bearded Darnel, Ivraie (Fr.), *Lolch, Taumelkorn* (Ger.), is the fruit (grain or *caryopsis*, commonly miscalled seed) of *L. temulentum* L. (fam. *Gramineæ*), an Asiatic grass, growing commonly in grain fields there and in Europe, and so introduced in this country. The general structure of this seed is that of a grain of wheat or rye. It is about a fourth of an inch long, and comes away with the palets attached and enclosing it, is convex on one side, grooved on the other, of a light brown color, smooth, starchy in structure, and gradually develops a bitter taste after chewing. Its presence in flour, if in large quantity, can be detected by the appearance of the starch grains, which are much smaller than those of wheat starch, nearly circular, white-margined, the rest of the body without markings, and having a peculiar brightly shining surface. The poisonous constituent is the alkaloid *temuline* ($C_7H_{12}N_2O$), existing with *temulentic acid.* There is a good deal of obscurity regarding the mode of action of this poison, but the substance is in general classed as a narcotic of the delirifacient type, producing much nausea, dizziness, and headache, with drowsiness. There is also at first considerable irritation of the stomach and intestines. Darnel-contaminated flour is not dangerous unless the substance is present in very large amount, from which condition a number of fatal cases have resulted.

Cockle or *corn cockle*, the seed of *Agrostemma Githago* L. (*Lychnis G.* Scop., fam. *Caryophyllaceæ*), is very common in grain fields, more so in Europe, where it is native, than in this country. The plant is a slender herb, two or three feet high, the branches terminating in handsome purplish flowers about an inch broad, and having the general appearance of a common single-flowered pink. The seeds are produced in a one-celled capsule and are numerous, black, and about as large as morning-glory seeds. Their active constituent appears to be a kind of saponin which is exceedingly common and abundant in this, the pink family. The properties of the poison are those of saponin, and a percentage of the seeds in the flour sufficiently large to produce fatal results is scarcely to be expected.

The closely related plant *Vaccaria Vaccaria* L. Britton (*Saponaria V.* L.; *V. vulgaris* Host.), the cow cockle, cow herb, or field soapwort, produces seeds which are apparently identical in action with the corn cockle. This plant is at present spreading widely through the grain fields of the Western United States, and the seeds are becoming increasingly abundant as a constituent of grain. Although they are rather easily screened out, yet their possible presence in flour is to be recognized as a distinct source of danger.

Ricinus or *castor oil* seeds have been rather fully considered under *Castor Oil*, so far as constituents and activity are concerned. These shining, reddish, and purple-spotted, bean-like seeds are very pretty and attractive to children. Their tendency to be eaten to excess is the greater because they have a bland and nutty flavor, quite free from the nauseous odor and taste of castor oil, unless they have become old and rancid. The common cultivation of the plant for lawn decoration conduces to accidents. In one case, a city resident, moving to the suburbs where a quantity of these seeds were strewn upon the lawn, fed them to his horses with the remark that it was a pity to see all those beans going to waste. The effect upon the horses was fatal.

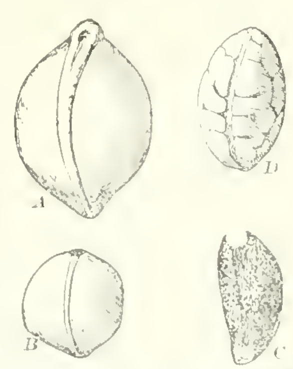

Fig. 3849. *A*, Daphne Mezereum; *B*, Tamus communis; *C*, Ligustrum vulgare; *D*, Hedera helix. (After Holmes.)

Several other Euphorbiaceous seeds were formerly much

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cultivated in gardens for use as cathartics, under the name of spurge or spurge seeds, and this habit has not entirely died out. They produce, in overdoses, poisonous results similar to those of ricinus.

Coral Bean.—Acting by a toxalbumin similar to ricin, or even more like www.libtool.com.cn seeds of several species of *Sophora*, especially *S. coralloides* Benth. (fam. *Leguminosæ*), have produced fatal poisoning in Texas and the regions to the southwest. These coral beans resemble a common bean in form, some being larger, some smaller, and are of a bright scarlet color. They grow in a brown or brownish cylindraceous pod, which is constricted between the seeds, so as to resemble beads upon a stick, and separating readily into its one-seeded joints. Treatment of this poisoning has proved difficult and uncertain.

Lupines (fam. *Leguminosæ*).—Many species of the genus *Lupinus* (wild bean or blue bean) are employed, in both Europe and America, either as fresh fodder or for the production of a hay very similar to clover hay. Although these fodders are used upon a great scale, with only the best results in most cases, yet wholesale and fatal poisoning has at times resulted. Many observations, together with some careful experimentation, have apparently determined the fact that the poisoning is due to the seeds, which resemble small beans and are produced in bean-like or pea-like pods. When the herbage is eaten previous to the formation of these seeds, or after they have been discharged from the pods, no bad results follow; but if the seeds are eaten, especially when ripe, either acute or chronic poisoning may follow. The symptoms indicate a poison similar in its general nature to digitalis or, still more so, to sparteine or ononis. There is cerebral congestion, with frenzied and very active delirium. The heart is slow and strong, the blood pressure high. Convulsions, with extreme alternations of strength and weakness, and finally prostration occur. There is powerful diuresis, the urine being often bloody, as in digitalis poisoning. Death usually occurs in acute cases within two hours of the appearance of the first symptoms.

Æsculus.—The common horse chestnut (seed of *Æ. Hippocastanum* L., fam. *Hippocastanaceæ*) is regarded as slightly poisonous, and certainly contains acrid saponin-like principles (*argyræscin* and *aphrodæscin*) which, consumed in large amount, would prove disastrous. Deprived of this principle by powdering and maceration in alcohol, the residue of the kernel is highly nutritious (protein eight per cent., fat seven per cent., non-nitrogenous extract containing among other constituents fourteen per cent. of sugar), and it is now being so manufactured in Germany. It is readily conceivable that, as this industry extends, insufficient purification may lead to the distribution of a poisonous product. A western and southwestern species (*Æ. Pavia* L.), the buckeye, is apparently much more active, various fatal cases of poisoning by it being on record. Its poisonous constituent is similar to, but distinct from, argyræscin. The symptoms are violent emesis and catharsis, convulsions, and other common accompaniments of poisoning by the saponin group. It would appear from the accounts that narcosis comes on rather more quickly than in cases of poisoning by other saponin-containing drugs.

Poisonous Barks.

In the nature of the case poisoning of human beings by barks is not at all likely to occur, except in medical cases where a poisonous bark has been taken by mistake, or overdoses of the bark have otherwise been given. It is true that many barks are employed by savages as arrow poisons (see *Curare*), but this subject scarcely pertains to the present article. The poisoning of stock by the eating of nutritive barks is in general prevented through the natural instinct of the animal. In times of scarcity of food, however, grazing animals sometimes eat the bark of the common locust tree (*Robinia pseudacacia* L.) with poisonous results. This tree pertains to the family Leguminosæ, or bean family, so noted for its production of albuminoid nutrients. Its poisonous constituent has been determined by Power as a toxalbumin, very subtle and difficult of isolation. Nothing is known of the treatment, except what is derived from a knowledge that the chief symptom is extreme nausea with violent retching, persisting for days, accompanied by dizziness and great depression. In animals marked salivation has been noticed. The barks of wild cherry and of several Ericaceous plants are poisonous to stock in the same way as their foliage, and the latter will be considered under *Herbage*. The barks of various species of elder (*Sambucus*) are more or less poisonous, though it does not appear that they produce accidents. This subject will be considered under *Roots*.

Poisonous Roots.

Besides the true roots, that name is generally applied by the public to all underground parts, such as mandrake, lily of the valley, Solomon's seal and other rhizomes, the potato and the artichoke, which are tubers, and the onion and garlic which are bulbs. All these are therefore here considered together.

The two important poisonous roots of our region are pokeroot and Cicuta. Probably no year passes without some fatal cases of poisoning by these, and it occasionally happens that quite a number of them occur at about the same time.

Pokeroot has already been considered at length as a drug, under that title, and its fruits have been elsewhere discussed in this article. The root has been quite often eaten by mistake for horseradish, which it rather closely resembles, and for other edible roots. The strong acridity of horseradish tends to avert the suspicion which would otherwise be excited by that of the pokeroot. When freshly dug it is quite attractive, being large, whitish, fleshy, and succulent, and containing large amounts of starch and sugar, so that it is readily mistaken for a wholesome and nutritious article. Suspicion once aroused, pokeroot is easily recognized. The base of the stem, which is usually present in a broken condition, is seen to be divided by thin transverse partitions. The surface is finely papillose, and usually presents a spiral appearance, and the cross section exhibits a conspicuous concentric arrangement of the tissues. Since the young shoots are often cut and eaten as a substitute for asparagus, portions of the root are apt to be thus taken by too deep cutting. Thorough cooking ameliorates, but does not destroy its activity.

Cicuta (Water Hemlock, Cowbane, Brook Tongue, Children's Death, Spotted Parsley, Beaver Poison, Muskrash Poison, etc.; Ger., *Wasserchierling, Giftwütherich*; Fr., *Ciguë vireuse*) is the root of various species of the genus *Cicuta* L., fam. *Umbelliferæ*, a genus closely related and very similar to conium, some of the species even having gone by that name (see Figs. 3850 and 3851). These plants grow in swamps or other wet locations, along lakes, streams, and ditches throughout almost the entire North Temperate zone, and are particularly common and abundant in Eastern and Central North America. Our illustrations give an excellent idea of the roots, foliage, inflorescence, and fruits. The plant grows to a height of from three to five feet, and branches and spreads rather widely. The stems and leaf bases are thick, hollow, crisp, and juicy, and the former are usually more or less purplish and glaucous. The base of the petiole clasps the stem. The leaf blade as a whole, though successively much divided into small segments, is very large, often two feet or more broad and long, and is thin and quite green. The entire plant is smooth, and exhales a not unpleasant odor when bruised. The fine white flowers are in decompound umbels, terminating the branches. The base of the stem, when longitudinally cut, exhibits thin transverse partitions, though these are obscure in some species. The roots, in fascicles like dahlia roots, are usually from three to ten in number. They have about the consistency of a raw potato, are starchy, crisp, and juicy,

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somewhat aromatic, and not unpleasant to the taste. They are externally of a brownish color, internally white. They are about the size of Jerusalem artichokes, which they somewhat resemble, and for which they have been mistaken. Boys visiting swamps for calamus often get hold of them. Frequently also they are turned out in

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FIG. 3850.—Cicuta maculata. (One-half natural size.)

ditching operations, and they have then been experimentally eaten by workmen with fatal consequences. The aromatic stem and the fruits have also been mistaken for angelica. The constituents are believed to include coniine (see *Conium*). Cicutoxin is also a very active constituent. Although the nature of the poison partakes of

FIG. 3851.—Cicuta maculata. (One-fourth natural size.)

that of conium, yet there is far more of a tendency toward irritation and convulsions. Tremors, violent contractions and relaxations of the muscles, astonishing mobility of the eyeball and eyelashes, widely dilated pupil, frothing, often bloody, of the mouth and nose, epilepsy, and after death a peculiar greenish fluid in the stomach and exuding from the mouth, cold, contracted, pale surface and some diarrhœa have been noted. Prompt emesis

FIG. 3852.—Œnanthe crocata. Reduced. (After Holmes.)

by the aid of zinc sulphate has been found effective The further treatment is indicated by the symptoms.

FIG. 3853.—Sambucus Canadensis. (One-third natural size.)

Œnanthe Crocata.—In Europe this species, closely related and rather similar to cicuta, is regarded as taking

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first rank among poisonous plants. Like cicuta, it grows in damp soil and produces a fascicle of fleshy roots (see Fig. 3852). Its leaves bear a strong general resemblance to those of celery, and it is free from disagreeable or warning taste. The symptoms of poisoning are only in a minor degree similar to those resulting from cicuta, and the nature of the poison is probably quite different. The symptoms develop very rapidly, death frequently occurring within an hour or two. Dryness of the mouth, with great thirst, vomiting, then dizziness, slow and weak pulse, pale and cold skin, reduced blood pressure, pupils greatly dilated and failing respiration, inducing convulsions, result. Death occurs apparently from heart failure. Judging from these symptoms, it would appear that the administration of digitalis would constitute a rational line of treatment.

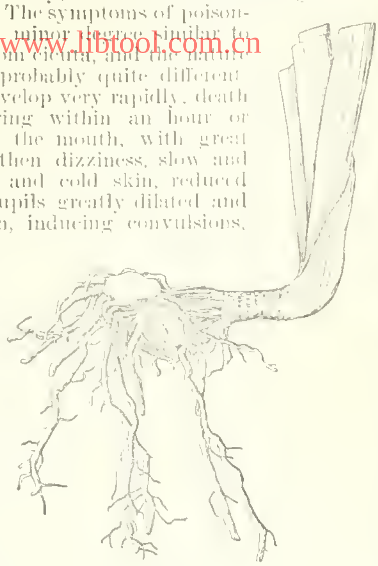
FIG. 3854.—Iris versicolor. (One-half natural size.)

Sambucus or *Elder* (fam. *Caprifoliaceæ*). (See Fig. 3853.)—Apparently closely related to cicuta as a poison, is the root of the common elder, and probably of other species of the genus. These roots (or more properly rhizomes) are elongated, cylindrical, crooked, somewhat branched, whitish, and possessed of a rather thick, juicy bark. Commonly, some small shoots can be seen upon them, and these are usually of a bluish-purple color at the place where the young leaves are forming. When bruised, these roots exhale a rather disagreeable odor, and the after-taste is acrid. Coniine is said to have been extracted from some of the elders. The symptoms of poisoning are much like those from cicuta, and promptly fatal results have been recorded.

Iris or *Blue Flag* rhizome (fam. *Iridaceæ*), growing commonly in swamps or low ground, along with calamus or sweet flag, is liable to be mistaken for the latter. The distinctions between the two, once known, are sufficiently easy for recognition. Iris grows in small or only moderately large clumps, while calamus covers large patches, almost to the exclusion of other growth, and usually in wetter situations. Its leaves are longer, narrower, less thick and fleshy, and are greener, lacking the bluish-green tinge of iris. The plant is also taller. The rhizome of calamus is long and rather uniform in thickness for a considerable distance. That of iris is much thickened at short intervals. Calamus is bitter and somewhat acrid, so that the acridity of iris, though greater, is apt to be endured by the heroic calamus chewer, thinking that he has the rhizome of the latter. The properties of iris have already been considered (see Fig. 3854). The fresh rhizome is much more irritant and violently emetic and cathartic than the dry drug.

Veratrum (fam. *Melanthaceæ*).—Growing in the same swamps with iris, though usually in more wooded or shaded situations, veratrum is often found. Although a mistake is here not easy, such a possibility should not be overlooked, as the rhizome is fleshy and succulent. Beyond referring to our illustration and to our account of the drug (see Fig. 3856) this subject requires no discussion.

Camas.—Various western species of the genus Zygadenus Mx., of the same family with Veratrum, are known by this name, and several of them are recognized poisons, especially *Z. venenosus* Watson, or Death camas, a name which has been applied to a polymorphous species, or a group of very similar species, according to the varying views of different botanists. In all probability most, if not all, of the species of this genus are poisonous, but only the death camas has produced serious results. The genus is characterized as follows: Plants smooth, perennial, from rhizomes or bulbous bases, the stem bearing linear, somewhat succulent leaves, and terminating in a raceme or panicle of yellowish-white or greenish-white marcescent flowers, the perigone six-parted, its segments gland-bearing near the base. Stamens six, borne at the base of the perigone but free from it, the anthers cordate or reniform. Ovary three-celled with three styles. Pod completely dehiscent and containing narrow, angular seeds. The genus is closely related to veratrum. *Z. venenosus* is here figured (see Fig. 3855). It is extremely common and abundant in Montana and other Northwestern grazing regions, and is very destructive to stock. All parts of the plant appear to be poisonous. The bulb, which is especially so, is recognized among the Indians as dangerous to man because of its close resemblance to several edible species. It appears to be bitter at times, quite free from bitterness at other times. It is considered fatal to about twenty per cent. of the sheep poisoned by it. The symptoms are said to be uneasiness followed by incoordination, then muscular paralysis, especially of the posterior limbs. There are dizziness, disordered vision, regurgitation of frothy matter, salivation and weak respiration, with little cerebral disorder. The nature of the poisoning may thus be regarded as paralysis of the motor centres, progressing from below upward. The nature of the poisons is unknown, though the indications are those of one or more glucosides. They are extracted both by alcohol and by water. Potassium permanganate appears to be a very efficient antidote.

Closely related to Zygadenus, and by some botanists regarded as pertaining to it, is *Chrosperma muscætoxicum* (Walt.) Kuntze (*Melanthium m.* Walt.; *Amianthium m.* Gray) the Fly poison, Crow poison, or Fall poison, a common bulbiferous perennial of sandy soil of the Eastern United States, especially near the coast, and in parts of the Southern Central States. It reaches a height of two to three feet, bears long, linear grass-like leaves, nearly an inch in breadth at the base, and large, much-branched panicles of greenish white flowers, about a half inch broad. The perigone consists of six distinct parts, without glands, and is marcescent. The stamens are six in number, and borne upon the base of the perigone segments. Ovary and pod are three-celled, the latter splitting only at its upper portion, the styles persistent upon the valves. The ovoid brown seeds are

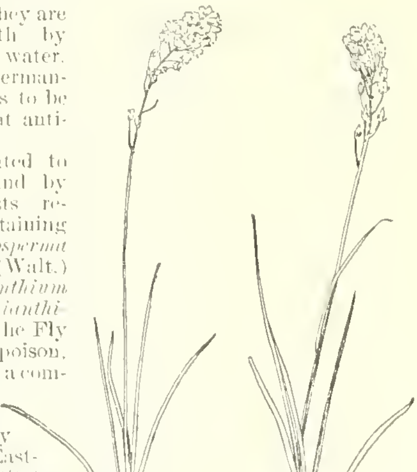
FIG. 3855. Death Camas. (One-fourth natural size.) (After United States Department of Agriculture.)

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Poisonous Plants.

few and are apparently more poisonous than any other part of the plant. As its names indicate, this plant, especially the seeds, is in use as an insecticide, and it is poisonous to birds. Little is known about the nature and treatment of the poisoning, but it appears to be in a general way quite www.libtool.com.cn.

More or less closely allied to the above-named bulbs, as well as to colchicum, are those of various species of *Narcissus*, *Hippeastrum*, and *Amaryllis*, which are severely poisonous. A number of species of agave, pertaining to this family (the *Amaryllidaceæ*), as well as of Liliaceæ, yield so-called soap roots, used for their detergent properties on account of their large content of saponin, and for the same reason actively poisonous.

Other similar articles, poisonous if eaten, but not likely to be eaten except through mistake, are podophyllum, sanguinaria, leptandra, arum, and actæa, all elsewhere considered, and all so strongly acrid and disagreeable, or even painful, that no considerable amount could be consumed by a sane individual.

With convallaria, aconite, Solomon's seal, and apocynum the case is somewhat different.

Convallaria (see *Lily of the Valley*) rhizome is sweetish and not unpleasant except in the after-taste; and it is so highly poisonous that it would not be improbable for a child to eat enough to produce poisonous symptoms. So common an ornamental plant requires no description.

Aconite.—The fresh tuber of this highly ornamental garden flower is said not infrequently to have been mistaken for horseradish, incredible as this may seem. Its biting taste is even exceeded by that of the horseradish, so is not apt to excite suspicion, but it even more closely resembles other roots which might grow in the garden beside it. It is to be regarded as an exceptionally dangerous article. Its toxicology has been sufficiently described under the title of the drug.

Apocynum or *Dogbane* possesses a long cylindrical rhizome, running horizontally at a short distance below the surface, and fleshy and milky-juiced. It has an amylaceous taste, only slightly acrid, and might be eaten. Its properties have already been discussed.

Violet.—The roots of pansies and all other violets, though not likely to be eaten, should be remembered as possessing emetico-cathartic poisonous properties, almost identical with those of ipecac.

Euphorbia.—The large, fleshy, and milky-juiced roots of *E. corollata*, *E. ipecacuanha*, and other euphorbias, have been well-known and much used cathartics.

E. corollata is known as the Blooming, White, Purslane, or Large-flowered spurge, Apple root or Wild hippo, and is abundant in Eastern and Central North America. It reaches a height of about three feet, is slender, widely branched and smooth, and the flower clusters which terminate its branches are subtended by showy and petallike white involucres, each bract of which bears a green gland at its base. The root is cylindrical, an inch or more in thickness, and one and a half or two feet long, of a very dark or blackish-brown externally when dried, much lighter brown when fresh. It has a thick white bark in cross section and a radiate spongy central cylinder. Its taste is at first sweetish and pleasant, though the after taste is a little acrid. Its active constituent is a resin. Overdoses are very powerfully emetico-cathartic, the action being much like that of ipecac.

E. ipecacuanha is known as the White, Wild, North American, Milk, or Spurge ipecac or Ipecac spurge, and is very abundant in sandy soil along the Atlantic coast. Its very slender, much-branched stems are numerous and prostrate, so as to form a sort of mat-like growth. The leaves are of most diverse forms on different plants, ranging from narrowly linear to broadly oval. The herbage and inflorescence may be light green or more or less purple. The root itself is vertical, much longer and more slender than that of the last, rather lighter in color, but the woody centre more yellowish. Its properties, as well as its uses, are identical with those of the last.

Potato.—Our consideration of poisonous roots may well close with a few words concerning the poisonous properties of the tuber, and more especially of the sprouts, of the common potato. The potato at all times contains traces of the highly poisonous alkaloid solanine, and probably others, but ordinarily the percentage is too slight to produce perceptible effects. Since the greater portion of this poison exists in the external layer, the peeling of potatoes which contain it in excess, may easily prevent trouble. The substance appears to exist in greatest amount in the rhizome of the potato, upon the end of which the tuber develops. It is therefore much more likely to be present in the young ("unripe") potato than when it is fully developed. Similarly, when the sprouts (young rhizomes) develop upon potatoes in storage, the solanine becomes present in them in considerable quantity. When the sprouts are first forming and of a lurid purple color, the percentage of poison is large, gradually decreasing as they elongate, thicken, and whiten, and especially as they put forth green leaves. Wholesale poisoning has resulted when, in times of scarcity, an attempt has been made to eke out the potato supply by consuming the young sprouts. Potato tubers which form above ground or at its surface, so that they are exposed to the atmosphere and develop a purplish-green color, also contain larger amounts of solanine. Finally, it may be mentioned that very serious results have followed the eating of potatoes containing black fungus spots, the solanine percentage being greatly increased in and just about the spots themselves.

Similar to the potato, in that it is perfectly wholesome under some conditions and highly poisonous under others, is the cassava, manihot, or tapioca root (fam. *Euphorbiaceæ*), so largely used as a food in tropical America. Of this root there are two varieties—the one sweet, the other, bitter. The former is in general not poisonous, or not so much so but that thorough cooking renders it wholesome. Nevertheless, a small percentage of hydrocyanic acid is almost always contained in or to be yielded by its bark or the tissues near it. In the bitter variety an important amount of this deadly poison is always found, so that it is not safe to employ it, even for the manufacture of tapioca, without a thorough preliminary maceration and perfect cleansing. There are certain species of yams eaten in the East Indies which also have to be treated by thorough washing in order to remove a poisonous bitter constituent, although not in this case hydrocyanic acid.

The poisonous nature of the roots of belladonna, bryonia, spigelia, caulophyllum, colchicum, squill, and hellebore, will be found discussed under those respective titles, as drugs.

Poisonous Herbage.

In the nature of the case poisonous herbage is far less likely to be eaten by human beings than are fruits, seeds, or roots, and similar organs. Nevertheless, the use of leaves as salads and potherbs, especially in times of scarcity of food, as during famines or in the course of explorations, renders necessary a careful attention to some of them. Furthermore, the frequency of stock poisoning through their use is greater than that resulting from any other portion of the plant; and a reference to the more serious stock-poisoning agents is not out of place in an article of this kind.

As human poisons, tansy, aconite, chelidonium, lobelia, henbane, conium, belladonna, and viola, may be dismissed with the statement that they are scarcely likely to become effective except through accidents attending their use as drugs, which subject will be found discussed under their respective titles in that connection. Tobacco may poison, partly in this way and partly through its use as a popular narcotic, or during its application for parasites infesting plants and domestic animals, under which circumstances it has frequently caused poisoning by its entrance to the system through wounds or other openings in the skin. The symptoms and treatment of tobacco poisoning are elsewhere fully described. Absinthium is a well-known poison, either acute, through overdosage,

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or chronic, through the use of beverages containing it. Both forms of poisoning are described under its title. A sufficient reference to poisoning by the foliage of the cedars, pines, hemlock, and other Coniferæ of the savin

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FIG. 3856. Veratrum Viride. (One-fourth natural size.)

or arbor vitæ type will be found under the poisonous family Pinaceæ. Related to these, but acting through its poisonous alkaloid, is the yew or taxus, which subject has been presented in speaking of its fruit. Poisoning by any of these is extremely unlikely to occur. The same is true of poisoning by the buttercups, clematis, etc., of the Pulsatilla type, in the poisonous family Ranunculaceæ. The foliage of the elder has already been stated as open to the same suspicions as those affecting its bark and root, and it need not be further considered. The foliage and flowers of lily of the valley, or convallaria, contain the same poisonous constituents as those of its rhizome, and there is the same slight possibility of poisoning accidents being caused by it. The occasional use of the stem and herbage of cicuta, mistaken for angelica, has already been mentioned. It contains the same constituents as the roots, and the symptoms and treatment are identical. Poisoning by the herbage of the black nightshade (see the section on Fruits and Seeds) is said to have occurred, although it is claimed that this herbage has been used as a potherb, after cooking, without injury. It is certainly open to grave suspicion. Should poisoning by it occur, it would doubtless be found identical with that of solanine from other sources. Another plant whose herbage has not been recorded as causing poisoning, but which, for obvious reasons, is to be regarded with caution, is the pokeberry, or phytolacca. Watercresses, though commonly regarded as quite innocent, are capable, when eaten in large excess, of producing dangerous and extremely painful symptoms. In one case seen by the writer, a painful, severe cystitis was established in this way. The possibility of an abortion being produced by this article, as well as by horseradish, is worthy of consideration.

Probably the two most dangerous leaf poisons in existence, all things considered, are stramonium and veratrum. The former has been fully discussed as a drug, and under poisonous seeds. It possesses the peculiarity of flourishing in periods of drought, resulting in famine conditions. The whole aspect of the plant is luxuriant and succulent, and a temptation to consume it under such circumstances may often be great. As a matter of history, numerous poisoning cases have occurred in this way, especially in India. Other cases are recorded in which travellers destitute of food have ignorantly eaten it. Veratrum (fam. *Melanthaceæ*) is a plant which grows in swamps in the vicinity of caltha, or American cowslip, the herbage of which is eagerly sought in many sections for cooking purposes, appearing as it does in early spring when fresh vegetables are scarce. Various cases are on record in which the foliage of veratrum has thus been mistaken and eaten with serious consequences. Veratrum poisoning has already been fully discussed (see Fig. 3856).

The young shoots of Tamus communis (see the section on Fruits) have been eaten like asparagus in the Old World with serious results.

Sorrel.—This name has been applied to two groups of plants, very different from a botanical standpoint, but agreeing in their sensible properties, constituents, and toxicology. The name *Wood Sorrel* has been applied to the common *Oxalis acetosella* L. (fam. *Oxalidaceæ*), which is very common in cool woodlands in both the Old and the New World, and bearing white or pinkish tinged and veined flowers. The trifoliolate leaves closely resemble a small clover leaf, but are somewhat fleshy, and the whole herbage is strongly acid. Oxalic acid, free and combined, is the poisonous constituent, and is said to have been first derived from this source. A number of very slender, branching species, with smaller and yellow flowers and smaller leaves, grow commonly as garden and roadside weeds and are known as ladies' sorrel or ladies' sour-grass. In tropical regions hundreds of species occur, some of them very large. Many species are favorites among household flowers. All have the same composition and properties.

The other group represents the sheep sorrels or field sorrels, namely, *Rumex acetosa* L. and *R. acetosella* L. (fam. *Polygonaceæ*), pernicious weeds growing in poor, gravelly, or sandy soil throughout the northern hemisphere. They are used to some extent as ingredients of salads. These also contain oxalic acid and have, like oxalis, caused fatal poisoning of both children and adults. The treatment and symptoms may be inferred from the above statement that oxalic acid is the active agent. It may be added that very large quantities of either are required to produce dangerous effects.

Ailanthus or *Tree of Heaven* (fam. *Simarubaceæ*).—These nasty smelling leaves are not at all likely to be eaten either by human beings or by domestic animals. It is said even that flies will not visit decayed meat when hung in the branches of these trees. The leaves have been utilized for the manufacture of substances both odious and toxic to flies. They have also, like the bark, been somewhat utilized in medicine; they contain a peculiar nauseous green oil, as well as an amaroid. This oil has been indefinitely stated as possessing poisonous properties. The bitter substance, though stomachic in medicinal doses, is a gastric irritant in larger doses. Chronic gastritis of a rather serious type is reported as having occurred in all members of a family, as the result of having drunk the water of a well in the vicinity of these trees. The roots extended into the water in great numbers and probably the leaves also had blown into and accumulated in the water.

Kalmia.—The members of this genus, the American laurels (fam. *Ericaceæ*), are distinctly poisonous, being frequently fatal to sheep, though not at all likely to be eaten by man, since the foliage is very bitter and disagreeable. The large species (*K. latifolia* L.) is the well

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known mountain laurel or calico bush, spoon wood, or ivy bush, so common throughout Eastern North America. The smaller species of common occurrence is *K. angustifolia* L., the small, dwarf, or sheep laurel, lambkill, calfkill, or kidkill. It grows in more open situations, on dry hillsides, and rarely exceeds three feet in height. Its leaves are mostly in whorls of three, its flowers less than half as large as those of the other, and of a deep rose color. Other small species are more rare. The poisonous constituent of the laurels is the amaroid *andromedotoxin* ($C_{31}H_{51}O_{10}$), a neutral crystallizable substance, rather soluble in both alcohol and water. Mineral acids color its solution bright red. It is an extremely poisonous substance, and has been said to be, in the pure state, more emetic than either emetine or apomorphine, and more toxic than aconitine. Animals are not fond of laurel, eating it only when other food is scarce. The common symptom of poisoning by laurel is narcosis with muscular weakness. Animals become quiescent and stupid. In the early stages a staring glassy eye is notable, with great disorder of vision, objects being apparently distorted. A staggering gait progressively develops, and finally the animal lies down and goes into a condition of stupor. There is no disposition either to eat or to drink, the reappearance of such desire being a pretty sure indication of recovery. A thin liquid frequently flows from the mouth. Stomach digestion is apparently completely paralyzed. There are faint convulsive movements of the limbs, and death finally ensues from general weakness, specially of the respiration.

FIG. 3857.—Pieris Mariana. (Two-thirds natural size.)

The poisonous constituent described above occurs commonly in this family, other members of which have poisonous records by reason thereof. The most important of these is *Pieris Mariana* (L.) B. et H. (*Andromeda M.* L.), which bears the suggestive name of stagger bush (see Fig. 3857). It grows throughout the Atlantic region as far north as New England, preferring shrubbery along the salt marshes. It is a shrub, from three to five or six feet high, and its profuse flowers are whitish or purplish and of a waxy appearance. A flowering branch is here figured. The symptoms of poisoning by stagger bush are identical with those resulting from laurel. In this connection the *Rhododendrons* may be mentioned as having precisely similar poisonous properties.

Ledum or *Labrador Tea*, *Marsh*, *Swamp*, *Continental* or *James tea*, and *Marsh rosemary*, are names applied to the two species (fam. *Ericaceæ*) *Ledum Groenlandicum* Oeder (*L. latifolium* Ait.), the broad-leaved and *L. palustre* L., the narrow leaved (see Fig. 3858). They are marsh shrubs, the former ranging from Greenland through Northern North America, the latter extending also through Northern Europe and Asia. The broad-leaved species has been a much used substitute for tea among British-American voyagers, and is only moderately narcotic. The narrow-leaved species is much more active. Both are somewhat used medicinally in domestic practice. The narrow-leaved species is distinctly narcotic, the symptoms closely resembling those of laurel poisoning. If, as claimed, andromedotoxin is not a constituent, some very similar body must be present. A flowering branch of ledum is here figured. The leaves are well distinguished by their somewhat thick and leathery texture and their smooth upper and brown woolly lower surfaces. The flowers are white.

FIG. 3858.—Ledum latifolium. (Two-thirds natural size.)

The leaves of such plants as the cherry, peach, plum, etc. (fam *Drupaceæ* or *Rosaceæ*) yield appreciable amounts of hydrocyanic acid. Although the consumption of injurious quantities by human beings is not at all likely to occur, yet the leaves of the common wild cherry constitute a well-known and much-dreaded stock poison. The branches, trimmed out for fence rows or broken down by boys in search of the fruit, have very frequently been recorded as poisoning cattle, often fatally (see Fig. 3859). An unexplained but well-established fact is that cattle will eat them from the living trees without ill effects, but will be poisoned upon eating them in a wilted condition. That the effects are due to the hydrocyanic acid liberated is fully evidenced by the effects.

FIG. 3859.—Prunus serotina. (One-half natural size.)

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Delphinium or *Larkspur* (fam. *Ranunculaceæ*).—The general subject of larkspur, as to constituents and activity, has been considered under the title of Stavesacre Seed. So well known a garden flower scarcely requires description. The accompanying illustration of *D. glaucum*, the tall larkspur, often miscalled aconite, gives a sufficiently good idea of the genus in general (see Fig. 3860). Some of the species are larger, many much smaller. The flowers are usually of some shade of blue, sometimes pur-

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FIG. 3860.—Delphinium glaucum. (One-third natural size.) (After United States Department of Agriculture.)

plish. Many species abound in the grazing regions of Western North America, and they are much dreaded as stock poisons by herders, though the poisoning of human beings is not recorded, and is not likely to occur. These poisons are to be classed partly with aconite, to a lesser extent with stavesacre, as to the nature of their effects. The symptoms are muscular incoördination, motor paralysis, beginning at the posterior extremities, great cardiac and arterial weakness, and hypersensitive skin, with the special senses not affected. Convulsive tremors, especially of the posterior limbs, come on early and are followed by convulsions which increase in violence, and in one of which the animal usually dies. Death appears to be due chiefly to failure of the circulation. Atropine has been found a fairly good antidote, and potassium permanganate has also been found useful.

Loco Weeds (fam. *Leguminosæ*).—Although poisoning by this famous group is confined practically to stock, especially horses and sheep, yet no article on poisonous plants could be considered complete without reference to it, particularly as it represents a very large and varied class of leguminous poisons which more or less affect the human system as well. The loco weeds pertain to the two genera *Astragalus* and *Aragalus* (*Oxytropis*), and knowledge as to their specific identity is in a number of cases indefinite and uncertain. They are perennial herbs, growing mostly in tufts or hummocks, with a dense rosette of radical leaves and papilionaceous, mostly purple or purplish flowers in spikes or racemes. The leaves are elongated and pinnate, the leaflets mostly numerous and more or less oblong or varying from ovate to obovate. The fruits are constructed like small pea pods, the seeds mostly resembling small peas and often rattling loosely in the dry pod. The herbage is without disagreeable taste. Animals are not naturally disposed to eat it; but having once done so, in case of scarcity of other food, they become ravenously fond of it and forsake all else in order to eat it. The poisonous constituents are not known, though great efforts have been made to isolate them. All indications point to their being of the nature of toxalbumins. Whatever they are they are excreted in the milk of the mother, since suckling lambs are frequently fatally poisoned together with the mother. Poisoning may be either acute or chronic, the latter being much more common. The symptoms are chiefly cerebral. There are incoördination and remarkable disorders of vision, though rarely blindness, and this usually in acute poisoning. The effect upon the vision seems to be that of causing objects to appear distorted. A similar effect upon hearing is observed. There are great and progressive disorders of nutrition, and these are especially referable to the skin and its appendages, sheep frequently losing the whole or part of their fleece and the teeth becoming loosened. Death, in cases of long duration, is usually from malnutrition. Very often the animal dies as a result of accidents, incurred either through frenzy or through weakness incident to the poisoning, such as falling into the water while drinking, and being unable to rise again. There is no known treatment for this form of poisoning other than to remove the cause and apply general restorative treatment.

Henry H. Rusby.

POISONOUS REPTILES.—All poisonous reptiles, with the single exception of the lizard Heloderma, belong to the order Ophidia—snakes. It is a popular error that snakes are easily divided into harmless and poisonous ones by readily recognized characteristics. Such division, however, is by no means a simple affair. The usual classification into Colubridæ—comprising all harmless snakes,—Colubridæ venenosæ, and Viperidæ indicates the close anatomical relationship between harmless and venomous snakes, and in external appearance mimicry is so frequently displayed that no one at a hasty glance is able to distinguish a harmless snake from its venomous relation. Thus, even experts have been subject to fatal mistakes. Indeed, nothing but a close inspection of the dentition can determine the nature of a specimen in question.

Distribution of Snakes.—It is but natural that the popular mind and imagination should have been occupied since time immemorial with poisonous snakes. The frequent and almost mysterious deaths after snake-bite have surrounded the whole class with a halo of fear and reverence which has not been confined to a few localities, but, in fact, has spread throughout the whole inhabited world, for poisonous snakes are found in all countries of the temperate, and more so, of the tropical zone. Numerous genera of the Hydrophids, elegant swimmers with a laterally compressed tail, swarm throughout the whole intertropical part of the Pacific Ocean. Their bite is justly dreaded. The tropical islands, however, and the tropical countries of the old continent are haunted by the worst kind of snakes, the Elapidæ. A large number of genera and innumerable types of every genus render parts of those countries, and especially of the islands, almost uninhabitable. The chief representatives of this genus are the Cobra di capello (Naja tripudians) and the somewhat smaller, though not less dangerous Krait (Bungarus fasciatus), both living throughout the whole of East India. The most formidable is the King Cobra or Hamadryas (Ophiophagus elaps), the largest of all poisonous snakes; it attains the length of fourteen feet and it alone enjoys the reputation of attacking and even pur-

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Poisonous Reptiles.

saing man. Its nearest relative, the Aspis of Cleopatra (Naja haje), the symbol of the Egyptian kings, lives throughout almost the whole of Africa. In the Western world this genus is represented by the beautiful coral snakes alone; one of them, Elaps fulvius, lives in our Southern States, where it is little feared on account of its alleged good nature, or rather its lack of irritability; its poison is, however, as active as that of its East Indian congener. Snakes are very numerous in Australia. Two-thirds of these are poisonous, and they belong exclusively to the family Elapidæ; the Tiger snake (Hoplocephalus curtus) and the black snake (Pseudechis porphyriacus) have a fearful reputation. Europe has none but various species of vipers; the well-known common viper (Pelias berus) lives in England, Germany, and chiefly in France. In the departments of Vendée and Loire Inférieure alone were reported 321 cases of bites with 62 deaths in six years, in Auvergne 14 cases with 6 deaths; in the South around the Mediterranean the more dreaded sand viper (Vipera ammodytes) is found. East India again has one of the most formidable vipers, the chain viper (Daboia Russelii), and in Africa there is the sluggish but very poisonous puff-adder (Clotho arietans). The greatest number of species of vipers are found in America, all of them belonging to the sub-family of the Crotalidæ or pit-vipers, so called from a deep pit lying between the nostril and the eye.*

The chief representatives of the pit vipers in the United States are the rattlesnakes. The banded rattlesnake (Crotalus horridus) is present throughout the whole territory from the Atlantic to the Rocky Mountains and far into Canada. Of the remaining six species of rattlesnakes we have to note the largest of all North American snakes—the diamond back (Crotalus adamanteus) of Florida and the South, and the swift prairie rattler (Crotalus confluentus) in the Mississippi Valley, and in the great Western basin; finally the smallest of all, the massasauga or ground-rattler. To the same sub-family belong the Southern water-snakes, the moccasin (Ankistrodon piscivorus)—animals so sluggish that they do not try to escape from an approaching man, and hence are not a little dreaded by the negroes working in the rice-fields, and finally, the beautiful copper head (Ankistrodon contortrix), which is not at all rare in the whole East—in fact, lives almost in the same expanse as the banded rattlesnake. In the Tropics almost all species grow to a larger size; thus the copper head is repeated in the larger *fer de lance* (Bothrops lanceolatus) of the West Indies; the rattlesnakes of Central America grow larger, as does

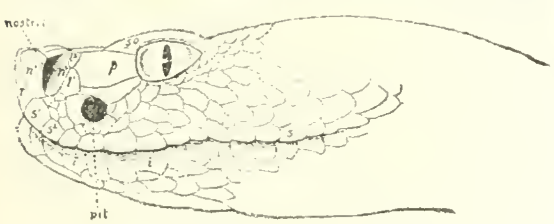

FIG. 3861.—Head of Rattlesnake.

the Crotalus durissus; and in the Orinoco Valley there lives the bushmaster of the Dutch settlers (Lachesis mutus), about as large as the Hamadryas of India.

* The object of this pit, which sinks into a cavity of the maxilla—as it were, a reversed maxillary sinus—is unknown. Leydig calls it the seat of a sixth sense, which means nothing else but that he has no explanation. At closer inspection I found the bottom of the pit not lined, but overspread by a thin membrane, the continuation of the external integument. Under this membrane, showing abundant ramifications of nerves, we find a cavity which opens by a duct at the anterior margin of the orbit. According to the careful investigations of Dr. Pollitzer, who followed it up by serial sections, the nerve connects with the auditory nerve. Pricking or any other irritation did not produce any reaction, nor did the destruction of one or both membranes have any effect upon the movements or the hearing of the snake. The hearing capacity of snakes is still a mooted subject with authorities in natural history.

Poison Apparatus.—Snakes are provided with numerous teeth—solid, pointed, recurved hooks, which serve rather to drag the prey down into the œsophagus than for purposes of attack and defence. While the teeth stand in a single row along either branch of the mandibula, they seem to be almost indiscriminately scattered all over the maxilla and palate; nevertheless, two rows of larger maxillary with two nearly parallel rows of palatine teeth are readily distinguished. These are the functionary teeth which, after being shed,—a frequent occurrence,—are replaced by the numerous succedaneous teeth scattered throughout the mucous membrane of the palate. A poisonous snake exhibits the same arrangement of palatine teeth. Almost the entire row of maxillary teeth, however, is wanting, and its strength, as it were, is concentrated into one powerful tooth, the poison fang, which projects at the anterior end of the maxilla. It is true, we often find two or three teeth at this point; these are the functional fangs with one or two succedaneous ones which replace the primary functionary whenever lost by accident or shedding. Only the Elapidæ exhibit one or two ordinary conical teeth which are situated directly behind the grooved fang. The fangs are in all cases firmly inserted in the maxilla, immovable, almost erect, in one family, the Colubridæ venenosæ (comprising the cobras and hydrophids); in the Viperidæ, however (including the true vipers and pit-vipers), the

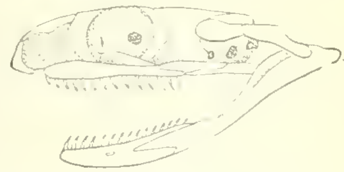
FIG. 3862.—Skull of Harmless Snake.

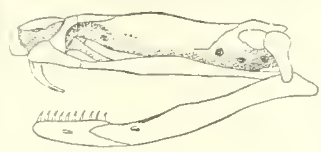
FIG. 3863.—Skull of Cobra (Elaps).

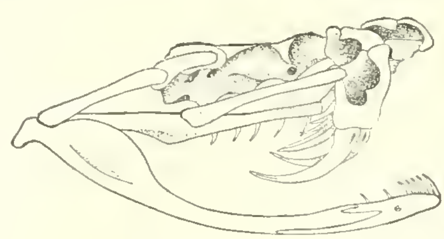
FIG. 3864.—Skull of Rattlesnake.

movable fangs are only erected for biting, and otherwise in the resting they are folded back toward the palate like the blade of a pocket-knife in a plica of mucous membrane. The maxilla of the Colubridæ venenosæ is rather elongated and horizontal like that of the harmless snakes, but it is considerably shortened and placed almost vertically in the vipers. This short jaw bone, bearing at its lower end the firmly socketed fang, articulates at its upper end with the lachrymal bone, around which it rotates by the action of the pterygoid muscle.

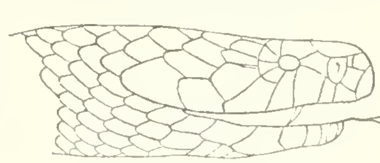
FIG. 3865.—Head of Cobra.

Some writers are of the opinion that, by looking at a wound inflicted by a snake, the species of the animal can be ascertained, and from the foregoing description it can readily be understood how from the

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accompanying figures the bite of a harmless or poisonous snake could be determined. We must, however, bear in mind that a snake, while biting, very seldom implants

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FIG. 3866.—Impression of the Teeth of A, harmless snake; B, cobra; C, viper. f, fang; m, maxillary; p, palatine; pt, pterygoid teeth.

all its teeth, and a wound scratched sideways by a gliding fang may be more dangerous than the impression of the whole dentition.

Another classification is sometimes made by dividing the venomous snakes according to the shape of their fangs, whether they carry short, cone-shaped, furrowed fangs or long, pointed, tubular ones. This condition is brought about developmentally in the first instance by the folding of the dentine which leaves a longitudinal furrow with an indication of a perforation at the upper and lower end along the anterior surface; and in the second by a complete approximation which produces a perfect tube. The pulp cavity is entirely separated from the poison canal. To the first class, the Proteroglypha, belong the Hydrophids and Elapidæ, or cobras; the latter class, the Solenoglypha, comprises the vipers and pit-vipers. The intensity of a poisonous bite is not dependent upon the shape of the fangs, except that a longer tooth, such as that of the viperine snakes, is capable of injecting the poison to a greater depth; indeed, the viperine poison apparatus is the most perfect of any in the venomous snakes.

There is a third class of poisonous serpents, the so-called Opisthoglypha, the furrowed fangs of which, as the name indicates, are situated toward the rear of the mouth. It has long been doubted whether they should be classed among the poisoners, and for this reason they were grouped under the name of "suspecti." Recent investigations, however, have proven to a certainty that they also poison their prey, which mostly consists of small, cold blooded animals. Catching them first with the innocuous front teeth, they push them gradually backward into the reach of the poison in the back teeth, to the action of which they soon succumb.

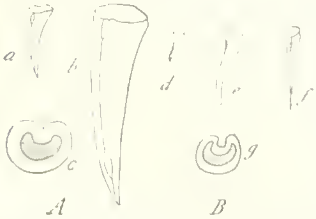

FIG. 3867.—Proteroglypha. A, Elapidæ. a, Fang of king cobra, eleven feet long (natural size, 8 mm. in length); b, the same enlarged (3 diam.); c, cross section. B, Hydrophidæ. d, Fang of pelamys (natural size, 3 mm. in length); e, the same enlarged (3 diam.); f, front view; g, cross section.

The poison gland completes the poison apparatus, the former is closely in contact with either side of the skull, directly below and behind the eye and is under the influence of the different portions of the temporal muscle. The button-, tube-, or almond-shaped glands taper to a narrow anterior duct, which carries the secretion of the gland to the base of the fang and is provided with a sphincter muscle, so that the snake is able to retain the poison at will, and, indeed, may do so for months. The extraordinary development of the glands, as in the Crotalids, gives to the head that triangular shape which was erroneously considered the characteristic of all poisonous snakes, and which gave to some species the name Trigonocephalus. The elongated glands of the Ethiopian snake Causus rhombeatus extend under the skin on both sides of the spine to the extent of one-sixth of the body's length, while in the East Indian Callophis they reach from the head into the abdominal cavity about one-third of the total length of the body. In spite of these abnormities the poison gland must be considered physiologically as the homologue of the mammalian parotid; the latter is the only one of the salivary glands which produces an albuminous secretion. It is anatomically of great interest that even in harmless snakes the beginning of a poison gland can be traced. It was long known that a part of the supralabial gland—the yellow portion (Duvernoy, Schlegel, Leydig)—is easily separable from the rest; it has not only a duct of its own which in the "suspecti" leads to the posterior grooved tooth, but it also possesses a histological structure differing from that of the supralabial gland. Undoubtedly, this yellow portion of the innocuous snakes is the analogue of the poison gland; even its aqueous extract has been shown to be poisonous to small animals (Blanchard). The structure of the poison gland is that of a compound racemose gland with elongated acini; the glandular substance has columnar, the duct pavement epithelium.

Description of Venom.—The secretion of the other salivary glands and of the mouth is alkaline, while the

FIG. 3868.—Solenoglypha; Viperidæ. a, Fang of banded rattlesnake, three feet long (natural size); b, fang of diamond-back rattlesnake, six feet long (natural size); c, the same enlarged (2 diam.); d, front view of the latter; e, cross section.

poison is always acid. The color of the latter varies from a light straw or greenish-yellow to a deep orange. The viscous fluid, either clear or turbid (bitter in Naja) is not odorless as often asserted; it has a specific smell for every species, which is not easy to describe, but easy to recognize. Thus the odor of crotalus poison may be called "mousy"; that of the *fer de lance* is said to resemble the odor of fresh salt water. Its specific gravity varies from 1.030 to 1.077; the solids are variously stated as from twelve to sixty-seven per cent.; my own samples are mostly dried down to twenty-five or twenty per cent. of the original weight. The dry poison cracks on scaly translucent chips of a light yellow or deep brown color and also has a characteristic odor. Fresh poison under the microscope shows nothing but a few scaly epithelia and a number of finely granulated, amorphous, albuminoid masses, which undergo no change in a hanging drop, even after a long while. It was often, and even is to day, asserted that bacteria or cocci exist in the poison. After thoroughly sterilizing the collecting apparatus I was not able to see the least sign of bacterial life in broth or gelatin cultures of the fresh poison; also in acid media in which the experiments were repeated no trace of life was to be found. In order to determine whether the poison, which itself destroys life, might for that reason be free from microbes, I mixed fresh poison with B. subtilis and B. coli for one half hour and then inoculated it on gelatin. The growth was lively, even more so than in the control plates, probably because the gelatin was lique-

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fied at the points of contact with the poison.* A bacterial action, therefore, cannot be assumed; the rapidity alone with which the poison acts in the system would exclude bacterial influence.

Chemistry of the Venom.—The first chemical analysis was made in 1843 by Prince Lucien Bonaparte, who established the proteid nature of viper poison, and called the poison "viperin." Almost twenty years later (1861) Weir Mitchell found a similar proteid in crotalus poison, which he named "crotalin." Other investigators claimed to have found alkaloids or ptomaïns, when Weir Mitchell, associated with Reichert, published in 1883 the results of their studies, that the active principle of snake poison was of an albuminoid nature; but instead of one ingredient they had discovered two. One of them, easily dialyzable and not coagulable by heat, was called venom peptone; the other, not dialyzable but coagulable by heat, venom globulin. The proportions of both were not alike in cobra and crotalus poison; even among the Crotalidæ they found wide differences. Thus cobra poison had 98 per cent. of peptone and 2 per cent. of globulin; but moccasin venom had 92 per cent. of peptone and 8 per cent. of globulin, diamond-back only 75 per cent. of peptone and 25 per cent. of globulin. Besides the proteid there are a coloring substance, several salts, and some fat. Mitchell's report was mainly corroborated in 1886 by Wolfenden, who discovered globulin and several albumins in variable proportion in the poison of cobra and daboia; one of the latter he designated serum albumin; the other, corresponding to Mitchell's peptone, syntonin, or albumose. Kanthack's analyses likewise demonstrated the presence of a proto- and heteroalbumose in cobra poison. Martin and McGarvey Smith found a harmless albumin and two very toxic albumoses in the poison of the Australian snakes. It may be asserted that in no instance, up to the present time, has a definitive analysis of any poison been worked out; but all investigations centre in this one fact, that the active principle in all snake poisons is some form of albumose.†

Although probably both of Weir Mitchell's bodies are albumoses, we may still, in default of accurate analyses, use the convenient terms venom peptone and venom globulin in our further discussion. Not only do the various poisons differ in the percentage of peptone and globulin, but also in the toxicity of the constituents themselves. The venoms retain their efficacy for long periods of time under suitable conditions. Poison, when dried or mixed with glycerin, has proved itself as active as fresh poison, even after a lapse of twenty-two and twenty years respectively. Putrefaction destroys it after a long time; freezing, continued through weeks, does not alter it, but it is soon changed by heating when the temperature is raised to different heights, according to the different chemical composition. The globulins are rendered innocuous at 80° C. after fifteen minutes, while the peptones are destroyed only by applying higher temperatures for hours. The coagulated proteids are inert in this state, but they regain their

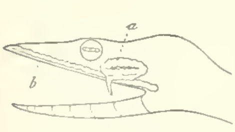

FIG. 3869. Location of the Poison Gland in Tragops belonging to the Opisthoglypha. *a*, Poison gland; *b*, supralabial gland.

toxicity when redissolved.* It is the more or less evident capability of chemicals to coagulate proteids which determines their relative power of destroying the efficacy of venoms, when they are mixed with the poison

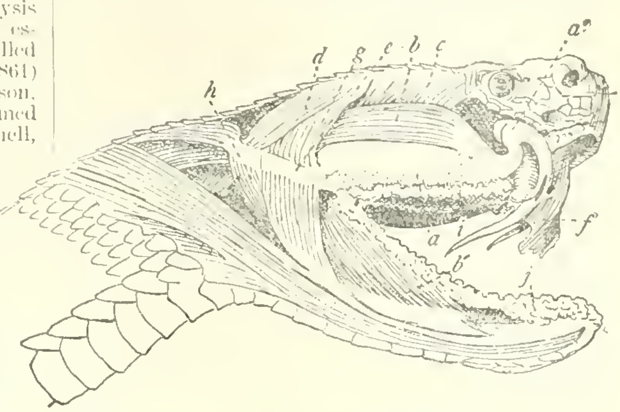

FIG. 3870.—Head of Crotalus. *a*, Poison gland; *a'*, poison duct with sphincter muscle; *b*, *d*, portions of temporal muscle; *f*, plica of mucous membrane.

in a test tube for experimental purposes. Alcohol renders it inert for a time only. Absolute alcohol seems to coagulate all poisonous ingredients, but the presence of an infinitesimal part of water is sufficient to retain the toxicity of the supernatant fluid. Poisonous serpents, when preserved in alcohol, have to be handled, even after years, with the greatest care, as has been demonstrated by a fatal accident to an assistant in the St. Petersburg Museum.

Physiological Effects.—Absorption of venom from connective tissue, whether introduced by hypodermic injection or by the bite of a snake, takes place through the blood-vessels, more rapidly when the blood-vessel is wounded directly. Serous membranes absorb it very readily. Its resorption through mucous membranes varies; rattlesnake venom seems not to be absorbed in this way; cobra venom, however, passes through the ileum and conjunctiva, but not through the stomach and rectum. Gastric juice and bile do not affect it, but the pancreatic secretion destroys it. The resulting complex of symptoms varies partly on account of the varying rapidity of absorption, but more so because of the difference in the nature of the several venoms.

The physiological effects of both ingredients named, whenever they are tested separately in animals, are widely different. The peptone, though causing some local œdema, is more productive of general nervous symptoms, which, commencing as irritation, twitching, and convulsions, finally end in paralysis; paralysis of the respiratory centre is especially characteristic. The globulin, on the contrary, incites a violent local reaction with hemorrhages around the point of injection, hemorrhages of the mucous membranes, and destruction of the coagulability of the blood. The latter phenomenon recalls to us the results of experiments performed on animals with pure peptones and albumoses of digestion; these excite not only characteristic hemorrhages and necroses, but also paralyses, the intensity of which is in correspondence with the higher hydrolysis of the albumoses. And thus, to go one step further: all the symptoms produced by snake venoms classify them distinctly among the toxins, especially those of bacterial origin.

SYMPTOMATOLOGY.—From the foregoing remarks it will be perceived that different cases of snake poisoning cannot have an identical course, and that the numerous contradictions of the mostly incomplete records of snake-bites are to be explained only when we consider each

* Experiments with sterile snake poison have demonstrated that it liquefies gelatin like some digestive ferments, *e.g.*, trypsin. Wehrmann finds that it peptonizes fibrin weakly and does not clarify amylum. Flexner states that in agar culture of B. anthracis, B. coli, and B. typhi the bacteria underwent rapid involution. My own numerous observations, recorded above, do not confirm this view.

† It is well known that albumoses, the products of the hydration of albumin, formerly called propeptones and accurately defined by Kühne and Chittenden in 1884, differ widely as to their toxicity. While our modern means do not allow yet a chemical differentiation of those albumoses which are generated by superheated steam, by gastric digestion, by bacilli, or—as in our case—by the parenchyma cell of a gland, the varying reaction of the more sensitive living organism toward them demonstrates decisively their different nature.

* Recent advices of researches going on in Germany assure me that the toxic principle does not belong to the albumoses, in fact, that it is not at all of a proteïd nature.

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type of poisoning separately. Leaving aside the cases of almost instantaneous death which are due to general thrombosis, especially when the venom has been accidentally injected into a large blood vessel, we have first to make a distinction between the two great classes of snakes, the colubrines and the vipers.

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To illustrate the first class, let us briefly describe the effects of a cobra bite: two small, scarcely visible punctures in the skin are found, whence radiates a burning and stinging pain with gradually extending moderate œdema. Within an hour, on an average, the first constitutional symptoms appear—a pronounced vertigo, like that of drunkenness, quickly followed by weakness of the legs, which is increased to paraplegia, ptosis, falling of the lower jaw with paralysis of the tongue and epiglottis, inability to speak and swallow, with fully preserved sensorium. A mass of viscous, frothy saliva is constantly dribbling from the open mouth; nausea and vomiting set in; the paralysis becomes general, the patient lies motionless. The pulse, a little accelerated, is somewhat weaker in the beginning, but keeps a moderate strength until even a few minutes after the cessation of respiration. The latter, also accelerated in the beginning, soon becomes slower, labored, and more and more superficial, until it dies out almost imperceptibly. The pupils, somewhat contracted, react up to the last moment. Slight convulsions, which we are accustomed to see in asphyxia, sometimes occur shortly before death. Absorption is exceedingly rapid; already after thirty seconds a distinct areola is visible around the bite. Death occurs at the latest within fifteen hours, in thirty-two per cent. in the first three hours. When the patients do not die of paralysis, they recover remarkably quickly and without later consequences. The autopsy reveals no changes in the skin at the point of injection; the subcutaneous tissue, however, is thickly infiltrated with reddish serum; the surrounding blood-vessels are congested. All the internal organs are congested, and the bronchi are filled with frothy mucus and perhaps with fluids which have been forced into the patient's throat. The blood is mostly liquid and dark.

Viper.—After the bite of a viper, *e.g.*, a rattlesnake, the local disturbance is most pronounced; violent pains at the bleeding wound, hemorrhagic discoloration of its surroundings, and later also of more distant parts; bloody exudations on all the mucous membranes (nose, mouth, conjunctiva), and hæmaturia or rather hæmoglobinuria. Usually, somewhat later than after cobra poisoning, but possibly within fifteen minutes, constitutional symptoms develop, viz., great prostration with nausea and vomiting. A continuous fall of blood pressure is noticed. Respiration, in the beginning accelerated, grows slow and stertorous. After a temporary increase of reflexes, which in susceptible animals and after large doses may rise to convulsions, opisthotonos, and tetanus, paresis supervenes, with paraplegia of the lower extremities, which progresses in an upward direction, ending in complete paralysis. Albuminuria appears after about six hours. In such a condition death may result inside of twelve hours. If the patient recovers from the paralysis, a septic fever may develop in consequence of the enormous and multiple hemorrhages, to which he may succumb after a lapse of time. Eventual recovery sets in very suddenly, even in the most desperate cases. Not rarely, however, there remain suppurating gangrenous wounds which granulate poorly, break open repeatedly, and may lead later on to a deep necrosis, even of the bones.

The effect of the bite of the tropical vipers, especially the East Indian Daboia Russelii, is undoubtedly more pronounced and violent. Sanious discharges from all mucous membranes are prominent features, such hemorrhagic extravasations from lungs and bowels may persist even during recovery. Albuminuria is never missed; even hæmaturia is observed as a rule. The autopsy shows a deep bloody infiltration at the bite down into the necrotic muscles, hemorrhages of distant muscles, particularly of the intercostals; all serous membranes, chiefly the endocardium and the peritoneum, are completely covered by countless ecchymoses of all sizes; the lungs show subpleural ecchymoses and infarctions; the kidneys are hemorrhagic in the glomeruli and pelvis, and there is cloudy swelling of the epithelium of the canaliculi. Hemorrhages have been observed also in the serosa and in the substance of the central nervous system. The blood is fluid and does not clot, even after a long time.

A disproportionate swelling is to be noted in poisoning by the European viper; it sometimes extends over the whole body. The poison of the African viper, the puff adder, acts in a stupefying manner from the very beginning; the animal stricken stands without motion or reaction as if the whole cerebral cortex were eliminated; complete sensory and motor paraplegia ascends gradually with sharply defined limits.

The Australian snakes occupy an intermediate position between the two types just described, for, besides a prominent cobra effect, they produce moderate hemorrhage and always hæmoglobinuria.

Wall relates a peculiar variation after the bite of the East Indian Bungarus fasciatus. Some cases cannot be distinguished from the acute cobra poisoning, yet in others a certain chronicity of symptoms is seen which can be compared only to the incubation period of infectious diseases. From two to six days may have elapsed after the bite without any symptoms, when unexpectedly a general debility sets in with albuminuria and a sanious discharge from the eyes, nose, and rectum. The patient invariably succumbs within a short time.

An interesting incident is the periodical relapse of inflammation and suppuration which is said to occur mostly annually, almost to the day of the first injury. The cases reported are too numerous, and have been observed by too good authorities, to admit of a doubt. While in some instances there appeared only a scaly or vesicular eruption of the skin, in others a suppurating inflammation set in, *e.g.*, with regular loss of a nail. All the cases on record are from the United States and include all species of snakes—copperhead, rattlesnakes, and Elaps. They have been watched for six, ten, twelve, and even eighteen successive years. Perhaps the best authenticated case is that of a draughtsman of the Smithsonian Institution, who, according to Yarrow and Stejneger, for ten years had the same inflammation of the finger, bitten by an Elaps, almost to the date of the accident. A cure was finally effected by the use of the South American herb, Micania guacho.

To use for comparison a well known and familiar complex of symptoms, we might call the sequelæ of a cobra bite an *acute bulbar paralysis* of the most furious and vehement type. Likewise, for the second type, that of viper poisoning, an analogy is found in *acute ascending spinal paralysis*, the last stage of which exhibits alike bulbar symptoms and inhibition of respiration. It should be remembered that the common ascending spinal paralysis is also ascribed to an infection. Yet, whereas in the two diseases named, the development of the nervous symptoms is very slow and gradual, and they may take years or at least weeks to advance to a fatal exitus, in snake poisoning the effect is almost instantaneous. It may, therefore, be considered firmly established that snake venoms affect the motor ganglia of the anterior horns and chiefly the medulla oblongata, exercising a selective influence upon the adjacent centres of respiration and deglutition. There exist records of a few accurate microscopic examinations of all organs after snake poisoning (Nowak). In general they resemble the changes which we are wont to find in all kinds of poisoning of whatever origin, especially by the toxins of zymotic diseases—*e.g.*, fatty degeneration of the liver with inflammation of the bile ducts, beginning as early as thirty-five minutes after poisoning; in chronic cases focal necrotic destruction of liver cells, acute parenchymatous nephritis, disseminated pneumonic patches, slight beginning of fatty degeneration of the heart muscle, etc. Of the pathological changes in the central nervous organs, we

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also have some accurate records (Ewing, Bailey). As we may expect, they demonstrate a pronounced acute degeneration of the ganglion cells throughout the central nervous system. The chromatic bodies generally disintegrate with some loss of the chromatic substance, the outlines of the Nissl bodies being completely obscured; the nucleus and nucleolus may be normal or swollen and opaque; the dendrites irregular, shrunken, or detached. These changes are to be found in the cells of the cortex, the cerebellum, olfactory lobe, basal ganglia, medullary nuclei, anterior horns, and spinal ganglia, most marked, however, in the anterior horn and in the Purkinje cells and the mitral cells of the olfactory lobe. These changes were exhibited only in their beginning in those animals which had been killed in a short time by a large dose of venom, but were more advanced and involved a much greater number of cells in the cases of more chronic poisoning. Alt, after poisoning with puff-adder venom, finds the changes in the posterior columns so marked that they are perceivable to the naked eye.

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The old question whether snake venom is a nerve or a blood poison, therefore, must receive the answer that it is both a neurotoxic and a hæmolytic substance. Nay, recent investigations have shown that both principles are physiologically distinct, for Flexner has demonstrated *in vitro* that in a mixture of venom with an emulsion of brain substance, the chief (neuro) toxic constituent unites with nerve cells while the agglutinating and hæmolytic element combines with blood corpuscles. It is of considerable interest to analyze more accurately its influence upon the circulatory system, which is such a prominent feature in viperine poisoning, but is nevertheless of paramount influence in cobra poisoning as well. The assumption that the action on nervous tissue is but a secondary sequela of its primary action upon the circulation must be positively denied, inasmuch as extremities whose circulation is entirely obstructed by constriction respond readily to the action of the venom upon the nervous centres; neither do we miss any of the characteristic nervous symptoms in frogs, in which the blood has been entirely replaced by decinormal saline solution.

Notwithstanding the facts just related, some of the phenomena might be referred to a disturbance of the vaso-motor centres. Some investigators ascribe them to an enormously increased diapedesis, as is seen after the local application of poison to a capillary area; while others consider it to be a rupture of the capillary walls. The blood cells escape after a hypodermic injection of venom, and are destroyed to such an extent that a few hours later but one-half of the normal blood corpuscles may be counted.

The point which has been creating the greatest diversity of opinions is the poison's influence upon the coagulability of the blood. Formerly it was an accepted dogma that cobra venom increased and viper venom inhibited clotting, until recent investigations of Heidenschild and the more accurate experiments of Martin, of Sydney, have cleared up the matter. The doses as well as the mode and rapidity of introduction are matters of the greatest importance. As a rule coagulation is inhibited for a long period. A small dose injected intravenously causes a positive phase of coagulability of two or three minutes, which is followed by a negative phase of longer duration. A second larger injection brings on the same positive and a much longer negative phase. A third still larger injection, which is borne remarkably well, destroys coagulability for a long period and, as it were, immunizes the blood against further coagulative influence of the poison. At the same time the leucocytes disappear almost entirely from the circulating blood; they are massed in the liver, lungs, and bone marrow, and reappear only when the blood regains its coagulability (or perhaps inversely). Auché found the bone marrow much congested soon after poisoning, and regards it as evidence of a reaction of the blood-forming organs,—a reaction which, within a few hours, floods the circulation with an abundance of leucocytes. A hypodermic injection, and therefore the majority of all snake bites, acts in the same way as a small intravenous injection. Immediate introduction of a larger quantity of poison into a blood vessel may cause a sudden complete clotting of the whole mass of blood, with the exception of that in the pulmonary veins and the left heart. Many contradictory reports of the blood pressure, sudden stoppage of respiration, etc., are explained by the sudden massive thrombosis. The immediate cause of coagulation is probably a nucleo-albumin, analogous to the fibrinogenic substance of Wooldridge, also a nucleo-albumin. It is not preformed in the venom, but, as Martin has it, is liberated instantaneously by the action of the poison, from the stroma of the destroyed erythrocytes and from the endothelium of the blood-vessels; it brings on extensive thrombosis at one stroke. Or, according to the theory of Delezenne, which would explain the different phases of coagulability and fluidity, nucleo-histon is formed which splits into leuconuclein and histon; the former, which is retained by the liver, accelerates coagulation; the latter, which remains, retards it.

Many of the symptoms noted in former experiments are now explained by the recent interesting methods of study in hæmolysis. The first effect of snake venom upon blood *in vitro* is agglutination, speedily followed by hæmolysis; the escaping hæmoglobin is not changed, the spectrum remaining normal. A great variation in susceptibility to this latter reaction is distinguished in the different animals, but most noticeable is the difference of hæmolytic power in the several varieties of venom. Contrary to what we should expect from the prominent symptoms, cobra venom is most actively hæmolytic; those of moccasin, copperhead, and rattlesnake are hæmolytic in less degree, in the order named. The action upon leucocytes is similar to that upon erythrocytes, although the several varieties of white cells show different susceptibility.

Another important effect of snake venom is the loss of the germicidal property of the blood plasma. It is well known that normal blood serum destroys micro-organisms, or at least retards their growth. Ewing, of Washington, was the first to show, in 1894, that this faculty was annihilated in the blood of animals killed by crotalus poison, and Martin has confirmed it for the venom of the Australian black snake. This explains both the well-known rapid putrefaction of the poisoned organs and the danger of subsequent decomposition of the extravasated blood, and the resulting sepsis during convalescence. The recent hæmolytic studies mentioned above have shown that the germicidal power of serum is rendered inactive through the fixation of the serum complements by the venom.

A closer similarity in the two types of poison can be created in an artificial way by heating. The agglutinating power is destroyed by a temperature of from 75° to 80° C., a temperature which leaves the hæmolytic power undisturbed. The latter is somewhat reduced in crotalus poison by 90° to 96° C., while it requires 100° C. for at least fifteen minutes to make an impression on cobra, copperhead, and moccasin venom. A prolonged heating, however, of viperine poison destroys the intense influence upon the circulation to be ascribed to the globulin; after such heating it approaches cobra venom in character.

In briefly summarizing the mode of dying from snake poison, we might say that death occurring within a few minutes is due to general thrombosis; a patient who dies within twenty-four hours may succumb in the first hours to paralysis of the respiratory centre, later to general paralysis; lethal exitus, after such a period, days or even weeks after the bite, may be the result of sepsis or of general prostration following prolonged suppuration.

From what has been said, it will be seen that the danger of a snake-bite must vary considerably. Statistics cannot give us an adequate idea as regards this point. Not all cases are reported, and not all bites reported are those of venomous snakes. Moreover, chance is an important factor as regards the sequelæ: *e.g.*, in what condition was the snake when biting? Were one or both

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fangs deeply implanted, or was the skin merely scratched? How old and in what condition of health was the bitten individual? India, as is generally known, has the largest mortality from snake bites—a fact easily explained by the enormous number of snakes, and these the most deadly of all, the cobras. Nevertheless, indolence and superstition of the population may increase the number of fatal accidents considerably. Those may be right who consider the smaller number of deaths in America and Australia as due to the greater intelligence of the people, because a rational treatment, especially the early application of a ligature, is instituted in time.* In default of reliable analyses, the only way to decide this point has been shown by Calmette to be that of comparative experiments. After carefully graded hypodermic injections, to determine how much poison may kill a kilogram of animals (mostly rabbits), the following table has been worked out:

1 gm. of cobra and aspis kills	4,000 kgm. of rabbit.
1 gm. of hoplocephalus kills......	3,450 kgm. of rabbit.
1 gm. of fer de lance and pseudechis kills.	800 kgm. of rabbit.
1 gm. of Crotalus horridus kills...	600 kgm. of rabbit.
1 gm. of Pelias berus kills	250 kgm. of rabbit.

But even this method has not yet yielded undisputed results, for Martin claims for hoplocephalus 4,000 and for pseudechis 2,000 kgm. At any rate the toxicity of snake venom is exceedingly high. A comparison with the toxins of infectious diseases shows that only that of diphtheria comes up to 4,000 kgm., toxopeptone to 3 kgm., and the albumose of anthrax to not more than 80 gm. Besides the high toxicity it is also the extremely rapid absorption and consequent early appearance of grave symptoms which distinguish snake venom from other toxins.

If the most serious cases (*e.g.*, when both fangs, and especially those of a large tropical snake, have thrown their full dose of poison into the tissues) are left out of consideration the prognosis is not so bad as is generally believed. Weir Mitchell gives the mortality of crotalus bites in one place as 25 per cent., in another as not more than 12 per cent.; that of the Australian snakes is said to be only 7 per cent.; but for India Fayrer states it at from 25 to 35 per cent. It has been mentioned how quickly an amelioration may set in, even after the most serious nervous symptoms have preceded. This is undoubtedly a reason why so many remedies have gained the undeserved reputation of being a sure cure. Most of the patients would have recovered without them. Comparing these conditions with the results obtained in experimental bacteriology, we should say that in most cases of snake-bite the minimum lethal dose of toxin is seldom injected, so that the body cells are still able to combine with and fix the toxin, in consequence of which they not only speedily recover, but also, as we shall see later on, develop a certain immunity by casting off antitoxin.

TREATMENT.—The proof of the utter helplessness of therapeutics of past years is the long array of remedies recommended and used at all times for snake-bite. The object of treatment is threefold: first, to prevent absorption of the poison; second, to accelerate its elimination; third, to destroy or neutralize it, and to treat symptoms of imminent danger. If the wounded limb, *e.g.*, a finger, cannot be amputated quickly, at least the circulation should be checked or retarded by a ligature, as practised since time immemorial. A ligature is applied as tightly as possible, not only at one, but at two or three places—*e.g.*, when a finger has been bitten, round the finger itself, at the wrist and at the elbow. The experienced Wall is so convinced of the advantages of Esmarch's rubber band that he not only recommends every physician in India to have one in readiness, but wants to see it in every well-regulated household. The ligature is relaxed at intervals of some hours to prevent gangrene, but is applied again as soon as practicable.

It has been an often recommended custom to suck the wound with the lips or to apply cups. The result of such a measure is at least doubtful, because of the finely punctured bites; the sucking ought to be preceded by a long scarification into the deeper tissues. It is still safer to excise a large area of these tissues or to destroy them with the actual cautery. Wall, taught by long experience, recommends proceeding in the most ruthless manner. By these means the absorption of poison can be limited to a possible minimum, so that the system shall gain time to overcome the whole quantity at intervals.

How can we hasten the elimination of the injurious substance? The kidneys are attacked to a greater or lesser degree by the poison, especially that of vipers; hence it is doubtful whether we should be permitted to increase their activity. The vicarious excretion by perspiration, stimulated by diaphoretics (*e.g.*, jaborandi) has had dubious results. It has been demonstrated, however, that part of the poison is excreted by the stomach. Alt found that alkaloids, chiefly morphine, after hypodermic use were excreted by the stomach almost to one-half of their amount. When he tried the same method for snake venom, it was discovered that the animals whose stomachs were washed out were saved, whereas the controls died; at the same time, the washed-out fluid was again poisonous to other animals. Hence it is probable that the use of the stomach pump may be of good service. Those who have read a minute description of, or have personally witnessed, the snake dance of the Moki and Zuñi Indians of Arizona will remember that after the performance the dancers, who are sometimes bitten by the snakes, receive a potion prepared by the priests which contains an emetic. The whole crowd stand around a certain part of the parapet to empty their stomachs freely. This custom has undoubtedly been justified by long experience.

The question then remains, Are we able to render innocuous the poison in the tissues surrounding the bite? This efficacy has been claimed for a whole series of specifics, which owe their reputation partly to old traditions, partly to experiments in the test tube. The majority of these specifics, which it is true neutralize the poison *in vitro* after a shorter or longer period (carbolic acid, *e.g.*, only after twenty-four hours), destroy all tissues to such an extent that it seems preferable to apply the cautery. Even the much-praised permanganate of potassium, recommended especially by Lacerda, of Rio, Brazil, has not fulfilled the high expectations, for neither locally applied in a one-per-cent. solution nor injected intravenously has it the elective faculty to single out snake venom for oxidation in presence of other proteids. One per cent. of chromic acid has gained somewhat of a reputation; it does not destroy the tissues simultaneously with the poison, but it merely makes them shrink. Calmette has frequently tested hypochlorite of lime in a solution of 1 to 60.* He found both its local and repeated hypodermic application near the bite as well as its internal administration of good effect; not less so a one-per-cent. solution of chloride of gold as a local remedy.

Ammonia, extensively used internally and externally, is nothing but a stimulant. Feoktistow actually advises against it, because he thinks he has seen after its use increasing hemorrhages, caused by higher blood pressure. Wall also cautions against exciting the circulation by stimulants; he advises to keep the victim as quiet as possible and to husband his strength. Neither has alcohol any local effect as a coagulating medium; it is to be rated also as a mere stimulant. It has always met with appreciation on the part of the real or, more so, of the alleged victim. Indeed, the use of this infallible specific has often been carried to such an extent that it was impossible to decide whether the patient succumbed to snake venom or to an acute alcoholism. In one case,

* The statistics of the Indian Government have given for years an average annual mortality of 20,000 persons. Recent advices, however, have called this number again into doubt, as has been done before. It seems to be the practice of officials in remote, isolated districts to ascribe in their reports any case of death to snake-bite, whenever it is thought desirable to cover a crime or even a neglect of duty on the part of the official.

* He advises against the employment of more concentrated solutions which are less active and produce eschars.

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e.g., the use of five quarts of whiskey is recorded. It is, moreover, a fact that intoxicated persons, when bitten in this state, have not proved to be better protected against snake bites than sober people; and the enormous doses which we often hear of as having been administered deserve nothing but condemnation.

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As to a rational treatment, it is necessary to inquire first as to the prominent morbid changes which threaten life. Are they irremediable or are they transient? That they are transient is proved by the many individuals who survive a snake-bite in spite of the gravest symptoms. We have seen that the poison exerts, first, a hæmolytic action; second, a destructive influence upon the cells of the medulla. We know at present of no pharmaceutical remedy which will arrest either the escape of the hæmoglobin into the plasma or the rupture of the capillaries, nor is any drug known that will check the influence of toxin upon the nerve cells. The changes in the ganglion cells, the dissemination and disappearance of the Nissl granules, whatever this may mean, must be fully reparable, since, as we have seen, rehabilitation takes place rather suddenly without leaving any sequelæ. If we are not able, *e.g.*, to re-establish the function of the respiratory centre immediately, could we not at least tide over the dangerous period of deep depression? One method suggests itself to a medical mind, *i.e.*, artificial respiration. The heart beat ceases several minutes later than respiration, and in one experiment Fayrer succeeded in keeping up the circulation for eight hours longer by artificial respiration. Fayrer and Lauder Brunton strenuously recommend that it be continued not only for hours but for days, with or without a tracheal cannula. This advice seems to have fallen somewhat into disuse, especially since Martin claims that in poisoning by Australian snakes he saw no good results from artificial respiration, death occurring in spite of it in fifteen minutes after the heart stopped. Notwithstanding some failures, we are justified in trying it for an extended time, always keeping in mind that an abrupt change may set in in the most desperate cases.

In this connection we have to consider a remedy which even recently has been praised with a certain persistency as a specific, *i.e.*, strychnine. First used by Pringle in Australia, it was tested in India, and in spite of the little encouraging reports was enthusiastically championed by Dr. Muller, of Sydney. He declared that the failures were due to insufficient doses, and he began with a dose of at least 0.01 gm., repeated several times until slight tetanic symptoms appeared.*

Many cases in Australia have been treated with strychnine, and upon the advice of the Government Indian surgeons have also used it quite extensively. Nevertheless, the results are not so convincing that we could rely upon this drug as a specific. The experiments of Kanthack and Feoktistow were negative. Interesting, however, is the latter's positive experiment that artificial tetanus, brought on by strychnine, was arrested by snake venom. Roux states that tetanus antitoxin has a certain influence upon snake poison, but not inversely. Atropine has been recommended as a stimulant for the respiratory centre. Not many instances of its use are recorded, but there is no reason why it should not be resorted to as well as strychnine.

It may be appropriate to relate the few instances in which snake poison has been used therapeutically. Dr. Amaden, of Glens Falls, near Lake George, a country abounding in rattlers, cured a man, aged twenty-five years, with unmistakable tetanus by two injections of one drop of fresh rattlesnake poison. It should be mentioned that snake venom has been used in an unsystematic way for several other diseases (*e.g.*, yellow fever), of course without success. Recently it has been asserted that during the plague in India some successful inoculations of cobra poison (gtt. $\frac{1}{50}$ and $\frac{1}{40}$) were made, and that some similar experiments in monkeys gave equally good results. Later correspondence, however, is silent regarding these experiments. The treatment of lepra with snake venom has been without any result.

Antivenomous Serum.—The therapeutics of snake bite were in this state of hopelessness when in 1895 Calmette, and almost simultaneously Fraser, surprised both the scientific and the lay world with an antivenomous serum. It is to serum therapy and immunization, as we shall presently see, that we have to look for the successful treatment of snake-bites.

Regarding this topic the question first arises: Are there animals, as often asserted, which are immune to snake poison? In East India the mongoose, a kind of weasel, the deadly enemy of the cobra, has the reputation of immunity; and in Europe the droll, bristled hedgehog (Erinaceus europæus) is considered as the natural destroyer of vipers because of its reputed invulnerability. More accurate observers have shown that the mongoose owes its apparent safety to a low susceptibility (from ten to twenty-five times less than rabbits, Elliot) against both cobra and viper venom, but more to its agility, and that the hedgehog is partly protected by its spinous coat. It possesses, however, a higher resistance to snake poison than other animals, and from my own investigations I might figure a resistance of about four times that of a rabbit of equal weight. A relative immunity toward various toxins is well known to exist in different animals. The poisonous snakes themselves possess a perfect immunity against their own poison, the species with weaker poison a relative immunity toward those with stronger venom, and even the non-poisonous snakes enjoy a certain security against the bites of the poisonous ones. The king-snakes of our Southern States, which are the enemies and destroyers of our poisonous serpents, seem to enjoy a perfect immunity.* Although Weir Mitchell finds that, at least in some cases, crotalus is not immune against its own poison, it is a common occurrence among venomous snakes in captivity that they bite each other furiously without any evil effect. One of Cunningham's cobras resisted inoculation with an amount of cobra venom sufficient to kill one thousand fowls. This faculty is ascribed to inner secretion, to the incessant influx of toxin into the circulation. The discovery of Blanchard, that the extract of the yellow part of the supralabial gland of Tropidonotus natrix, and even its blood serum, kills small animals with distinct symptoms of poisoning, seems to corroborate this theory. Cunningham, however, finding after many experiments with cobras that their serum has no antitoxic action, comes to the conclusion "that the natural immunity of cobras is perfectly distinct in its nature from the artificial immunity, which is established in other animals as the result of continued treatment with cobra venom, and that it is unconnected with any material of the nature of an antitoxin in the blood."

The idea of immunization is by no means a modern one. Even in antiquity we hear of it, and among savage tribes of ancient and modern times, wherever poisonous snakes abound, attempts at protection against snake venom are made under various forms, sometimes associated with mystic ceremonies. The poison is rubbed into the skin, as is done in Bengal, or it is taken internally in the fresh state, or parts of the dried poison glands are eaten (as practised by the savages of South Africa). A shepherd, immunized in this way, admitted that the dried gland of the cobra had an intoxicating effect, which he compared to that of Indian hemp, except that, whereas the latter lost its effect gradually, the action of the first was not impaired by habit. Or it is used as an inocula-

* The tolerance toward strychnine seems to be quite extraordinary in these cases: thus 0.035 gm. was used in the case of a boy thirteen years of age within three and three-quarter hours, 0.05 gm. in five and one-half hours, 0.05 gm. in four and one-half hours, 0.066 gm. in seven hours, 0.25 gm. in six days.

* I have injected a king-snake (*Ophibolus getulus*) of Florida, of 700 gm. weight, with 1 gm. of fresh moccasin poison, a quantity which can never be injected by a single bite of the largest venomous snake. With the exception of a pronounced local swelling and some apparent sick feeling for a few days, the snake survived this experiment well. A crotalus of three feet in length and about 500 gm. weight received four drops of cobra venom: it sickened within half an hour and was found dead the next morning.

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tion in the interior of Africa (Serpa Pinto). Sometimes one of the reputed antidotes is employed for an extended time, as, *e.g.*, the *curados de culebras* of Mexico use a composite plant, Micania guacho.*

Sewall, of Ann Arbor, Mich., was the first to introduce methodical inoculation of snake venom with the idea of immunization. His experiments, in which, by gradually increased doses, he made his pigeons secure against seven times the lethal dose of massasauga poison, were published in 1887. Calmette, director of the Pasteur Institute of Lille, France, after a number of failures succeeded in securing immunity, and at the same time in elaborating a protective antivenomous serum which, in spite of some weighty opposition, must be considered today the only reliable antidote to the deadly action of snake poison. Fraser, who worked independently of Calmette for six years on the same subject, has produced a similar serum, called by him antivenene. It is dried, in which state it is said to keep indefinitely. Calmette manufactures his serum by inoculating with cobra venom or with a mixture of cobra, crotalus, viper, and hoplocephalus venoms, in both of which the hæmolytic agent has first been eliminated by heating to 80° C. The inoculation of horses has been carried on in some instances for three successive years, so that these animals, which succumb to a dose of 15 mgm. of cobra poison, finally tolerate a dose of 2 gm. A prolonged feeding also imparts immunity, but requires larger doses and induces less protective power. Antivenomous serum is put up and sold in vials of 10 c.c. each. Its protective value is calculated by Calmette in the following way: If 1 c.c., injected into the ear vein, is found to protect a rabbit of 2,000 gm. (2 kgm.) against a dose of venom, fatal within fifteen to twenty minutes, it is said to contain 2,000 antivenomous units, and a vial of 10 c.c. consequently 20,000 units. No serum is sent out without possessing a strength of at least 10,000 units; and for the tropical countries serum of as high as 40,000 units is manufactured.

It has been shown by experiment (Myers, Martin, Semple, Flexner) that 0.1 cgm. of Calmette's serum neutralizes 0.1 mgm. of dried cobra poison, both *in vitro* and *in corpore*. This proportion holds good for the hæmolytic and antibacteriolytic and the inhibitory action of venom upon clotting of the blood. Of rattlesnake venom even 3 mgm. are neutralized by 1 c.c. of the serum. For the counteraction of the neurotoxic principle of the venom, somewhat larger doses of antivenomous serum are required. For practical purposes it may be stated that it acts as a full protective in a dose of from 5 to 20 c.c.; and the 10 c.c. contained in Calmette's vial are therefore amply sufficient for the average case of snake-bite when injected even one and a half hours after the introduction of venom. If more time has elapsed, or graver symptoms have set in—as may occur after the bite of a large tropical snake—it is advisable to inject 20 or even 30 c.c. simultaneously. Fraser recommends injections into the injured limb rather than into distant parts, and the administration of repeated smaller doses instead of one large dose; but Calmette thinks they are best made into the lax skin of the hypochondrium. Although antivenomous serum is absorbed rapidly from the subcutaneous tissue, it may not be quick enough in severe and belated cases; then it is advisable to resort to direct intravenous injection. Immunity thus conferred by antivenomous serum acts very rapidly and energetically, but disappears very soon again, inside of from two to four days, while immunity, created by gradually increased inoculations of venom, lasts for months (five to eight), the longer the larger doses were finally employed (active immunity). Even the young guinea pigs of a mother thus immunized acquire immunity for several months.

Calmette's statements have not been accepted without contradiction. Fraser does not agree with him on all points, nor did the experiments and practical experience of the Indian surgeons and of Martin thoroughly confirm his premises and predictions. Not only has controversy arisen as to the curative value of antivenomous serum, but also other questions have been stirred up in relation to the chemical and physiological action of toxin and antitoxin, questions which promise to be of the greatest importance in settling this vital problem of therapeutics. The interest of the subject warrants us going into some details as regards the controversy.

First, it was objected that Calmette asserted his antivenomous serum to be equally effective against all kinds of venom, in direct opposition to Behring's law that every toxin requires a specific antitoxin. It should be borne in mind that Calmette's horses are immunized with a venom in which the hæmolytic element has been destroyed. Hence while he may work out an antitoxin to the more important constituent, the nerve poison, he neglects the other agent entirely. And indeed Cunningham declares an antivenomous serum which is efficient against cobra venom entirely valueless against Daboia venom and inversely, while Martin claims that Calmette's serum has a slight but distinct protective effect against one of the constituents of Australian snake venom; but, on account of its present slight antitoxic strength, it is practically valueless in Australia. Calmette, after having elucidated experimentally all these points of objection, comes to the conclusion "that his antivenomous serum acts as a perfect preventive against the venom of any species of snake." He admits that in a case of viper poisoning some local disturbances may persist, even with consequent suppuration, but that fatal exitus is at all events prevented. Other experiments seem to prove that also the hæmolytic agent in venom as well is decidedly influenced by antivenomous serum (Stephen and Myers). Furthermore, we must consider that a dose of venom may not be sufficient to kill, even though only one of its constituents has been neutralized. And as a most decisive proof, a number of reports from different parts of the globe leave no doubt of the curative value of Calmette's serum. It has been used with beneficial effect in East India, in Egypt, Africa, and the West Indies, against the different serpents of those countries. Some of the failures reported by the Indian surgeons may be accounted for by the deterioration and consequent diminution of power, to which antivenomous serum is subject in a hot climate. Notwithstanding this impairment, however, there are even reports of the effective application of such weakened samples of antivenene.

Another objection was made that the curative power was entirely overrated, since Calmette used as a test for estimating its value only one minimum lethal dose of poison. Fraser thus calculates that for a man weighing 60 kgm. a dose of 330 c.c. of antivenene would be required,* an amount which because of its bulk and price would preclude its practical employment. Statistics and calculations do not, however, bear out this objection, for, with rare exceptions, not much more than the lethal dose is injected by the snake in the average instance.

More theoretical, but not less interesting, is the question of action of the antivenene, whether it is chemical or physiological. Whereas Calmette with Roux and Buchner insists that antitoxin elicits or stimulates the resistance of tissues, Fraser and Martin assert with Behring that the action can be only chemical. The experiments with snake poison and its antidote conducted by Martin and others point positively to a chemical action.

Observations of great interest were reported by Phisa-

* From facts to be reported later on, it seems not at all improbable that certain herbs may contain substances which are capable of reducing the toxicity of venom.

* The logic of this argumentation is not quite obvious. Assuming that more or less power of natural immunity is dormant in every animal which enables it to overcome a subminimal lethal dose of poison, we ought to expect that this power increases in the same ratio as the size of the animal, no matter whether the power is ascribed to the whole system or to one or several separate organs. The average dose of poison in a snake-bite will remain the same in the large as in the small victim; part of it is immunized by the injured organism itself, and only the surplus remains for the action of the antivenene. Consequently, the larger animal stands a better chance and requires comparatively less antivenene. Calmette and others have already expressed this opinion by formulating a law that the quantity of antivenomous serum required is not only in inverse ratio to the susceptibility of an animal, but also to its weight. Man shows more power of resistance than the animals experimented upon.

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lix. While experimenting with viper venom exclusively he found many substances which exhibited apparently a decided antitoxic effect—*e.g.*, cholesterin, separated from biliary calculi and from carrots, or tyrosin, obtained from the bulbs of the well-known flower Dahlia, and from mushrooms.* All these bodies, some of vegetable origin and the highest final products of proteid metabolism, had a decided immunizing effect against viper venom, as had also the serum of the animals treated with these substances. They were capable, however, of raising the resisting power of the organism but little above the minimum lethal dose of venom; and, moreover, to be at all efficacious, they had to be injected at least twenty-four hours previous to the administration of the venom.† A similar antitoxic influence is exerted by the cortical substance of the suprarenal glands.

Calmette, after repeating the above experiments, has extended them by using bouillon, bile, normal and antitetanic serum, etc., with the same apparent antitoxic effect, which is little pronounced and transient. He claims that all these substances act only as cell stimulants, to counteract the deleterious influence of the venom. Advocates of Ehrlich's theory would as well say that they stimulate the cell to the overproduction of a toxophil side chain, which as antitoxin is received and kept ready for use by the blood plasma. It is immaterial which theory we may apply. The observations of Phisalix are still in an experimental stage, and, though they may result in very practical conclusions, they may in the mean time serve to unravel the mysteries of the relation between toxins and antitoxins. And to investigations of this nature snake poisons, as Martin has pointed out, are particularly well adapted. They have the advantage of being less sensitive than other toxins to light and heat, and of being comparatively easy to obtain in a form which preserves a remarkably constant composition.

To sum up, the most commendable treatment would be:

One or several tight ligatures should be made above the wound, followed perhaps by deep scarifications; then injection of antivenomous serum, if at hand. If the latter cannot be had, injections should be made of 20 to 50 c.c. of a solution of hypochlorite of lime, 1 to 60, at several points near the bite and elsewhere. Stimulation, if necessary, by either strychnine or atropine (or alcohol?); lavage of the stomach; artificial respiration for hours; and, not least of all, continuous encouragement of the victim, for a deep mental prostration goes together with the physical depression of the nervous centres.

HELODERMA.—It remains now to consider the only poisonous reptile not belonging to the snake group, the lizard heloderma, which is represented by two species.

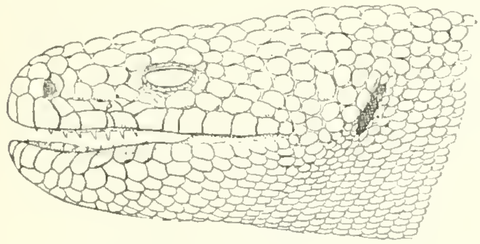

FIG. 3871.—Head of Heloderma. Side view.

The habitat of one of them, Heloderma suspectum Cope, is in the southwest of the United States, in New Mexico and Arizona, around the Gila River, while its somewhat larger congener, Heloderma horridum, lives in Central America. Its popular name, "Gila monster," denotes the awe and fear with which the animal is regarded by the native population, but the same is hardly justified by its exterior nor by its habits. The length attained by the adult animal varies from eighteen to twenty-two inches. Its skin, which is studded with innumerable horny elevations, like small, round nail-heads, exhibits a salmon or orange color, interrupted by black rings and irregular figures; the slow and sluggish, dragging gait does not enable it to make an attack or onslaught. The breath is said to be offensive and to issue from the mouth in puffs of black vapor; but only the black tongue is sometimes thrust out, and the exhalations and saliva have the pleasant odor of fresh calamus or sweetflag. Its reputation as a monster seems to be founded upon the fact that the natives have occasionally observed grave consequences following its bite. It undoubtedly bites very rarely, and then only when it is teased or cornered. When pursued it throws itself upon its back and bites in this position, holding on as tightly as a bulldog.

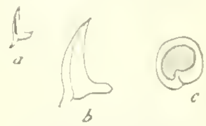

FIG. 3872.—Teeth of Heloderma. *a*, Natural size (3 mm. in length); *b*, enlarged 3 diam.; *c*, cross section.

The fact that but occasionally grave sequelæ follow the bite of a Gila monster accounts for the many discrepancies that have prevailed as to its toxicity until very recently, not only among the natives, but also among the best scientific observers. The first confirmation of its poisonous nature seemed to be established by the discovery of grooved teeth, about 3–4 mm. long, four on either branch of both maxilla and mandibula, in shape similar to those in the snakes Opisthoglypha or "suspecti."* The mandibula appears somewhat swollen, owing to the projection of its disproportionately large, elongated submaxillary glands, whose four separate ducts lead to the base of the above-described grooved teeth. The buccal secretion is whitish, transparent, slightly turbid, somewhat viscid, alkaline, mostly contaminated with traces of blood; it has the fragrant odor of calamus and shows some scaly epithelia, salivary corpuscles, and some amorphous granules. A hanging drop soon swarms with bacteria. Gelatin is liquefied with lemon-colored colonies. When biting on a rubber cord an animal yields on the average five to six drops; a large animal once gave twenty-two drops. The saliva dries in grayish-white scales to one-eighth or one-tenth of its original weight.

The arrangement of the teeth and of the glands makes us understand why opinions as to the poisonous nature of heloderma have differed so widely. When an animal seizes its victim only with the front teeth, or does not lie on its back while biting, none or very little of the buccal secretion may enter the wound. When, however, a vigorous bite has been inflicted, the consequent phenomena have proven the venomous character beyond any doubt, and the hypodermic application of the pure saliva in sufficient doses has invariably proved fatal to the animals experimented upon—rabbits, mice, and frogs.

The first effect of the injection—an inability to sit or stand—is manifested after a short time, about ten to fifteen minutes in frogs, thirty minutes in rabbits. A certain drowsiness, similar to a narcosis, overpowers the animal; paralysis and insensibility seem to proceed from behind forward. The respiration is not labored, but becomes gradually slower and superficial until the animal expires after a few hours with some hardly noticeable twitchings. The heart has first a period of increased activity, which is followed by gradual paralysis and a great fall of arterial pressure, due to vascular dilatation. While these symptoms prevail after a small dose of ven-

* There are, no doubt, many other substances of similar action, and it is not improbable that some of the popular antidotes to snake venom, like the plant mentioned before, Micania, owe their partly deserved reputation to an influence similar to that stated above as exerted by cholesterin, etc.

† Possibly in these cases the presence of a large amount of cholesterin in the blood serum acts in the same way as it does with other protoplasmic poisons, *e.g.*, saponin; it combines directly with the toxic substance, thus preventing the cholesterin of the blood cells themselves from doing so, and from being destroyed. (Ransom.)

* There is possibly another poisonous lizard in East India, Lanthanotus Borneensis, which differs considerably from Heloderma, but which is provided with shallow grooved teeth. As to its toxicity nothing is known (Steindachner).

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om, large doses seem to act directly upon the heart muscle, the animals dying within ten to twenty minutes with dyspnœa and convulsions. Some investigators explain these symptoms as the consequence of general muscular paralysis (Santesson); others, as a paralysis of the central nervous organs (Van Denburgh). A faint hæmolysis is noticed *in vitro*, but in the body no effect upon the blood is visible, no exudation or hemorrhage appears. The local symptoms, with rare exceptions, are entirely wanting; it is even difficult to find the spot where the venom has been injected. Yet it ought not to be forgotten that a few cases of persons bitten by a heloderma are on record in which extensive and painful local swelling is noted.

The autopsy shows nothing but a very much dilated heart and an enormous venous congestion of all internal organs. The microscopical examination of the spinal cord, however, reveals extensive changes in the ganglion cells of the anterior horns; in fact, Bailey found the changes almost identical with those described as due to the action of snake venom. It is not hard to believe, therefore, that snake venom and the saliva of heloderma are almost identical in chemical composition. Santesson has demonstrated that this saliva contains albumoses as well as some nuclein bodies, the latter perhaps responsible for the slight action upon the blood.

Treatment.—It is to be expected that the persons bitten by a heloderma will seldom exhibit grave symptoms, except when accidentally a blood-vessel has been struck directly. A treatment after general surgical principles will suffice to subdue the local phenomena, while the organism has time to overcome the effects of the injected toxin. Yet a ligature ought not to be omitted, and otherwise the use of antivenomous serum should be resorted to as well. The similarity of the toxins of snake venom and the saliva of heloderma justifies the administration of the same antidote. Calmette even claims for his antivenomous serum the same success in stings of scorpions as for snake-bite. *Gustav Langmann.*

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POISONS.—A concise definition of the term poison, which will satisfy the medical, the legal, and the popular acceptations, is a practical impossibility. To the layman a poison is any substance which, when administered in small doses, causes disturbance to health or destruction of life; in a legal sense it is any substance of a destructive or noxious character, whatsoever its nature or mode of operation, which, taken into the system, produces injurious or fatal effects. The popular definition excludes many well-recognized poisons which act injuriously only in large doses; the legal includes, or may be made to include, many substances not strictly poisonous, such as powdered glass, iron filings, and other things of a similar character, which are merely mechanical irritants. To the physician and toxicologist the term means any substance of inherent deleterious character, either organic or inorganic, and incapable of self-reproduction, which, acting chemically upon the tissues or fluids of the body, may, by causing alteration or destruction of the same, or disturbance of function, seriously affect the health or destroy life. This definition excludes mechanical agencies, direct thermal changes, electricity, bacteria, and the low forms of animal life.

The published statistics of poisoning are very meagre, but the few tables which we have are interesting in several ways, indicating the classes of substances and special substances most frequently selected or accidentally administered, at different times and in different countries, and showing the proportion of accidental, suicidal, and criminal deaths due to poisoning.

The returns made by the English coroners of the inquests held during 1837 and 1838 showed the whole number of deaths by poisoning to be 541. Of this number opium was the cause in 196 cases, the majority of which were accidental or suicidal. Arsenic stood next in order, with 185 cases, the majority of which were criminal. Thirty-two cases were due to sulphuric acid, 27 to prussic acid, 19 to oxalic acid, and 15 to corrosive sublimate and other preparations of mercury.

During the years 1863 to 1867 there occurred in England and Wales 2,097 deaths from poison. Of this number no less than 628 were due to opium and its preparations, 151 to prussic acid and potassic cyanide, 83 to arsenic, 77 to mineral acids, 66 to oxalic acid, 61 to strychnine, 58 to compounds of mercury, 15 to phosphorus, and 11 to ammonia.

In France, during the years 1851 to 1871, out of 873 cases, 287 were due to arsenic, 267 to phosphorus, 159 to copper, 36 to sulphuric acid, 35 to cantharides, while opium and its preparations were responsible for but 6.

In Finland, of 30 fatal cases occurring between 1860 and 1866, arsenic caused 7, phosphorus 5, and strychnine 4.

Out of 45 cases reported in Massachusetts during the period 1878 to 1881, opium was responsible for 18, arsenic for 13, and all others for 14.

Although poisoning is a frequent means of suicide, the percentage of these cases is not nearly so high as is generally supposed; but yet, judging from what figures we have been able to obtain, this method of terminating an unsatisfactory existence is gradually becoming more popular. In Prussia, for instance, while there was a great increase in the number of suicides from all causes during the period 1871 to 1876, the relative frequency of self-poisoning was very much greater. The increase from all causes over preceding years was 43.60 per cent., but suicide from poisoning alone had more than doubled in frequency, the increase being 126.10 per cent.; but, even then, poisoning was the means employed by but a fraction over three per cent. of the whole number of suicides. During the eight years ending with 1876, the whole number of these cases was 24,918, and of this number 786 were by poisoning (3.15 per cent.). Solid or liquid poisons were elected by 707 persons, and gaseous by 79. It is interesting to note further that, while by far the greater number of suicides were men, the proportion being 80.50 against 19.50, or more than 4 to 1, the 786 suicides by poisons were nearly evenly divided between the two sexes, the proportion being 52.9 men to 47.1 women.

Of the whole number of suicides reported in Bavaria

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during the fourteen years ending with 1870, 2 per cent. were due to poisoning. In 1871 the percentage increased to 3.2; during 1872 it was 3.00; in 1873 it fell to 2.20, increased again in 1874 to 2.70, and fell off again slightly in 1875 to 2.50. The popularity of poisoning as a means of suicide varies greatly in different countries. In Sweden, from 1843 to 1855, nearly a fourth of the suicides chose this means (21.7 per cent.); in England, in 1858 and 1859, 9.10 per cent.; and in other countries as follows: France, 1835–44, 2.48 per cent.; 1848–57, 1.80 per cent.; Belgium, 1840–49, 1.80 per cent.; Denmark, 1840–56, 1.50 per cent.; Würtemberg, 1857–70, 1.20 per cent.; Geneva, 1838–55, 4.90 per cent.

Of the accidental deaths occurring in Prussia during the years 1869–76, 54,363 in number, 2,448, or 4.50 per cent., were due to poison. This number includes 1,873 men and 575 women; 348 of the victims were under and 2,100 over fifteen years of age. During the fifteen years ending with 1877 there were 77 cases of criminal poisoning in Prussia, or 0.056 per cent. of all crimes. In France, during 1826–29, out of 2,663 capital offences, 150, or 5.63 per cent., were for poisoning. In England and Wales, during 1840, there occurred 349 deaths from poisoning (181 men, 168 women); 161 cases were suicidal (74 men, 87 women); and 188 were accidental and homicidal (107 men, 81 women). Among the latter, opium caused the death in 42 children under five years of age.

Classification.—Various methods of classification of poisons have from time to time been recommended; but no system has as yet proved wholly satisfactory. The old classifications, according to source or chemical properties, such as: (1) animal; (2) mineral; (3) vegetable; or, (1) organic; (2) inorganic; or (1) acids; (2) alkalies; (3) salts, are of no value, since they convey no idea regarding the properties of a poison or its mode of action. Orfila's division into (1) irritants; (2) narcotics, and (3) narcotico-irritants; Tardieu's into (1) irritants and corrosives; (2) hyposthenisants; (3) stupefacients; (4) narcotics, and (5) tetanics; and Taylor's into (1) irritants, and (2) neurotics, are all good; but each has its defective points. Taylor's is, perhaps, the best. The irritants are derived from the animal, vegetable, and mineral kingdoms; those from the latter source may be further subdivided into acid, alkaline, non-metallic, and metallic. The neurotics are subdivided into (1) cerebral; (2) spinal; (3) cerebro-spinal, and (4) cerebro-cardiac.

The irritant poisons include many which are also corrosive in their action, causing disintegration of the parts with which they come in contact. The pure irritants exert no such chemical action, and are much slower in the development of symptoms. They cause irritation and inflammation of the parts to which they are applied, with violent vomiting and purging, intense pain, and well-marked effects on the nervous system. These symptoms occur after a greater or lesser interval, according to the nature of the particular poison. The pain, which is usually of an intense burning character, is, unlike that due to colic, much increased by pressure. Septic irritants produce additional symptoms of a character formerly known as typhoidal.

The neurotic poisons act chiefly on the brain, cord, and nerves; occasionally, the symptoms manifested partake more or less of the character of irritant poisoning. Those acting chiefly on the brain, producing stupor and insensibility, preceded by fulness in the head, vertigo, impaired vision, delirium, etc., belong to the cerebral; those affecting chiefly the cord, producing tetanic or clonic convulsions, to the spinal; those producing symptoms referable to the brain and cord, to the cerebro-spinal; and those affecting the brain and heart, to the cerebro-cardiac class.

Action.—The action of poisons may be local, remote, or both. Local action is physical and chemical, and is manifested by inflammation, corrosion, and direct effect upon the nerves, whereby the functions of organs are impaired or destroyed. If the chemical affinity of the poison for the tissues at the point of application be not great, the result is irritation and inflammation; if, however, the affinity be great, the action is most intense and we have actual corrosion. Remote action depends upon absorption into, and transportation by, the blood to the various organs which may be affected. Thus, for instance, digitalis affects the heart, strychnine the cord, and opium the brain. In any case of acute fatal poisoning, death is the result of the remote action of the poison, which may or may not have a local action.

The ordinary action of poisons may be modified by the size of the dose, by the chemical combination of the substance, by the state of aggregation or admixture, by the condition or absorptive power of the part or membrane to which it is applied, by the condition of the patient, by habit, and by idiosyncrasy. The young and old are more susceptible, as a rule, than the middle aged; women more than men; and fasting more than well-fed persons. Disease also may render the subject less susceptible, or, on the other hand, may facilitate the action of the poison. Habit diminishes the effect of many poisons, so that a much larger dose is required for the manifestation of symptoms than would be for persons not so habituated. Idiosyncrasy is a peculiar condition of the system which enables harmless substances to produce violent symptoms similar to those of irritant poisons. Thus many persons are unable to eat certain articles of food, even unknowingly—such as shell-fish, fish, strawberries, some kinds of meat, butter, honey, and other things. In the same way, many persons are seriously affected by small medicinal doses of opium, strychnine, arsenic, and other pharmaceutical preparations. A second form of idiosyncrasy is a tolerance for exceptionally large doses of poison by persons in no way protected by the influence of habit.

Absorption.—In order to produce poisonous symptoms, the presence of a certain amount of poison in the blood is usually necessary, and the amount required depends upon rapidity of absorption and of elimination. A certain amount of any poison in the blood is incapable of producing any symptoms. Beyond this is that amount which is capable of producing characteristic symptoms—the poisonous dose; then that amount capable of destroying life—the minimum fatal dose; and beyond this up to a certain point, the action is increased in violence and rapidity. The poisonous and minimum fatal doses are relatively large if absorption is slow and elimination rapid, and small if the latter conditions are reversed. The rapidity of absorption depends greatly upon the physical properties of the poison; liquids are more rapidly absorbable than solids, soluble solids more than insoluble, and gases more than liquids or solids. Some insoluble solids may be rendered soluble, and hence more absorbable, by the action of the juices of the stomach and intestines.

Poisons may be taken into the system directly through the blood, as in absorption from wounds or injection into blood-vessels; they may be absorbed through the skin or from the cellular membrane, from inflamed serous surfaces, and from all mucous membranes. Absorption directly into the blood from wounds occurs with great rapidity. Through healthy skin covered with cuticle, absorption is very slow and in small amount. It is increased by rubbing and by the addition of fatty substances or solvents of the poisons. Gaseous substances are more absorbable than watery solutions, particularly if the latter are warm or hot. On the other hand, absorption from a diseased skin is very rapid, and many fatal cases have been noted from the application of washes, ointments, and dressings to diseased surfaces.

Mucous surfaces absorb poisons in the following order of rapidity: (1) lungs; (2) stomach; (3) intestines; (4) mouth; (5) nose; (6) eyes; (7) tear passages; (8) rectum; (9) vagina; (10) uterus; (11) bladder; (12) prepuce. The mucous surfaces of the lungs and the air passages absorb poisons with great rapidity, and particularly those in the form of gas or dust. The lining membrane of the stomach and intestines is usually the absorbent surface in ordinary cases of poisoning. Fulness of these organs retards, and emptiness favors, absorption. Certain poi-

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sons which are rapidly fatal when introduced into the circulation (snake poisons, curare, etc.) are harmless in a full stomach, and, indeed, are absorbed only in small amount when that organ is empty.

Concerning the absorbent power of other mucous membranes, it is necessary only to remark that all are efficient, though in a somewhat varying degree. On account of the absorption of poisons by the mucous membranes of the intestines and bladder, it is sometimes necessary in treatment to administer cathartics, or to catheterize, in order to prevent the reabsorption of substances which are undergoing elimination from the system by the saliva, the juices of the stomach, pancreas, and intestines, the bile, or the urine.

Elimination.—As soon as absorption begins, the substance is diffused through the whole body by the circulation, and at the same time the process of elimination is begun. Coincident with this is still a third process, that of deposition in the various tissues of the body, from which, however, the poison is eventually eliminated, unless death intervenes. Deposition goes on chiefly in the liver, kidneys, spleen, brain, and heart. The effect of a poison depends upon the relative rapidity of absorption and elimination, and these processes go on with greater or lesser rapidity according to the nature of the substance. If elimination proceeds as rapidly as absorption, fatal results do not occur; but with a slower elimination the poison accumulates in the system, and, provided a sufficiently large amount has been administered, destroys life. Elimination is influenced by the chemical affinity of the poison for the constituents of the blood or of the tissues of the affected organs. If this affinity is great, the process is slow; if weak, the process is very rapid.

Gaseous and volatile poisons are excreted chiefly by the lungs; others chiefly by the kidneys, though all secretions of the body play a more or less important part in the process. Certain poisons appear to elect particular secretions, though the kidneys act in most cases as the most important organ of elimination. Thus mercury elects the salivary glands, arsenic and antimony the mucous and serous membranes, and many metallic poisons the liver.

Diagnosis of Poisoning.—The diagnosis of the administration of a poison is based on the symptoms and their course, the detection of poison in articles of food and drink or in the ejecta and excreta, on the post mortem appearances, and on the detection of the suspected substance in the organs of the deceased. The symptoms are usually of sudden onset, in a person previously in good health, soon after eating or drinking. If several persons are affected at the same time there is commonly a marked similarity in the symptoms. Where the poison is administered to a sick person, the diagnosis is rendered more difficult on account of symptoms already present, which may appear to be modified or exaggerated, and the phenomena of poisoning may seem to be only the natural course of the disease. Too much importance should not be attached to the fact of recent eating or drinking, since a poison may be inhaled, injected, or applied externally. The diagnosis of the particular kind of poison involved is of great importance for the determination of the treatment to be pursued, and it is therefore essential that the medical attendant should know, if possible, the exact course of the symptoms from their first appearance, the previous history of the patient, and the exact nature of any medicines which may have been administered. Owing to the similarity of symptoms of particular diseases to those produced by certain poisons, one must often exercise great care in making a differential diagnosis. The physician is often aided in forming an opinion by the moral aspect of the case.

Acute irritant poisoning may be suspected when violent purging and vomiting, accompanied by pain in the region of the stomach or complete prostration, occur in a person without some assignable natural cause. Acute neurotic poisoning manifests itself by more or less sudden symptoms referable to the nervous system, such as stupor, insensibility, delirium, or convulsions. Chronic poisoning is more difficult of diagnosis than acute or subacute, on account of the less marked character of the symptoms, which are often, or indeed usually, ascribable to natural causes.

In making a diagnosis in a case of suspected poisoning, it is to be borne in mind that symptoms may be delayed by fulness of the stomach, sleep, or intoxication, or may be modified or intensified by disease or debility. Among the diseases which may be confounded with irritant poisoning may be mentioned cholera asiatica, cholera morbus, gastritis, enteritis, gastro-enteritis, colic, peritonitis, intussusception, and dysentery; among those which may simulate neurotic poisoning are apoplexy, sunstroke, uræmia, septicæmia, epilepsy, tetanus, diseases of the brain and of the heart, pulmonary embolism, cerebro-spinal meningitis, rupture of the stomach or gall-bladder, typhoid fever, and coma of various origin.

Of very great importance in the diagnosis and subsequent treatment of poisoning is the detection of the substance in the remains of food or drink, or in the vomitus; but as it is possible, in any case of criminal poisoning, that these substances may have been removed and others substituted, or in cases of feigned poisoning that a poison may be introduced into the food remains or vomited matters, reliance cannot always be placed upon this evidence. But the detection of the poison in the urine of the patient establishes the diagnosis beyond any doubt. Yet, at the same time, it should be remembered that the non-detection in that fluid does not by any means prove its non-existence in the body.

The Treatment in cases of poisoning depends altogether upon the nature of the particular substance involved. The first indication, except when corrosives or poisons administered otherwise than by the mouth are involved, is evacuation of the stomach and administration of antidotes, stimulants, etc. (See special poisons under their appropriate heads. See also article on *Antidotes*.)

Post-mortem Indications.—It frequently happens, in cases of suspected poisoning, that an autopsy is all that is necessary clearly to establish the cause of death, particularly in cases of sudden death, which to the uneducated mind are associated usually with suspicious circumstances. The popular belief in poison as an agent of sudden death is doubtless, in great part, due to works of fiction and the stage, where the interval occurring between the swallowing of the poison and the termination of life is so short that the two events are almost simultaneous. As a matter of fact, sudden death is much more likely to be due to disease than to poison, and, indeed, the only poison which approaches heart disease and apoplexy in rapidity of fatal effect is anhydrous prussic acid, a poison not easily obtainable. But, in consequence of the popular tendency to associate the two ideas, innocent persons frequently are suspected or accused of a heinous crime, which may be easily disproved by the appearances on section. On the other hand, with perhaps equal or greater frequency, the autopsy serves to direct suspicion or to strengthen it in cases of poisoning which have resembled disease. But it not seldom fails to throw any light whatever upon the question of the cause of death, and then a chemical examination may be required.

The external appearances indicative of poison are very few, and of no great value. Evidence of corrosive action is sometimes furnished by the skin and clothing. The presence of certain poisons may be betrayed by their odors, and of others by stains. There is nothing characteristic to be observed from the attitude of the body, rate of cooling or of decomposition, or expression of the countenance. Rigidity is usually more marked and longer continued in death from strychnine, and is often diagnostic of this poison; in other cases, no great difference is to be observed. Internal appearances vary according to the poison; they may be absent, or so slight as not to attract attention in cases of death by neurotics, or they may be very marked and characteristic where irritants, and particularly corrosives, have been employed. The chemical and physical properties of the blood

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sometimes undergo marked changes; it is darkened by chloroform, ether, carbonic acid, sulphuretted hydrogen, and other gases, and by prussic acid and cyanides, oxalic acid, etc.; by morphine, strychnine, and some others, it is both darkened and rendered more fluid. The greater number of mineral poisons have no effect on the blood. The blood-vessels of the brain are sometimes observed to be engorged in narcotic poisoning, but this appearance may be very slight or entirely wanting. The principal post-mortem appearances due to poison are to be found in the alimentary canal and abdominal viscera. Corrosion of any part of the alimentary canal, softening of the mucous membrane, which is changed in color and easily detached, and evidence of intense inflammation or perforation, are diagnostic of corrosive acids or alkalies, etc. In irritant poisoning, the stomach and intestines show signs of inflammation of a more or less intense character, and sometimes ulceration and perforation, thickening of the walls, or even thickening and softening. The changes produced in other organs are chiefly engorgement and fatty degeneration; the latter occurs sometimes with surprising rapidity in the liver in poisoning by arsenic and phosphorus.

The post-mortem appearances in any case of suspected poisoning will be but imperfect evidence of the presence or results of poison, unless it is possible to distinguish them without doubt from analogous appearances which may be the result of disease. Otherwise the proof of poisoning must rest on the detection of the poison in the body, or on outside evidence. The changes which may be referable to disease or to the action of irritant poisons as well, are softening, thickening, reddening, ulceration, and perforation. Softening of the walls of the stomach may be due to poison, to disease, or to post-mortem change. If it is due to poison, similar changes are usually to be found in the mouth and œsophagus; if to disease or post-mortem digestion, these additional changes are wanting. Reddening may be due to poisoning or to gastritis, gastro-enteritis, gravitation, or to contact with the liver or spleen. But these appearances are not likely to be mistaken by one accustomed to post-mortem examinations; the redness of poisoning is usually accompanied by some peculiarity of appearance which renders it readily distinguishable. Ulceration is more commonly referable to disease than to poison. When it is due to the former, the accompanying redness is confined to the immediate locality, whereas in poisoning it is more or less widely diffused. There is also a considerable difference in the symptoms. Care should be taken not to confound ulceration, which is a vital process, with corrosion, which is chemical. Perforation of any part of the alimentary canal is, like ulceration, of more common occurrence in disease than in poisoning. When due to disease perforation of the stomach is accompanied by little if any vomiting and no purging, and death is due to peritonitis. The aperture, if due to ulceration and not to corrosion, is usually small in size, and with smooth, regular edges, instead of large, rough, and irregular. Perforation from post-mortem digestion is very rare; it may be suspected from the fact that there has been no peritonitis, nor any symptom before death, to indicate such a severe process. Perforations of the œsophagus and intestines are commonly due to ulceration from the presence of a foreign body, and in such cases the latter is usually discoverable. The intestinal wall is perforated frequently in disease, as, for instance, in typhoid fever.

Chemical Examination.—When a chemical analysis of the body is deemed necessary, the greatest precautions should be observed in performing the autopsy, and in the preservation of organs and fluids. The stomach should be ligatured at both ends before removal. On its being opened the contents should be received in a clean glass or porcelain vessel, and their quantity, color, odor, reaction, and consistency, and the presence of any unusual substances should be noted; the intestines should be treated in like manner. Each organ, on removal, should be placed in a clean vessel by itself, sealed with a private seal, and labelled. Any suspicious vials or powders, and all remnants of food, vomitus, urine, or other substances connected with the case should be sealed at the same time and delivered to the chemist. In case of exhumed bodies, where decomposition has proceeded so far that the coffin is no longer entire, it is often advisable to take, in addition, a sample of earth from above and below the receptacle. On the delivery of the organs, *et cetera*, to the chemist, it is well to give also a more or less complete history of the case, in order that he may have an idea as to the nature of the poison for which he has to search. From the symptoms and post-mortem appearances, it is frequently possible to cut the work of chemical analysis down to a minimum. Failure to detect a poison in the body is by no means conclusive that death has been caused naturally, for there are many poisons which cannot be isolated. The fatal dose of many is so very small that, even if not eliminated in great part before death, its distribution over the system renders it impossible, with our as yet imperfect means, to be isolated. In such cases the proof depends on symptoms and other attendant circumstances. Nor is the presence of poison in the dead body proof that it has caused death, for it is conceivable that poisonous substances may be introduced into the body after death has already occurred, or may have been used in the process of embalming. But the discovery of the poison in the liver and other viscera, and particularly in the urine, usually indicates ante-mortem administration. In many cases in which death is the result of chronic poisoning, it may be impossible to detect any of the substance, which, having performed its work, has been eliminated from the system. Volatile poisons also may be lost within a very short interval after death, and others may be decomposed or oxidized in the living body. In most cases, the ability to detect the poison depends upon the length of time which has elapsed after death, upon the interval between the first manifestation of symptoms and dissolution, upon the amount taken, and upon the amount remaining in the stomach and other organs when death occurs, for reasons which have been given.

Before proceeding to a chemical analysis, a careful examination of the stomach with the aid of a magnifying glass should be made. Such inspection may reveal crystals or powders admitting of ready examination, or particles of vegetable matter may be detected which may be identified from their botanical characteristics with the aid of the microscope. The organs subjected to analysis should be accurately weighed, and any peculiarities observed should be noted. It is best to divide the organs into several portions: one for preservation; one for volatile substances; one for alkaloids, etc.; one for metallic substances; and one for special poisons. The reagents and chemical apparatus used in an investigation must be free from any impurities. The work should be carried on with great precautions, and without assistance except such as is absolutely necessary; for the chemist must be prepared to swear to the identity of the organs, and to the impossibility of any tampering with his work on the part of others.

The methods of analysis to be pursued vary with the nature of the poison. Many substances require special processes for themselves alone, while others may be grouped together under a single process. It is best to look first for volatile substances which are easily lost with keeping, such as chloroform, ammonia, volatile acids, alcohol, ethereal oils, etc. The substance suspected of containing a volatile poison is rubbed up with sufficient distilled water, made acid or alkaline according to the substance sought for, and distilled; the distillate is then further examined by special tests.

The analysis for metallic compounds requires that the organic matter of the examined substances shall be destroyed, since otherwise it interferes with the characteristic reactions. For this purpose the substance is heated in an open dish, or glass flask, with chemically pure hydrochloric acid and potassic chlorate, the latter being added a little at a time until the color of the resulting liquid remains straw-yellow for half an hour after the last

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addition. The excess of chlorine is then driven off by prolonged heating over the water bath, or by the passage of a stream of carbonic acid through the liquid, which is then filtered and subjected to the regular process of qualitative analysis.

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The analysis for alkaloids, glucosides, etc., is one which requires great care and delicacy of manipulation. The amount present in any one case is usually very small and widely distributed, and it is, therefore, not at all surprising that an analysis for this class of poisons often yields negative results even in the best of hands, when the administration of the poison may be proved absolutely. The method of Dragendorff for this class is the one most favorably regarded. This process is briefly as follows: The tissues are cut up small and extracted with acidulated water for several hours at 40° to 50° C., strained through cloth, and filtered. The filtrate is evaporated to beginning syrupy consistence, mixed with three or four volumes of alcohol, and allowed to stand twenty-four hours. It is then filtered, the alcohol is driven off by evaporation, and the residue is transferred to a stoppered flask after being cooled and filtered. The fluid is next shaken in the flask with freshly rectified naphtha, and then allowed to stand until the two fluids separate into two layers. The naphtha is then decanted, and the process is repeated as long as a portion of the naphtha decanted each time leaves any residue on evaporation. The naphtha removes piperine, picric acid, camphor, and similar substances, a constituent of the black hellebore, ethereal oils, capsicin, carbolic acid, and decomposition products of aconite. The fluid is next shaken with benzol, which removes caffeine, cantharidin, santonin, caryophyllin, cubebine, absetin, digitaline, colchicine, chrysammic acid, picric acid, and colocynthin. It is next shaken with chloroform, which removes cinchonine, theobromine, papaverine, narceine, picrotoxin, helleborein, digitalein, saponin, and jervine. It is then shaken with naphtha, which removes the excess of chloroform, and next is made alkaline with ammonia, and shaken again with naphtha, which removes strychnine, quinine, sabadilline, conhydrine, brucine, veratrine, emetine, coniine, lobeline, nicotine, aniline, and trimethylamine. From the alkaline fluid benzol removes atropine, hyoscyamine, strychnine, brucine, physostigmine, quinine, cinchonine, narcotine, codeine, thebaine, veratrine, sabadilline, delphinine, nepaline, aconitine, napelline, and emetine. Chloroform is then used to remove morphine, papaverine, and narceine, and amyl alcohol for morphine and solanine. The fluid is then evaporated with glass powder and extracted with chloroform, which removes curarine. These separate extracts are evaporated each in several watch-glasses, and the residues subjected to chemical and physiological tests.

Charles Harrington.

POISONS, ABSORPTION AND DISTRIBUTION OF, IN BOTH ACUTE AND CHRONIC CASES.—All poisons are absorbed. They may enter the body by various channels, but sooner or later they find their way into the circulating blood and lymph, and are then distributed in greater or less quantity throughout the body. Toxic action is directly dependent on the absorption of the poison, and the extent of action is in direct proportion to the rate of absorption. A substance in itself insoluble and indiffusible, or incapable of being rendered soluble and diffusible by the juices of the body, is incapable of being absorbed, and hence cannot be a poison.

The fact of absorption cannot now be questioned. All poisons capable of detection by chemical or other methods are found after death in the blood itself, and in parts of the body remote from the point of introduction, and this is true whether the poison has been introduced into the body through the mouth or rectum, through the lungs by inhalation in the form of vapor, by hypodermic injection, by contact with an abraded surface, or even through the sound skin.

CIRCUMSTANCES WHICH MODIFY THE ABSORPTION OF POISONS.—Obviously, one of the most important circumstances modifying the absorption of a poison is its solubility and diffusibility. Everything else being equal, the greater the solubility and diffusibility of a poison, the more rapid its absorption, and hence the more rapid its manifestation of toxic action. As a rule, the salts of the alkaloids are more soluble than the alkaloids themselves, and hence the toxic action of the former is more rapid than that of the latter. Arsenite of potash is more rapid in its action than arsenious acid; and this is due in great measure to the rapid absorption of the more soluble compound. The action of many chemical antidotes is confined wholly to the conversion of the rapidly soluble form of the poison into a compound either wholly insoluble, or insoluble to such an extent as to delay its absorption, and thus admit of its removal from the body before it has been absorbed in sufficient amount to lead to a fatal result. Thus, in poisoning with oxalic acid the exhibition of lime water in large quantities leads to the formation of calcium oxalate, a compound comparatively insoluble and hence limited in its toxic action.

Again, the absorption of a poison naturally soluble is increased by introducing it in the form of a solution. Thus arsenious oxide introduced into the stomach dissolved in water, is more rapidly absorbed than when introduced in the form of powder. Further, when dissolved in dilute alkalies, thereby being converted into a new body, it is still more rapidly absorbed, thus introducing another feature into the problem, viz., that of diffusibility. It is here much the same as it is with certain foods: in order to have absorption we must have not only solubility, but also diffusibility. Thus raw egg albumen, while readily soluble, is of little use as food until by the action of the digestive juices it is converted into *diffusible* products. Arsenious oxide, then, when dissolved in a given volume of water, is rapidly absorbed; but the same equivalent of arsenic introduced in a similar manner, in the form of an alkali arsenite, is still more rapidly absorbed by virtue of its greater diffusibility. Hence, everything else being equal, the more soluble and diffusible the form of the poison, the more rapid is its absorption, and consequently the more vigorous its toxic action.

Again, the nature of the surface to which the poison is applied modifies materially the rate of absorption. This depends mainly on vascularity; the greater the supply of blood, the more rapidly does absorption go on. Hence the introduction of a poison in the form of vapor into the lungs leads to more rapid absorption than does injection into the intestine; and similarly, the injection of a soluble poison into the intestines or vagina is ordinarily followed by more rapid absorption than when it is introduced into the stomach. While, then, the natural vascularity of an organ or tissue has some modifying influence on the absorption of a poison, the condition of the blood-vessels also exerts some influence. Fulness of the blood-vessels opposes a mechanical obstacle to absorption and this no doubt explains, in part, why it is that poisons taken on retiring at night are sometimes delayed in their action until the morning, since during sleep the withdrawal of blood from the brain leads to an accumulation in the abdominal organs, and hence retards absorption from the alimentary canal. For a similar reason, poisons taken on a full stomach are much less rapidly absorbed than when the stomach is in a comparatively empty condition. The delayed absorption incident to the former state is, of course, due in part also to the mechanical obstacle afforded by the food itself, the latter keeping the poison for a time away from the stomach walls. Hence absorption, and consequently toxic action, is most rapid when the poison is taken into an empty stomach, less rapid when taken with food, and still less rapid when taken after a hearty meal.

In considering absorption from the alimentary canal, we have to notice, further, the modifying action of the digestive juices. Insoluble substances are not directly absorbed, but many compounds, by the action of the digestive juices, are so altered that their solubility is either increased or diminished, thus modifying their ab-

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sorption, and hence their toxic action. As examples of the former there are many metallic carbonates, as lead, copper, zinc, and manganese which, when taken into the stomach, may be changed by the acid of the gastric juice into soluble chlorides, so that what was in itself an insoluble and non-poisonous substance may be converted into a vigorous poison.

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Disposition of the Poison after Absorption.—Once entered into the circulation, there is a twofold disposition of the poison possible. Either it is deposited for a time in the various tissues and organs of the body, or else it is at once eliminated through some one or more of the various emunctories. Ordinarily, if sufficient time intervenes between the taking of the poison and death, there is a temporary deposition of the poison throughout the body—after which, however, the deposited poison is gradually redissolved and eliminated. Careful study of collected facts further shows that, as a rule, the poison is deposited in the largest amounts in the liver, kidneys, spleen, heart, lungs, muscles, brain, and bones. In other words, these organs and tissues have the power of absorbing and retaining poisons, and furthermore, this absorbing power is not the same for the different organs. Chemical analysis in poison cases, and in experiments on animals where the conditions are known with much more definiteness, clearly testifies to the accuracy of this statement. Further, variation in the conditions under which the poison is taken modifies not only absorption as a whole, as already indicated, but also the absorption by individual organs and tissues. The form of the poison; the character of the dosage, whether small and oft-repeated, or a single large one; the mode of administration, etc., all are liable to exert their own modifying influence on the absorption of the poison by the different organs. A knowledge of such modifying influence must then necessarily be of great value, especially in medico-legal cases; for in time the accumulated facts will serve as data on which to found definite conclusions concerning the form of the poison, the mode of administration, the length of time intervening before death, and many other points of a similar nature, so important in criminal cases.

In this connection, therefore, the results of the quantitative analysis of the various organs and tissues of the body in poison cases are of great importance, for, as they show the distribution of the poison under known conditions, the time may come when it will be possible to draw deductions in unknown cases from the analytical results.

During the past few years many data have been collected in this direction, a few of which may be advantageously mentioned.

Carbolic Acid.—A man swallowed 15 c.c. of an officinal preparation of carbolic acid (100 parts phenol + 10 parts of water), and died in fifteen minutes. With the internal organs Dr. Bischoff [1] obtained the following results:

112	gm. of blood........	contained	0.0259	gm.	phenol	= 0.0231	per cent.
1,480	" liver	"	.6370	"	"	= .0430	"
322	" kidney	"	.2010	"	"	= .0620	"
508	" heart muscle	"	.1866	"	"	= .0367	"
1,445	" brain........	"	.3140	"	"	= .0217	"
12.5	" urine........	"	.0014	"	"	= .0112	"

This case is particularly interesting as showing how rapidly a readily soluble and diffusible substance may be absorbed, and how quickly it may be distributed throughout the body. Further, it is to be seen that the poison was, at the time of death, in position to be eliminated, having entered into the urine.

Oxalic Acid.—An unknown dose of oxalic acid, followed by death in fifteen minutes. The amounts of oxalic acid found by Dr. Bischoff were as follows:

In 2,240	gm. stomach, intestines, etc............	2.280	gm.	oxalic acid.
" 770	" liver....................................	.285	"	"
" 180	" heart blood	.043	"	"
" 350	" heart	.020	"	"
" 290	" kidney	.014	"	"
" 40	" urine	.007	"	"
" 730	" brain	....		

Potassium Cyanide.—An unknown case of potassium cyanide. The analysis made three days after death.[2]

223	gm. stomach and contents	contained	0.0632	gm. HCN.
595	" intestines..........................	"	.0186	"
122	" intestines..........................	"	.0031	"
505	" liver	"	.0170	"
[illegible]	" heart................................	"	.0025	"
352	" brain................................	"	.0144	"

Arsenic.—The case of an adult female who lived two days after taking a fatal dose, furnishes the following results reported by Dr. E. S. Wood.[3]

179	gm. stomach........................	contained	0.0442	gm. arsenic.
6	" stomach contents...............	"	.0097	"
490	" intestines	"	.0638	"
62	" intestines contents	"	.0205	"
1,227	" liver................................	"	.0497	"
149	" left kidney	"	.0043	"
125	" right kidney.......................	"	.0026	"
318	" uterus..............................	"	[illegible]	"
521	" brain................................	"	.0088	"

In all these cases of poisoning the order of distribution of the poison is much the same as that previously stated, the liver standing first, then the kidneys, heart, lungs, etc. In experimenting on animals, however, where the poison can be variously introduced, it has been noticed that the distribution of the absorbed poison is not always the same. It is easy to see how there might be a decided difference in an acute and chronic case of poisoning, for if elimination of the poison commences at once, it follows that the relative amount of poison contained in the liver and kidneys must necessarily be different in a chronic case than where a single large dose of the poison is taken. Again, it is not difficult to see how the *form* of the poison might modify the rate of absorption and the order of distribution. This latter fact has been clearly indicated by results obtained with arsenic, both in experiments on animals and in poison cases. Thus Scolossuboff,[4] under the impression that the muscular paralysis noticed in the extremities of animals poisoned with arsenic was accompanied by a localization of the poison in the muscles, subjected his hypothesis to the test of experiment, feeding the animals experimented on with a solution of sodium arsenite. The results obtained in this manner were all of a like nature, and in several respects different from all preconceived ideas. Thus, in one experiment with a bulldog, which had been fed for thirty-four days with the arsenite, the following amounts of absorbed arsenic were found:

100	gm. of muscle	contained	0.25 mgm.	of arsenic (As).
100	" liver.....................	"	2.71	" "
100	" brain.....................	"	8.85	" "
100	" spinal cord	"	9.33	" "

It is to be noticed in this experiment that the amount of arsenic in the brain is three times as great as in the liver. In another experiment, with a griffin dog, the brain contained, per 100 gm. of tissue, double the amount of arsenic contained in the muscles. In every experiment, comparatively large amounts of arsenic were found in the brain, thus giving evidence of a special localization of arsenic in nerve tissue; but this result was contrary to the experience of all toxicologists in arsenic cases. Scolossuboff gave his results to the world as characteristic of arsenic poisoning in general, without apparently considering that he was experimenting with a *form* of arsenic seldom used as a poison, and with which toxicologists had had little practical experience.

In the white oxide of arsenic (As_2O_3), the arsenic of commerce, and the form most commonly used as a poison, we have to deal with a substance but slowly soluble, while in sodium arsenite we have one of the most readily soluble and one of the most easily diffusible of the solid compounds of arsenic. If the amount of arsenic in the brain could be taken as an index of the *form* in which the poison was taken, whether as a soluble or as a comparatively insoluble compound, it would in many cases of poisoning be a point of great importance. But in order to have the point in question of any practical value, we must be certain, on the one hand, that

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under no circumstances can the taking of the white oxide of arsenic, either in the form of powder or dissolved in water or other neutral fluids, be attended with accumulation of arsenic in the brain other than in the merest trace; while, on the other hand, the taking of a soluble arsenite should be attended with a proportionally large amount in the brain. It might be argued that in chronic cases of poisoning with arsenious oxide, where the person has for weeks or months been taking small or gradually increasing doses of the oxide, the poison might then accumulate in the brain. Such arguments have been made, but the facts at our disposal tend to show the incorrectness of such a theory. On the other hand, the use of the more soluble arsenite (and doubtless all of the other soluble salts of arsenious and arsenic acids) should be attended with a noticeable deposition of arsenic in the brain. The literature of the subject contains but little definite, the amount of arsenic in the brain being generally expressed as a mere trace or in other equally ambiguous terms; implying, however, in the generality of cases, that when present it was only in very small quantity. But recent data on this point are quite decided. E. Ludwig,[5] of Vienna, writing from a large experience on the distribution of arsenic in the organs and tissues of suicides poisoned with arsenious oxide, and likewise in the organs of dogs poisoned with the same form of arsenic, both in acute and in chronic cases, says: "In all experiments it was invariably found that most arsenic was collected in the liver, that in acute cases the kidneys also contained considerable arsenic, while the bones and brain showed but very small quantities of the poison." Ludwig, moreover, states that "in chronic poisoning with arsenic, where death does not result, the poison remains longest in the liver, while from the other organs it is excreted much earlier." Quoting one of his cases, that of a suicide, an acute case of poisoning with arsenious oxide, the following results are worthy of notice:

1,480	gm. of	liver	contained	51.90	mgm.	of arsenic (As.)
144	"	kidney	"	7.09	"	"
600	"	muscle	"	.78	"	"
1,461	"	brain	"	.59	"	"
		bones	"	only a trace.		

In 1880, the writer,[6] in conjunction with Professor Johnson, reported on two cases of poisoning with arsenious oxide, in which the poison was detected and determined in all parts of the body. In one case there was no question whatever as to the form in which the poison was taken, for a mass of the white oxide was found undissolved in the stomach itself. Here there was present in the stomach, liver, and other internal organs, 83.9 grains of the poison, while the brain contained a hardly perceptible trace of arsenic. It would thus appear that the *amount* of the poison taken has little influence on the amount absorbed by the brain. In this particular instance there was as large an amount to draw upon as is often found in cases of poisoning, yet the quantity contained in the brain could not have been much smaller and been recognizable. The length of time, however, intervening between the taking of the poison and death was probably not long, although there had been time for decided absorption by the liver and other organs. In the second case referred to, where there was decided evidence of chronic poisoning, a somewhat similar result was obtained. In this case there was present in the entire body 5.22 grains of arsenious oxide, most thoroughly and evenly distributed, even to the bones, and yet the brain contained only an unweighable trace of the poison. Again, experiments carried on in the writer's laboratory, on animals have led to the same result; whenever the animals have been fed with arsenious oxide, the amount of arsenic found in the brain has been extremely minute, while in poisoning with a soluble arsenite a much larger amount has been found in the brain. At one time it was considered that the presence of arsenic in the brain was proof positive of the ante-mortem character of the poison; that in no case would the poison, introduced into the stomach or rectum after death, find its way by osmosis to so remote a part as the brain. Sutton,[7] however, by experiments conducted on dead animals, finds that arsenic may pass by diffusion quite rapidly even to the brain. Such being the case, the only way to distinguish between ante- and post-mortem introduction of arsenic would be to determine the amount of poison contained, for example, in the outer portions of the liver, as compared with the percentage amount in the centre of the organ. Guareschi[8] has also reported on the distribution of arsenic in a case of poisoning with arsenious oxide, and he likewise found only traces of the poison in the brain. Many other cases of poisoning with the more insoluble forms of arsenic, in which the distribution of the poison has been studied, lend favor to this view, that arsenic is to be found in the brain in any quantity only when the poison has been taken in a readily soluble form. One case which came under the writer's observation is particularly important in this connection. A laboring man ate for his dinner a quantity of bean soup; almost immediately after he was seized with the ordinary symptoms of acute arsenic poisoning, and died in nine hours. The autopsy showed a marked condition of inflammation of the alimentary tract, and a chemical analysis showed 76.0 mgm. of arsenic in the liver, 0.6 mgm. in the kidney, while one-half of the entire brain contained only a recognizable trace of the poison. A portion of the soup (125 c.c.) yielded 314.6 mgm. of arsenious sulphide, while the fact that the arsenic was introduced in the form of arsenious oxide was proved by finding in the sediment from the soup an abundance of the octahedral crystals of the oxide. Such a case as this must necessarily carry considerable weight with it. Everything favored the absorption of the arsenic, yet the brain contained only the merest trace. Again, the writer has obtained like results in an acute case of poisoning with Paris green, or aceto-arsenite of copper, in which the liver (2,984 gm.) was found to contain 12.7 mgm. of arsenic; the kidneys (515 gm.), 3.4 mgm.; 735 gm. of muscle, 0.9 mgm., and the brain (1,179 gm.) only a slight trace. These results certainly indicate that the relative distribution of the poison may offer some suggestion as to the form in which the poison was administered, and that, with arsenic at least, a comparatively large amount in the brain may be indicative of a readily soluble form of the poison. In this connection, however, there are always other facts to be learned in the distribution of the poison, which may substantiate the indications obtained by analysis of the brain, and at the same time, perhaps, enable us to distinguish between an acute and a chronic case of poisoning.

It is a favorite defence in poison cases, particularly with arsenic, morphine, and some other poisons, to claim that the poison found in the body of the deceased came from some hypothetical medicine containing the poison, and which the deceased had long taken, or that the person was habituated to the daily use of the toxic agent. A study of the distribution of arsenic in acute and chronic cases of poisoning shows plainly that many times, with this poison at least, it is quite possible to decide definitely whether the poison has been for a long time in the body, taken in oft-repeated doses, or whether it has been introduced in one or two large doses.

As preliminary to a discussion of this point I will quote two results of my own experience.

(*a*) In this case there was every reason to suppose a case of chronic poisoning with arsenious oxide. The following results were obtained by analysis of the parts a year and a half after burial:

	Weight of organs. Grams.	Weight of arsenic. Grams.	Per cent.
Stomach and spleen	514	0.05359	0.01040
Kidneys	80	.00660	.00825
Liver	590	.01788	.00811
One lung and heart	441	.01451	.00329
Intestines and uterus	978	.02582	.00260
One lung and liquid from thorax	402	.00583	.00140
Bladder	73	Trace.	....
Brain	477	Trace.	....

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	Weight of organs. Grams.	Weight of arsenic. Grams.	Per cent.
Upper arm (left)	665	.00542	.00081
Forearm "	[illegible]	.00158	.00055
Hand "	150	.00019	.00012
Lower leg (right)	1,323	.00864	.00065
Thigh "	3,160	.01635	.00051
Foot "	468	.00105	.00022
Thigh bone "	615	.00040	.00006
Transverse section of body above pelvis	1,920	.03011	.00156
Muscle and ribs from left breast	406	.00371	.00091
Abdominal muscle, right side	615	.00358	.00058

(*b*) In this case the evidence pointed to acute poisoning with some readily soluble form of arsenic. Following are the results obtained by analysis:

	Arsenic as As_2O_3. Grain.
Stomach and œsophagus *	0.158
Large and small intestines	.314
Liver (one-half)	.109
Kidneys	.029
Heart (one-fourth)	.028
Lungs and spleen (two-thirds)	.114
Brain (one-third)	.025
Diaphragm	.010
Trachea, larynx, and tongue	.081

* The internal organs were preserved separately in alcohol, hence the weights of tissue analyzed are not given.

	Weight of tissue. Grams.	Weight of arsenic. Grams.	Per cent.
Left arm	1,230	0.00609	0.000495
Right leg	4,650	.00764	.000164
Thigh bone	216	....	....
Transverse section of body at pelvis	4,060	.01205	.000296
Muscle from breast (right)	510	.00635	.00124
Muscle from back (left)	620	.02306	.00371

In (*a*) the total amount of arsenic was 5.26 grains, in (*b*) 3.119 grains; yet it is to be noticed in (*b*) that the brain contained a comparatively large amount of arsenic, while in (*a*) there was found only a trace. This fact, if our theories concerning absorption by the brain are correct, would imply the administration of a soluble form of the poison. Further comparison of the two series of analyses shows other noticeable points of difference which point to the same conclusion, and also throw some light on the character (acute or chronic) of the poisoning.

When there has been time for even distribution of the poison, as in chronic cases, there would seem to be no reason why one set of muscles should contain more arsenic than another, aside from such differences as might arise from differences in vascularity, etc. On the other hand, there is every reason for supposing that when death ensues only a few hours or less after the poison has been taken, the distribution might be quite irregular.

The following table shows the distribution of the arsenic through the muscle tissue in the two cases, calculated to *grains of* As_2O_3 *per pound* of tissue:

	(*a*)	(*b*)
Thigh bone	0.004	....
Leg	.033	.011
Transverse section	.109	.021
Arm	.046	.034
Muscle from breast	.063	.087
Muscle from back	....	.260
Muscle from abdomen	.040	....

In (*a*) the results, with the exception of the transverse section, show a fairly close agreement. There is not that gradual increase from nothing in the bone up to a fourth of a grain per pound as seen in (*b*). The irregular distribution of the poison in tissue of the same kind, noticed in (*b*), is certainly indicative of the arsenic having been taken but a short time before death, particularly as there was none whatever found in the bones, which fact would certainly exclude the possibility of chronic poisoning.

Again, in (*b*) the two kidneys yielded only 1.5 mgm. of metallic arsenic, while the tongue and adjacent parts (175 gm.) gave 4 mgm., and a portion of the muscles (200 gm.) gave 5.65 mgm. of metallic arsenic.

Assuming the usual order of distribution, the amount of arsenic in the kidneys in (*b*) would suggest only a proportionally smaller amount in the muscles; and yet in this particular instance the amount of arsenic contained in 620 gm. of muscle tissue is greater than the amount contained in the entire liver and kidneys together. The kidneys, however, are the organs above all others concerned in the elimination of arsenic. Elimination usually commences almost immediately, and yet in this particular case there is but 0.029 of a grain of arsenic in the kidneys, while in less than three pounds of muscle tissue there is contained half a grain of the poison. This fact would necessarily imply that elimination had but just commenced, and that consequently the poison had not been long taken. It might, perhaps, be argued that the proportionally large amount of poison contained in the muscles, as compared with the liver and kidneys, might imply chronic poisoning, but coupled with the peculiar distribution is the entire absence of arsenic from the bones. Ludwig, moreover, states that in "both acute and chronic poisoning with arsenious oxide, most arsenic is invariably found collected in the liver," and that "in chronic poisoning with arsenic, where death does not result, the poison remains longest in the liver, while from the other organs it is excreted much earlier." It is impossible, therefore, to make the results obtained in (*b*) accord with a case of chronic poisoning with arsenious oxide; and further, the amount of poison found in the brain, and the proportionally large amount in certain muscles, would apparently indicate an extremely soluble and diffusible form of arsenic as the toxic agent.

Such results as these certainly favor the belief that it is quite possible to draw definite conclusions as to whether we are dealing with an acute or a chronic case of poisoning. Further than that, it is possible, in some cases, to decide even more definitely regarding the time at which the poison was taken prior to death. In this connection, the fact to be considered most closely is the amount of poison contained in the liver, as compared with the amount present in the alimentary canal and in the different organs of the body. When arsenic, for example, is taken into the stomach, absorption by the liver through the portal circulation commences almost immediately; and, as Dr. Geoghegan[9] has plainly demonstrated, deposition of arsenic in the liver continues to increase up to about fifteen hours after the poison has been taken, after which it commences to diminish. Dogiel,[10] who has confirmed Geoghegan's results as to the time required for maximum saturation of the liver, says, "a maximum of arsenic in the liver kills the animal." The absolute amount of arsenic involved in maximum saturation of the liver must necessarily vary somewhat in different cases. Barker,[11] from his analysis of portions of the liver of Horatio Sherman, concluded that the entire liver contained nearly five grains of arsenic. In the case of Dennis Hulburt, also analyzed by Professor Barker, the liver contained over seven grains of arsenic, and it would seem as if these amounts must approach near to the maximum. When such large amounts of the poison are found in the liver, it is safe to assume that the poison must have been taken at least fifteen hours before death.

In recent cases of administration of arsenic, it has been claimed by Taylor[12] that the poison may be found in the stomach and intestines, and not in the liver or other organs. This can hardly be correct under ordinary circumstances, since death seldom results so quickly from arsenical poisoning as to prevent the absorption of at least a small trace of the poison by the liver. Dogiel,[10] who has experimented somewhat on the rapidity of absorption by the liver, found that on forcing 500 mgm. of arsenious oxide dissolved in water, into the stomach of a dog, death resulted in one hour and five minutes. In a second experiment, conducted in the same manner, death

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resulted in one hour and thirty-eight minutes. In the first case the liver was found to contain 94.5 mgm. of arsenious oxide; in the second case, 137.8 mgm. Thus, judging from the amount in the liver at the end of an hour, certainly but a few minutes would have been required for the absorption of a detectable quantity of arsenic.

Arsenic having been deposited in the liver or elsewhere, gradually diminishes, and if the person should survive, entirely disappears in from two to three weeks. A case bearing directly on this point came under the writer's notice some time ago. An entire family were taken sick, directly after eating, with all the symptoms of arsenic poisoning; all of them recovered except one, a middle-aged man, who died just two weeks after partaking of the poisoned food. An autopsy was made, the internal organs were delivered to the writer for analysis, together with the various articles of food partaken of by the family at the time of their sickness. A portion of the bread (786 gm.) contained 32.7 grains of arsenious oxide, while a piece of cake (166 gm.) was found to contain 55.5 grains of arsenious oxide, thus proving the character of the poison.

Analysis of the internal organs gave the following results, showing that at the time of death elimination was nearly, but not quite, complete:

Stomach (365 gm.)	contained	0.10 mgm.	arsenic	(As).
One-third liver (428 gm.)	"	.20	"	"
One kidney (283 gm.)	"	.15	"	"
One-half intestine (487 gm.)	"	.20	"	"
Thigh muscle (389 gm.)	"	.25	"	"
One-half brain (390 gm.)	"	trace	"	"

Concise experiments on animals, carried out quantitatively, are capable of yielding many instructive results in reference to the relative distribution of a poison under different conditions. The writer has recently conducted a series of experiments with antimony,[13] a few of the results of which may be advantageously given, as confirmatory of some of the preceding statements.

(*a*) *Hypodermic Injection of a Solution of Tartar Emetic.* —0.120 gm. of tartar emetic was introduced under the skin (right thigh) of a cat weighing 1,262 gm. The animal died in two hours. Following is the distribution of the poison:

	Total weight. Grams.	Weight of Sb. Milligrams.	Sb. per 100 gm. of tissue. Milligrams.
Liver	52.0	6.35	12.21
Brain	27.5	.60	2.18
Heart and lungs	32	.70	2.18
Kidney	12	.15	1.25
Stomach and intestines	74	.80	1.08
Muscle from back	138	1.25	.90
	335.5	9.85	....

In a second experiment a smaller amount of tartar emetic (0.082 gm.) was injected hypodermatically, and instead of being introduced in a single dose, it was divided into three, and injected separately, several hours apart. As a result, the animal lived twenty-two hours after the first dose. The following results show the distribution of the poison:

	Total weight. Grams.	Weight of Sb. Milligrams.	Sb. per 100 gm. of tissue. Milligrams.
Kidneys	11.5	0.60	5.21
Liver	63	1.50	2.38
Brain	9	.20	2.22
Stomach and intestines	98	2.00	2.04
Heart and lungs	17	.25	1.47
Muscle from back	106	.70	.66
	304.5	5.25	....

The only difference of importance between these two cases is the element of time. As might naturally be expected, therefore, there is a more even distribution of the poison in the second case than in the first. Further, in the second case the kidneys stand first in their content of antimony, the liver contains a proportionally smaller amount—much smaller proportionally than was found in the first case. This is, of course, due to the fact that in the second case the animal had lived long enough to admit of extensive elimination, and, consequently, those parts which had originally contained the most, particularly the liver, had been drawn on to the greatest extent; so that at the time of death the excretory organs, notably the kidneys, were the richest in poison. Quite noticeable in both of these cases is the comparatively large amount of antimony in the brain—which fact would agree with the previous statements regarding absorption by the brain when a readily soluble and diffusible form of poison is used.

(*b*) *Injection of a Solution of Tartar Emetic per Rectum.* —0.24 gm. of tartar emetic, dissolved in a little water, was injected into the rectum of a rabbit, in two doses. Death resulted in about twelve hours. Following was the distribution of the poison:

	Total weight. Grams.	Weight of Sb. Milligrams.	Sb. per 100 gm. of tissue. Milligrams.
Stomach and small intestines	172	8.89	15.30
Brain	9	.40	4.40
Rectum and adjoining intestines	18	.55	3.05
Liver	54	1.60	2.96
Kidneys	13	.25	1.92
Muscle	100	1.10	1.11
Urine	20	.20	1.10
Heart and lungs	17	Trace.	....
	403	12.99	....

Perhaps the most noticeable feature of these results is the comparatively large amount of antimony contained in the stomach and small intestines; a result which, taken in conjunction with other similar ones, would appear to indicate special absorptive action on the part of the epithelial cells of these parts. The amount of antimony in the kidneys, and particularly the amount in the urine, indicates plainly that at the time of death elimination was going on rapidly; but the fact that the percentage content of antimony in the liver was greater than in the kidneys, might perhaps be taken as an indication that absorption was not completed.

(*c*) *Experiment on a Dog with Antimonious Oxide.*—A dog weighing 14.2 kgm. received, with his food, 2.073 gm. of antimonious oxide, during a period of seventeen days, in doses of from 0.032 to 0.125 gm. per day. The dog was then killed by chloroform eighteen hours after the last dose of antimony had been given. The following results show the distribution of the poison:

	Total weight. Grams.	Weight of Sb. Milligrams.	Sb. per 100 gm. of tissue. Milligrams.
Liver	452	23.7	5.24
Lungs	140	1.8	1.28
Muscle from [illegible]	157	1.2	.76
Brain	79	.4	.50
Muscle [illegible]	200	.9	.45
Kidneys	82	.1	.12
Heart	117	Trace.	....
Blood	440	Trace.	....
	1,667	28.10	....

In this experiment, which may be termed a chronic case of poisoning with an insoluble form of antimony, the relative distribution of the poison is seen to be somewhat different from what it was in the preceding cases. First, the brain contains relatively less antimony than in

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the preceding; secondly, the liver contains a noticeably large amount of the poison, while the kidneys contain only a trace. This latter result would seem to indicate that elimination was going on quite slowly; but analysis of the twenty-four hours' urine showed that the amount eliminated by the kidneys in one day was considerable. Thus on one day, the entire twenty-four hours' urine contained 13.5 mgm. of metallic antimony; on another day, 22.5 mgm.

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With copper, Ellenburger and Hofmeister have found, by experiments on sheep,[14] that the liver contains the most copper when small doses have been regularly administered, and, further, that this organ retains the metal with the greatest tenacity, they having found it there forty-one days after the last dose. The pancreas was also found to retain the copper with nearly equal tenacity; the kidneys do not contain so much of the poison. Elimination is mainly by the bile or through the intestine. Deposition of copper in the nerve tissue is quite small, but still smaller in the muscles, though copper is to be found in the muscles after administration of copper salts. Ellenburger and Hofmeister also state that the deposition of copper is proportionally much greater if it is administered in numerous small doses, the cells then having time to absorb it.

With lead, Victor Lehmann[15] has obtained some interesting results. In his experiments the lead was introduced by hypodermic injection in the form of nitrate, the animals used being rabbits. Two of his series of results are given in full.

(*a*) 0.5 gm. of lead nitrate introduced at one dose.

(*b*) 0.01 gm. of lead nitrate introduced daily, until finally a total of 0.21 gm. of the lead salt had been injected.

Distribution of Lead in (*a*)

	Weight of the organ. Grams.	Content of lead. Milligram.	Lead per 100 gm. of tissue. Milligrams.
Liver	40	0.250	0.625
Kidneys	13	.625	4.807
Heart	3	.125	4.166
Lungs	6	.125	2.083
Intestine	16	.312	1.953
Muscle	30	.187	.625
Bones	7	.187	2.678
Brain	8	.062	.781
Bile	3	.125	4.166

Distribution of Lead in (*b*).

	Weight of the organ. Grams.	Content of lead. Milligram.	Lead per 100 gm. of tissue. Milligrams.
Liver	25	0.062	0.250
Kidneys	4	.125	3.120
Heart	5	.187	3.750
Lungs	2	.062	3.125
Intestine	7	.125	1.785
Muscle	10	.031	.312
Bones	3	.125	4.166
Brain	3	.125	4.166
Bile	2	.125	6.250

Very noticeable in both series is the small content of lead in the liver, an organ which, as a rule, contains the largest amount of absorbed poison. The relatively large amount of lead in the bile naturally suggests that the elimination of the metal takes place mainly through this channel, which would account for the small content of metal in the liver. Further, experiments conducted on rabbits show plainly that more lead is excreted in the fæces than in the urine, the lead in the former doubtless coming from the bile poured into the intestines. Quite noticeable also is the large amount of lead in the bones, which amount probably grows larger the longer the lead has time to act.

Naturally, such systematic work as has been done in studying the relative distribution of poisons has been confined mainly to mineral substances, but it is to be hoped that the time will come when there will be a collection of data embracing all poisons capable of detection by chemical means. When such a time does come, it will doubtless be found that we cannot establish any general laws regarding the relative absorption and distribution of poisons as a class, but rather that each individual poison or group of poisons will show some peculiarity characteristic of itself—which possibility, or rather probability, makes it all the more needful for us to acquire, as speedily as possible, accurate knowledge of the relative absorption and distribution of the individual poisons.

Post-mortem Imbibition of Poisons.—Ante-mortem distribution of poisons is, as we have seen, due to the carrying power of the blood and lymph. Poisons are absorbed, distributed, and temporarily deposited. Poisons may, however, travel through the *dead* body, after circulation has ceased, by a process of imbibition or diffusion, by the same method as that by which salt works its way gradually through a barrel of fresh pork when placed on the upper layers. The rate of imbition of poisons depends in large measure upon the interval elapsing between the death of the body and the introduction of the poison. Arsenic, for example, introduced into the rectum shortly after death, before the tissues have become rigid, travels with a fair degree of rapidity and in time may be found in distinct traces even in the brain and spinal cord, while in the abdominal organs the amount present may be quite large. Where a long interval elapses after death, the poison introduced post mortem travels more slowly, but even in this case it gradually penetrates to remote parts. In view of these facts, it is obvious that in cases of poisoning where a surplus of the poison remains in the gastro-intestinal tract after death, and the body is buried for some time prior to the autopsy, the apparent ante-mortem distribution of the poison is liable to modification by post-mortem imbibition. This is an important fact to be kept in mind in drawing conclusions from the analytical data, especially in cases in which a large surplus of the poison is unabsorbed. With metallic poisons, however, putrefaction may quickly put a stop to post-mortem distribution, since the formation of hydrogen sulphide from the decomposing proteid material is very liable to transform the metallic salts into insoluble sulphides, thereby preventing further migration. *R. H. Chittenden.*

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[15] Zeitschrift für physiologische Chemie, vi., pp. 12 and 528.

POKE ROOT AND BERRY.—*Phytolaccæ radix*, and *Phytolaccæ fructus* (U. S. P.), Scoke, Garget. These two drugs are defined respectively as "the dried root" and "the fruit" of *Phytolacca decandra* L. (fam. *Phytolaccaceæ*).

This plant is a very large perennial herb with a thick, fleshy root and bearing cylindrical racemes of dark purple juicy berries. The root, at the crown, attains a diameter of several inches and divides into two or three large branches. It is brownish-white externally and faintly yellowish-white internally. It bears quite a close general resemblance to horseradish, a fact which has led to numerous fatal poisoning accidents. The stems, when young, are bland and juicy and are used by country people in some localities as a pot-herb. They at length attain a height of 1 to 2, in the Southern States 3 or 4 metres, are at first green, afterward red or purple,

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branched widely, are smooth and cylindrical and hollow when old, though with thin transverse partitions. The leaves are large, alternate, petioled, ovate or oblong, entire and smooth. The flowers are in terminal racemes, becoming lateral and extra-axillary by the growth of the stem. They are regular and perfect, having five sepals, ten stamens, and a ten-celled ovary. The fruit contains ten thin putamina, enveloped in a purple flesh, and each containing a single seed. The fruit, when fresh, is about 1 cm. ($\frac{3}{8}$ in.) broad.

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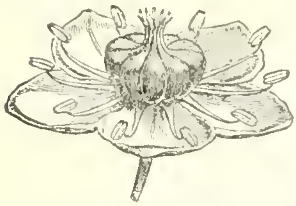

FIG. 3873.—Poke Weed Flower.

For medicinal purposes the root is gathered in the autumn, sliced lengthwise or crosswise, and dried. The berries are gathered when ripe and dried in the sun, in masses.

Description of the Root.—Consisting mostly of transverse or longitudinal slices of sparingly branched, cylindrical, somewhat tapering, usually twisted roots, rarely exceeding 7 cm. (3 in.) in diameter, externally of a rich or yellowish-brown, finely wrinkled (longitudinally or spirally) and thickly annulate with lighter-colored, low ridges; transverse slices exhibiting several concentric rings of interrupted wood wedges, the intervening zones much retracted; longitudinal slices exhibiting the wood bundles as bands, with the intervening medullary tissue greatly retracted; fracture fibrous; internally yellowish-gray; inodorous, the powder highly sternutatory; taste sweetish, afterward highly acrid.

The Fruit.—The dried fruit forms a close and heavy, agglutinated, purple black mass, the stones conspicuous as brightly shining particles, the odor slight, the taste fruity, but peculiar, acidulous and sweetish, somewhat acrid. The structure of an individual fruit is given above.

Poke root contains an actively poisonous, bitter and acrid, amorphous glucoside, which is believed to be saponin, a small amount of the white crystalline alkaloid *phytolaccine*, large amounts of sugar and starch, gum, a little fat, resin, etc. The tannin has been called *phytolaccin*. *Phytolaccic acid* occurs in the root and is, next to the coloring matter, the most important constituent of the fruit.

ACTION AND USE.—All parts of the adult plant are active, and cause in sufficient doses vomiting and purging. It has also some narcotic or stupefying power, and in poisonous doses causes, in addition to the intestinal symptoms, convulsions and coma. Death frequently follows. Its action is slow and protracted. Poke root has been administered as an emetic, but the practice is exceedingly bad. It is also recommended in rheumatism, scrofula, inflamed breasts and testicles, and as a dressing for cancers and indolent ulcers, but is in very little favor in regular practice, probably not nearly so much as its properties warrant. Enough may be absorbed from washes and ointments to produce its constitutional effects. It is said to be useful as a parasiticide in sycosis, tinea capitis, the itch, etc., but there are doubtless many better drugs for this purpose.

The Pharmacopœia, with very poor reason, provides a fluid extract of the fruit but no preparation of the root, of which latter the best form of administration is the fluid extract. The root has been given in 1 gm. (gr. xv.) doses as an emetic, as an alterative in doses of 0.06 to 0.3 gm. (gr. i. to v.), and the dose of the fluid extract should correspond. The fruit and its fluid extract are given in doses five or six times as large. The juice of the fresh fruit is often administered in country practice in doses of 2 to 4 c.c. (fl ʒ ss.–i.), but its action is very weak indeed.

Henry H. Rusby.

POLAND SPRINGS.—Androscoggin County, Maine. —POST-OFFICE.—South Poland. Springs Hotel.

This resort is located in the town of Poland, twenty-five miles north of Portland and ten miles west of Lewiston, at an elevation of about 800 feet above the sea-level. Poland is reached from Boston by the Boston and Maine Railroad. The spring boils up from a fissure near the crest of a magnificent mound of the oldest rocks at the rate of about eight gallons of water per minute. The bed of the spring is composed of gneiss, scarcely distinguishable from the original granite, this gneiss being, as the geologists inform us, the oldest of the sedimentary rocks. The unvarying temperature of the water throughout the year, as well as its freedom from organic matter, would indicate a very deep origin. The surroundings of the spring have been extensively improved since 1859, in which year, it is said, the water was first described by a physician. The Poland Spring House was erected in 1876, and after various alterations and additions reached its present proportions in 1889. It is situated upon an elevated plateau, and commands a beautiful and diversified view of the surrounding landscape. The analysis of the water made in 1879 by Prof. F. L. Bartlett, State Assayer and Chemist, resulted as follows: One United States gallon contains: Silica, gr. 1.07; calcium carbonate, gr. 1.36; calcium fluoride, a trace; lithia, a trace; organic matter, gr. 0.28; potassium sulphate, gr. 0.18; sodium chloride, gr. 0.17; alumina, a trace; magnesium carbonate, gr. 0.31; iron carbonate, a trace; sodium carbonate, gr. 0.09. Total, 3.76 grains.

This may be classed as a mild alkaline-calcic water, with very slight ferruginous properties. It has long had an extensive reputation in the treatment of rheumatism, gout, and dyspepsia, and in renal and hepatic disorders. It is best known, however, as a table water, for which purpose it has an extensive sale throughout the United States.

James K. Crook.

POLARIMETRY.—Polarimetry is the measurement of the angle of rotation of a ray of polarized light, and instruments adapted to the purpose are termed polarimeters. Polarized light is light which (as explained by the accepted theory) has been changed so that vibrations transverse to the path of propagation have been reduced to a single plane. By this change the rays become much more susceptible to interference and may be used for detecting difference of structure not appreciable to ordinary light. Polarization may be brought about by reflexion or refraction of ordinary light, and also by direct transmission through some substances, such as tourmaline, Iceland spar, and quinine iodosulphate. Of these, Iceland spar is the only practicable material, and all laboratory instruments employ it. The crystal in its natural state, composed of pure calcium carbonate, is rhombohedral and double-refracting, that is, a ray passing into the crystal is split into two rays, both of which are polarized. For the best results in polarimeters the crystal is cut in an oblique direction and the pieces are re-cemented in their original position with Canada balsam. By this means one of the polarized rays is prevented from passing through, while the other is transmitted. A crystal so prepared is called a Nicol's prism. When a ray of light, white or of any color, passes through this prism, it will not be completely transmitted through a second similar prism unless the latter is placed in the same relative position, or 180° of arc from it. At any intermediate position, more or less of the polarized ray will be intercepted, and at a 90° position—technically termed "crossed nicols"—only traces of the light pass. Many substances possess power to affect the ray in such a way that when they are placed between the nicols, these must be turned slightly from the above angles to get the maximum effect of transmission or obstruction, and such an effect is believed to be due to the fact that the intervening body twists the plane of vibration of the polarized ray, and the second nicol has to be twisted to compensate for this. Any substance which possesses this twisting (rotating) power is termed "optically active." The degree of rotation is fairly constant for any given substance under definite conditions, and hence the amount of an optically active substance may be meas-

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ured by measuring the extent to which the nicols have to be adjusted in order to correct the rotation produced.

In the actual construction of polarimeters many details have to be regarded in order to secure delicacy and accuracy. Many forms have been devised, but only a few are now employed. In all these a beam of light passes through a Nicol's prism, called the "polarizer," then through the substance to be tested, then through another Nicol's prism, called the "analyzer," and then to the eye. As the mind cannot carry a recollection of the exact brightness of a field of light, some comparison is provided as a zero point, and the degree of alteration of the analyzer required to bring the whole field to uniformity is the measure of rotation. Substances differ as to the direction in which the light is rotated. When this rotation is such that the analyzer has to be moved to the right in order to compensate, the substance is termed dextrorotatory and designated +; when the opposite effect is produced the substance is termed lævorotatory and designated —.

The adjustment of the analyzer to restore the zero may be made by the direct rotation of it, and the extent measured in degrees of arc; but in the instruments now usually employed the compensation is made by means of superposed wedges of quartz, which are shifted horizontally to the right or left as required and the amount of shifting indicated on an arbitrary scale termed the "sugar scale." This is graduated and adjusted so that if a solution containing 26 gm. of pure cane sugar dissolved in sufficient water to make a volume of 100 c.c. at 20° C., is examined in the instrument, the rotation will correspond to 100. This scale has been introduced because the principal use of the polarimeter is the determination of the amount of cane sugar in raw sugar and syrups. It enables the analyst to read directly the percentage, but this applies to cane sugar only. For some purposes, monochromatic light must be used, for which a non-luminous gas flame charged with some sodium salt is the best. This gives a pure strong yellow light. The common polarimeters are now constructed to use white light from any ordinary source.

Fig. 3874 shows a form that is now extensively used, the Landolt-Lippich polarimeter, as made by Schmidt & Haensch, of Berlin. *K* is a lens and mirror for illumination and reading the scale. *J H* is the analyzer with the compensating quartz wedges. The details of the optical train are also shown in outline. At the polarizing end, also shown in detail, a large Nicol's prism, which receives and polarizes the light from the lamp, bears in front two small similar prisms, so arranged that the central rays are unaffected by them. By this means is obtained a field uniformly illuminated when the adjustment is at zero; but when any rotating body is introduced, the central segment becomes darker or lighter than the side segments. In a cheaper form of the instrument only one accessory prism is used, and a "double field" instead of "triple field" is obtained. The material to be examined is dissolved in a suitable solvent, clarified if necessary, and a portion placed in a tube of known length closed by glass caps. On now viewing the field, any rotation of the ray will be marked by a contrast in illumination, and to restore the uniformity the quartz wedges must be shifted more or less. A given substance has usually constant rotating power under given conditions, but temperature, density of solution, nature of solvent, and many other factors produce variations. Some bodies have a high rotation when freshly dissolved, but fall off much when allowed to stand or when heated to boiling. This abnormal effect is termed "birotation." Milk sugar shows it to a high degree. In order to make comparisons between different bodies, a factor termed

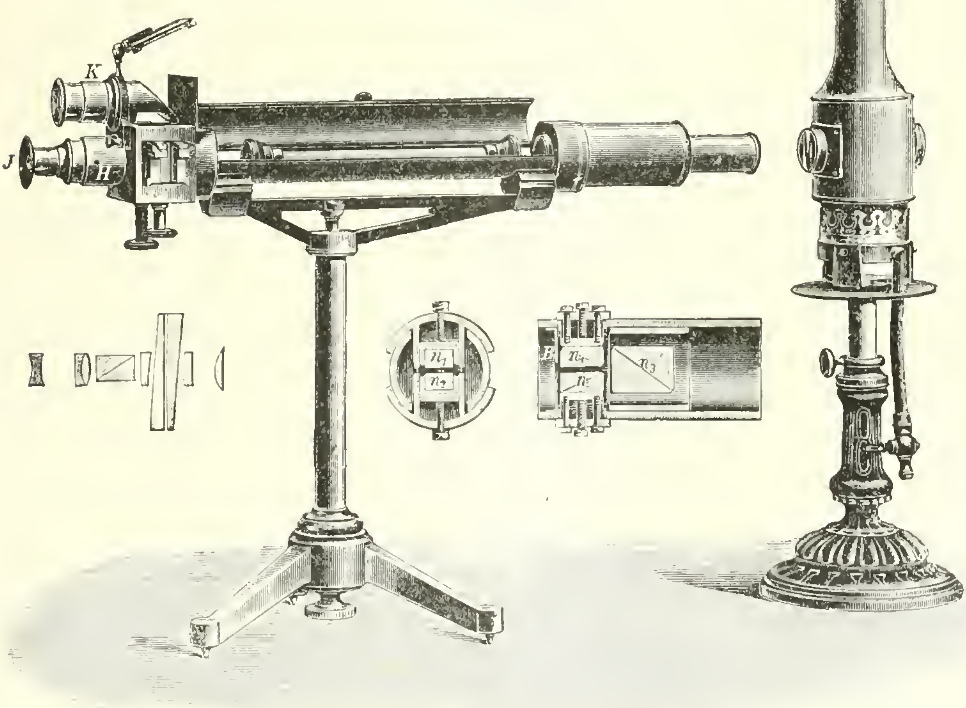

FIG. 3874.—Triple Field Polarimeter with Details of Polarizing and Analyzing Apparatus. (With permission of Eimer & Amend, New York.)

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specific rotatory power, indicated by $[a]$, is calculated by the formula $\frac{100a}{cl}$, in which a is the angular deviation observed; c the number of grams of the substance in 100 c.c. of solution; and l the length, in decimetres, of column of liquid examined. As the rotation differs somewhat with light of different colors, the specific rotatory power is now usually given for yellow light corresponding to the D line of the solar spectrum (see *Spectroscope*), and the symbol is written $[a]^D$. In practice certain weights, termed "normal weights," of material are employed. At the International Commission for Uniform Methods of Sugar Analysis held at Paris, 1900, it was agreed that the normal weight "shall be 26 gm. of pure sugar weighed in air with brass weights," and dissolved in 100 true cubic centimetres. Though the principle of the operation of these instruments is simple, yet accurate results are obtained only by much care and experience.

The expense of the standard form of polarimeter has led to efforts to construct cheaper forms for clinical use. The instrument of von Fleischl has met with most favor. It employs white light and is so constructed that two spectra are shown at once with a dark band in each, the two being coincident when there is no rotating body; but one of the bands is displaced when a rotating body is introduced, and the analyzer can be revolved until the coincidence is restored. The instrument is graduated so that the percentage of rotating body can be read off directly. It is constructed for estimation of sugar.

Clinical Applications.—Polarimeters are of but limited application in clinical diagnosis. Apart from the expense, the conditions interfering with accuracy are numerous. Practically, the estimation of sugar in diabetic urine is the only medical use made of them. Albuminous substances rotate polarized light, but the fact has no diagnostic value. Diabetic urine is apt to contain several optically active bodies, not all of which are dextrorotatory; hence the observed reading will be a resultant of all the actions. The polarimeter may be of use in making routine tests in a given case to determine the effects of treatment; but even then it will be necessary to check occasionally by the chemical tests which can now be performed with ease and celerity, and with sufficient accuracy for clinical purposes.

Urine, as a rule, will require clarification and decolorization for examination in the polarimeter. A solution of lead subacetate is commonly employed; 50 c.c. of the sample are added to 5 c.c. of the official solution, the liquids well mixed and filtered through a dry filter. The first 10 c.c. are rejected and the examination is made on the next portions. The dilution must of course be allowed for by increasing the reading ten per cent.

Henry Leffmann.

POLYCHROMATOPHILIA.—(*Polychromasia.*) The term applied by Ehrlich to that condition of the red cells in which they take, not only the diffuse stain, but also the nuclear, so that they exhibit a bluish red or violet tinge, or may even take a deep blue stain when stained with hæmatoxylin and eosin, or methylene blue and eosin. By Ehrlich and others this phenomenon is regarded as essentially degenerative, a progressive "coagulation necrosis," whereby the cell loses its affinity for acid stains. They are supported in this view by the presence of such cells shortly after hemorrhage and in starving animals, and by the polychromatophilic character of megaloblasts. Further, cells showing this characteristic are usually ragged in contour or show vacuoles. On the other hand, Askanazy and others hold that the polychromatophilic cells are the *youngest* cells of the blood, and are not degenerating forms. This view is based chiefly upon the fact that a large portion of the red cells of the fœtus are polychromatophilic. According to Sherrington, the brownish color frequently seen in red cells is to be regarded as due to an incomplete oxidation of hæmoglobin. Ewing would regard this as a form of polychromatophilia and would limit the term polychromasia to this diffuse brownish color of the cell, which occurs in anæmias and is also seen in the normal marrow. On the other hand, he would class the bluish-staining granules and areas in red cells, originally designated as polychromatophilia, with Grawitz's *granular degeneration* of red cells. Even though the phenomenon be proved to be identical in significance with the last-named, it would appear best to use the term polychromatophilia in its original application by Ehrlich, and not to transfer it, according to Ewing's suggestion, to an entirely different process.

Aldred Scott Warthin.

POLYCYTHÆMIA.—The increase in number of the red blood cells, due either to an absolute increase in the number of the red cells or to a decrease in the volume of the plasma. An absolute increase in the number of red cells above the normal has not yet been demonstrated to occur. Theoretically, such an increase could be brought about by an increased formation of red cells, or through a longer life of the individual cells. A relative polycythæmia is of frequent occurrence. It occurs in the new-born, and is usually highest before nursing begins, and gradually disappears during the first few weeks. Its cause is doubtless to be found in the temporary concentration of the blood due to various factors. Ewing finds that the polycythæmia bears a rather close relation to the degree of cyanosis exhibited by the expressed drop, and believes that the concentration of blood is principally referable to a state of relative stasis which is established in the peripheral capillaries in the first hours after birth. The average count of red cells in the new-born ranges from 5,368,000 to 6,500,000. Too early ligation of the cord may cause a reduction of 500,000 to 1,000,000 (Hayem and Helot). After nursing begins, the red cells fall about 250,000 a week, until the usual average is reached.

According to many observers there occurs a polycythæmia in individuals residing at high altitudes. The change may take place within twenty-four hours, the increase amounting to a million or more, reaching the limit in two weeks and then remaining permanently high. On return to low altitudes the polycythæmia disappears very rapidly. The percentage of hæmoglobin is less affected, and the volume of the red cells not at all. The phenomenon has been variously explained: by some writers as a compensatory increased production of red cells, by others as due to concentration of the blood, by still others as an error in estimation, due to the fact that the results obtained by the blood-counter are dependent upon temperature and barometric pressure.

Polycythæmia occurs also in the diarrhœal diseases, particularly in cholera, as a result of the concentration of the blood. In chronic dysentery it may be offset by the anæmia produced. Similarly, in typhoid fever the progress of the anæmia may be obscured by the concentration of the blood. A relative polycythæmia occurs also in chronic valvular disease of the heart with passive congestion, in endocarditis, in excessive sweating, in phosphorus poisoning, after cold baths or the application of drugs causing contraction of the vessels (alcohol, etc.), and in cases of poisoning with illuminating gas. In phosphorus poisoning an increase to over 8,000,000 has been observed; it is probably due to the depletion of the blood from vomiting. An increase of 2,000,000 to 3,000,000 may be observed after large doses of salts.

Aldred Scott Warthin.

POLYDACTYLISM.—See *Hands and Fingers, etc.*

POLYFORMIN, INSOLUBLE, is prepared by dissolving resorcin in an aqueous solution of formaldehyde, and adding an excess of ammonia. It is an odorless, tasteless, yellowish brown, amorphous powder, insoluble in all ordinary solvents and rich in formaldehyde. It is used as an antiseptic.

W. A. Bastedo.

POLYFORMIN, SOLUBLE—di-resorcin hexa-methylene-tetramine—occurs in white crystals which are very soluble in water or alcohol, but insoluble in ether or oils.

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It is decomposed by heating in solution, setting free formaldehyde. Externally, it is employed in parasitic skin diseases, and internally has been used as an antiseptic in the alimentary and urinary tracts and as a diuretic. It is said to appear as formaldehyde in the urine.

W. A. Bastedo.

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POLYSOLVOL.—Solvin, sodium sulphoricinate—is prepared by acting on castor oil with strong sulphuric acid, adding a solution of sodium chloride, then neutralizing the free acid with soda. It is a thick, clear, light-yellowish oily liquid, insoluble in water, but forming with it a good emulsion. Polysolvol possesses the property of dissolving thirty per cent. of phenol, twenty-five per cent. of menthol, ten per cent. of salicylic acid, and other substances in like proportion.

W. A. Bastedo.

POLYURIA.—(Synonyms: Hyperuresis, Diabetes Insipidus, Diuresis, Essential Polyuria.)

Polyuria means an excessive flow of urine. There are numerous cases in which this occurs temporarily, and is due to dietetic or nervous changes, and a few in which it occurs persistently. The latter are best named *essential polyuria* or *diabetes insipidus*. I shall at the present time describe the latter cases. Instances of persistent or chronic hyperuresis were recognized and described at an early period of medical history, but no attempt was made to classify them. In 1670, however, Thomas Willis discovered the existence of sugar in the urine of some of them, and nearly a century later Sauvages described anew the excretion of sweet urine, as a distinct form of disease, under the name of diabetes anglicus. But it was not until near the end of the eighteenth century that Cullen and P. Frank placed all cases of persistent polyuria in two classes, the one having sugar in the urine and the other none, the first being called diabetes mellitus and the second diabetes insipidus. This distinction has been maintained by all subsequent observers. Diabetes mellitus is now classed with the morbid conditions of assimilation and nutrition. Therefore only the non-saccharine cases, or those of diabetes insipidus, are still thought of as essentially polyurias.

Etiology.—Cases of temporary polyuria are due to a variety of conditions such as the drinking of large quantities of fluid or the eating of excessively large amounts of sugar. It is also caused by such nervous diseases as hysteria and epilepsy. Chronic polyuria has been ascribed to exposure to cold, and to a residence constantly in damp and dark rooms. However, the causative influence of these conditions has not been proved. Injuries affecting the brain and spinal cord, more especially penetrating wounds in the region of the fourth ventricle and medulla oblongata; violent mental emotions and persistent functional diseases of the nervous system are known causes in certain instances. But many cases are on record which can be traced to no special cause. Age evidently exerts a predisposing influence, as shown by the following statistics: Of 242 recorded cases 18 were under five years, 32 between five and ten years, 50 between ten and twenty years, 59 between twenty and thirty years, 42 between thirty and forty years, 20 between forty and fifty years, 13 between fifty and sixty years, and 8 between sixty and seventy years, which is equivalent to 75 per cent. between the ages of five and forty years. Observations in regard to sex show more than twice as many cases in the male as in the female.

There are not a sufficient number of reliable observations on record to justify the conclusion that the disease is hereditary. It seems probable that either a functional or structural disease of the centre in the medulla which controls the blood supply to the kidneys and excretion by them exists in all cases of diabetes insipidus.

Symptoms and Clinical History.—When not the result of direct injuries to the central portions of the nervous system, or of sudden mental emotions, the symptoms of polyuria generally develop slowly and without marked changes, except the gradually increasing quantity of urine which is voided and the correspondingly increased thirst.

When the urine is greatly in excess, the skin appears dry and somewhat shrunken, but much less than in diabetes mellitus. There are some paleness of the features, mental despondency, disturbed sleep, unusual weariness from moderate exercise, excessive appetite for food as well as constant thirst, and frequent eructations and flatulence, with constipation of the bowels. As much as twenty-five to fifty pints of urine may be voided daily. In most cases the specific gravity of the urine is diminished in proportion to the increase of its quantity, varying from 1.001 to 1.008. The fluid is nearly colorless. Its reaction is often neutral or feebly alkaline. Therefore it readily undergoes decomposition. Although the amount of solids in the urine is small, the proportion of urea is often great. A considerable thirst is felt and the mouth and lips rapidly become parched. Appetite is variable. A moderate loss of flesh is the rule, but such patients do not become emaciated. In spite of an appearance of average plumpness these patients lack endurance and ambition. When the disease is not caused by, or associated with, injuries or structural diseases of the brain or spinal cord, it may continue many years, and rarely proves fatal unless from the nature and extent of complications. Some cases have been observed to present great variations in their progress, the quantity of urine sometimes diminishing to the normal, with corresponding improvement in other symptoms, and then increasing again. In some cases exacerbations are traceable to unusual mental or nervous excitement, in others to exposure to cold and damp air, and in still others to excesses in eating and drinking.

During the active progress of essential polyuria the increased quantity of urine consists entirely of water, while the quantity of the other natural constituents voided in the twenty-four hours remains nearly the same as in health.

This explains why the waste of tissues and impairment of health is so much less in this form of disease than in diabetes mellitus, even when the actual quantity of urine discharged in the twenty-four hours is greater in the former than in the latter. The condition of the digestive organs varies much; sometimes food is imperfectly digested, causing acid and gaseous eructations, flatulency, and constipation, alternating with diarrhœa. These symptoms, however, appear to depend more directly on the morbid conditions that have caused the polyuria or have existed as complications, than upon the excessive flow of urine.

Prognosis.—The duration of the disease depends almost entirely upon the nature of the causes and complications. Those cases which are associated with diseases or injuries of the cerebral and spinal centres usually either recover or prove fatal at an early period, while those which are dependent upon chronic functional disorders may continue for many years. R. Willis has left on record a case that continued for fifty years, and Neuffer one that ended fatally in four months. It is generally conceded that permanent recovery from this disease is rare, but it does occur sometimes spontaneously. Complications or intercurrent diseases cause death in much the larger number of instances.

Diagnosis.—The most reliable and characteristic symptoms of diabetes insipidus, or essential polyuria, are persistent daily excretion of quantities of urine above the ordinary maximum of health, or of low specific gravity (between 1.001 and 1.008), and destitute of sugar and albumin; unnatural thirst, increased in direct ratio to the increase in the quantity of urine voided; and a loss of endurance. At first, cases in which polyuria is caused by habitually drinking very large quantities of fluids, may be mistaken, for example, for cases of diabetes insipidus. In the early stage chronic interstitial nephritis may be mistaken for it. This can happen only when albumin does not occur in the urine or occurs only occasionally. In this stage of interstitial nephritis the in-

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creased flow of urine is moderate rather than excessive, and the specific gravity is almost uniformly above 1.008. A careful study of the circulatory disturbances, which are a part of interstitial nephritis and do not exist in essential polyuria, makes a diagnosis easy.

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PATHOLOGICAL ANATOMY.—Essential polyuria generally continues for many years, and rarely terminates fatally except through the intervention of other diseases; few opportunities, therefore, are afforded for careful post-mortem examination. However, in some cases the kidneys have been found slightly enlarged and more vascular than natural, but often they appeared unaltered.

Much the most numerous and important changes have been found in the brain and cord. These consist of inflammatory and degenerative changes in the region of the fourth ventricle, and less frequently in the meninges; of gummata and exostoses; and of tumors. Such changes within the cranium are evidently the results of prior constitutional disorders, and are in no sense dependent on the polyuria. Chemical analyses of the blood have shown a moderate increase of the solid constituents in proportion to the water. It may be safely assumed that uncomplicated polyuria does not involve uniform structural changes either in the kidneys or in other parts of the body, but rather such a modification of the renal vaso-motor nervous mechanism as to induce and maintain an increased blood pressure, and consequent increased elimination of urine.

TREATMENT.—In the treatment of this affection, it is of the highest importance to ascertain from the history of the patient what accidents, injuries, coincident diseases, or constitutional morbid conditions, hereditary or acquired, may have been influential in developing or perpetuating the disease. In all cases in which such causative conditions can be found, the removal when possible, or alleviation when removal cannot be accomplished, should demand careful and persistent attention.

For permanently controlling the diuresis no remedies have been found to be reliable or uniformly successful. Those who suffer from this disease should live in well-ventilated, well-lighted, warm and dry rooms; should wear warm flannel underclothes, take a warm water bath, followed by rapid light friction with dry flannel, daily or at least two or three times a week; and take as much exercise in the open air daily as is possible without fatigue. Such quantity and quality of food may be eaten as the digestive organs of the patient will tolerate without developing gastric distress or much flatulency; but sugar should be eaten sparingly, for an excess of the latter in the blood will aggravate the polyuria. Very cold beverages should be avoided, and especially such as are diuretic, like beer, cider, and milk. Melons and grapes among fruit increase diuresis and must be eschewed.

Rest and sleep should be had at regular intervals and in sufficient amounts. Emotional excitement and fatigue must be avoided. To promote vicarious elimination by skin and lungs, the hot baths and friction of the skin, already advised, are important. Breathing exercise, slow climbing of hills, and a residence in a high altitude and dry climates are useful.

Among the numerous drugs which have been employed are pilocarpine and cathartics as means of provoking elimination by other channels than the kidneys. Their utility is transitory and slight.

For their effect upon the tone of the renal blood vessels such drugs as strychnine, ergot, and astringents have been tried. They all tend to increase blood pressure, which we would expect to aggravate, not to relieve, the important symptoms of the disease. Although in individual cases they have seemed useful, they cannot be said to have a specific action.

Valerian, castor, musk, asafetida, camphor, belladonna, opium, and potassium bromide are other drugs which have occasionally seemed beneficial.

Drugs, however, are not to be relied upon. They may be used to meet indications in individual patients, and hygienic and dietetic treatment is important.

N. S. Davis, Jr.

POMEGRANATE.—*Granatum. Granati Cortex*, or *Cortex Granati. Grenadier.* "The dried bark of the stem and root of *Punica Granatum* L. (fam. *Punicaceæ*)." U. S. P.

This is a very beautiful shrub or small tree, producing a dense crown of glossy dark-green foliage, handsome deep-scarlet or crimson (in one form white) flowers, and the delicious fruit well known under this name. It is a native of Southwestern Asia and is now everywhere cultivated in tropical and subtropical countries. Some pharmacopœias require the root bark only, a judicious restriction (see *Constituents*). The French Codex recognizes also the flowers and fruit, and the rind of the latter, but all these are very inferior.

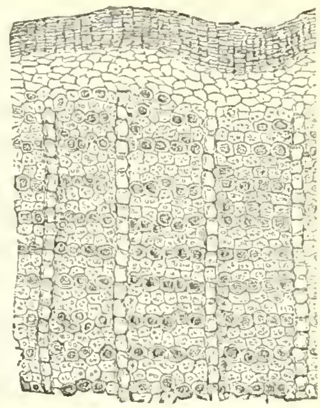
FIG. 3875.—Pomegranate Bark.

The bark occurs in quills several inches in length, and 0.5 to 2 cm. ($\frac{1}{5}$ to $\frac{4}{5}$ in.) in diameter, or in broken pieces of the same, the bark 1 to 3 mm. ($\frac{1}{25}$ to $\frac{1}{8}$ in.) thick; outer surface consisting of broad, shallow, rough, commonly short and reticulated, yellow fissures, alternating with less roughened, gray or slightly purplish-gray bands having sharp, lightly elevated margins, and usually more or less marked with small blackish spots of lichen; root bark, especially the thicker pieces, browner, less fissured, and more or less scaly and roughened; inner surface finely striate, with some longitudinally elongated, blister-like elevations, and varying in color from pale greenish-yellow to cinnamon-brown; fracture short, granular, greenish-yellow, and showing a somewhat laminated structure; taste astringent, very slightly bitter.

Constituents.—The important constituents of pomegranate bark are four alkaloids, together aggregating from one per cent. to three per cent. of the weight of the drug. Although evidence on this point is contradictory, it appears pretty well established that the root bark contains about a half more alkaloid than the stem bark and that the barks of the white-flowered variety are richer than those of the red-flowered. There is a large amount of tannin (twenty per cent. or more), some mannit ("punicin" or "granatin"), much yellow coloring matter, and a very large amount (ten to fifteen per cent. or more) of ash. The tannic acid is interesting, being partly gallotannic and partly a form peculiar to this drug. The alkaloids exist for the most part as tannates. The most important is *pelletierine* or "punicine" ($C_8H_{15}NO$), which is a volatile liquid, soluble in water, alcohol, ether, and chloroform, and rapidly oxidizing, upon exposure, into a resin-like body. Its salts are crystalline. *Methyl-pelletierine* ($C_9H_{17}NO$) is similar, but somewhat less soluble in water. This alkaloid is more abundant in the root bark, the former more in the stem bark. The other alkaloids are *iso-pelletierine* and *pseudo-pelletierine* or "granatonine" ($C_9H_{15}NO \cdot 2H_2O$), the latter occurring in prismatic crystals, soluble in water, alcohol, and chloroform, and in nine parts of ether.

Pomegranate bark deteriorates rapidly on keeping. The alkaloids undergo a change, rendering them less soluble, soon after which they become decomposed. It is to be particularly noted that the commercial substances passing as pelletierine and its salts are in reality mixtures of all the alkaloids named above.

ACTION AND USES.—The important use of pomegranate bark is as a tænicide, its alkaloids being active. Opinions differ as to whether the parasite is killed or merely paralyzed by the drug. In any case, a brisk

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cathartic is required after its administration, owing to the strongly astringent effect of its tannin. Its astringent properties are often utilized for gargling and similar purposes and have been used internally, though the large doses thus used have frequently been followed by unpleasant emetic, and to some extent narcotic, effects. There is no official preparation, though an unofficial fluid extract is often employed, in doses of 2 to 6 c.c. (fl ʒ ss.-iss.), and the powdered bark is given in corresponding doses. A very good method is to suspend the latter in mucilage. The ten-per-cent. decoction is the form probably most used, in wineglass doses. The tannate of the alkaloids (so-called "pelletierine-tannate") is now very largely employed in doses of 0.2 to 0.4 gm. (gr. iij. to vi.). This is after all the best form of administration, since the inhibiting action of the free tannin of the bark is thus avoided.

The rind of the fruit (*Granati Fructus Cortex; Cortex Malicorii*) is largely utilized for its astringent properties. It contains rather more tannin than the bark, together with a still larger amount of gum, and is free from the alkaloids which, as stated above, often render the use of the bark as an astringent undesirable. This rind occurs in irregular, curved, chip-like fragments, about 2 mm. ($\frac{1}{12}$ in.) thick, externally brown, with a yellowish or sometimes reddish tint, finely tuberculate roughened, internally of a lighter or whitish color, marked with conchoidal depression indicating the position of the masses of seeds. The terminal pieces bear the thick, tubular, cup-shaped remains of the calyx tube. The fracture is short, sharp, and granular. The drug is nearly odorless and strongly astringent. *Henry H. Rusby.*

POMPHOLYX.—(Synonyms: Cheiro-Pompholyx; Fr., *Dysidrosis*; *Dysidrose*.)

DEFINITION.—An acute exudative eruption characterized by the formation of vesicles and blebs, usually of moderate size, and occurring for the most part on the hands and feet; in some instances it may be limited to the palms and soles. It is a disease seldom encountered, and is liable to be confounded with other eruptions of the bullous type.

SYMPTOMS.—The clinical features of pompholyx are well-defined and distinctive, and in most works on dermatology the disease is recognized as a distinct affection. It was first described by Jonathan Hutchinson and Tilberry Fox, of London. The former gave it the name of cheiro-pompholyx, while the latter in reporting the same case gave it the name of dysidrosis. During a period of twenty years the present writer, in encountering many thousand cases of skin diseases, has seen but one or two instances of this affection; nor could these be regarded as typical examples of the disease, for the eruption during its whole course was not confined to the regions most frequently involved—namely, the hands and feet—but extended to the forearms as well. While a student in the Black Friars Skin Hospital in London I had the opportunity of studying several cases that were regarded by Mr. Hutchinson as typical examples of the affection. In some of these, if I remember correctly, the disease likewise extended to the forearms, and frequently the feet were exempted. The disease usually begins in the summer, especially during excessively hot weather. The first symptoms complained of are burning and tingling, with the development of deeply seated vesicles which are single and later become grouped by the development of new lesions; the most characteristic position at first being the sides of the fingers, and the eruption gradually extending to the palms. When the lesions are confined to the thick skin of the palms of the hands and the soles of the feet they have been very aptly compared to boiled sago grains embedded in the skin. This appearance is due to the thickened epidermis, as pointed out by Crocker, rather than to any special variation in the lesions themselves. The eruption is usually symmetrically distributed. As the lesions develop the groups of vesicles not infrequently coalesce, forming large, irregularly outlined bullæ filled with a serous fluid, and projecting above the level of the skin. At first the contents are translucent, but later they become opaque. In reaction the fluid is neutral or slightly alkaline. At no time is there much inflammation in the surrounding skin, in which respect the disease differs from certain affections with which it may be confounded. In the course of two or three weeks the lesions begin to subside, although new ones appear from time to time. The contents become absorbed and finally the outer epidermic wall exfoliates, exposing a reddish area of delicate new skin, which marks the site of the former lesion. The disease often runs its course in a few weeks, or at most in one or two months, although it is liable to recur the following year. At times, in debilitated subjects, the lesions may assume a red color and the surrounding derma become slightly œdematous. The epidermis not infrequently becomes undermined and then soon ruptures, exposing to view a red, exudative surface. Gradually, however, this process subsides, and recovery may take place as before stated. The subjective symptoms are usually slight. Aside from the burning and tingling previously mentioned, there may be marked impairment of the general health, in which case excessive sweating is sometimes complained of. Itching is never a prominent symptom.

PATHOLOGY.—As the name given to the disease by Tilberry Fox[1] indicates, this writer regarded the affection as in some way associated with the sudoriparous glands. Later investigators, and especially Robinson,[2] have demonstrated that the lesions show no especial connection with these structures. On the other hand, it has been shown that the pathological condition is one of inflammation which takes its origin in the rete, gives rise to a serous exudate from the capillary blood-vessels, and then, collecting between the rete cells, forms variously sized vesicles or bullæ. As this effusion takes place there follows a gradual degeneration of the cells of the rete mucosum. While some of the vesicles, especially those situated on the outer surface, may rupture when the inflammatory process is more extensive, there may be a general extension of the fluid at the periphery, thus causing the undermining previously mentioned. Later, the entrance of pus corpuscles changes the translucent fluid to one of an opaque or even yellow color.

ETIOLOGY.—The disease is nearly always associated with general debility, or it occurs in those whose nerve tone is below par. It is especially liable to occur in women who have been subjected to excessive mental strain or worry; and yet, while it is more frequently met with in women, men are by no means exempted. Middle age seems to be the period of life in which the disease is most frequently encountered; only a few cases have been reported in children and the disease is extremely rare in old age. Crocker has not seen it under twelve years, and the oldest patient was thirty-eight, while Hyde[3] records a case at sixty. The disease is supposed to be due to some abnormity in the innervation of the skin, although its exact nature has not been determined. On the other hand, Unna has found a bacillus resembling the tubercle bacillus, although slightly thicker, and he is disposed to regard it as an essential pathological factor in the disease.

DIAGNOSIS.—The limitation of the disease to the palms of the hands and the soles of the feet—a characteristic which is considered by some authorities to be essential—renders the affection less liable to be confounded with other affections to which it bears some similarity; namely, with eczema, pemphigus, and dermatitis herpetiformis. In my own experience the line of demarcation is not so sharply drawn, and the affection gradually merges in type with other well-recognized diseases. When limited to the palms and plantar surfaces the only condition to which it bears a close resemblance would be blisters from slight traumatism, eczema, and an accumulation of sweat under the thickened epidermis. Eczema is seldom limited to these surfaces, and is always accompanied by inflammation and marked itching; while inflammation and itching are usually insignificant features in pompholyx. The persistence of the eruption, together with the formation of new lesions extending over a period of a week or more,

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would enable one to exclude blisters arising from slight injuries. More difficulty, however, would be encountered in differentiating the affection when seen on the lateral surfaces of the fingers and on the backs of the hands. Here the affection bears a close resemblance to eczema; but in eczema there are more extensive inflammation and less tendency to the formation of bullæ, and in eczema the outer wall of the lesions easily ruptures, giving rise to excoriated itching surfaces of irregular outline. In pompholyx, on the other hand, the epidermic wall seldom ruptures and the lesions remain circumscribed, or coalesce in such a manner as to form bullæ. Furthermore, it should be borne in mind that pompholyx is most liable to occur in adults, and especially in women who are debilitated or who have been overwrought, and that the disease tends to a spontaneous recovery, and at the same time is likely to recur upon the recurrence of conditions favorable to its development. Ivy poisoning must likewise be excluded in making a diagnosis, but the acute inflammatory character of this disease and the tendency of the eruption to appear on other parts, render it, as a rule, easy to distinguish it from pompholyx. The last doubts, however, would be removed if the history of an exposure to the poisonous plant could be obtained in addition.

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Prognosis.—The prognosis in pompholyx is good so far as the individual attack is concerned, although there is a tendency for the disease to return with successive years. In some instances the irritation to which pompholyx gives rise has engendered an eczema which may persist indefinitely. On the other hand, the disease may not return for several years, although, upon the return of ill health, it will be very likely to appear again.

Treatment.—The treatment should be partly constitutional or general and partly local. The former seems to be of the more importance, as the individual attack is self-limited. First, all debilitating influences should be removed, and as far as possible the patient should be urged to avoid worry, over-excitement, or intense mental labor. General hygienic measures should be advocated, namely, exercise in the open air, cold bathing with vigorous friction immediately thereafter, and diversions of a relaxing nature. Change of location from inland to the seashore, or from the seashore to the mountains, is in some cases highly beneficial. In addition to this the patient should be given a generous diet and in some instances tonics, and the room which he occupies should have a sunny exposure and should be well ventilated. Aside from these general measures individual cases should be treated according to the indications present. Strychnine is a drug which must frequently be called into requisition. Iron, especially in its more assimilable forms, quinine, cod-liver oil, and in some instances arsenic, are valuable drugs.

The local treatment consists partly in soothing applications and partly in such as protect the surface from the air and from the irritation of clothing and other extraneous substances. It is best forcibly to rupture the lesions, especially when large, and flush out the cavity with a saturated solution of boric acid and water. In some cases, when the lesions rupture, black wash may be used. I can also recommend the following application: Salicylic acid 2 per cent., and diachylon ointment q. s. 100 per cent. This should be spread on some firm white cloth and kept constantly applied to the diseased area. Every twenty-four hours the surface of the skin should be cleansed with a saturated solution of boric acid, or with water to which a small quantity of carbolic acid has been added, and a fresh application of the ointment should be made. This ointment is especially valuable when the soles of the feet are involved. Stelwagon [4] recommends the following: Menthol, gr. ij.; acidi salicylici, gr. x.; emplastri plumbi, emplastri saponis, āā ℥ iss.; petrolati, ℥ v. M. The prevention of local infection is one of the main objects in treatment, and, to accomplish this, we may with benefit apply a solution of corrosive sublimate (1 to 2,000) or white precipitate ointment (five per cent.), the latter serving as a parasiticide as well as a protective agent.

William Thomas Corlett.

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PONCE DE LEON SPRINGS.—Crawford County, Pennsylvania. Post-Office—Meadville.

Access.—Viâ Erie Railroad or by Pittsburg, Shenango and Lake Erie Railroad to Meadville (separate depots), thence about two miles to springs.

The Ponce de Leon Springs may be said to be in a process of development. An electric line of railway from Meadville is now being constructed, and a modern first-class hotel will soon be built. The location is very favorable for a pleasant summer resort, being twelve hundred feet above the sea-level and surrounded by picturesque hills. There are six mineral springs, only one of which has been submitted to a qualitative examination. An analysis by Prof. Henry Leffmann, of Philadelphia, resulted as follows: One United States gallon contains:* Sodium sulphate, gr. 0.17; sodium chloride, gr. 0.90; calcium bicarbonate, gr. 1.89; magnesium bicarbonate, gr. 0.47; sodium bicarbonate, gr. 16.73; silica, gr. 0.70. Total, 20.86 grains.

A second analysis by J. Singley, Ph.D., professor of chemistry in the Western Pennsylvania Medical College of Pittsburg, resulted substantially as above. The following gases were also found: Carbonic acid, 1.33 cubic inches per gallon; oxygen and nitrogen, 7.23 cubic inches per gallon; hydrogen sulphide, abundant traces.

The water is a bland antacid and diuretic. It will be found of value in certain stages of Bright's disease, especially when the urine is scanty, high-colored, and irritating. It is also useful in assisting the diminution of calcareous deposits and of uric acid in gout and gravel. The water will speedily relieve acidity of the stomach and heartburn. It is used commercially, and also for the manufacture of a number of temperance beverages.

James K. Crook.

PONS AND MEDULLA. See various articles under *Brain*.

PONTRESINA. See *Engadine*.

POPLAR. See *Willow*.

POPPY.—The principal products of the poppy plant will be found described under the titles of opium and its more important alkaloids. Some minor products are here considered.

Poppy Capsules (*Papaveris capsulæ*; *Fructus* or *Capita Papaveris immatura*) are more or less employed in medicine for the opium which they contain. Their botanical origin has been fully stated under *Opium*. For the purposes here considered, they are gathered when nearly ripe and are dried in the sun. They are more or less spheroidal, but vary in the different varieties, from strongly oblate to strongly prolate, and they range from one and one-half to three inches in diameter. The larger ones, and those of prolate form, known as the "black" variety, are generally regarded as superior. The color is pale brown, and the surface nearly smooth. At the summit there are from eight to sixteen, or occasionally twenty short, nearly sessile, recurved stigmas, indicating an equal number of placentæ, the latter projecting as sharp ridges upon the inside of the capsule. Partly concealed under the stigmas are a circle of small pores through which the mature seeds escape. The seeds are not a part of the capsule considered as a drug. Numerous constituents have been reported as occurring in these capsules, but from a medicinal point of view they may be regarded as identical with those of opium. The morphine content

* Reduced from grains per imperial gallon.

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rarely exceeds a fourth of one per cent., notwithstanding that claims for a much larger yield have been made. The younger the pods the less morphine do they contain.

Poppy capsules were official in the United States Pharmacopœia of 1870, and are still so in the British Pharmacopœia, but their use in the United States has almost entirely given place to that of other and more definite forms and preparations of opium. In Great Britain the syrup is probably the most largely used preparation, and is mostly administered to children, though the extract is also considerably employed. The dose of any preparation should represent from one to two drachms of the capsule.

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Poppy seeds possess no narcotic properties whatever, though it is said that traces of morphine can be found in them. They are used purely for their fixed oil, which is an important article of commerce. The oil is quite bland and possesses only the nutritive and demulcent properties of vegetable fixed oils in general.

Poppy Petals, or *Red Poppy Petals* (*Rhœados Petala*) are the petals of *Papaver Rhœas* L., the common red or field poppy of Europe. They resemble rose petals, but are larger. The color of the fresh petals is a brilliant scarlet red, with a large black spot at the base, but the color becomes pale and dull in drying. They are used entirely for their coloring matter, for the tinting of pharmaceutical preparations, and hence are greatly preferred in the fresh condition. The coloring matter is divisible into two portions: *rhœadic acid*, which is dark red, soluble in both water and alcohol; and *papaveric acid*, which is of a brilliant red, soluble in water but not in alcohol. An alkaloid (*rhœadine*) exists in very small amount, but is unimportant. It is said that a trace of morphine has been extracted, but the article can scarcely be regarded as medicinal. *Henry H. Rusby.*

POROKERATOSIS.—(Synonyms: Hyperkeratosis eccentrica, Keratodermia eccentrica, Hyperkeratosis figurata centrifuga atrophicans, Porokeratose.)

Definition.—A unique form of hyperkeratosis, beginning as a small papule. This papule having slowly enlarged becomes depressed at the centre, and its margin usually develops into a ridge involving a rift and defining an area of varying extent.

In 1887 Maiocchi reported a case, marked by a singular appearance of the skin, which he diagnosed as a form of ichthyosis hystrix. After a lapse of six years the same case was brought to the notice of Mibelli, who pronounced the lesion exceptional and peculiar, claimed that the pathological process was distinctive, and finally characterized the affection by the name of porokeratosis. Simultaneously with the observation by Mibelli, an article was published by Respighi describing a number of similar cases under the name of hyperkeratosis eccentrica. The disease has been especially observed in Italy, particularly in the district of Parma. Cases occurring in the United States have been reported by Hutchins, Gilchrist, and Wende. A few cases have been noted in Germany, France and, very recently, in England.

Symptoms.—The disease is of slow development, first appearing as a papule of varying size, dirty brown, dry, and invariably surrounded at the base by a collarette of scales. As the papule increases it takes on a decided change. The lesion, the periphery of which is subject to a gradual development, extends centrifugally; the central portion becomes slightly depressed, and the margin resolves itself into a unique border which represents a non-inflammatory hypertrophy, sharply defined against the outlying sound skin, and forming a continuous or broken ridge. In the middle of this ridge is found a rift somewhat irregularly dividing the same into two lateral halves, all of which constitutes a lesion unlike any other known, and which has been characterized as a "seam," "dike," or "wall." It is dirty gray or blackish in color and usually quite pronounced, though in ill-defined cases it may appear simply as a loose rim of epidermis. The

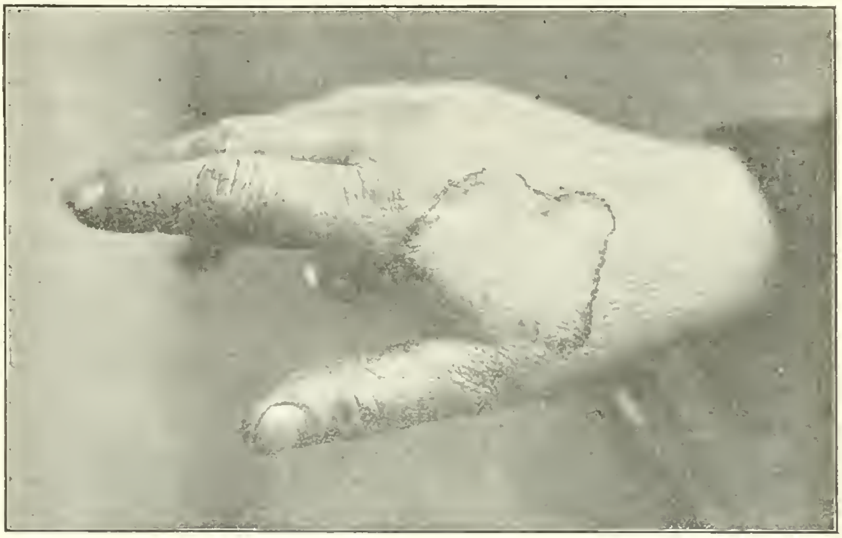

Fig. 3876.—Case of Porokeratosis of Five Years' Standing. The affected area is bounded by the characteristic rifted ridge. The lesion shown here was the only one present in this case. (From Grover W. Wende's collection of photographs of skin diseases.)

centre, so long as the lesion is small, consists of a horny, thickened, epidermic patch. After the lesion has attained a certain size the centre may become normal in appearance. Sometimes the natural furrows of the skin are erased; again, there is clear evidence of atrophy. The functions of the sweat and sebaceous glands are interrupted. In some areas absence of hair is observed. Epidermic concretions, the size of a millet-seed, are sometimes present, now divided by the furrow, again attached to the inner side of the seam; or they may appear at any point within the affected area.

The areas affected by hyperkeratosis vary in size—many do not measure over one-eighth of an inch in diameter, while some become much larger and may even cover the greater portion of an extremity. As a rule, they do not exceed an inch in diameter, and in the majority of cases they are much smaller.

The lesion is always slow in development; at times the condition remains stationary. The shapes assumed are round, oval, or elliptic; they may become polycyclic by confluence or may all run together, especially when their dimensions are greatly increased.

The lesions often affect the mucous membranes lining the mouth. All or any part of the skin may be attacked. The favorite regions, however, are the face—especially the nose, forehead, and cheeks—the ears and neck, the dorsal surfaces of the hands and feet, and the extensor surface of the forearms.

The lesions of the mouth are generally not very numerous, although present in a large number of cases. They consist of small asymmetrical spots varying from

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the size of a pin to that of a lentil. Like the lesions of the skin, they may be oval, polycyclic, or irregular.

The subjective symptoms are without special importance; only occasionally does the patient complain of pruritus, either slight or intense. When the feet are affected the shoes sometimes cause pain by pressure.

The evolution of www.libtool.com.cn slow; sometimes a single focus continues during many years. Subsequently the disease extends by the development of new lesions, and, in the end, the lesions are distributed bilaterally.

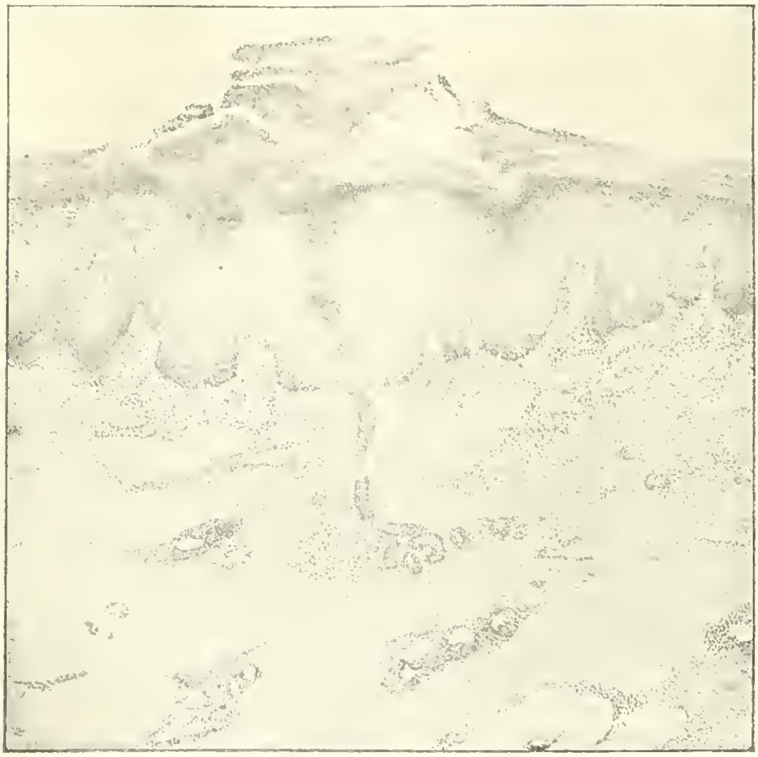

FIG. 3877.—Cross Section of the Characteristic Ridge in a Case of Porokeratosis. In addition to the condition of marked hyperkeratosis, which is revealed in the picture, there may be seen a sweat pore which is obstructed by the presence of a black horny plug that extends down to the level of the acini. (Grover W. Wende.)

ETIOLOGY.—The cause of the disease is largely a matter of conjecture. It may show hereditary tendencies, though often it does not. The possibility of hereditary transmission is shown in the cases published by Gilchrist, in which eleven members of one family were discovered to be affected in the course of four generations. Respighi also reports an instance of the malady which recurred in several generations. Most of the cases occur in laborers. Males suffer more often than females; sometimes the affection is developed in children between the ages of two and eight; generally, however, it appears in adolescents or adults.

The proof that the affection is parasitic in its nature is wanting, although in a series of four inoculations made upon as many different individuals by Wende, one was successful, undoubtedly owing to local irritation upon a susceptible skin. Respighi made experiments in transplantation, but they proved to be negative. All examinations for micro organisms have been without result.

PATHOLOGY.—The main feature of this disorder is a special form of hyperkeratosis. The elevated and circinate margin is composed of a mass of cornified cells, which however, still retain their nuclei. The lesion forms a conical plug corresponding to the interpapillary depression into which the enlarged glandular orifices combine, but are obliterated by horny masses—a condition which strongly resembles lichen spinulosus. All parts of the epidermis are involved, especially the lower horny and upper rete layers. A small amount of cellular infiltration with œdema is seen in the papillary layer of the cutis immediately underlying the affected epithelium. The derma undergoes a sclerotic degeneration in the upper layers. At first it is hypertrophied, but in the advanced stage atrophied. The sweat glands are dilated and reveal epithelial proliferation and hyperkeratinization. Epithelial accumulations in the sweat ducts and sebaceous glands, as well as in the hair follicles, have been observed by Mibelli, Respighi, and Gilchrist.

DIAGNOSIS.—The clinical characteristics of porokeratosis are so unique that a mistake in diagnosis is not likely to occur. In the early stage the lesions may be mistaken for lichen planus, but this is generally accompanied by itching, is not continuous, and does not attack several members of the same family. The essential lesions are the characteristic papules, striated on the surface, and of a dark red color. There are instances of lichen planus essentially annular, but in that case the rings are limited by a red prominence, and one does not see either the furrow or the edge of the porokeratosic circles so characteristic of the disease.

PROGNOSIS.—The disease does not affect the general health, and, beyond the possible disfigurement, need not create any anxiety. Sometimes the lesions disappear spontaneously. When located about the joints, especially of the fingers or feet, the affection may cause some pain from pressure and the interruption of functional operations.

TREATMENT.—The same treatment is required as that given to some forms of ichthyosis. The lesions, in the early stages of the disease, are to be removed by salicylic acid plasters or the use of the curette. Joseph has obtained good results by excision. Gilchrist recommends electrolysis. Both of these modes of treatment were employed in the case illustrating this article, but without favorable results. Undoubtedly this peculiar treatment is applicable, only to small lesions.

Grover W. Wende.

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PORRO OPERATION. See *Cæsarean Section.*

PORTER SPRINGS.—Lumpkin County, Georgia.

POST-OFFICE.—Porter Springs. Hotel.

ACCESS.—Viâ tri-weekly hack line from Gainesville,

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the springs being twenty-eight miles north of that city, and ten miles north of Dahlonega. They were discovered only a few years ago in a beautiful cove on the southern slope of the Blue Ridge Mountains. The waters have acquired an extensive reputation on account of their valuable chalybeate properties. The hotel has a capacity for about one hundred and fifty guests, and is kept open from June 15th to October 15th.

The situation is very high for this region, being more than three thousand feet above the sea-level, an elevation greater than the top of Lookout Mountain. Some of the peaks in the vicinity reach an altitude of almost five thousand feet. Although located in a semi-tropical latitude, the high elevation of Porter Springs gives the climate an invigorating, bracing character not subject to exhausting heated spells. The waters are said to contain, besides iron, hydrogen sulphide gas with sulphates of magnesia, potassa, and soda. Some of the springs contain also small quantities of iodine, lithia, and manganese. It is unknown by whom these determinations were made. A proper quantitative analysis is needed.

James K. Crook.

PORTLAND, MAINE.—The largest city and commercial metropolis of Maine, with a population of about fifty thousand, one hundred and fifteen miles northeast of Boston, is beautifully situated at the head of Casco Bay. Portland is the centre of a number of attractive seaside resorts which are easily reached from this city by sea or land. Such are Old Orchard Beach, Scarborough Beach, Prout's Neck, Kennebunkport, Pine Point, Saco Pool, and Wells Beach to the south; and Boothbay, Harpswell, Islesboro, Isle Au Haut, Vinal Haven, Deer Isle, Camden, and Castine to the northeast. Indeed, the whole coast of Maine with its innumerable indentations and many islands affords a great variety of attractive summer resorts with a cool, delightful climate. It is visited at this season by thousands of people from the inland cities of the North, South, and West. Portland itself and its picturesque surroundings offer very many attractions, and possess a cool summer climate and a steady sea breeze.

There are many fine buildings and churches in the city, a number of parks, notably the Eastern Promenade with a fine view of the city and harbor, and many points of historical interest. The drives are delightful, and excursions by water through the harbor and Casco Bay with its many islands, are numerous and pleasing. Diamond, Peak's, and Cushing Islands are favorite resorts near the city, easily and quickly reached by water. The accommodations, both in Portland and the various other resorts mentioned above, are abundant, good, and of varying prices. The following table represents the climate of Portland and will also convey an idea of the climate of the resorts lying to the north and south. In general, the summer climate is seen to be a cool marine one, with frequent sea breezes, a majority of pleasant days, and a humidity of about seventy per cent. There are often quite sudden and marked changes in temperature, and fogs are not infrequent. Such a climate is a stimulating one and well suited for the overworked, for neurasthenics, and for those suffering from anæmia, scrofula, and bone and joint tuberculosis. Convalescents from chronic diseases also do well in this climate. It is too damp and variable for laryngeal and pulmonary cases and those subject to neuralgic affections. Especial mention should be made of the exceptionally fine beach at Old Orchard, the finest in New England, extending for a distance of ten miles and affording most excellent surf bathing. This is a very much frequented resort, and offers accommodations of every kind and description. Hinsdale (vol. iv., Book II., "Health Resorts," "Physiological Therapeutics") says that the climate of Kennebunkport is not excelled on the New England coast. "The south and southwest breezes," he says, "are from the water; a hot land breeze is a rarity, and fogs are not of frequent occurrence." He recommends the climate for neurasthenics and those suffering from insomnia and melancholia.

Portland, as well as the various resorts about it, can be easily reached from Boston either by rail or by water.

Edward O. Otis.

PORTLAND, OREGON.—This is the largest city in the State of Oregon, with a population of 90,428, and is situated at the head of ship navigation on the Willamette River which flows into the Columbia. It is in no sense a health resort, but it is mentioned here, and a climatic chart is given, for the sake of contrasting the climate of the eastern and western sides of the North American continent. By comparing the charts of Portland, Me., and Portland, Ore., the contrast will be seen. "Portland, Ore., lies nearly two degrees farther north than Portland, Me., yet its mean winter temperature is no less than fifteen and one-half degrees warmer than that of its namesake on the Atlantic coast. It is within one degree of being as warm as that of Norfolk, Va., and is about ten degrees warmer than that of New York City. On the other hand, the summer at Portland, Ore., is slightly cooler than at Portland, Me., and is about seven degrees cooler than that of New York City and almost exactly the same as that of Montreal." "The range of temperature is decidedly less at Portland, Ore., than it is at Portland, Me. The rainfall is much greater, and the relative humidity is higher (especially in winter), and the number of cloudy days is much greater. The great cloudiness of the Oregon winter weather is a feature of the climate not characteristic of any other part of the United States except the Lake region and St. Lawrence Valley district" (Richards). Richards (previous edition of the HANDBOOK) calls attention to the close resemblance between

CLIMATE OF PORTLAND, ME., LATITUDE, 43° 39′, LONGITUDE, 70° 15′. PERIOD OF OBSERVATION TWELVE YEARS.

	January.	March.	May.	July.	September.	October.	November.	Spring.	Summer.	Autumn.	Winter.	Year.
Temperature, degrees Fahr.—												
Average mean temperature	23.2°	32.6°	51.8°	69.7°	60.6°	50.4°	38.0°	43.5°	67.2	49.6°	25.6°	46.5°
Average daily range	15.8	14.2	16.2	16.6	14.4	14.2	13.1					
Mean of warmest	31.9	41.2	64.1	79.	69.5	58.8	46.7					
Mean of coldest	16.1	27.0	47.9	62.1	55.1	44.0	33.6					
Highest or maximum	58.0	65.0	94.0	97.0	94.5	83.0	66.0					
Lowest or minimum	−11.5	− 7.0	34.0	51.0	37.0	28.6	− 6.0					
Humidity—												
Average mean relative	72.6%	68.4%	64.7%	70.1%	73.6	70.8%	70.8%	65.3%	70.1%	71.7%	71.8%	69.7%
Precipitation—												
Average in inches	3.22	3.25	2.94	3.52	3.16	3.66	3.85	8.95	10.40	10.67	9.02	39.04
Wind—												
Prevailing direction	N. W.	N. W.	S.	S. W.	S.	S. W.	N. W.	N. W.	S.	S. W.	N. W.	N. W.
Average hourly velocity in miles	7.6	9.1	7.8	6.6	6.7	7.3	8.3	8.5	6.4	7.4	8.0	7.6
Weather—												
Average number clear days	9.7	7.2	8.3	8.6	10.2	8.9	9.1	23.2	27.8	28.2	28.5	107.7
Average number fair days	12.0	11.6	11.8	14.2	11.1	11.5	10.6	34.8	40.2	33.2	35.9	144.1
Average number clear and fair days	21.7	18.8	20.1	22.8	21.3	20.4	19.7	58.0	68.0	61.4	64.4	251.8

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Climate of Portland, Oregon, Latitude, 45° 32′; Longitude, 122° 43′. Period of Observation, Twelve Years.

	January.	March.	May.	July.	September.	October.	November.	Spring.	Summer.	Autumn.	Winter.	Year.
Temperature, Degrees Fahr.												
Mean average temperature	39.6°	47.3°	56.0°	66.2°	60.9°	53.0°	45.1°	51.5°	64.2°	53.0°	41.0°	52.4°
Average daily range	10.8	16.2	20.5	21.9	20.0	14.2	12.3					
Mean of warmest	45.2	55.8	67.4	76.8	70.7	59.2	51.4					
Mean of coldest	34.4	39.6	46.9	54.9	50.7	45.0	39.1					
Highest or maximum	58.0	76.5	86.0	95.5	90.0	79.0	68.0					
Lowest or minimum	3.0	25.5	33.0	46.0	39.0	31.0	22.5					
Humidity—												
Mean average relative	78.4%	75.9%	64.9%	63.7%	69.2%	77.6%	78.4%	70.3%	65.1%	75.1%	78.7%	72.3%
Precipitation—												
Average in inches	7.34	7.27	2.44	.71	1.62	4.95	7.37	13.19	3.34	13.94	23.72	54.18
Wind—												
Prevailing direction	S.	S.	N. W.	N. W.	N. W.	S.	S.	S.	N. W.	S.	S.	S.
Average hourly velocity in miles	6.0	5.1	4.8	4.7	4.2	4.1	4.5	4.9	4.5	4.3	5.3	4.7
Weather—												
Average number clear days	3.4	4.4	5.1	15.3	12.4	7.1	4.7	14.7	37.0	24.2	9.6	85.5
Average number fair days	7.0	7.0	9.9	7.4	9.5	9.9	8.8	26.1	26.4	28.2	21.1	111.8
Average number clear and fair days	10.4	11.4	15.0	22.7	21.9	17.0	13.5	40.8	63.4	52.4	30.7	187.3

the climatic conditions characteristic of Portland, Ore., and those prevailing along the western coast of the European continent. The temperatures of the Oregon coast, he says, are strongly suggestive of those found throughout northwestern Europe; further, the almost rainless summer with heavy winter rainfall is a feature of climate in which the Oregon coast resembles the Mediterranean basin rather than the more northerly parts of Europe.

Edward O. Otis.

PORTSMOUTH, N. H., AND ADJACENT RESORTS.—This "old town by the sea" is noticed here not only on account of its own attractions, but because in its vicinity are a number of well-known summer marine health resorts: the Isles of Shoals; Rye and Hampton Beaches and Little Boar's Head; York Harbor and Beach; Ogunquit, Passaconaway, Kittery, and Newcastle.

Portsmouth, fifty-seven miles from Boston, is situated a few miles above the mouth of the Piscataqua River, and possesses an excellent harbor. It is the only seaport of New Hampshire, and in the days of wooden shipbuilding was a very prosperous town, as is evident from the stately mansions still remaining there.

The present population is about ten thousand, and the town presents a quiet, tranquil aspect quite in contrast to its by-gone activity when ships were launched from its yards and were entering and departing from its spacious harbor. The streets are beautifully shaded, and the old residences of the architecture of seventy five or a hundred years ago, with their attractive gardens, together with the water views from the decaying wharves, all combine to give this old city a most picturesque appearance. There are also many points of historic interest in and about the city, for it was first settled in 1623. On an island opposite, in the town of Kittery, is the United States navy yard. There are no meteorological observations to be had in regard to Portsmouth, but a fairly accurate idea of the climate may be obtained by striking an average of the climatic data of Boston and Portland, which are on the coast fifty miles east and west of Portsmouth, and which differ but little from each other. Estimating in this manner we have the following figures: Mean average yearly temperature, 47.3° F. Mean average temperature for the four seasons: spring 44.1°, summer 68.1°, autumn 50.3°, winter 26.8°.

The annual mean relative humidity of Portland and that of Boston are almost identical, and that at Portsmouth is, therefore, probably the same, which is 69.6 per cent., varying but little during the year. The average number of clear and fair days is: spring 58.3, summer 65.6, autumn 61, winter 59.6; year, 244.7. The yearly rainfall is 43.6 inches. The prevailing wind is from the southwest and west. All along this coast there may be a few very hot days during the summer, but generally the air is cool and delightful, and the sea breeze is almost a daily occurrence. The accommodations are good, among them one very excellent first-class hotel. Although Portsmouth is a city, yet it is such a mild and quiet one that it offers many advantages for even a whole summer's sojourn. The society is exceptionally good, to which the adjacent navy yard makes valuable contributions; the air pure and cool; the scenery in the vicinity very attractive, and there are many excursions both by land and water. There are various churches, one the historic old St. John's, a good library, a well-equipped hospital, and excellent physicians. Frequently some of the vessels of the North Atlantic Squadron visit Portsmouth during the summer, and there are always one or more warships at the navy yard.

The water supply of Portsmouth is from springs and driven wells a few miles from the city, and is regarded as of excellent quality. Sewers emptying into tide water are being slowly introduced, although many of the old-time vaults still remain.

The average yearly mortality for the last eight years (1894–1901) is 19.25 per thousand.

An old resident and practitioner of Portsmouth assures the writer that the sanitary condition is good, and that there are very few cases of sickness which can be attributed to unsanitary conditions.

One is referred to the writings of T. B. Aldrich, Lowell, and Mrs. Celia Thaxter for charming accounts of Portsmouth and the Isles of Shoals.

Newcastle.—This small island at the mouth of the Piscataqua River, about two miles from Portsmouth, is a popular summer resort, with a large hotel, boarding-houses, and cottages. The situation of Newcastle is very picturesque, and it has a beautiful and extensive ocean exposure. It is connected with the mainland by bridges, and has frequent communication with Portsmouth by land and water. There are opportunities for golf, tennis, boating, and bathing. There is a military garrison at Fort Constitution. The climate is the same as at Portsmouth, with the exception that being directly on the ocean, it is more peculiarly marine.

Kittery Point, at the mouth of the Piscataqua River, opposite Newcastle, is very attractively situated and is a popular summer resort, affording good accommodations, both in hotels and cottages. It has frequent communication with Portsmouth both by trolley and by boat.

Isles of Shoals.—This group of small, rocky islands lies about nine miles off the coast, and has communication in the summer with Portsmouth several times a day by a comfortable steamer, the voyage occupying about an hour. Appledore is the largest of the group, which consists of eight islands, and contains two hundred and fifty acres. The formation of these islands is granitic, and they present a rugged picturesque appearance, barren and with very sparse vegetation. Huge, irregular reefs jut out into the ocean, and after a storm the play of the

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surf is very imposing. Only two of the islands provide accommodations for summer residents, Appledore and Star Island, there being extensive hotels on both islands. The accommodations are rather more elaborate and expensive on the former (Appledore), and there are several cottage annexes. These islands have been a popular summer resort for many years, owing to the cool, equable marine climate found there, with an absence of dust and flies. Here one can experience all the climatic influences of a sea voyage without the discomforts incident to ship life. They are far enough removed from the mainland to be free from all contaminating influences, and from whatever quarter the wind blows it brings pure air. From a "weather record" for the summers of 1897–98 (June 25th to September 15th) kindly furnished the writer by Dr. J. W. Warren, who has been a summer resident of Appledore for over twenty years, the following data are condensed:

Mean temperature (Fahrenheit scale) from two daily observations at nine and four o'clock. June (25th to 30th) 63.2°, July 65.7°, August 67°, September (1st to 15th) 64.8°. The maximum temperature for this period was: June (25th to 30th) 70°, July 81°, August 78°, September (1st to 15th) 80°. Minimum, June (25th to 30th) 56°, July 56°, August 53°, September (1st to 15th) 56°. The summer temperature is said to be several degrees cooler than it is on the coast. Cold, raw days are infrequent, and the difference in temperature between day and night is slight, so that one can generally sit out in the evening. In general, the variations in the temperature are never as pronounced as on the mainland.

The average number of fair days for the two years was: June (25th to 30th) 4, July 15, August 17, September (1st to 15th) 9. Number of partly cloudy, misty, or foggy days: June (25th to 30th) 2, July 13, August 10, September (1st to 15th) 2. Partly rainy or rainy days: June (25th to 30th) 1, July 1.5, August 1.5, September (1st to 15th) 1.5.

The prevailing summer winds are southwest and south-southwest, and are not generally high. Fogs are not so prevalent as farther east, although they occasionally occur. The average number of rainy days is said to be much less than at Portland or Boston.

Therapeutically this climate has been found to be of great benefit to convalescents and to certain cases of neurasthenia. It is peculiarly valuable for those who, for one reason or another, wish to be much in the open air and at rest, for there are few inducements or opportunities to take exercise. Many years ago the late Dr. H. I. Bowditch considered the summer climate of these islands favorable for early cases of pulmonary tuberculosis, and they surely possess the requisite of pure air. Many cases of hay fever find immunity here. On White Island is a lighthouse, a prominent object from the mainland. There is good sea fishing and sailing about the islands. A steam launch affords frequent communication between Appledore and Star Island.

For much of the above information the writer is indebted to Dr. J. W. Warren.

York Harbor and Beach.—These resorts, on the Maine coast, are about nine miles distant from Portsmouth, and can be reached from the latter place by steam railroad, or by ferry, and a most attractive trolley ride. York Harbor is the principal resort, and enjoys a wide popularity. Cottage life predominates, although there are several good hotels. The coast is bold and rocky, and the York River winds inland for some nine miles, and has a large flow of tide water. The residential portion of the town is built upon ledges with little or no subsoil, so that there is good surface drainage, aided by the natural declivity of the land toward the sea. Further inland are wooded districts and tillage lands. The climate is a particularly stimulating one, favorable for convalescents, for whom a marine climate of this nature, combined with sea bathing, is desired. The air is generally cool and the temperature equable, an extremely hot or cold day in the summer being rare. Fogs are unusual. The following climatic chart was obtained through the kindness of Dr. Seabury W. Allen, a summer resident of York Harbor, as also much of the information contained in this account. The prevailing wind is southwest to southeast during the summer months, and is only exceptionally of sufficient velocity to interfere with canoeing or sailing.

CLIMATE OF YORK HARBOR—PREPARED BY DR. SEABURY W. ALLEN.

	June.	July.	August.	September.	October.
Temperature, Degrees Fahr.—					
Average or normal	62.3°	69.9°	65.8°	58.4° } For three years, 1892–1894	
Highest or maximum	92.3	95.5	87.3	79.3	
Lowest or minimum	45.0	51.6	48.3	39.6	
Precipitation—					
Mean annual precipitation for twenty-five years, 40 to 50 in.					
Mean monthly average rainfall (April to September) twenty-five years, 3.4 in.					
Average number of days in which rain fell (for three years).	11	9	7	9	
Average daily temperature (for nine years)	8 A.M.—67 8 P.M.—68	8 A.M.—67 8 P.M.—67	8 A.M.—65 8 P.M.—70	8 A.M.—56 8 P.M.—57	8 A.M.—45 8 P.M.—46

Thunder storms are frequent in summer, but a continuously rainy day is the exception. The water supply is excellent; it is obtained from an inland lake some five miles distant. The ice, milk, and farm produce are also of good quality. The larger houses and hotels have sewers running into the sea, the smaller ones either connect with one of these sewers or have cesspools of their own.

So far as known there have been no cases of illness attributable to imperfect drainage. Indeed, this resort enjoys almost complete immunity from zymotic and infectious diseases. Gastro-intestinal disorders, especially in children, are rare. Such a climate, or indeed any cool marine one, is obviously not suitable for patients suffering from rheumatism, bronchial and pulmonary affections.

York Beach, situated a few miles to the eastward of York Harbor, possesses essentially the same characteristics as the latter, with the exception of the drainage. Here, on account of an extended swamp, lying behind the beach shingle, and which is imperfectly drained, there is always more or less stagnant surface water, and for this reason this locality is not so desirable as a place of summer residence.

Several miles beyond York Beach and to the northward is the Passaconoway Inn, on a rocky promontory, affording good accommodations, and still farther along the coast is the extensive Ogunquit Beach, reaching toward Wells.

Rye Beach.—This well-known and favorite summer resort is eight miles distant from Portsmouth by electric road, and is also easily reached from Boston by rail to North Hampton and thence by trolley. The air is warmer than on the Maine coast, but is fresh and cool, with an almost daily sea breeze. Moreover, the humidity (about seventy per cent.) is considerably less than at many other marine resorts. The majority of summer days are clear or fair, and the rainfall at that season is moderate. The general healthfulness of this resort is noteworthy, and children especially thrive here. The rapidity with which delicate and sickly children improve in this climate is often quite remarkable. It is also fa-

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vorable for the aged and delicate persons and convalescents from various diseases. The surf bathing is good, although the water is cold, averaging about 60° to 65° F. during July and August.

The drives are very delightful, over good country roads, and through pleasant pastoral scenery. An ocean boulevard extending along the whole coast of New Hampshire is in process of construction at Rye Beach, and when completed will afford an exceedingly attractive drive of about eighteen miles from the Piscataqua River, on the north, to Hampton River on the south.

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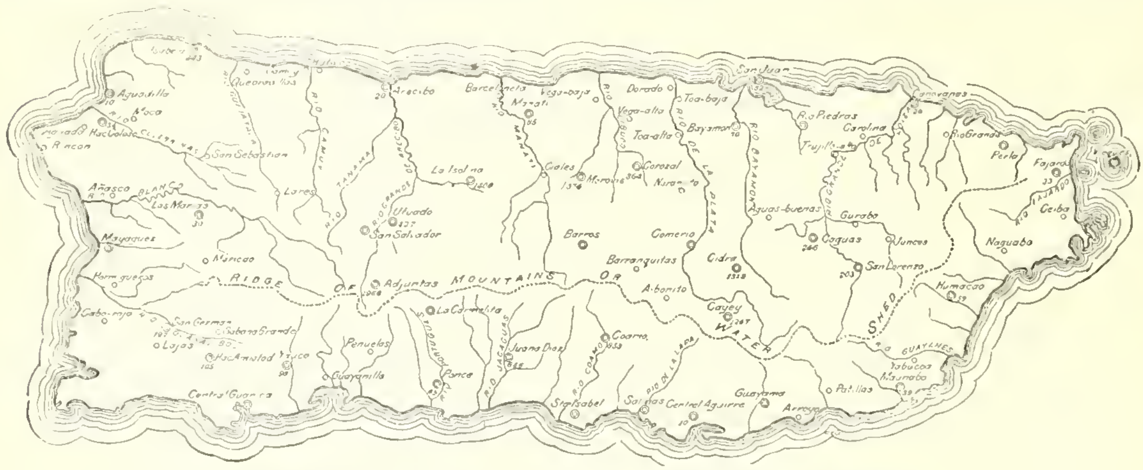

FIG. 3878. Island of Porto Rico. (Figures near names of places indicate altitude in feet.)

There are well-kept golf grounds with an attractive club-house, and a picturesque stone Episcopal church near the water, "St. Andrew's by the Sea." The sanitary conditions are generally good, and all the hotels and large boarding-houses have sewers running to the sea. The water supply is from springs, artesian and surface wells. The accommodations are excellent, though rather expensive, and there are many social attractions. Cottage life here as well as at the neighboring Little Boar's Head has become quite an important feature.

Little Boar's Head, situated about a mile south of Rye Beach, possesses the same characteristics as the latter. The name is derived from the bluff upon which it is situated. The views over the marshes and toward the sea are particularly charming. The accommodations and class of visitors are quite like those at Rye Beach. Indeed, both from its contiguity and identity of interests, Little Boar's Head can be regarded as a portion of Rye Beach. It is reached by trolley from Portsmouth or from Boston by railroad and trolley.

Hampton Beach.—Although not so fashionable as Rye Beach, this is a much-frequented resort, with several hotels of moderate price and fair accommodations, and many small cottages stretching along the beach. There is a long, hard, sandy beach extending for some miles, and affording excellent surf bathing. In the rear of the beach are extensive marshes. There are many attractive drives in the vicinity, although the wooded and cultivated land does not approach the water so closely as at Rye Beach.

This is a favorite resort for excursions, and consequently might not be so attractive to the permanent guest. It is reached by electric road from Portsmouth and Exeter, and is within three miles of the steam railway. *Edward O. Otis.*

PORTO RICO.—Porto Rico (*Spanish*, Puerto Rico), aboriginal name Borinquen, in size the fourth island of the West Indies, is situated between latitudes 17° 50′ and 18° 30′ north, and longitudes 65° 30′ and 67° 15′ west, Greenwich. On the north is the Atlantic Ocean, on the south the Caribbean Sea, on the west Mona passage separates the island from Hayti, and on the east lie the Virgin Islands and Saint Thomas. Porto Rico is about 1,000 miles southeast of Florida, and about 1,500 miles from New York City. The shape of the island is that of an elongated quadrangle, its long axis running east and west. The greatest length of the island is 108 miles and its average breadth is 37 miles. The estimated area is 3,600 square miles, or about 1,000 square miles greater than that of the State of Delaware and 1,300 square miles less than that of Connecticut. In appearance Porto Rico is an agglomeration of hills and mountains channelled with innumerable steep and narrow valleys. The hills and mountains abut more or less abruptly on the ocean, with but here and there an intervening strip of flat or gently sloping shore. Notwithstanding the striking unevenness of the island, there is a definite orographic system traced as a sinuous crest from near the southwestern corner eastwardly, and about one-third nearer the southern coast than the northern. In the eastern part of the island this crest bends sharply and terminates near the northeast extremity of the island in the peak, El Yunque, 3,609 feet above sea-level, the highest point in Porto Rico. The general elevation of this crest ranges from 2,000 to 3,000 feet above sea-level, with here and there a pass somewhat lower or a peak somewhat higher. From this general crest the mountains and hills decline coastward. The coastward fall is much greater toward the south as a consequence of the proximity of the mountain crest to the southern coast. This crest divides the island into practically two watersheds, the larger one draining north and west, the smaller draining south and east. Flowing down these two sheds, rapidly and often precipitously, are more than thirteen hundred named streams. But few are navigable, and then only for a few miles. The coast, unlike that of Cuba, has but few fringing reefs to interfere with the close approach of vessels to the shore. There are a number of good natural harbors. San Juan, on the north, is the most important commercially. It now has a depth of twenty-nine feet in the roadstead and twenty-two feet at the wharves. Other ports that may be entered by the average ocean-going vessels are Arecibo, Aguadilla, Mayaguez, Guanica, Arrayo, and Fajardo. When it is considered that the total coast line is not much more than three hundred miles, Porto Rico appears well provided with harbors. Viquez, a small inlet off the east coast, has two excellent harbors.

Geology.—Though one of the earliest colonized islands of the New World, practically nothing is known of the geology and mineral resources of Porto Rico. The early Spanish settlers worked some placer gold, and some is still to be found in the rivers of the northeast part of the

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island. Mercury, magnetic iron ore, copper, coal, salt, and several other minerals are found, but till a systematic survey is made no estimate of the actual importance of these minerals and of others not mentioned can be given. Several thermal and mineral springs, and one or two caves of interesting formation and beauty are known.

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Fauna.—The indigenous mammalian fauna have practically disappeared with the exception of a few species of rodents, of which the only peculiar one is the somewhat squirrel-like agouti (common also to all the other West Indies). A number of bats are found. The curious marine mammal, the manatee, frequents the shoal waters of the coast. Fish, both fresh- and salt-water varieties, are plentiful. Noxious reptiles are said not to exist, and insect pests are not over-plentiful. The usual domestic animals thrive well, and good beef is to be had throughout the island.

Flora.—Vegetable life flourishes even to the tops of the highest peaks. However, it is now only on the more inaccessible mountain slopes and tops that considerable remnants of the once large indigenous forests are found. Some of the native woods possess properties that are peculiarly suitable for certain purposes, but their scarcity precludes their general use. Intelligent reforestation would seem to offer returns of commercial value. Among the many native trees, Baron Eggers describes a beautiful talauma with immense white odorous flowers and silvery leaves, a hertella with crimson flowers, an unknown tree with orange-like foliage and large purple flowers, and most conspicuous of all, the Cocoloba macrophylla, with its great purple spikes of more than a yard long. Of woods common to other of the West Indies, there are found hard and soft Spanish cedar, sandalwood, and ebony. Tree ferns are numerous and of large size. The absence of epiphytes is in striking contrast to their abundance in the forests of the neighboring islands. Coffee, of excellent quality, sugar cane, yams, oranges, cocoanuts, and many of the other tropical fruits are cultivated and yield well. A species of rice, requiring no irrigation, is found growing upon the highlands, and forms one of the staple foods of the laboring class. An excellent grass, Hymenachne striatum, covers the lowland pastures, and on it is fattened the beef for which Porto Rico is esteemed by its neighboring islands.

Climate.—Though somewhat nearer the equator than Cuba, Porto Rico is not correspondingly warmer. On the contrary its temperature, taken as a whole, is slightly more comfortable. This is due to the situation of the island farther out in the ocean, and at the windward angle of the Antillean system. This position, combined with its slightly more southern latitude, gives it the unobstructed flow of the northeast trades at all seasons of the year. Porto Rico, again compared with Cuba, owes somewhat of its more agreeable temperature to its smaller size, giving it a nearer approximation to the true marine air temperature of its latitude. The only statistical data of value in determining the climate of Porto Rico are the observations made by the United States Weather Bureau station at San Juan. This station was established late in 1898. At the same time a number of what are now known as voluntary stations were established, but the data furnished by them are not yet accurate enough to be of much use, climatologically. The table given below shows the principal climatic values for San Juan, as determined from four years' observations.

Temperature.—A record of temperature was kept by the Jefutura de Obras Publicas, prior to American occupation of the island, but it does not present on its face that evidence of accuracy that well-kept meteorological records exhibit. However, the results are given that they may be compared with those of the annexed table. The average annual temperature for twelve years was 78.9°; the highest recorded temperature 100.8° and the lowest 56.1° F.

The hottest season of the year is from July to October, inclusive, with an average temperature of 80° to 81°. The coolest season is from December to March, inclusive, with an average temperature of 75° to 77°. It appears probable that this regimen holds for the island generally. Local differences in altitude and exposure should be taken into consideration as affecting the numerical size of the values given. If we take two interior stations, Cayey, 1,205 feet elevation, and Adjuntas, 1,970 feet elevation, the records of which, though broken, may still give an approximation of the inland temperature, we shall find that the average seasonal temperatures are from two to six degrees lower than those of San Juan. The highest temperature in three years at Cayey was 97°, and at Adjuntas in the same years 92°. The lowest recorded was 52° at both places. At San Juan the average diurnal range of temperature is about 10° to 11°, and at the two other stations it appears to be about 20°. Cayey is in the east central part and Adjuntas in the west central part of the island.

Rainfall.—The average yearly rainfall at San Juan for four years was 75.52 inches. From the records of the Spanish authorities before referred to it appears to have been 61.2 inches. Fair records of the rainfall in other parts of the island are not yet to be had. However, there is no doubt that the rainfall varies greatly, even in localities but few miles apart. The rainfall is much greater on the northern watershed than on the southern, and much greater on the northeastern part of the first-named shed. Generally speaking, the rainfall is everywhere greater on northeast exposures. On the southern watershed there are many localities where the rainfall is insufficient for the tropical vegetation and barren tracts are not uncommon. Irrigation is necessary in many localities on this shed.

The greatest amount of rain falls from May to October. The months of February and March are comparatively dry, February noticeably so at San Juan. In Porto Rico, as in other tropical regions, the greater part of the rain falls as an accompaniment of the almost daily thunder storm. The usual cloud regimen is clear skies in the

SHOWING CERTAIN CLIMATIC FACTORS FOR SAN JUAN, PORTO RICO; AVERAGE OF FOUR YEARS' OBSERVATIONS.

Stations.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual.
Temperature, Degrees Fahr.													
Average monthly	75°	76°	76°	78°	79°	80°	80°	81°	81°	80°	78°	77°	78°
Average maximum	81	82	82	83	85	85	85	86	87	86	84	82	84
Average minimum	70	70	70	72	73	74	75	75	75	74	73	71	73
Highest (absolute)	86	89	89	93	93	91	89	91	93	90	89	88	93
Lowest (absolute)	66	66	66	66	68	70	70	70	71	68	65	65	65
Humidity—													
Average relative	81%	76%	74%	76%	80%	82%	81%	80%	80%	82%	83%	81%	80%
Rainfall (inches)—													
Average monthly	5.92	0.88	3.14	4.80	6.31	8.51	7.36	7.66	8.03	8.87	9.48	4.56	75.52
Greatest fall in 24 hours	3.07	.70	2.08	4.34	4.81	2.46	4.05	6.26	3.76	3.35	2.93	2.02	
Average number rainy days	20	8	15	13	17	22	23	18	17	21	18	17	
Sunshine—													
Percentage of possible	64	72	68	65	60	56	57	66	61	58	61	63	63
Wind—													
Prevailing direction	E.	E.	E.	E.	S. E.	S. E.	E.	E.	S. E.	S. E.	E.	E.	E.
Average hourly velocity (miles per hour)	10	9	11	10	9	10	12	11	9	7	8	9	10

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morning, cloudy in the afternoon, and clearing and clear at night.

Wind.—The prevailing winds are remarkably constant from the east or between northeast and southeast. The velocity is steady and averages ten miles an hour. It is subject to a regular diurnal range, rising gradually to a maximum at the hottest part of the day and subsiding from that time to a minimum at the coolest part of the day, just about sunrise. This regularity and steadiness of the wind cannot be over-estimated in its relation to the comfortable habitability of Porto Rico.

Storms.—Though visited August 8th, 1899, by one of the most destructive storms of recent years, the island is well to the east of the usual tracks of West Indian hurricanes. Thunder storms, though of almost daily occurrence and accompanied by great electrical display, are not destructive, and one soon becomes used to their apparent violence.

History.—Porto Rico was discovered by Columbus in 1493. The first settlement was made by a party of Spaniards under the leadership of Ponce de Leon, at Caparra, A.D. 1510, but it was shortly afterward abandoned. San Juan was founded by the same leader in 1511. The town was sacked by the English under Drake in 1595, and again under the Earl of Cumberland in 1598. Since then it has successfully withstood the assaults of the Dutch in 1615, the English in 1678 and in 1797, and the United States in 1898. On July 25th, 1898, the island was invaded by the United States forces, who landed without opposition at Guanica on the southern coast. Only a feeble resistance was subsequently encountered. The Spanish formally evacuated the island October 18th, 1898. By the treaty of Paris, December 11th, 1898, Porto Rico was ceded to the United States. A census taken by direction of the War Department, 1899, gave a total population of 953,243 inhabitants. Unlike most, if not all, the other West Indian islands, Porto Rico has a larger white than black population. In 1899 there were 589,426 whites and 363,817 blacks. The density of population is also great, averaging 264 persons to the square mile, a density equal to that of New Jersey and twice that of Pennsylvania. The greater part of the population is rural. The population of the largest cities in 1899 was: San Juan 32,048, Ponce and its port 27,952, Mayaguez 15,187, and Arecibo 8,008. The ratio of illiteracy is high, but twenty-three per cent. of the population over ten years of age being able to read. Agriculture, such as it is, is the chief occupation, employing about sixty-three per cent. of the working population. The most important products are coffee, sugar, and tobacco. The total value of exports from July, 1898, to December, 1899, was $11,621,049. The imports during the same period amounted to $12,654,542. Transportation facilities before American occupation were poor. There existed but one hundred and thirty-seven miles of railroad, and with the exception of the excellent military road from San Juan to Ponce, and a few connecting branches, there were no common roads at all. Much has been done since to improve matters in this respect. The sanitary conditions were equally in keeping with the general indifference shown in other improvements. Few, very few, houses had any efficient sewage disposal systems. In many the systems were even worse than none, being in their ultimate workings actually pernicious. The average death rate, calculated from reported deaths for eleven years, is 30 per thousand. There is reason to think that this is considerably less than the actual. The chief causes appear to be: Anaemia, 22.50 per cent.; tuberculosis, 6.78; diarrhoeal diseases, 3.83; cerebrospinal meningitis, 1.12; typhoid fever, 1.43; tetanus, 3.57. Smallpox was, prior to 1899, one of the chief causes of mortality, averaging annually 623 deaths. It is now, happily, no longer a factor of importance, owing to the thorough vaccination of the entire population carried out by the United States military authorities. Yellow-fever epidemics have occurred occasionally. The large mortality from anaemia appears to be due to the general infection of the drinking-water by the intestinal parasite, ankylostomum duodenale. Ordinary care exercised in filtering or otherwise purifying the water used for culinary and drinking purposes should be followed by a great reduction in this disease.

W. F. R. Phillips.

POST-MORTEM EXAMINATIONS. See *Autopsies*, and *New-Born, Pathology of*.

POTASSIUM.—I. General Medicinal Properties of Compounds of Potassium.—In its physiological relations potassium is the most individual of the alkali metals, producing effects sufficiently pronounced to be seen characteristically in the case of all its compounds that are capable of absorption. Such effects are as follows: Locally, potassic compounds are irritant—less so than the average of soluble compounds of the heavy metals, but yet sufficiently so to make a large portion of a strong solution of a potassic salt dangerous on the score of irritation alone. In the intestines, potassic salts tend to increase the secretion of fluid, so that salts of this base that are of low diffusion power prove watery purges. Constitutionally, the prominent effects are certain derangements of function and certain effects that find their simplest explanation in the assumption that potassium quickens the rate of oxidation within the organism as it does in laboratory experiments. The derangements of function are, first, an enfeeblement of the heart's action, passing, in poisonous dosage, to permanent arrest in diastole. The effect seems to be due, as results of all experimentation agree, to a directly paralyzing influence upon the musculature of the organ itself. Secondly, but requiring relatively larger dosage, there follows general motor paralysis, voluntary and reflex. This effect is proportionately much more strongly marked in cold-blooded than in warm-blooded animals, and, in therapeutic dosage in man, is practically not seen at all. It is probably accomplished by an action on nerve centres, nerve trunks, and muscles conjointly, but an action which is most intense upon the nerve centres and least so upon the muscles.[1] The effects commonly assigned to a quickening of oxidation are, in the healthy, an increase in the solid excreta of the kidneys, with a proportionate increase in the volume of the urine, and, in the lithæmic individual, a diminution in the amount of uric acid excreted, with a simultaneous increase of urea and appearance of calcium oxalate. These effects in lithæmia are translated to mean an oxidation of much of the uric acid into oxaluric acid, which product then splits into urea and oxalic acid.[2] In large doses, long continued, potassic compounds prove noxious to nutrition, the blood becoming thin and unduly fluid, newly formed and lowly vitalized tissues, such as cheesy deposits, tending to liquefy, and health and strength generally to suffer. Therapeutically, the effects of applications of potassic compounds, determined by the potassium element of their composition, are to depress the heart in sthenic fever, to oppose the lithic diathesis, and to provoke catharsis or diuresis. Other uses are derived from individual peculiarities of the different compounds.

II. The Compounds of Potassium Used in Medicine.—The compounds of potassium official in the United States Pharmacopœia divide, for purposes of study, into two groups—the one embracing compounds whose effects are either derived from the potassium or are *sui generis* to the salt, and the other such as owe their effects mainly to the acid radical of their composition. The members of the former group, which alone will be discussed in this place, are the *hydroxide*, *carbonates* (normal and acid), *citrate*, *acetate*, *tartrates* (acid and potassio-sodic), *sulphate*, *nitrate*, and *chlorate*. The second category comprises the *hypophosphite*, *bromide*, *iodide*, *sulphide* (in the preparation, *potassa sulphurata*), acid *chromate*, *cyanide*, *ferrocyanide*, *permanganate*, *arsenite*, (in the preparation, *liquor potassii arsenitis*), *potassio-aluminum sulphate* (alum), and *potassio-ferric tartrate*. For discussion of these compounds see, severally, *Hypophosphites*, *Bromides*, *Iodides*, *Sulphides*, *Chromium*, *Cya-*

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nides, Ferrocyanides, Manganese, Arsenic, Aluminum, and *Iron.*

Potassium Hydroxide (Potassium Hydrate): KOH. This is the compound which is both commonly and officially known as *Potassa*, Potassa, called also *caustic potash*. It is obtained first in aqueous solution by precipitating with lime a solution of acid potassium carbonate. Such aqueous solution, when rapidly boiled down, yields a fluid of oily consistence—simply the hydroxide melted by the heat—which, poured into cylindrical paper moulds, hardens on cooling into the cylindrical sticks in which form potassa is commonly met with. Potassa thus obtained is a white, hard substance, having a faint alkaline odor, and a very harsh, caustic taste. It is exceedingly deliquescent, and readily soluble in water and alcohol.

Beside the stick form, potassa is official in five per cent. aqueous solution under the title *Liquor Potassæ*, Solution of Potassa. This solution is made as just described, and is a clear, colorless liquid, odorless, but with the acrid, caustic taste of potassa. It should be kept in green glass bottles, glass stoppered, and the stoppers should be coated with vaseline or a thin layer of melted paraffin. Specific gravity about 1.036.

Potassa produces physiological effects which spring in part from an intense affinity for water, in part from its powerful alkalinity, and in part from its operation as a compound of potassium. Locally, in concentrated application, potassa is intensely caustic. A moistened stick swept even lightly over a tender surface produces speedy corrosion, which extends finally beyond the area of original application, the tissues breaking down widely into a brownish, slimy, pultaceous material. Taken internally, therefore, in strong solution, potassa is a corrosive poison. In such poisoning, the acrid, alkaline taste of the potion is followed immediately by severe pain in the pharynx, œsophagus, and epigastric region. These symptoms are in turn speedily succeeded by violent vomiting, where the ejecta have the greasy aspect and pultaceous consistency of tissues corroded by potassa, and prove strongly alkaline to test paper. The mucous membrane of the lips, mouth, and throat may be bright red from irritation, if the solution swallowed were not overstrong, or may, in the case of strong potions, show direct corrosion, being covered by a brownish film having a greasy or soapy feel. Loss of voice and extreme difficulty of swallowing are exceedingly common, but intestinal symptoms are generally wanting. Constitutionally, the symptoms are those of shock, from the suddenness and severity of the corrosion. In survival from serious grades of the poisoning, stricture of the œsophagus is a very common sequel. In the treatment, the only peculiar feature is to give harmless acids to neutralize the alkali, but since the damage is generally already fully done before the physician arrives, this chemical neutralization rarely avails for much. Vinegar or lemon juice are the acids most available, from their being strong but non-corrosive themselves, and at the same time readily procurable. Locally applied, in non-corrosive strength, potassa operates as a powerful and harsh alkali. Acids are neutralized, grease becomes saponified, epithelial tissues swell and soften, and acid secretions, such as the gastric juice and the sweat, tend to be called forth. Upon the skin, potassa lotions cleanse from dirt or the crusts of dried secretion and epithelium resulting from skin disease. Taken internally, the remedy excites appetite and increases the flow of the gastric digestive fluid, or in cases of fermentation of the food neutralizes acidity and so relieves the heartburn and nausea which such acidity excites. Constitutionally, medicinal doses of potassa produce, of course, the effects of all potassium compounds as already set forth, and also, because of free alkalinity, tend to neutralize morbidly developed acid in the blood or tissues, to diminish the acidity of the urine, or even to reverse the reaction of that secretion to the alkaline. Probably in part because of the peculiar action of potassium as such, and partly because of the alkalinity of potassa, this compound is of special efficacy in the diatheses leading, severally, to rheumatism, gout, and lithæmia, and in the skin diseases urticaria, psoriasis, eczema, lepra, acne, and recurring boils.

The medical uses of potassa are for the purposes above detailed, yet, except as a caustic, it is not so much used as its acknowledged potency would seem to suggest, simply because it is rough and harsh, while at the same time other and milder potassic compounds are equally efficient. Thus for direct local alkaline action the carbonates, and for constitutional alkalizing, the citrates and tartrates, are respectively preferable.

To *cauterize* with potassa, the adjacent parts should be protected by adhesive plaster, and the doomed area, if covered by skin, should then be rubbed with a moistened stick of the caustic until discoloration appears. If the part be a mucous membrane or raw tissue, a single light sweep of the caustic is sufficient for even a profound cauterization. In no case should the agent be used where an exact limitation of the caustic effect is essential, as where the part to be destroyed is in close contiguity to important, or large, blood-vessels or organs. To render the corrosion of potassa less spreading, a mixture of equal parts of potassa and quicklime has been devised, and is official in the United States Pharmacopœia, under the title *Potassa cum Calce*, Potassa with Lime. This mixture, commonly known as *Vienna caustic*, is a grayish-white, deliquescent powder, soluble in hydrochloric acid. It is less diffusive in its action than potassa, by reason of the peculiar action of the lime of its constitution. For use the powder is made into a paste with a little alcohol.

For a potassa lotion, the solution of the Pharmacopœia is to be prescribed, diluted with several volumes of water. For internal giving, the same solution is employable, in doses ranging from 0.65 to 4 gm. (♏ x. to fl. ʒ i.) greatly diluted with some syrupy or mucilaginous fluid. But potassa, as an internal remedy, is very objectionable for any but a very temporary medication.

Normal Potassium Carbonate: $(K_2CO_3)_2.3H_2O$. The salt is official in the United States Pharmacopœia under the title *Potassii Carbonas*, Potassium Carbonate. It is a white, granular powder, very deliquescent, odorless, having a strongly alkaline taste, and an alkaline reaction. It is readily soluble in water, but is insoluble in alcohol. Potassium carbonate is so deliquescent that unless carefully put up in well-stoppered bottles it will eventually transform itself into an oily fluid, by dissolving in moisture attracted from the atmosphere.

Physiologically, potassium carbonate is simply a weakened potassa, yet not so weak but that, in strong solution, it may prove a corrosive poison. Its use is mainly in ointment or in aqueous solution as a strong alkaline potassic application in skin diseases. Ointments of the carbonate are made with lard, the strength ranging from two to ten per cent. Solutions of the salt for service as lotions range in strength from one-half to one per cent.

Acid Potassium Carbonate: $KHCO_3$. The salt is official in the United States Pharmacopœia under the title, *Potassii Bicarbonas*, Potassium Bicarbonate. It occurs in colorless, transparent, prismatic crystals, and differs from the normal carbonate in being permanent in the air. It is odorless, and of a slightly alkaline taste and reaction. It is soluble in 3.2 parts of cold water and is decomposed by boiling water. It is practically insoluble in alcohol. It should be kept in well-stoppered bottles.

Physiologically, this carbonate is similar to the normal salt, but weaker. The taste is mild, though mawkish; the alkalinity feeble, and the salt is hardly capable of being corrosive. The uses are, locally, as an alkaline application in skin disease, in preparations such as are described above in speaking of the normal carbonate, and, internally, as a stomachic or constitutional alkali. But for stomachic purposes sodic salts are more agreeable, and for constitutional alkalies the potassic citrates and tartrates. If given internally, the dose ranges from 1 to 4 gm. (from gr. xv. to ʒ i.).

Normal Potassium Citrate: $K_3C_6H_5O_7.H_2O$. This salt, formerly known as *Salt of Riverius*, is official in the

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United States Pharmacopœia under the title *Potassii Citras*, Potassium Citrate. It is a deliquescent salt occurring in transparent prismatic crystals or as a granular powder. It is odorless with a slightly alkaline and cooling taste. It dissolves readily in water, but slightly only in alcohol. Potassium citrate is a not disagreeable tasting, cooling salt, which is devoid of all local harsh effect, and yet after absorption seems to undergo decomposition as regards its acid radical, becoming converted into a carbonate. Such secondarily formed carbonate thereupon exerts the usual action of an alkaline potassic compound, as detailed under Potassa above. Potassium citrate is thus available as a gentle diuretic, diaphoretic, and cardiac sedative in fevers, and also as an agreeable and yet efficient agent for constitutional alkalizing. It may be given freely in doses of from 1 to 2 gm. (gr. xv. to xxx.) in water or in effervescing water, sweetened or aromatized to taste. In order to obtain the salt in effervescing solution, in which condition it is more grateful to a fevered stomach, the following preparations are official in the United States Pharmacopœia: *Potassii Citras Effervescens*, Effervescent Potassium Citrate. This preparation is a powder consisting of a dry mixture of citric acid, potassium bicarbonate, and sugar. When added to water, reaction instantly takes place between the citric acid and the potassium bicarbonate, with the formation of potassium citrate and carbon dioxide. One or two teaspoonfuls make a dose, to be taken in water and drunk during effervescence. Such effervescent solution takes the place of the old, so-called "neutral mixture," or "mixture of citrate of potassium," formerly but now no longer official. Such mixture was simply fresh lemon juice, strained, and neutralized with potassium bicarbonate. *Liquor Potassii Citratis*, Solution of Potassium Citrate: This is a simple aqueous solution of the salt effected by bringing together in water six per cent. of citric acid and eight per cent. of acid potassium carbonate. It contains nine per cent. of potassium citrate, and should be made fresh when wanted. But the effervescing draught made from the "effervescent citrate" is a better way of getting the same solution.

Potassium Acetate: $KC_2H_3O_2$. The salt is official as *Potassii Acetas*, Potassium Acetate. This is an exceedingly deliquescent salt, having a warming, mildly pungent, salty taste. Very soluble in water and in alcohol. It must be kept in well stoppered bottles. Potassium acetate is generally similar in properties to the citrate, undergoing, like that salt, conversion into a carbonate after absorption, and so operating constitutionally as a potassic alkali. It is not so agreeable to the taste nor so grateful to the stomach as the citrate, but has a considerable reputation as a diuretic, as evidenced by its old cant name of *Sal diureticum*. As a matter of fact, however, it—often, at least—does not prove more diuretic than the citrate or other potassic salts. Potassium acetate may be used for the same purpose and in the same doses as the citrate.

Potassio-sodium Tartrate: $KNaC_4H_4O_6.4H_2O$. This well-known salt, commonly called Rochelle or Seignette's Salt, is official in the United States Pharmacopœia under the title *Potassii et Sodii Tartras*, Potassium and Sodium Tartrate. This salt occurs in colorless, rhombic crystals, or as a white powder. It is odorless, with a cooling, saline taste, and effloresces slightly in dry air. It dissolves readily in water, but is almost insoluble in alcohol. This salt is decomposed by acids, with the production of a crystalline precipitate of acid potassium tartrate ("bitartrate"), and also by soluble plumbic, calcic, and basic salts.

Rochelle salt is mild in flavor and local action, agrees well with even a sensitive stomach, and differs from the citrate and acetate in being of low, rather than high diffusion power. Hence in full dose it is purgative, but as compared with the average of saline purges ranks among the milder. In non-purgative dose, especially if given well diluted, it is absorbed, changes to carbonate after the manner of the citrate and acetate, and then exerts, as efficiently as other salts, the specific action of alkaline potassic compounds. From its mildness it is preferred by many to other potassium preparations as a constitutional alkali in rheumatism, lithæmia, etc. For constitutional action as an alkali or as a diuretic the salt is to be given in comparatively small but frequently repeated doses, not to exceed, as a rule, 4 gm. (ʒ i) at a time. As a purge, the dose will range, according to the intensity of the effect desired, from 8 gm. to 30 gm. (ʒ ij. to ℥ i.) in water, plain or aromatized. A favorite mode of administration is in effervescent solution, as obtained by use of the official *Pulvis Effervescens Compositus*, Compound Effervescing Powder. This is the well known *Seidlitz powder*, and consists of two parts, one a powder in blue paper, made up of about 2.60 gm. (gr. xl.) of acid sodium carbonate ("bicarbonate") and about 8 gm. (ʒ ij.) of Rochelle salt, and the other a smaller powder in white paper, consisting of about 2.25 gm. (gr. xxxv.) of tartaric acid. Each portion is to be dissolved separately in about 60 gm. (fl. ℥ ij.) of iced water, sweetened and aromatized if so desired, and the solution of the acid then to be added, half at a time, to that of the salts, and the potion drunk during the effervescence which immediately occurs. The reaction upon mixing the solutions is, of course, the decomposition of the sodium carbonate by the tartaric acid, with the formation of a sodium tartrate and the evolution of carbon-dioxide gas. A single "powder" is a medium purgative dose.

Acid Potassium Tartrate: $KHC_4H_4O_6$.—This well-known salt, the *cremor tartari* or *cream of tartar* of common parlance, is official in the United States Pharmacopœia under the title *Potassii Bitartras*, Potassium Bitartrate. It is prepared by a process of purification from the impure salt occurring as an incrustation developing in casks of wine, especially of acid wines. Such incrustation is called *argol*, or *crude tartar*, the latter name being derived from the *tart* quality of the wines that furnish the greatest yield of the substance. The purified salt may be in crystals, but as furnished to pharmacists it is in fine powder, to which condition especially the cant name of "cream of tartar" applies. The salt is permanent in the air, and has an agreeable, subacid taste. It is peculiar in being comparatively insoluble in cold water (201 parts), although much more soluble in boiling water (16.7 parts). It dissolves sparingly only in alcohol. The solubility in water can be increased till the salt dissolves in one part, by the addition of borax, two parts to five of the tartrate. Commercial cream of tartar always contains more or less calcium tartrate, which salt is a normal constituent of crude tartar, but, according to the pharmacopœial standard, the proportion should not rise above six per cent. Besides this natural impurity adulterations are often found, such as chalk, gypsum, clay, sand, or flour. Purchase of the article in crystals affords the surest way to avoid these sophistications.

Cream of tartar is a cooling, acidulous salt, agreeing well with delicate stomachs. Like Rochelle salt, it is of low diffusion power and is therefore cathartic, and in its purgative action is characterized by the copiousness of the watery dejections it determines. For this reason it is a favorite ingredient of cathartic mixtures intended for carrying off a dropsical effusion, such as the compound powder of jalap of the United States Pharmacopœia. In non purgative dosage the salt is refrigerant and diuretic —perhaps more generally diuretic than any other potassic compound, but, unlike the other potassic salts of organic acids, it does *not* appear to suffer the usual conversion in the blood into a carbonate. Such, at least, is the inference from the clinical observation that cream of tartar is not of the same value for constitutional alkalizing as are, respectively, the other tartrates, the citrate, and the acetate. The uses of the present salt are therefore restricted to its application as a purge, a diuretic, or a grateful, cooling saline in feverishness. The doses are substantially the same as those of Rochelle salt for the same several purposes. The powdered cream of tartar may be suspended in water or mixed with molasses for giving as a purgative, or, for use as a fever draught,

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may be dissolved in boiling water, and the solution, when cold, given sweetened with sugar. The old-fashioned, so-called *imperial* draught is made by dissolving one per cent. of cream of tartar in boiling water, adding one per cent. of sliced lemon and eight of white sugar. *Cream of tartar whey*, so called, consists of one and a half per cent. of the salt in milk.

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Normal Potassium Sulphate: K_2SO_4. The salt is official in the United States Pharmacopœia under the title *Potassii Sulphas*, Potassium Sulphate. It is a permanent salt, occurring either in transparent, colorless rhombic crystals, or as a white powder. It dissolves in about 9.5 parts of cold water, and in 4 parts of boiling water. It is insoluble in alcohol. Potassium sulphate is, like all sulphates, comparatively harsh, and in large concentrated dose has caused fatal irritant poisoning. It is of low diffusion power, therefore purgative, and its medical use has been as a saline cathartic. It is, however, little used, because of its occasional harshness. The dose will range from 8 to 16 gm. (ʒ ij. to iv.), to be given in solution, well diluted. This is the salt formerly called *vitriolated tartar* and *sal de duobus*.

Potassium Nitrate: KNO_3. This salt, the well-known substance *nitre*, or *saltpetre*, is official in the United States Pharmacopœia under the title *Potassii Nitras*, Potassium Nitrate. This is a permanent salt, occurring in colorless, transparent, six-sided rhombic crystals, or in a crystalline powder. It is odorless, with a cooling, pungent taste. It dissolves in about four parts of cold water and in less than one part of boiling water. It is almost insoluble in alcohol. It deflagrates when thrown upon red hot coals. Under the name of *sal prunelle* or *crystal mineral*, nitre is also to be found in the shops in small circular cakes, moulded from the salt, fused. Commercial refined saltpetre is the quality of the salt to be employed in medicine, and an article in small crystals is preferable to one in large, since large crystals are apt to contain some water, mechanically entangled in the process of crystallization.

Potassium nitrate, like the sulphate, is a powerful salt in local operation, but, unlike the sulphate, is of high diffusion power, so that even a large dose will be comparatively quickly absorbed. Taken internally it is therefore doubly potent, and even poisonous, a large dose exciting severe irritant poisoning, and consecutively producing in the highest degree the dangerous constitutional effects of the potassic compounds generally. The salt undergoes no decomposition in the system, and is therefore incapable of exerting any *alkaline* effects, either local or constitutional. In medicinal doses nitre produces the antifebrile effects of the potassium salts generally, being cooling and grateful to the stomach, and tending, after absorption, to quiet a bounding heart and at the same time to prove gently diuretic and diaphoretic. Being of high diffusion power, it does not purge except in considerable dose. A peculiar property of nitre is that, mixed with fresh venous blood, it turns the blood bright red and impairs its coagulability; but in spite of much theorizing, the fact does not lead to any special therapeusis. Medicinally nitre is nowadays rarely used internally, except as an ingredient of fever draughts or of diuretic mixtures. Formerly it had considerable reputation in the treatment of acute rheumatism, being pushed in full doses, but alkalies and salicylates have now supplanted the salt for this application. The single dose of nitre should not exceed 2 gm. (gr. xxx.), and the salt is best given in dilute solution. Considerable single amounts, especially if in concentrated condition, are dangerous, but so rapid are the absorption and elimination of the nitrate that, by means of small and frequent doses, properly diluted for the taking, a very large quantity—from 30 to 62 gm. (℥ i. or ij.)—can be passed through the system in the course of a single day without injury. A special therapeutic application of saltpetre is the inhalation, for the relief of spasmodic asthma, of the fumes arising from its combustion. As usual in antispasmodic medication, some cases find relief from the agent and others do not, or even suffer aggravation thereby. For the application, white unsized paper, free from wood, is steeped in a twenty-five-per cent. aqueous solution of nitre and allowed to dry. A piece is then burned, and the patient, with the face as near as can be borne without undue irritation, inhales the white fumes that are given off. Such prepared paper is official in the United States Pharmacopœia under the title *Charta Potassii Nitratis*, Nitrate of Potassium Paper. It is sometimes called *asthma paper*. Toxicologically nitre is of some importance, cases of poisoning by the salt not infrequently occurring. An ounce, swallowed at a draught, has proved fatal in a number of instances. Taken, as it commonly is in such cases, in pretty strong solution in mistake for purgative salts, it produces symptoms of severe gastro-intestinal irritation—burning pain in the stomach, violent vomiting and purging, the dejecta being sometimes bloody, and general collapse. Whether the constitutional symptoms are merely symptomatic of shock from the irritation, as occurs so commonly with powerful irritant poisons like the mineral acids, or whether they are in part the expression of the specific potassium poisoning of nerve and muscle, is not always easy to determine, and is of no practical bearing on the treatment of the poisoning. Special symptoms are urinary suppression, with strangury, tenesmus, and bloody urine, and aphonia. These may or may not occur. Death may take place in two hours after the swallowing of the poison. There is no chemical antidote to nitre, so that the treatment of a case of poisoning must be conducted simply on general medical principles.

Potassium Chlorate: $KClO_3$. The salt is official in the United States Pharmacopœia under the title *Potassii Chloras*, Potassium Chlorate. This is a permanent salt, occurring in colorless, shining, prismatic crystals or plates, odorless, and having a cooling, saline taste. It dissolves in 16.7 parts of cold water, but in 1.7 parts of boiling water. It is slightly soluble only in alcohol. If heated or triturated with organic substances, such as sugar, tannic acid, or cork, or with easily oxidizable chemicals, such as sulphur or phosphorus, a dangerous explosion is likely to occur. The salt should, therefore, be kept in glass-stoppered bottles and handled with care.

The chemical relationship between chlorates and nitrates is paralleled, as usual in such cases, by resemblance in physiological action. The present salt thus closely resembles nitre in its effects, the principal difference being in intensity of power, the chlorate being the weaker—a fact probably in part due to the less ready solubility of the salt. Yet the chlorate is strong enough, in full concentrated dose, to be fatally poisonous, with symptoms of intense gastro-intestinal irritation, and, in too lavish medicinal use, as has been the fashion in diphtheria, to be the likely cause of much of the nephritic disorder thoughtlessly assigned, in etiology, to the disease instead of to the medicine.[3] For, like the nitrate, the chlorate of potassium has a distinct tendency to irritate the kidneys, which, in the choked condition of the organs common in diphtheria, may easily lead to dangerous congestion. Potassium chlorate was forced into medicinal notoriety largely by the theoretical consideration that, since chlorates readily part with some of their oxygen, thus proving active oxidizing agents, the salt ought to serve as a constitutional source of oxygen within the animal system, and so prove of benefit in diseases that tax the nutritive powers of the organism. Clinical experience, however, does not bear out the prognostications of theory, and physiological chemistry accounts for the failure by finding that, under the conditions of the animal circulation, potassium chlorate suffers no decomposition, but is eliminated by the kidneys and other organs unchanged. The only rational place of this salt in medicine hinges on the following fact: The chlorate is largely eliminated by the salivary glands, and probably also by the mucous follicles of the mouth and pharynx, and in inflammatory conditions of the surface textures of these parts distinctly tends to healing. Sore mouth or sore throat, catarrhal or ulcerative, is therefore treated with advantage with potassic chlorate in the form of

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wash or gargle, or, better still, for the sake of continuous application to the parts through the avenue of the saliva and buccal mucus, given internally. A convenient practice is to prescribe a five-per-cent. aqueous solution of the salt, which is upon the verge of a saturated solution, and direct this to be used as a mouth wash or gargle every two hours, and at the same time a couple of teaspoonfuls to be taken internally. Such quantity will represent about 0.50 gm. (gr. viij.) of the salt—a moderate single internal dose. Among the varieties of buccal disorders amenable to potassium chlorate may be mentioned mercurial stomatitis; and some practitioners even combine the potassium salt with their mercurials in constitutional mercurialization, with the view of lessening the risk of salivation. In diphtheria, also, the chlorate is a good deal used, the good effects being probably the local ones only, and the risk to kidneys or heart from too free dosage being genuine and considerable. Of preparations, the United States Pharmacopœia makes official *Trochisci Potassii Chloratis*, Troches of Potassium Chlorate, the ingredients being the salt, sugar, and tragacanth, and a little of spirit of lemon for flavoring. Each troche contains 0.30 gm. (about gr. v.) of chlorate. In ordinary sore throats or sore mouths, for the treatment of which affections the preparation is especially intended, these lozenges, if allowed to dissolve naturally without chewing, may be taken continuously through the day.

Edward Curtis.

[1] Ringer and Murrell: Journal of Physiology, i., p. 88.
[2] Basham: Practitioner, vol. v., p. 259
[3] Jacobi: Medical Record, vol. xv., p. 241.

POTASSIUM, TOXICOLOGY OF.—Independently of the corrosive action which characterizes the oxid, hydroxid, and carbonates of potassium, those compounds of potassium with acids, which have little or no toxic qualities, such as the chlorid, sulfate, or tartrate, exert a distinctly poisonous action. In this respect the potassium compounds differ notably from those of sodium.

Experiments on dogs demonstrate that the injection of from 1 to 2 gm. of potassium chlorid, nitrate, sulfate, etc., directly into the circulation, produces death very quickly from cessation of the heart's action. Smaller quantities produce a slowing of the pulse, more or less gastritis, dyspnœa, convulsions, and sometimes death.

Diluted doses seem to have a less serious effect than the same weight of the salt in a concentrated form.

All fatal cases of poisoning in the human subject by the potassium salts of non-toxic acids have been due to ignorance or accident.

Potassium Bromid—KBr.—Two cases have been reported in which death followed the administration of very large quantities of potassium bromid. Duncan (*British Med. Journal*, 1882, Part I., p. 616) relates a case of a child three years old, who died in less than half an hour after taking between 5 and 6 gm. of the drug. The other case was that of an adult female, to whom was administered by her physician 4.2 gm. every four hours for four days. The patient died five days after taking the last dose (Hamer, *Columbus Med. Journal*, vol. iii., p. 259).

Aside from bromism several non-fatal cases are on record, in some of which the patient exhibited a peculiar idiosyncrasy as regards the tolerance of this substance.

Potassium Chlorid—KCl.—The poisonous action of this compound upon animals has been to some extent investigated. When injected into the blood supply of a nerve, the latter loses its excitability. The salt is eliminated with the urine, but much more slowly than sodium chlorid. I find no fatal cases reported as a result of the poisonous action of this salt upon human beings.

Potassium Nitrate—KNO_3.—This substance is commonly known by the name of nitre or saltpetre. Its use as a preservative of meat and other articles, and among agriculturists in the treatment of diseases of domestic animals, makes it one of the common household drugs.

In poisoning by potassium nitrate it is quite certain that the acidulous constituent plays no small part in the toxic action. This conclusion follows from observations upon man and lower animals, when subjected to the action of sodium nitrate (see two cases of poisoning by sodium nitrate, Collischorm, *Deutsche med. Wochenschrift*, vol. xv., p. 844). Large doses (3–5 gm.) cause uneasiness in the stomach and intestines, followed by vomiting, diarrhœa, and generally a frequent desire to urinate. Fifteen to twenty grams produce an acute gastro-enteritis, the vomit tinged with blood, pronounced weakness, cold sweats, and cramps, especially in the calves of the legs.

Woodman and Tidy ("Forensic Medicine and Toxicology") report six fatal cases in which the dose varied from 15 to 45 gm., and the duration from two to sixty hours. Wormley ("Micro-Chemistry of Poisons," p. 69) mentions an instance of an aged man who died in half an hour after taking a quantity of potassium nitrate in mistake for sodium sulfate. Size of dose not given. Bailey (*Phila. Med. and Surg. Reporter*, June, 1872, p. 75) records a recovery after taking 125 gm.

Lesser (*Vierteljahr. f. ger. Med.*, 1898, 3. F., xvi., 93) reports the case of a woman aged forty-six, who died twelve hours after taking about 70 gm.

Most of the cases of poisoning by potassium nitrate have been due to mistaking the substance for magnesium or sodium sulfate or sodium chlorid. In several instances overdoses produced serious results.

The symptoms consist of a severe burning pain in the abdominal region, nausea, vomiting, purging, vomit and stools containing blood, coldness of the extremities, facial tremors, weak and irregular pulse, and collapse. Difficult respiration was observed in some cases.

No chemical antidote is known. The treatment should be to remove the poison from the stomach, give mucilaginous drinks, and treat the symptoms.

Post-mortem Appearances.—The stomach is usually highly inflamed, with dark-colored patches, and the mucous membrane partially detached. Similar appearances have been observed in the duodenum and intestines. Sometimes the indications of asphyxia are present; the lungs are congested, and the right heart is filled with thick, very dark blood.

Potassium Sulfate—K_2SO_4.—This substance was formerly employed to produce abortion, several fatal results having occurred from such use. Bayard reports a case (*Ann. d'Hygiène*, April, 1842) in which 33 gm. of potassium sulfate were administered as a laxative after delivery. Death followed in two hours. A case is recorded in the *Medical Times and Gazette*, 1856, p. 420, in which 8 gm., administered to produce abortion, caused death.

The symptoms noted were pain in the stomach, nausea, vomiting, purging, and cramps in the limbs. A post-mortem examination showed the stomach to contain a reddish liquid, and the mucous membrane to be of a purple color.

Potassium bitartrate—$KHC_4H_4O_6$.—Although this substance, commonly called cream of tartar, may be found in every household, I find recorded but two fatal cases of poisoning by its use. In Tyson's case (*Lancet*, vol. i., 1837–38, p. 162) death followed in four days the taking of 125 gm. Roger reports a case (Friedreich's *Blätter f. ger. Med.*, xxviii., 1887, p. 196) in which 200 gm. caused death in twelve hours.

The prominent symptoms were severe abdominal pain, persistent vomiting and diarrhœa, thirst, feeble pulse, and paralysis of the legs. A post-mortem examination showed the interior surface of the stomach covered with red streaks and patches, and the intestines somewhat inflamed.

ANALYSIS.—Since potassium compounds are normally present in the body fluids and tissues, the analyst cannot report them as having been introduced into the system, unless he can prove them present in abnormal quantity, or in unusual combination. Cream of tartar, on account of its sparing solubility, may be found in the stomach in the solid form.

Louis Warner Riggs.

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POTT'S DISEASE. See *Spine, Diseases of.*

POWDER SPRINGS.—Cobb County, Georgia. Post-Office.—Powder Springs.

Access.—Take Western and Atlantic Railroad to Marietta, and from thence private conveyance to the springs, ten miles distant.

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These springs were discovered about fifty years ago, but for want of improvements their reputation has been confined to the surrounding country. There are four springs, one of which has been approximately analyzed as follows:

One United States gallon contains: Iron sulphate, gr. 2; calcium sulphate, gr. 1; iron oxide, gr. 1.50. Total solids, 4.50 grains. The contained gases are: Carbonic acid, 1 cubic inch; hydrogen sulphide, 1.5 cubic inches.

The other springs contain about the same ingredients. The flow of water is about two and a half gallons per minute. The waters are evidently chalybeate, and we are informed that they have been found highly useful in depressed and debilitated states of the system where a fairly potent ferruginous tonic is indicated.

James K. Crook.

POWHATAN LITHIA AND ALUM SPRINGS.—Powhatan County, Virginia. Post-Office.—Tobaccoville.

Access.—From Richmond viâ Farmville and Powhatan Railroad to Tobaccoville station, forty-eight miles west, thence three-quarters of a mile by private conveyance to springs.

These springs are two in number, one known as the Lithia, the other as the Alum Spring. They yield about five hundred gallons of water per day. A qualitative analysis of the lithia water by Dr. W. H. Taylor, State chemist at Richmond, showed the presence of lime, magnesia, soda, lithia, potash, iron, silica, sulphuric acid, carbonic acid, and chlorine. The alum water was analyzed at the Smithsonian Institution and found to contain about the same ingredients, except that the lithia was replaced by alum. The water is sold to some extent, but the property has never been much developed and no hotel accommodations have been provided.

James K. Crook.

POWNAL SPRING.—Cumberland County, Maine.—Post-Office.—West Pownal. Hotel.

Location.—Eighteen miles from Portland and ten miles from Poland Spring.

Access.—Viâ Grand Trunk Railroad to West Hanover Station, or Maine Central Railroad to Pownal Spring Station.

The surroundings of the spring are very pleasing to the eye. The White Mountains, in the distant northwestern horizon, form an impressive background, while to the southward a wide panorama is unfolded to the view of the beholder, even Portland harbor being easily seen by the aid of a small glass. The location of the spring is upon land higher than any other in the immediate vicinity, thus giving no opportunity for surface pollution. The water comes apparently from the solid rock, and is clear and sparkling. The average temperature of the water as it emerges is 42° F. This is subject to a variation of only one degree in either direction during the entire year. The following analysis was made by State Assayer Franklin C. Robinson, professor of chemistry at Bowdoin College in 1893:

Reaction neutral. One United States gallon contains: Silica, gr. 0.41; iron carbonate, gr. 0.04; calcium carbonate, gr. 0.33; magnesium carbonate, gr. 0.02; sodium carbonate, gr. 0.09; sodium sulphate, gr. 0.08; sodium chloride, gr. 0.16; potassium carbonate, gr. 0.02. Total solids, 1.15 grains.

Organic and volatile matter, 0.01 grain. The water is bottled and sold. It is recommended for the table, and is said to be useful in dyspeptic and urinary complaints, but the remarkable attenuation of the water would appear to require the ingestion of large quantities in order to secure appreciable therapeutic effects.

James K. Crook.

PREMATURE INFANTS.—By premature infants we mean those babies which are born before the two hundred and eighty days, considered the normal length of intra-uterine gestation, have elapsed, and after the period of viability of the child. This period, however, is only arbitrary, and varies within relatively wide limits. In this respect much depends upon the nourishment of the fœtus prior to birth, the health of the mother during pregnancy, the conditions demanding or leading up to the interruption of pregnancy, the character and duration of labor, the difficulty attending its birth, as well as the care of the infant after its advent into the world. Consequently, in a syphilitic, tuberculous, or albuminous mother, in a case of placenta prævia or of accidental hemorrhage or eclampsia, in a dry, protracted labor, after a breech, forceps, or version delivery—in all these conditions, on account of the immature development of the vital organs, the chance of survival of the baby is very much reduced.

There are cases on record in which it is claimed that the child in utero reached only the twenty-fourth week and yet lived. Perhaps, in the future, advances in our knowledge of their care will enable such infants, born before the date supposed to be compatible with life, to survive. It is more likely, however, that such cases are reported with mistaken calculations.

There are no characteristic appearances, no exact development upon which we can definitely state the age of the infant when it is born. The weight, the length, and development all vary for a given length of gestation and statistics given are only approximate, but yet of sufficient value to guide us somewhat in the management of such infants. It is therefore generally the rule that if the infant is born alive, we must endeavor, without regard to size and characteristics, by the best care and latest knowledge, to preserve its existence.

The general characteristics in the clinical picture of a premature child are as follows: The head is very large in proportion to the body, the abdomen is prominent, the movements are very weak, the body is limp, and the child has a senile, emaciated, and wizened-up appearance.

At the *twenty-fourth week* of intra-uterine life a fœtus, when born, usually breathes feebly. Some cannot cry, although others will give a faint mewl. The infant is covered by lanugo. Its eyelids have separated, though it is so feeble that it cannot often open and shut them. There is very little subcutaneous adipose tissue. It measures about 28–34 cm. (11¼–13¾ in.) in length and weighs 676 gm. (℥ xxiii.). The testicles are only at the inguinal rings. This fœtus may live from a few hours to fifteen days, but would in all probability die from insufficient assimilation after a weak digestion of food, from rapid loss of heat or from imperfect respiration. At the *twenty-eighth* week the fœtus measures in length from 35 to 38 cm. (13.75 to 15 in.) and weighs 1,170 gm. (41¼ oz.). The soles of the feet and palms of the hands are not covered by lanugo. The pupillary membrane, which had hitherto obscured the pupil, has now disappeared. The skin is still wrinkled, covered by vernix caseosa. The child still has an emaciated appearance. Such an infant with good care can live, but most of them die. There persists, however, in the minds of some of the old practitioners and among the laity, the idea that a child born at the seventh month is more apt to survive than one born at the eighth month. Of course this is nonsense, for the development and functions of the vital organs are by far less advanced at the earlier than at the later date, and it stands to reason that the elder fœtus will be stronger thereafter. Professor Parvin, in his "Science and Art of Obstetrics," tells how this superstition has descended through more than two thousand years from Hippocrates. The Greek explained it in this manner, that the fœtus is placed with its head at the fundus in the uterus until the seventh month when the increasing weight of the head causes it to descend to the lower zone. As soon as this occurs, the fœtus attempts to escape, and if it is strong it succeeds; but if the attempt fails, it tries again

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at the eighth month, and if the infant now succeeds in escaping from the uterus, being exhausted by its previous effort, it is more apt to succumb.

At the *thirty-second* week the fœtus measures 39–41 cm. (15½–16 in.) in length, and weighs 1,571 gm. (3½ lbs.). The hair on the scalp is longer and more abundant; the down on the face is disappearing. One of the testicles, usually the left, has descended into the scrotum. The nails are firmer, but do not quite reach the finger tips. There is ossification beginning in the lower epiphysis of the femur. The child has lost some of its senile appearance and emaciation due to the increased deposition of subcutaneous fat. At this period, with proper care, the child ought to live. At the *thirty-sixth* week the infant measures 42–44 cm. (16½–17¼ in.) in length, and weighs 1,942 gm. (4¼ lbs.). There is a decided increase in subcutaneous fat. The nails are not yet perfectly developed. The lanugo has disappeared and the bones of the head are still soft and very compressible. The infant is much stronger, but is still in a condition to die easily unless well cared for.

A detailed description of a premature child is as follows: The *head* is excessively developed and consequently its contents (the brain) are excessively developed in comparison with the diminutive characteristics of the rest of the body. Yet the head is very soft and compressible, for the bones themselves are very poorly ossified, thin, and parchment-like, crackling under pressure, and the sutures and the fontanels are wide open. Consequently the symmetry of the head is easily destroyed, considerably so in the moulding of delivery, not only by the bony pelvis, but also even by a rigid cervix or perineum, yet more so in prolonged positions of the head after birth. The moulding is usually temporary and the bones ordinarily quickly resume their proper relations. However, if the child continuously lies on one side of its head, even though the pillow is very soft, from its mere weight a marked deformity develops. This can be avoided by letting the child lie on alternate days first on one side and then on the other.

Abdomen.—The abdomen is almost always relatively distended, due in a great measure to the large size of the liver and the accumulation of gas in the intestines whose peristaltic movements are very weak. This distention may last for many weeks, and the gradual return of the abdomen to a normal size is a good sign in the gradual development of the infant to the status of a child born at term.

Skin.—The skin is of a dull, brownish-red, more markedly so at first than at a later period; when the child cries this color changes to a brighter and healthier red. Aside from this, the color is apt to vary considerably at different times, for premature infants are prone to erythematous rashes, and are almost regularly icteric after the second or third day. If the child is doing poorly the skin is pale, transparent, dry, scaly, and waxy white, sometimes œdematous. It is soft and delicate, so thin in some spots, especially over the forehead and skull, that the superficial veins shine through. In other places it is very wrinkled, due to lack of adipose tissue; a condition which gives to the body and extremities an emaciated appearance and to the face a senile expression. There is present a varying amount of lanugo, depending on the degree of prematurity. The nails are soft and short, they do not reach the ends of the digits; this is more noticeable on the toes. The sweat glands are supposed to be undeveloped, but certainly many premature babies perspire profusely if the temperature of the incubators is too high. On the other hand, the sebaceous glands are moderately active, yet more so before birth than afterward.

The *extremities* are thin and emaciated, with apparently atrophied muscles. According to Dane the instep is as well developed as is that of an adult.

The *movements* are few and slow, but at times spasmodic.

The *respirations* are shallow, irregular, and superficial, and often suspended for a time. The little one sucks slowly and weakly, and swallows with difficulty, and the mere effort is followed by more or less exhaustion.

The *tissues* of the infant are not yet sufficiently developed to meet the demands of extra-uterine life; this is especially true of the *gastro-enteric tract*. The capacity of the stomach is small, varying with the weight and size of the child. The walls are weak and thin, and an organ holding at first two or three drachms will easily dilate until it has a capacity of an ounce or even an ounce and a half, much to the infant's loss. Even absorption is slow and inefficient, and the digestive juices are lacking in ferments. The amylolytic function is practically suspended, and should not be depended upon at all for the digestion of starches. Sugar, on the other hand, is a foodstuff most easily taken care of by simple absorption. It is needed to keep up the animal heat, which is so easily lowered in the premature child, and consequently is of great importance. At first it should be given in lower percentages till the gastro-enteric tract is accustomed to the new work which it is required to perform. The function of digesting fats and albuminoids is far inferior to that of a full-term child; and all formulæ should consequently at the beginning be very low in such ingredients; even breast milk must be well diluted in the more premature children for a number of days after birth.

The *intestines* of a premature child contain meconium, and after a few days, if the digestion is good, the fæces assume the normal golden-yellow color. These infants, however, are prone to constipation on account of weak peristalsis, and often the stools contain curds, and too easily become frequent, green, acid, and slimy.

The *heart* is relatively large, but its action is weak. The foramen ovale often remains patulous for a longer period than if the infant were born at term. Inasmuch as the air cells of the lungs are by no means all in use for oxygenation, and inasmuch as the blood soon becomes impoverished from insufficient nutrition, large demands for increased work are made upon this vital organ. Consequently the infant should be kept quiet and no useless extra work should be put on the circulation, which is in such a precarious condition, not only on account of the many changes which occur with the first respirations in different structures of the body, but also for the reasons mentioned above. The pulse is more rapid than that of a normal infant, but it is not permissible to base a prognosis upon this fact.

The *blood* at birth contains an excessive amount of hæmoglobin, but it is loosely held in the red corpuscle, and the infant readily loses it and becomes anæmic. Destruction of hæmoglobin is going on rapidly and its manufacture progresses but slowly and for many days does not make up the loss. The blood itself, especially in those cases which are doing poorly, soon becomes thin, watery, and deficient in all its solid and vital ingredients. The child consequently often becomes waxy-white and œdematous.

The *animal heat* of the infant is easily affected. Deprived of its source of combustion and insulation (the subcutaneous fat), variations occur quickly and readily. Thrust at birth suddenly into an atmosphere twenty-eight degrees lower than that to which it had been accustomed hitherto, no wonder the temperature falls simply from radiation. The metabolism is too slow to manufacture enough heat to maintain a constant temperature, and the strain upon an uneducated heat centre is not borne. Again, another reason why the temperature is subnormal is that the premature infant with all its vital organs undeveloped is called upon to furnish more heat than the child at term, for we all know that the smaller the animal the greater is the surface exposed for radiation. Consequently the temperature is lowered both by an insufficient heat production and by an excessive loss of heat, which the heat centre is powerless to control and therefore to set in equilibrium. So spasmodically does this centre act that the temperature of the child will for trivial causes run very high. This is especially the case during the first few days of life, and it is often very difficult, even in a well-regulated incubator, to keep this

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temperature normal. Besides, slight gastro-intestinal troubles, as vomiting, constipation, or diarrhœa, will cause sudden rises which do not occur so readily in the full-term baby.

The *lungs* are also in a very undeveloped state, and although they are sufficiently developed to carry on their functions in extra-uterine life, the tissues of the respiratory tract are very sensitive and easily become inflamed. Especially is this true of the nose, nasopharynx, and mouth, for here infection readily occurs from inhalations of dirt and dust. Besides, even though the baby has cried very well at birth, the respiratory efforts do not at once aërate more than the anterior lobules of the lungs. Some of the children remain blue, breathing and crying weakly, and die in a few days. Others gradually make a greater use of their lungs, but from slight causes they acquire a secondary atelectasis in addition to the fœtal condition posteriorly. The irregularities of the respiration are very marked. Adriance explains this condition on the basis of his studies of the embryology and pathology of the lung. Before the fourth month of fœtal life there are no alveoli, and the bronchioles are far apart in the mesenchyma. In the development the tubes ramify rapidly. From this we see that, if a child is born prematurely, the bronchi predominate and the few alveoli are enclosed in connective tissue. The blood-vessels of the lungs are composed of a rich, unsupported capillary network, whose elastic walls are readily stretched and so encroach upon the air vesicles. The feeble respiratory movements permit of collapse of the air vesicles and engorgement of the vessels—conditions which result in hypostasis and atelectasis, posteriorly and inferiorly. Besides, the bony framework is poorly adapted for aëration. Being cartilaginous and very elastic, even with a strong muscular effort at respiration, the lower part of the chest is drawn in, especially over the sternum, and only a very little air really enters the alveoli. Cyanotic attacks consequently are very frequent and often fatal. The respiratory centre, like that of heat control, is spasmodic and weak in action. These respirations are often delayed, feeble, and even Cheyne-Stokes in character, and this undeveloped centre is often responsible for the cyanosis which ensues. Every autopsy on premature children who have died within a week or so after death shows atelectasis, and the weak pulmonary organs are responsible for most of these deaths.

The *liver* is very large and fills over one-half the space in the abdominal cavity. Bile is secreted in great quantities, and it is probably to over-production by the liver cells and to engorgements of the ducts that we must attribute the regular and early occurrence of icterus neonatorum.

The *kidneys* also perform their functions irregularly. For a day or two no urine is voided. Uric acid is secreted in abundance, for the napkins of the child are often stained with the characteristic pink color, and the pyramids almost always on autopsy are found to be plugged with uric-acid infarctions.

Prognosis.—The weight of a premature child varies, for the same duration of intra-uterine life, for many reasons; consequently we must base our prognosis less upon the weight at birth than upon the general condition of the child. Yet it goes without saying that, other things being equal, the more premature the child the less is the probability of its survival. The daily progressive gain, on the other hand, furnishes by far the best indication that matters are progressing satisfactorily; yet one has to wait a long time before this is manifest. Premature children, even though weighing less at birth, have a greater initial loss, and a loss which extends over a longer period, than the full-term child. It is not uncommon for a child weighing three and three-quarters pounds or thereabouts to lose from ten to fourteen ounces and to continue to lose for from ten to seventeen days. This is due to the immaturity of the digestive tract, and to the fact that the babies are invariably intensely jaundiced. On account of the latter condition they lie in a stupor, are with difficulty aroused, and take their nourishment very poorly; then besides, they gain more slowly. If the infant has, at the end of three or four weeks, regained the weight which it had at birth, it will have done very well. If, on the other hand, the loss is progressive, sooner or later there will be a fatal outcome. The prognosis then depends on the general condition at birth, on the degree of prematurity and most of all on the subsequent care. Extremes of temperature must be guarded against. Attacks of cyanosis are not necessarily fatal, but they render the chance of survival very doubtful. If the child lives for four or five days, and the attacks are decreasing in number, the outlook is more hopeful.

Treatment.—There are four distinct objects which must be kept in view in the care and management of premature children.

1. The maintenance of a proper temperature.
2. The prevention of exhaustion.
3. The administration of the proper amount and kind of nourishment.
4. The avoidance of infection.

Premature children can be divided into three classes: (1) Those treated as babies at term. (2) Those wrapped in cotton. (3) Those placed in the incubator.

The weight, length, appearance of the baby, and even the assumed period of gestation, calculated from the mother's last menstruation, are simply relative in estimating the exact duration of fœtal life. It is by far a better procedure to consider the general condition of the infant, together with the above, before we put it into one class or the other. The majority of the babies would do better if they were to be placed in the last class from the beginning. Without a couveuse the best plan is to put a baby in cotton and surround it by hot bottles. Some babies will thrive in this way, but most of the very premature will not.

There are many kinds of incubators in use, notably those of Denuce, of Bordeaux, who in 1857 produced the first one which gave satisfactory results. In 1880 Tarnier constructed one which was afterward improved by Auvard. Credé also invented one which was successfully used. The brooder of Dr. Rotch, of Boston, is a very intricate and elaborate affair, in which the baby can be weighed without removal. The best one is probably that of M. Lion, of Nice, first used in 1891. It is composed of a parallelopiped of metal, standing on iron supports. It can be disinfected without deterioration by means of a steam stove under pressure or by cleansing with a solution of carbolic acid or with formalin gas (Fig. 3879). Ventilation is obtained by means of a tube, of about three inches in diameter, which enters the compartment low down on the left side. The exit is through a chimney in which is a fan, indicating by its rotation the strength of the current of air. The air on entrance is filtered by a gauze and cotton diaphragm. The front is fitted with glass doors, through which the infant can be seen, while at the side is a glass window by means of which the nurse can attend to the infant's wants without removing it. The baby is placed in the middle on a soft pillow, the warm, fresh air circulating about it. The air is kept moist by a large pan of water placed in the bottom. A thermometer is hung close to the door, and a hygrometer is fastened to the posterior wall of the chamber. The heating is effected by means of a siphon through which hot water circulates, and which communicates with a reservoir at the side. The temperature is automatically regulated by a metallic thermostat, which lifts or lowers a cap over a flame. This apparatus is very expensive, and therefore adapted for use only in hospitals or in wealthy families. Besides the Lion incubator, there is available a cheap modification of the Tarnier or Auvard couveuse, which any carpenter can make at a small expense. The main point in its construction is that there should be plenty of inlets and outlets for free ventilation. The disadvantages of this apparatus are, first, the lack of filtration of the air, and, second, there is no thermostatic regulation of the temperature. To ob-

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viate the latter difficulty, therefore, careful attention will be necessary. A temperature as near constant as possible is to be obtained by varying the size of the flame and its distance from the tube connecting with the main tank of water (Fig. 3879).

In order to secure the maximum amount of fresh air the incubator—whatever kind is used—should be placed in the hall or in a large cool room. The direct rays of the sun ought never to strike it, because their heat would quickly unbalance a constant temperature. Before putting a baby into the chamber the apparatus should be thoroughly disinfected, as these infants are very susceptible to infection. The baby should lie on a very soft pillow.

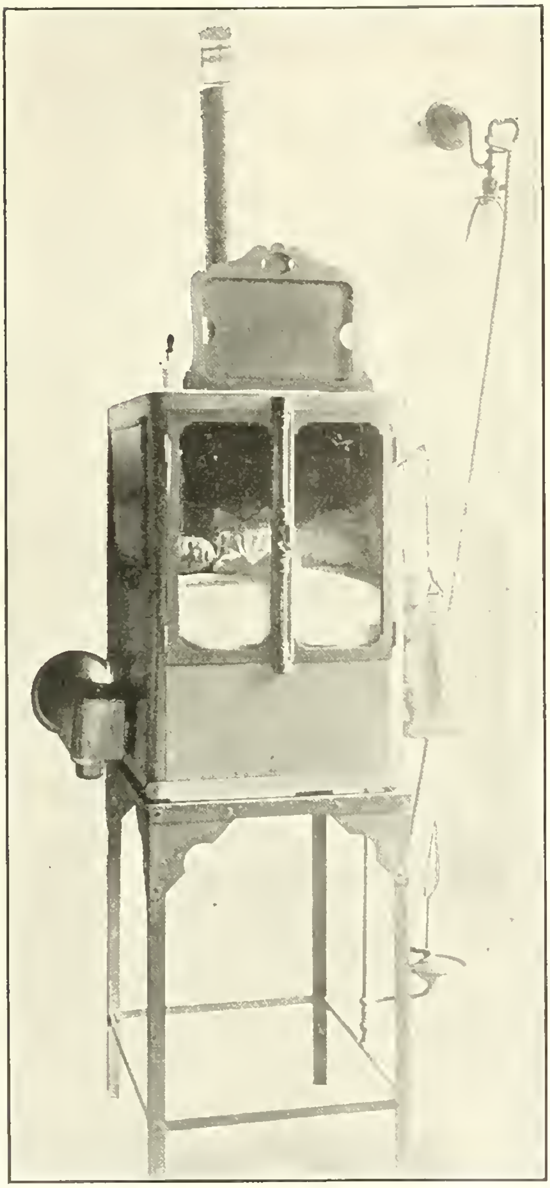

FIG. 3879.—Incubator of M. Lion, of Nice, France. (From the *Archives of Pediatrics*.)

The temperature should vary with the infant. It should be one which will keep the baby's temperature normal without exciting perspiration. I have found that a temperature of from 86° to 92° F. is about right. A variation of a degree or two makes but little difference. If a premature baby is expected, an incubator, the air of which is at a proper temperature, should be in readiness, at the time of its birth. The baby itself is first made to cry lustily (not with harsh methods of resuscitation, but mainly by the employment of hot baths and light titillation, and perhaps by easy swinging), and then the cord is quickly tied off and suitable dressings are applied. After the child has been weighed and anointed with albolene, but not bathed, it is dressed. A mistake is made in enveloping these infants in cotton. So wrapped up they will be too warm and will perspire too freely. The best clothing is a small light shirt and a napkin from the waist down, pinned over the feet and legs (Fig. 3881). When the baby is placed in the incubator it should not be removed, except to be weighed or nursed. The latter is not permitted until it is thriving. The weight is taken every five, seven, or ten days, and about once a week the infant is lightly sponged.

The napkins should be changed three or four times a day, only often enough for cleanliness, and in such a manner as to disturb the baby as little as possible. Before feeding, however, especially when the baby is stupid or sleepy, a light tap on the hand will make it take the bottle with much less coaxing and more rapidly.

The infant should be kept in the incubator until it has reached the development of full term, or longer if it is not improving. Some of the babies, nevertheless, will do well in cotton after having been given a good start in the couveuse. If possible, the temperature of the incubator should be gradually lowered almost to that of the nursery, before the baby is permanently subjected to the variation in the temperature of the air of an ordinary room.

In the administration of nourishment the amount and quality should depend on the age and digestive powers of the infant. Ordinarily, six hours after birth, the child should be given a warm sugar solution (five to six per cent. lactose in distilled water), about one-half to one drachm every hour. After from twenty-four to thirty-six hours an equal part of breast milk should be added. This is obtained by massage and expression, by the breast pump, or by spontaneous expression while a baby is nursing the other breast. If the best results are to be obtained, this milk should not be taken from the mother, but from a wet-nurse at least seven or eight days post partum—*i.e.*, at a time when the quality of her milk is about established, or at any rate when it is comparatively free from colostrum.

The amount of fluid nourishment administered is to be gradually increased, a drachm at a time, so that by the end of a week the child will be taking from six drachms to an ounce every hour. If the stools are normal, the breast milk can be gradually increased and the sugar solution gradually diminished; or, by the addition of a little lime water, the infant can often be put on pure breast milk at the end of two weeks. On this plan there should be little or no vomiting, and the stools should be normal, or nearly so, from the beginning.

The method of feeding can in almost all cases be carried on by means of sucking through a small nipple, especially if a little coaxing is resorted to. In some cases a medicine dropper or a feeder, such as is recommended by Rotch, can be tried if the baby refuses to suck. In others who are extremely weak and who will not swallow, gavage is necessary. In the experience of most men these cases do not do well; one likes, therefore, to get back to the bottle as soon as possible. The infants are apt to regurgitate, the milk fills the nares or nasopharynx, and when the baby takes its next inspiration some of the fluid is drawn into the larynx and even into the bronchi. This may cause an immediate asphyxia, an atelectatic area in the lung, a bronchitis, or a bronchopneumonia, which will soon end in death.

As soon as the baby is strong enough and is perceptibly gaining, it can be tried at the mother's breast. At first, two or three times a day is sufficient. If the child

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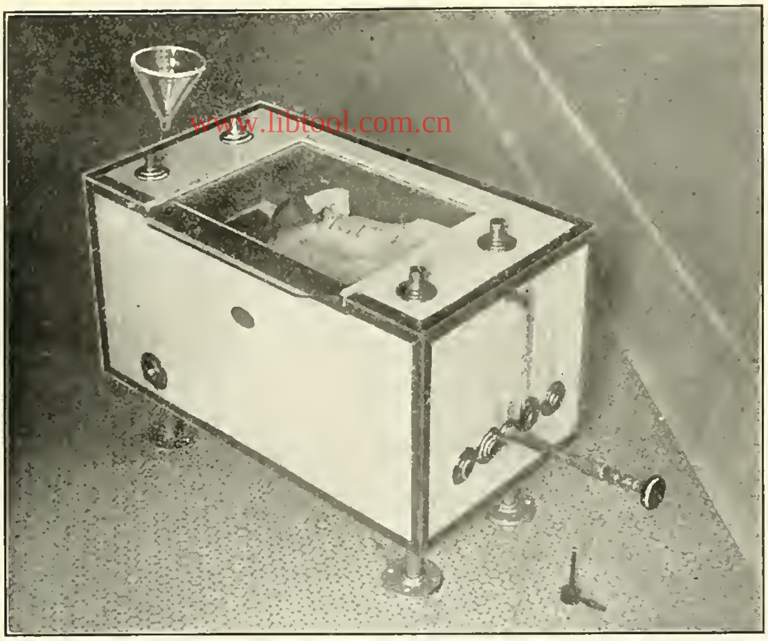

FIG. 3880.—Cheap Incubator in Use at the Sloane Maternity Hospital. (From the *Archives of Pediatrics.*)

does well, the number of nursings is gradually increased to every two hours. At the same time it is generally necessary to give the child the breast between these stated periods, and also to supplement the nursing by the bottle.

Dr. Rotch says that the best method of feeding premature infants is to give them the food which is carefully prepared at the milk laboratories; this food being, as he believes, far superior to mother's milk. In the experience of others, although weak modifications of cow's milk—as fat one per cent., sugar six per cent., and albuminoids 0.33 per cent., or even lower percentages—have been used, the results have not proved satisfactory, except in a very few cases. Mother's milk is the ideal food, and when it is possible to obtain it, every premature child should have it. Yet the variation in the composition of this breast milk in the first few days must be thoroughly understood if good results are to be obtained, for it often acts as a rank poison to the child. The colostrum is already well known as a highly albuminous laxative secretion, and in many cases it purges the new-born infant to an extreme. For a more complete and positive chemical analysis of human milk we are indebted to John S. Adriance. He has demonstrated the peculiarities in its composition during certain periods of lactation. His results are as follows: During the first few days the irregularities are most marked. The colostrum in the breast of a woman delivered at term shows a wide variation in amount of fat; the sugar is low at first, but increases rapidly, and by the end of the first two weeks makes a marked increase; the proteids, on the other hand, fail rapidly during the first few days from a maximum amount on the second day, but less rapidly thereafter. This colostrum then is rich in proteids, due to the sudden assumption of the mammary function and to the transudation of serum from blood-vessels into the breast secretion.

Even to a greater degree are these characteristics shown in the colostrum after a premature labor, and the high percentage of proteids exists for a much longer time. Consequently, the premature child should not at first nurse its mother, but a wet-nurse secured at least temporarily.

In the mean time the mother's breasts should be pumped and massaged or nursed by a baby at term, so that they will not dry up. After a time the mother's milk can be given diluted with a sugar solution, and this should be kept up until the mother's milk becomes normal, the change from wet-nurse to mother being made gradually. In this way gastro-enteric symptoms may be avoided.

In some babies the color is poor from the beginning, and at any time they are especially liable to attacks of cyanosis. For these conditions a little slapping to cause a good cry or the administration of oxygen will dissipate the blueness. Often the administration of a few drops of brandy in hot water every two or three hours will prevent further trouble. One must be very sure, however, that nothing has been aspirated into the larynx.

A great danger in the care of these babies is their susceptibility to infections. The incubator itself is a great germ carrier and should be regularly disinfected. The weakness of the lungs and gastro-enteric tract makes the infants especially vulnerable. Unless the air is filtered, dirt is carried in continuously; consequently the streptococcus, staphylococcus, and pneumococcus are always present.

FIG. 3881.—Clothing for Incubator Baby. (From the *Archives of Pediatrics.*)

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seeking an avenue of entrance. Through the skin in eczematous spots or in areas of irritation, at the navel, through the eyes, nose, mouth, larynx, lungs, stomach, and rectum, the bacteria can gain admission. To prevent infection, then, the most careful cleansing is necessary, both of the incubator and of the baby itself. Undoubtedly many of the later deaths can be traced to this source.

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Finally, in the carrying out of the above essentials in the proper management of the premature infant, the most patient and painstaking attention on the part of the nurse is necessary, and upon her conscientiousness depends the chance of its survival.

Results.—The statistics furnished here are taken from 2,314 births which occurred at the Sloane Maternity Hospital in the two years from October 22d, 1897, to October 22d, 1899, before which time there had been no incubator in use.

Four hundred and ten of these babies were premature, but of these 74 were still-births, which included macerated fœtus and the still-born babies of cases of placenta prævia, accidental hemorrhage, eclampsia, and the like. There remained, therefore, 336 which were suitable for treatment.

Among these cases was a set of triplets and there were 18 pairs of twins; 85 were treated as infants at term, and of these 4 died—a mortality of $4\frac{7}{8}$ per cent.; 145 were put in cotton, and of these 12 died—a mortality of 8 per cent. Some of this class should have been placed in the incubator, but for lack of room it was impossible to do this; 106 were incubator babies. These are divided into two classes: I. Those that died within four days of birth; II. Those that lived longer than four days.

I. Twenty-nine of the incubator babies died within four days. All of these but 3 were more or less asphyxiated at birth; 9 were breech cases, and of these 5 were difficult extractions; 3 were delivered after an accouchement forcé in placenta prævia. The rest were vertex presentations; but, of these, 2 were forceps deliveries; 6 were under seven months of uterine gestation; 22 had reached a period of between seven and eight months, and 1 a period of eight and a quarter months.

The causes of the premature labor were as follows: an endometritis in 14, syphilis in 2, albuminuria in 1, placenta prævia in 3, accidental hemorrhage in 1, persistent vomiting in 1, twin in 1, violence in 1, and in 4 the labor was induced. The largest baby weighed $5\frac{7}{16}$ lbs.; the smallest, $2\frac{7}{16}$ lbs. Only 5 infants lived over twenty-four hours; 24 were in such poor condition at birth that they survived only a few hours. In 16 of these cases autopsies were held, and in all of these there was marked atelectasis; in 7 hemorrhages of some degree, either into the brain or into the serous membranes; in 2 the foramen ovale was still patent.

II. Seventy-seven incubator infants survived the first four days; 51 were children of primiparæ, 27 of whom were out of wedlock; 3 infants were under seven months of gestation; 8 were over eight months, and the rest between seven and eight months along; 9 were breech presentations; 1 a transverse and the rest vertices; 2 were of triplets associated with albuminuria; 18 were in twin deliveries, associated with albuminuria or hydramnios. The causes of the premature labor were: endometritis in 27; syphilis in 4; phthisis in 2; albuminuria in 7; accidental hemorrhage in 1; placenta prævia in 1; in 2 the labor was induced for albuminuria and eclampsia; 1 was a Cæsarean section; another an ectopic gestation; the cause, in the remainder, was unknown. Seven were delivered by forceps, 2 by version, 1 by accouchement forcé, 1 by Cæsarean section, and the ectopic gestation by a laparotomy; 12 were slightly asphyxiated at birth, 9 moderately so, and 5 deeply asphyxiated; 2 after one and a half hours' work of resuscitation were put in the incubator, head downward, and their condition was so poor that they were expected soon to die, but they left the hospital gaining in weight; 5 weighed less than 3 lbs., 38 between 3 and 4 lbs., 33 between 4 and 5 lbs., 1 over 5 lbs.; the average weight was $3\frac{13}{16}$ lbs. During their incubator life 28 had one or more attacks of atelectasis. All but 10 were more or less jaundiced. The initial loss of the infants was from 1 to $17\frac{1}{2}$ oz.; the average was 7 oz. These figures are not quite correct, as the babies were weighed at different intervals, some on the fifth day, some on the seventh day, and others not till the fourteenth day.

The period of loss lasted for from five to twenty-two days, the average, eleven days; 10 lost steadily till death; 1 baby was in the incubator only three days, while another lived there eighty-two days. The average time was nineteen days. Some were removed early to make room for others who needed the place more urgently.

Only 3 of the 77 cases vomited. The stools were normal in 32.

One was discharged from the hospital as early as the eleventh day, and others also too soon, at their mothers' demand. One was eighty-nine days old, the average was twenty-four days.

In 16 diluted breast milk was supplemented, at times, with a mixture of cow's milk and water with Russian gelatin and lactose. In 10 a 1% proteid, 6% sugar, and 0.33% albuminoid modification of cow's milk was used. In all the rest diluted breast milk was relied upon. Twenty-seven never nursed at the breast; of these 12 died. A few nursed as early as the third or fourth day, two or three times a day; others not for three weeks, and one not till the sixty-eighth day. Of the 77, 13 died in the hospital, a mortality of nearly 17 per cent. The cause of death was atelectasis and bronchitis in 7, acute asphyxia from a curd in the larynx in 1, syphilitic pneumonia in 1, cerebral hemorrhage in 1, gastro-enteritis in 3, and a patent foramen ovale and ductus arteriosus in 1. The condition of 3 was poor at time of discharge, fair in 24, and very good in 37; 32 were above their birth weights and 57 were gaining in weight. To letters written about January 1st, 1900, no answer was obtained from 28. Thirteen were reported as having died; 1 of these lived fourteen months, 1 nine months, 1 four and a half months, 3 lived two months, 6 lived six weeks, 1 only a month. Five of these children died at the Nursery and Child's Hospital and 2 died at Bellevue Hospital. They were bottle-fed, and the probable cause of death was gastro-enteritis. Twenty-one were found to be *alive* and doing well. Some had nursed and the others were bottle-fed. The oldest baby was twenty-two months and almost all were good specimens of healthy children. One baby at seven months weighed 16 pounds. It weighed $4\frac{1}{16}$ pounds at birth and nursed its mother after leaving the hospital. The ectopic and the Cæsarean babies were in fine condition.

STATISTICS.

Incubators.	Tarnier.	Charles.	Sloane Hospital.	At the Sloane Hospital, not counting those which died in a few hours.
Saved at 6 months.	16 per cent.	10 per cent.	....	....
" $6\frac{1}{2}$ "	36 "	20 "	22 per cent.	66 per cent.
" 7 "	49 "	40 "	41 "	71 "
" $7\frac{1}{2}$ "	77 "	75 "	75 "	89 "
" 8 "	88 "	....	70 "	91 "

From this table it appears that the statistics* at the Sloane Maternity Hospital are not so good as Tarnier's, unless those babies who were in very poor condition at birth and who died in a few hours, are omitted.

James D. Voorhees.

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* Tables containing more extensive data relating to these seventy-seven cases will be found in the Archives of Pediatrics for May 1st, 1900.

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PRESBYOPIA—Pr—from πρέσβυς, old, and ὤψ, eye; Fr., *presbytie*, from πρεσβύτης, an old-sighted person—is "the condition in which, as the result of the increase of years, the range of accommodation is diminished, and the vision of near objects interfered with" (Donders[1]). The range of accommodation diminishes year by year, from about 15 dioptries, at the earliest age (ten years) at which accurate observations have been made, to about 1 dioptrie, at the age of sixty-five or seventy; at forty it amounts to something less than 5 dioptries, and at forty-five to about 3.5 dioptries.[2]

Of the 15 dioptries of accommodation which the child of ten years is able to bring into exercise, from two-thirds to three-fourths (10 to 11 dioptries) may be lost without greatly incommoding an emmetrope in ordinary near vision. In emmetropia the distance (P_2) of the binocular near-point (p_2) is the reciprocal of the number of dioptries representing the binocular range of accommodation; hence, with a binocular range of accommodation of 5 dioptries, $P_2 = \frac{1}{5}$ metre (20 cm.), at which distance the smallest print in ordinary use is easily deciphered by eyes of average visual acuteness; when the binocular range of accommodation is reduced to 4 dioptries, $P_2 = \frac{1}{4}$ metre (25 cm.), at which distance ordinary newspaper print may still be read easily; with the loss of another dioptrie of accommodation (leaving but 3 dioptries available), $P_2 = \frac{1}{3}$ metre (33.3 cm.), and the reading of fine print becomes difficult, except under the conditions of good illumination and perfect acuteness of vision. These several values of P_2 correspond, in emmetropia, to ages ranging from about thirty-eight to about forty seven years, and comparatively few emmetropes attain the latter age without seeking aid from convex glasses in reading or other fine work; the adoption of convex glasses by an emmetrope under forty is generally determined either by the exceptionally exacting nature of the work in which he habitually employs his eyes, or by the fact that his acuteness of vision is somewhat below the normal. When at the age of from fifty to fifty-five years the range of accommodation has become reduced to 2 dioptries, $P_2 = \frac{1}{2}$ metre (50 cm.), and the book must then be held at arm's length, at which distance only the larger sizes of print can be read; but, even with this range of accommodation, a public speaker may be able to read fluently from a plainly written manuscript lying before him upon a reading-desk or table.

The diminution of the range of accommodation with advancing years is a strictly physiological change, and is directly related to the progressive hardening of the crystalline lens, in consequence of which it becomes less and less capable of undergoing the change in curvature required for the adjustment of the eye for near vision. As this hardening of the crystalline occurs in all eyes alike, irrespective of their refractive condition as determined by the relation of the curvature of the refractive surfaces to the length of the axis of the eyeball, it would seem to be scientifically correct to define presbyopia as the loss of accommodative power incident to advancing years. Immemorial usage has, however, associated the name with the particular condition in which, as a result of increasing age, near vision becomes indistinct while distant vision remains either absolutely or relatively unimpaired. As thus defined, presbyopia is an incident in the life-history of all emmetropes and hypermetropes, and also of myopes whenever the myopia is of low grade—3 dioptries or less. In myopia of higher grades, 4 dioptries or more, the distance of the far-point remains within $\frac{1}{4}$ metre (25 cm.) of the eyes; so that, even with total loss of accommodation, it may still be possible to read fine print without the aid of glasses.

The striking contrast between the vision of myopes, who see only near objects distinctly, and that of presbyopes, who see distant objects clearly, while near objects appear confused, was very early recognized,[3] and, in the absence of any definite theory of accommodation, presbyopia was, for more than two thousand years, regarded as the opposite condition to myopia. Hypermetropia, the true opposite of myopia, remained confounded with presbyopia until after the middle of the nineteenth century, when the demonstration of a change in the form of the crystalline lens in accommodation by Cramer,[4] and, independently, by Helmholtz,[5] and the masterly analysis of the phenomena of accommodation in its relation to the several anomalies of refraction, by Donders,[6] dispelled the cloud of obscurity in which the whole subject had been so long enveloped, and through which only occasional glimpses of the truth had been previously enjoyed by a few exceptionally acute investigators.[7]

Premonitory signs of presbyopia may often be detected in emmetropes as early as the thirty-sixth year; exceptionally fine print, such as No. 1 of Jaeger's scale, being no longer read with the same perfect fluency as in youth, especially if the illumination is defective. Within the next five years newspaper print loses a little in sharpness of definition, and the finest needlework becomes difficult and perhaps deteriorates somewhat in quality. If the acuteness of vision (V—see *Optometry*) is normal, and the print not too fine, relief from the increasing strain in accommodation is obtained by holding the book or work a little farther from the eyes; but if vision is subnormal, or if the print is bad or very fine, a stronger illumination may be demanded, without increasing the reading distance. By the age of forty-five the disability has generally increased to the point that only fairly large print can be read with ease by ordinary artificial light, and a more powerful lamp is procured or the book is held nearer to the light; about this time the need of help from glasses commonly suggests itself.

A hypermetrope habitually wearing neutralizing (convex) glasses, or a myope wearing neutralizing (concave) glasses, experiences the disabilities of presbyopic vision at about the same age, and in about the same degree, as the emmetrope; thus, between the ages of forty and forty-five, the hypermetrope discovers that his convex glasses are no longer quite sufficient in reading, and similarly, the myope discovers that his concave glasses have become something of a hindrance in near vision, although in both cases the neutralizing (convex or concave) glasses continue to serve perfectly for distant vision. A change to stronger convex glasses by the hypermetrope, or to weaker concave glasses (or, perhaps, the temporary removal of his glasses) by the myope, is the remedy which now suggests itself, and which is, sooner or later, adopted. With a change of glasses reading again becomes easy, but with a corresponding falling off in the distinctness of distant vision. For this reason, an elderly emmetrope either removes his glasses or looks over them when not engaged in near work, and a presbyopic ametrope ordinarily requires two pairs of glasses, the one pair (neutralizing) for distance, the other pair (stronger convex or weaker concave) for reading and other near work; the inconvenience attending the use of two pairs of glasses may be obviated, in many cases, by wearing so-called bifocal glasses, in which both corrections are mounted in a single setting before each eye (see *Spectacles*).

A hypermetrope, not wearing convex glasses, experiences the disabilities of presbyopia at an earlier age than the emmetrope, after having, perhaps, passed through a more or less protracted stage of suffering from asthenopia (see *Asthenopia*). In myopia, on the other hand, if of low grade, the reading power with the unaided eyes is retained to a more advanced age than in

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emmetropia; in the higher grades of myopia it is retained indefinitely.

As a result of the very gradual increase in the resistance which must be overcome in order to effect such degree of accommodative adjustment as is still possible in presbyopia, the relation of the accommodation to the convergence undergoes a notable change, the binocular accommodation (A_2) associated with convergence for the habitual reading distance becoming at length nearly equal to the absolute accommodation (A). In other words, the binocular near-point (p_2) comes more and more nearly to coincide with the absolute near-point (p). Following closely upon the acceptance of convex glasses in near work, the distance (P_2) of the binocular near-point (p_2) undergoes a rapid increase, so that such reading power as may have been retained up to the time of the adoption of the glasses is speedily lost, and reading without glasses becomes impossible. Hence the common experience of presbyopes, that having once formed the habit of using convex glasses, their continued use becomes imperative; and this whether the glasses have been adopted somewhat prematurely, or only after the need of them has become urgent. The too early use of convex glasses is, therefore, to be deprecated, as entailing the disabilities of presbyopic vision several years, perhaps, before the normal age; on the other hand, as there is a positive limit to the range of accommodation at any given age, the use of convex glasses cannot, as a rule, be deferred by an emmetrope much beyond the forty-fifth year, unless he be content to forego the use of the eyes in reading ordinary print or in other fine work.

The total disuse of the accommodation for a considerable period, as in the case of protracted and exhausting illness, may lead to the premature development of presbyopic symptoms, which are apt to be interpreted as an indication for the immediate adoption of convex glasses. If glasses are used in such a case, they should be of the least power compatible with the use of the eyes under favorable conditions of illumination, and the patient should be encouraged in the hope that, as the accommodative power increases with use, the glasses may be laid aside. In cases of this kind it is often possible to bring the accommodation again into effective use by the instillation, once or twice daily for a few weeks, of a weak solution of pilocarpine, and thus to put off the use of glasses for perhaps several years.

In addition to the impairment of the accommodation, which is the essential characteristic of presbyopia, the refraction undergoes, in the course of time, a slight but positive diminution, so that ultimately an emmetrope becomes slightly hypermetropic (H *acquisita*—see *Hypermetropia*), a hypermetrope somewhat more hypermetropic, and a myope somewhat less myopic; a very low grade of myopia may thus give place to emmetropia, or may even pass through emmetropia to hypermetropia of low grade. A low grade of hypermetropia, which late in life necessarily becomes absolute (H *absoluta*), is, in fact, the ultimate normal condition of all emmetropes, so that in advanced age weak convex glasses come to be required for perfect vision at a distance; hypermetropes similarly require a moderate increase in the power of their convex glasses, and myopes require a corresponding diminution in the power of their concave glasses. This falling off in the refraction is ordinarily scarcely to be detected at the age of forty-five; at sixty it may amount to perhaps 0.5 dioptric, at seventy or seventy-five to 1 dioptric, and at eighty to 2 dioptrics or more.

The *treatment* of presbyopia consists essentially in the palliation of the disability by the use of such convex glasses as are needed to supplement the failing accommodation. A person originally emmetropic may, at the age of seventy, require convex glasses of as much as 5 dioptries, in order to read fairly good print at a distance of from 25 to 30 cm.; and if the acuteness of vision is below the normal, it may be necessary to use glasses of 6 or 7, or even 8 dioptries, in order to admit of reading at some shorter distance. In the case of a person originally hypermetropic, the measure of the required glasses will be increased by a quantity equal to the grade of the hypermetropia; in myopia the measure of the glasses will be similarly diminished.

The convex glasses first given to a presbyopic emmetrope of from forty to forty-five years of age, should ordinarily not much exceed 1 dioptric, and in some cases even weaker glasses may be more acceptable to the patient. These glasses should be used at first for only such work as is performed with difficulty without glasses, in order that the habit of using the accommodation may not be needlessly or prematurely abandoned, and they should not be exchanged for stronger glasses so long as they continue to afford the needed assistance. Subsequent changes should always be made with reference to the glasses already in use, adding perhaps 0.5 dioptric at each change, and it is often advisable to retain the old glasses for a time for reading by daylight, reserving the stronger glasses for more exacting work. It follows that a presbyope should always preserve a record of the power of the glasses which he is using, in order that, in replacing a lost pair, he may not be reduced to the necessity of selecting new glasses at random, or after hasty and generally imperfect tests made by a shopman whose knowledge, very probably, may be limited to the trick of selling his wares.

A presbyope, using glasses perfectly suited to his condition, is able to use his eyes in near work freely and without fatigue; glasses of insufficient strength fall short of affording the full measure of relief, and glasses of excessive strength compel the holding of the book at too short a distance, thus imposing needless work upon the recti interni muscles and so possibly giving rise to muscular asthenopia (see *Asthenopia*).

The clinical investigation of any case of presbyopia involves, first of all, the careful testing of the eyes in respect of the acuity of vision and for the estimation of any hypermetropia, myopia, or astigmatism that may be present (see these titles). As has been already explained, the measure of any hypermetropia that may be detected must be added to, and the measure of any myopia subtracted from, the value of the glasses ordinarily required by an emmetrope of corresponding age, in order to arrive at an approximation to the glasses to be given for reading. These tests are best conducted at a range of at least 5 metres, and only after the satisfactory determination of the refraction should a trial of reading glasses, chosen with reference to this determination, be made. The final tests are made in reading fine print. If astigmatism is present, it should, as a rule, be accurately corrected by having one surface of the glass ground to the appropriate cylindrical curvature (see *Astigmatism*).

A rapid falling off in near vision, necessitating frequent and considerable additions to the power of the reading-glasses used by a presbyope, should be regarded with especial solicitude as indicating the possible beginning of glaucoma. In view of the recognized danger of precipitating an acute glaucomatous outbreak, the routine employment of mydriatics in the investigation of the refraction of presbyopes is to be especially deprecated.

Repeated changes from weaker to stronger glasses, attended with a shortening of the reading distance after each change, point to a falling off in the acuteness of vision, oftenest from failure in the perceptive power of the retina, or of the conductivity of the optic nerve.

A marked diminution in the apparent grade of presbyopia is occasionally observed late in life as a result of the development of a myopic state of the refraction; this change, which is popularly known as "second sight," is a not infrequent symptom of incipient cataract.

John Green.

[1] Donders: On the Anomalies of Accommodation and Refraction of the Eye, p. 210. The New Sydenham Society, London, 1864.

[2] Donders: *Op. cit.*, p. 207.

[3] Aristotelian Treatise, προβληματα, xxxi., 25; Oribasius; Aetius; Paulus Ægineta; *et al.*

[4] Cramer: Tydschrift der Maatsch. voor Geneeskunde, 1851.

[5] Helmholtz: Monatsberichte der Akademie der Wissenschaften, Berlin, February, 1853.

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[6] Donders: Archiv für Ophthalmologie, vi., 1860; On the Anomalies of Accommodation and Refraction, 1864.
[7] *Vide* Donders: *Op. cit.*, p. 325, note.
[8] *Ibid.*, p. 208.

PRESERVATIVES.—Food preservation has been employed from a very early period. Many methods are available: drying, salting, pickling, smoking, the use of heat and cold, and addition of sugar, saltpetre, and various aromatic and astringent substances. The exigencies of modern food supply have greatly extended both the number of preservatives and their applications. Low temperature is probably the least objectionable method of preventing decay, but its application is limited and costly. It is unsuitable for some articles. In food preservation reliance is now largely on chemical substances that have decided antiseptic or germicide effect.

All preservation, even that by cold alone, affects to some extent the digestibility and nutritive value of food, but these changes are less objectionable than those caused by decomposition. Sterilization by heat finds wide application and has the advantage of producing a condition which permits of some exposure to the air without decay occurring. The medical questions which arise in this connection are mostly those concerning the newer preservatives. These are salicylic acid, benzoic acid, sodium benzoate, boric acid, borax, formaldehyde, sulphites, fluorides, beta-naphthol, saccharin, and a few synthetic products of complex composition and limited use. Each substance is found to be adapted to special uses. Thus, boric acid and borax are used largely for meats, milk, and butter; sulphites and fluorides are used in fermented beverages; salicylic acid, saccharin, benzoic acid, and sodium benzoates are used in jams, jellies, mince-meat, and preserved fruits and fruit juices. Formaldehyde is largely used in milk, and is the most common preservative in market milk and cream in the summer season. For the preservation of many vegetable products, sterilization in hermetically sealed cans is employed and no preservative material is needed.

The physiological effects and methods of detecting the different preservatives have been subjects of extended study. The latter problem has been solved in most cases, but the former is still under active discussion. At present, the weight of information seems to be that salicylic acid, formaldehyde, the sulphites, and the fluorides are objectionable either from inherent toxic qualities or by reason of interferences with digestive functions. Numerous investigations into the effects of boric acid and borax have failed to show that in moderate amount it has any injurious action, and the tendency is to permit its use in meats and butter, in which it satisfactorily replaces common salt. Sodium benzoate seems to be safe for use in fermentable foods, such as jams and jellies. Betanaphthol is but little used, but it and saccharin are probably objectionable except in special cases and under supervision.

Most of the substances above enumerated are not actively germicidal nor capable of coagulating proteids, but are rather inhibitory of bacterial growth and enzymic action, and thus prevent decomposition.

A dangerous phase of the modern use of preservatives is that many of them are sold under misleading names and their nature and effects misrepresented by manufacturers. Formaldehyde, for example, is sold in forty-per-cent. solution as "formalin," which is not an objectionable title, but weaker solutions are sold to milk purveyors under such fanciful names as "freezene," "icene," and the sellers' agents assert that the material is harmless and permissible. It has been found that a mixture of boric acid and borax is usually more efficient than either alone. This mixture is often sold under the title "boron preservative." Another danger is that chemical substances may be used to make up for deficiency in quality or sterilization of foods.

The regulation by law of the use of preservatives has so far been unsatisfactory. Wholesale prohibition of any but the old-established forms, such as smoking or pickling or salting, has been attempted in some places, but has resulted in much litigation and quarrelling. The question must be approached in a scientific way, and the regulations must regard the exigencies of trade as well as the interest of the consumer. For a comprehensive study of the main questions the report of the British Commission (Blue-Book, Cd. 833) will be found valuable.

Henry Leffmann.

PRIMROSE, EVENING.—The leaves and tops of *Onagra biennis* (L.) Scop. (*Œnothera biennis* L.—fam. *Onagraceæ*). This plant is an exceedingly common weed in waste fields and along roadsides throughout the United States, especially in the northeastern and central parts. It is hairy, the stem stout, erect, and branching, and is readily recognized by the large yellow flowers, with four obcordate petals, eight long versatile anthers, four linear stigmas, forming a cross, and the quadrangular ovary at the base of a long filiform calyx tube. It contains much tannin, with considerable gum, thus making it astringent and at the same time emollient to the intestine. It has consequently a considerable employment in the household in the treatment of diarrhœa. The dose is 2–8 gm. (ʒ ss.–ij.), and the infusion is the best form of administration. A number of species of the related genera Œnothera, Epilobium, etc., have a similar composition and use.

Henry H. Rusby.

PROAMNION.—This convenient term was introduced by Ed. van Beneden to designate that part of the *area embryonalis* at the sides and in front of the head of the developing embryo which remains without mesoderm for a considerable period, so that the ectoderm and entoderm are brought, in the region of the proamnion, into immediate contact. As found in one stage of the rabbit, it has already been figured in this work (Fig. 267, Vol. I.). A later stage in the rabbit, as seen in longitudinal section, is figured by Kölliker in his "Grundriss d. Entwickelungsges.," 2te Aufl., p. 107. We find that it had been observed in the chick by Remak, His, and Kölliker. Strahl was the first to direct special attention to it. It has since been observed by various writers; van Beneden and Julin have described it in the rabbit, Heape in the mole, Selenka in the opossum, and recently its exact history has been admirably worked out in the chick by Ravn, and in many birds and reptiles by Schauinsland. The proamnion, then, has been observed in representatives of the classes Reptilia, Aves, and Mammalia; hence we may conclude that it is common to all Amniota. It will be remembered that the mesoderm grows out in all directions from the blastopore, or hinder end of the primitive streak. In a chick of twenty-seven hours, the front edge of the mesoderm is a somewhat irregular transverse line, which crosses the germinal area about at the front border of the head. This line is well shown in His' drawings, *loc. cit.*, Pl. xii., Fig. 14. As the mesoderm expands, it does not grow forward in the median line, but does grow forward at the sides of the *area pellucida* in front of the head of the embryo. A space is thus enclosed between the mesoderm on each side; this space later becomes the proamnion; it contains no mesoderm. Later on, the lateral portions of the mesoderm approach the median line again, some distance in front of the head, so that now the proamniotic area is completely surrounded by mesoderm. We see, as the next phase of development, the head amniotic fold arising in such a position that the proamnion is embraced between the arc of this fold and the head of the embryo; the proamnion, therefore, constitutes the floor of the pit formed by the upgrowth of the head amnion. In the chick the proamnion never acquires any considerable development, but gradually disappears by encroachments of the mesoderm upon all sides, as has been well described by Ravn, whose Fig. 3, *loc. cit.*, Pl. xxi., will serve to give a clear general notion of the relation of the proamnion to the head, and to the true amnion in the chick. The disappearance of the proamnion in the chick involves some curious appearances in sections of embryos, which Ravn has correctly and fully elucidated.

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In the rabbit, according to van Beneden and Julin, whose observations have been confirmed to a certain extent by Kölliker and Heape, the rôle of the proamnion is more considerable. The history of the proamnion, as given by van Beneden, may be followed easily by the aid of the accompanying diagrams (Fig. 3882), copied from van Beneden. In A, the proamnion, *pro.A*, is very small, and the allantois, *Al*, is just growing out. In B, the embryo, which for greater clearness has been shaded with stippling, has grown very much, and the anterior half of its body is bent down at a sharp angle into the yolk sac. The embryo, however, remains separated from the cavity *Y*, of the yolk sac, by the proamnion, which forms as it were a hood, *pro.A*, over the anterior extremity of the embryo. The amnion proper is as yet developed only over the posterior end of the embryo. For the further history of the amnion see *Amnion*, Vol. I. of this HANDBOOK. The proamnion, as can be seen in C and D, retains its importance as a fœtal covering for a considerable period, during which the amnion *am*, and allantois *Al*, are rapidly pursuing their development. After the stage shown in Fig. 3882, D, by the expansion of the cavity marked *Coe*, the amnion proper, *am*, encroaches more and more upon the proamnion, *pro.A*, until at last the embryo is entirely covered by the true amnion, and the proamnion is altogether lost. It is to be noted especially that the amnion develops principally over the posterior end of the embryo, and grows forward. To this fact reference will be made again directly.

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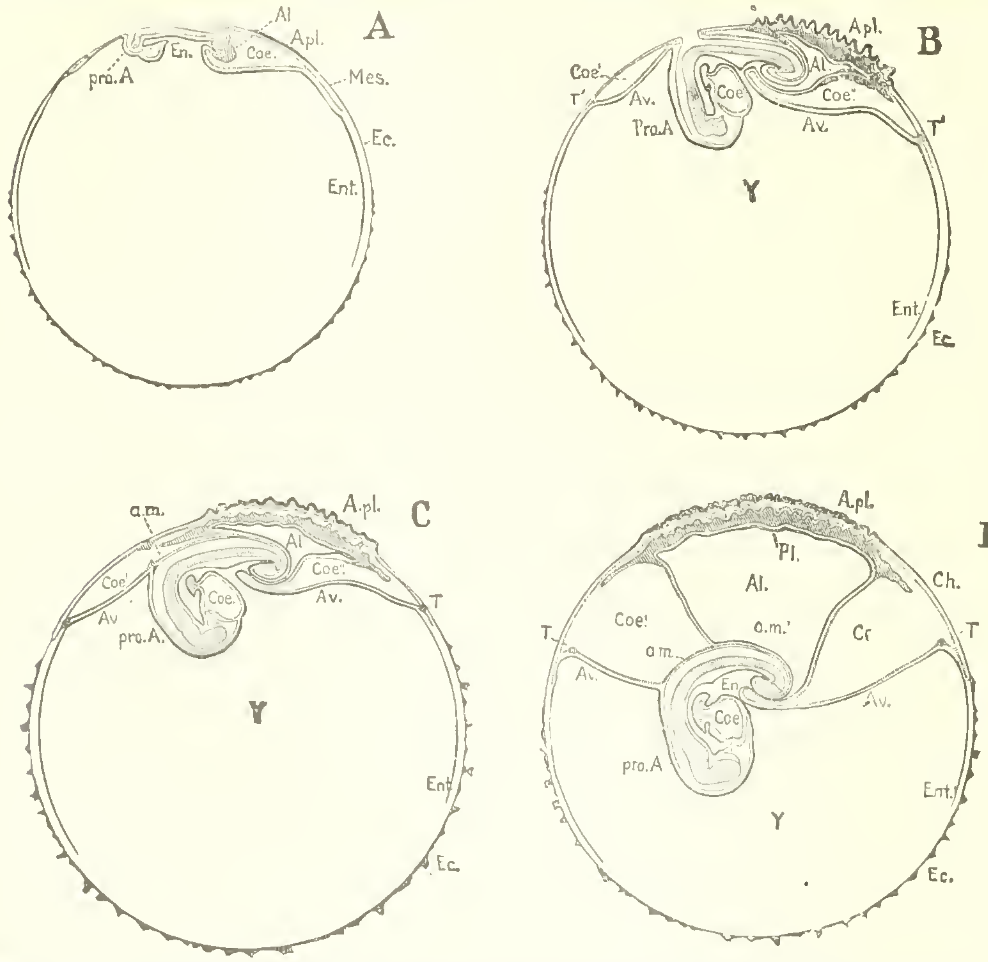

FIG. 3882.—Diagram of the Development of the Fœtal Adnexa in the Rabbit. (After van Beneden and Julin.) *A, B, C, D*, Successive stages; *pro.A*, proamnion; *Av*, area vasculosa; *Coe*, cœlom; *Coe'*, *Coe"*, extra-embryonic portion of the cœlom; *En*, entodermic cavity of the embryo; *Ent*, extra-embryonic entoderm; *Ec*, ectoderm; *Mes*, mesoderm; *Apl*, area placentalis; *Al*, allantois; *T*, terminal sinus of the area vasculosa; *Y*, yolk sac; *am*, amnion; *am'*, portion of the amnion united with the wall of the allantois; *Ch*, chorion.

We possess no observations, at present, as to the existence of a proamnion in man, and it is probable, owing to the precocious development of the human amnion and of the extra embryonic mesoderm, that no proamnion occurs in the course of human development.

Charles Sedgwick Minot.

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PROFESSIONAL NEUROSES. See *Hands and Fingers, Diseases and Deformities of.*

PROPYLAMIN—$CH_3.CH_2.CH_2.NH_2$—forms colorless crystals of ammoniacal odor, and for the treatment of chorea is administered in daily dosage of 2-4 gm. (ʒ ss.–i.) in spirit of peppermint. *W. A. Bastedo.*

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PROSECRETIN. See *Secretin.*

PROSTATE, THE.—The prostate gland (Gr. προστάτης, from πρό and ἱστάναι, to set, or ἵστημι, I stand) derives its name from its position at the entrance to the bladder.

Anatomy.—The prostate is a body largely glandular in character, and in shape much like a Spanish chestnut. In the upright position of the body it lies just below the bladder and behind the symphysis pubis. The base of this heart-shaped gland is in contact with the bladder and vesiculæ seminales, while the apex rests upon the posterior layer of the deep perineal fascia; the anterior surface looks toward the pubis, and the posterior surface rests upon the anterior rectal wall.

The urethra, as it leaves the bladder (pars prostatica urethræ), traverses the prostate from near the middle of its base to its apex, and rather more than one-half of the gland lies behind the canal.

The prostate weighs from five to six drachms, and measures approximately one inch and a half in length, one and a half to two inches in breadth, and one inch in thickness (antero-posterior diameter). Slight longitudinal furrows along its anterior and posterior surfaces show an indistinct tendency toward a division into two lateral lobes, although the two halves are structurally continuous with each other. In this connection it is worthy of note that in some animals the prostate consists of two separate lobes.

That portion of the gland which lies between the ejaculatory ducts and the urethra (pars supramontana, Mercier) is usually known as the middle lobe (Home). Situated upon the floor of the urethra, just at the entrance to the bladder, it often forms a little prominence continuous with an elevation of the vesical floor (uvula vesicæ).

The portions of the gland behind and in front of the urethra, connecting the lateral lobes, are known as the posterior and anterior commissures.

The substance of the prostate is made up mainly of three tissues: (1) Glands; (2) unstriped muscular fibres; and (3) fibrous tissue.

The glands are of the acinous variety, and are most abundant in the lateral portions of the organ, their ducts coalescing and opening along the floor of the urethra. The muscular fibres are disposed in circular bands which are continuous at the junction of the bladder with the circular fibres of that viscus. Hyrtl also describes a system of these fibres radiating from the caput gallinaginis. The fibrous tissue forms a firm enveloping capsule which sends off-shoots through the substance of the gland.

Just below the point of entry of the urethra the two ejaculatory ducts enter the prostate, one on each side, and, running forward through its substance and converging, they enter the floor of the urethra.

The prostatic urethra (pars prostatica urethræ) is slightly narrower where it enters and leaves the gland than it is within it. The hollowed floor of this portion of the canal is called the sinus prostaticus, and is divided into two equal furrows by a longitudinal ridge (verumontanum), the end of which farthest from the bladder is composed of erectile tissue, and is capable of considerable dilatation into a little round prominence which, with the verumontanum running back from it, presents a fancied resemblance to the head of a snipe—hence its name *caput gallinaginis.*

On the top of this little eminence is the opening of a minute sac—the utricle or sinus pocularis—which is thought to be the analogue of the uterine cavity in the female. Close to the edge of this sinus, and sometimes within it, are the orifices of the ejaculatory ducts. Along the sides of the verumontanum open the prostatic glands proper, to the number of from twenty to thirty.

The prostate is enclosed in a tough fibrous capsule which is a part of the pelvic fascia. Besides its attachments to the bladder and deep perineal fascia, it is further held anteriorly by the pubo-prostatic ligaments, and posteriorly by the recto-vesical fascia. Its slight mobility is provided for by the levatores prostatæ—muscular bundles, really parts of the levator ani—which, arising from the posterior surface of the pubis, are inserted along the lateral borders of the gland.

Its blood supply is derived from the internal pudic, the vesical and hemorrhoidal arteries, and the veins which form a plexus around the gland empty through the hypogastric vein. The nerves are branches of the hypogastric plexus of the sympathetic.

Physiology.—The prostate is a sexual gland. After birth it remains in a quiescent state up to puberty, when it begins to increase in size and development. It attains its full growth at about the twenty-fifth year.

The secretion of the glands, which are especially active during sexual excitement, is a slightly turbid fluid of feebly alkaline reaction, with a specific gravity of 1.010.

It is especially rich in chloride of sodium (one per cent.), and, as solutions of this salt are known to excite the spermatozoa to movement, its presence in the prostatic fluid is thought by some to perpetuate their activity. Probably the most important function of this secretion is in producing coagulation of the secretion of the seminal vesicles.

The prostate, further, in its character as a muscular organ, acts as an involuntary sphincter of the bladder. As the urine accumulates a point is finally reached at which the tension of the detrusor urinæ muscle pulls open the rings of involuntary fibres around the neck of the bladder and allows the urine to enter the pars prostatica urethræ. Its presence there causes an urgent desire to urinate, and the escape of the water is then prevented only by the compressor urethræ muscle, which is the voluntary urinary sphincter. If this muscle does not relax and allow urination to be completed, the prostate closes down and forces the contained urine back into the bladder, where it stays until the further increased tension brings on another "besoin d'uriner."

Malformations.—The prostate may be wholly wanting, in connection with a general lack of development of the urinary organs.

In exstrophy of the bladder there is no roof to the prostatic urethra, and the gland ducts may be seen opening through the mucous membrane over the site of the organ.

Injuries and Wounds.—The deep-seated position of the prostate makes it little liable to injury from without. In severe crushes of the pelvis with fracture about the pubis, it may be wounded. In perineal lithotomy it is always incised, and often somewhat contused by the extraction of the stone. If the crushing and laceration of the parts have not been serious, healing usually takes place kindly.

Injury of the prostate occasionally results from the passage of instruments through the urethra. This occurs most commonly in cases of hypertrophy, in which the irregular enlargement of parts of the gland has made the canal tortuous.

A specimen in the museum of the Harvard Medical School shows a very much enlarged middle lobe which so obstructed the entrance of the catheter that the instrument had been forced directly through it and had entered the bladder beyond.

The knowledge that such injuries are possible should lead to their avoidance. Much force is never needed in the passage of an instrument which is properly guided, but a thorough understanding of the nature of the possible obstacles, and considerable patience and care in overcoming them, are necessary to success in these cases.

Inflammation of the Prostate—Prostatitis—may be either acute or chronic.

Acute prostatitis is commonly the result of the extension of an inflammation from adjacent parts

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A gonorrhœal urethritis is by far the most usual exciting cause. In this case the inflammation runs back along the urethra to the prostate. That this is not the usual course of a gonorrhœa is due to the protection afforded by the constrictor urethræ muscle. This sphincter, surrounding the membranous urethra, prevents the discharge from penetrating to the prostate and bladder, and usually protects these deeper parts from participation in anterior inflammations. Occasionally the passage of an instrument, or the forcing of an injection through the constrictor, may convey infective discharges past this natural barrier.

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A non-specific urethritis or an inflammation of the bladder may, in similar manner, extend to the prostate. The passage of instruments, the application of caustics, the use of strong injections, the presence of calculi in the bladder or prostate, accidental injuries, or operations may be the exciting cause of an acute prostatitis.

Among other causes cited as occasionally giving rise to prostatitis may be mentioned sexual abuses, acrid irritating conditions of the urine, the use of stimulating diuretics such as cantharides and turpentine, the abuse of stimulants, and the presence of inflammation in the rectum. Probably these conditions are rarely, if ever, competent to excite an acute prostatitis in a healthy state of the gland, but only act to aggravate an already existing inflammation.

A stricture of the urethra greatly aggravates any deep inflammation of that canal, and makes its extension to the prostate much more liable to occur.

Pathology. In acute inflammation the prostate is much congested, with great swelling and œdema, which extend to the surrounding parts. The prostate itself may be enlarged to three or four times its natural size, and even with this degree of inflammation, resolution and a return to a comparatively normal condition are possible.

If, however, the inflammation runs a more acute course, it may lead to the formation of abscesses, which, starting as minute points of pus, may gradually enlarge and coalesce until, in an extreme case, the whole organ may be reduced to one abscess cavity.

Spontaneous opening may take place backward into the rectum, into the urethra, or into the bladder, and the pus may even occasionally find its way down through the ischiorectal fossa, or into the perineum, and point externally. Rarely, the abscess may open into the peritoneal cavity, or into an adherent coil of intestine.

Symptomatology. The prominent symptoms are pain deep in the perineum and in the rectum, with tenesmus of the bladder and the rectum. Urination is very frequent, and is accompanied by great pain, especially during the passage of the last few drops of water, which are frequently colored with blood.

Accompanying these local symptoms there is usually considerable fever, which may or may not be ushered in by a chill There is also often severe pain in the back, loins, and thighs.

As the inflammation increases the pains become even more severe, the urine in its passage scalds intensely, the pressure and throbbing pain in the rectum become very distressing, and defecation, which is constantly desired, is, when it happens, a new source of suffering.

The stream of urine becomes small and hard to start, owing both to the swelling of the prostate and to the spasmodic contraction of the constrictor urethræ muscle, and finally complete retention may result

If a gonorrhœal discharge previously existed, it may disappear at the onset of prostatic inflammation, or it may be changed into a slight mucous discharge.

There is usually a good deal of tenderness in the perineum, and sometimes also close above the symphysis pubis. A rectal examination is difficult on account of the extreme sensitiveness of the parts, accompanied by spasm of the sphincter muscle.

If the inflammation gives rise to an abscess, its formation is often heralded by rigors with high fever. If the abscess breaks into the urethra or bladder, there may be a sudden escape of pus in the urine, with an improvement of the general symptoms.

If the pus cavity attains any considerable size, its character may be made out through the rectum, where it is to be felt first as a hard, boggy swelling, which later softens and gives evidence of fluctuation.

If the abscess extends into the loose cellular tissue along the rectum pyæmic symptoms may develop, and in case of rupture into the peritoneal cavity the characteristic symptoms of peritonitis will come on abruptly, with a speedily fatal issue.

Treatment. Absolute rest is the first and most important measure when acute inflammation of the prostate makes its appearance.

The patient should keep in a horizontal position with the hips somewhat raised.

If severe pain is present—especially if frequent spasms of the bladder are aggravating the inflamed gland—opiates should be given; and it is to be borne in mind that these, by inducing rest from spasm, exert a really curative effect. Morphine and atropine subcutaneously, or opium and belladonna suppositories, may be administered under these circumstances.

All irritations from instrumentation, injections, or stimulating diuretics should be avoided.

The bowels should be kept gently open by aperients, if necessary, and this point should be carefully looked after when opiates are being used.

The urine should be rendered as unirritating as possible by the use of diluents and alkaline diuretics, and nourishment should be given in a bland, unstimulating form. Farinaceous gruels, milk, and light broths may form the bulk of the diet. Alcohol should be entirely avoided in the acute stage of the disease.

If at the outset the fever runs high, it may be somewhat mitigated by the use of quinine or some more temporary febrifuge, such as aconite or phenacetin. Late in the disease, when it has run a severe course—especially in case of exhausting suppuration—strong concentrated foods and alcoholic stimulants may be required.

Locally, all possible measures for limiting the severity of the inflammation should be employed. In an early stage of the disease, leeches applied to the perineum may be of considerable service. From six to eight should be put on along the raphe and close to the anus. The bleeding may be encouraged, especially in plethoric persons until from fourteen to sixteen ounces have been withdrawn.

Hot applications, either by fomentations or by hot-water bottles, to the perineum and over the pubes, are useful in diminishing pain and spasm, and probably assist somewhat in limiting the inflammation. Hot hip baths are recommended for this same purpose; but the exertion and the unfavorable position required for these add so much to the pelvic congestion as greatly to diminish the otherwise favorable effect of the heat. If used, they should not be prolonged for more than five or eight minutes, as the maximum effect on the surface is produced in that time.

If retention of urine occurs, it must be relieved by the careful introduction of a small, soft catheter (Nos. 12–14 French scale).

Sometimes, when there is a spasmodic stricture at the compressor urethræ, a soft catheter will not pass, and a stiff instrument must be used, requiring, of course, the greatest gentleness of manipulation.*

When the retention persists and requires repeated catheterization, an instrument tied into the bladder (*sonde à demeure*) will often cause less irritation than would its frequent introduction.

The possibility of abscess formation is always to be kept in mind, and the condition of the gland should be watched by rectal examinations. If fluctuation is made out, the abscess should be opened at once. This may usually be done through the rectal wall with a curved

* For the discussion of catheterization see under Hypertrophy of the prostate.

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bistouri caché, and the opening should be rather a puncture than a long incision. This is for the purpose of avoiding hemorrhage: and it is a good plan, with this same object in view, to make a careful examination before the puncture, to see that no vessel of any size in the rectal wall stands in danger of injury by the knife. In case of bleeding, ice www.libtool.com.cn into the rectum, and if these fail, pressure should be applied by a thorough plugging of the lower part of the bowel. If the abscess is a large one a drainage tube may be introduced into it through the rectal opening.

If examination shows that the abscess is working toward the perineum, it may be opened by an incision from that direction, and thus a urethro-rectal fistula with prolonged suppuration may be avoided.

When the abscess communicates with the rectum thorough irrigation of the bowel should be carried out, and an antiseptic, free from poisonous properties, should be selected, on account of the absorptive power of the rectal mucous membrane.

If the disease ends in resolution, care should be taken that the recovery is complete, for an acute inflammation may, if neglected, leave a chronic condition which is sometimes extremely hard to relieve.

Chronic Prostatitis.—Chronic inflammation of the prostate may, as has been said, follow an acute attack. It may, however, on the other hand, originate as a chronic or subacute affection.

What has been said in regard to the etiology of acute, will for the most part apply to chronic, prostatitis; but while the former is seldom the result of sexual errors alone, these are not infrequently almost wholly responsible for a chronic inflammation of the gland; and it is to be noticed that the imperfect sexual indulgence of masturbation, or partial intercourse, is much more productive of prostatic trouble than is the normal excitement of proper coition. This is probably due to the unrelieved congestion of the gland, left after these unnatural practices.

Pathology. A chronically inflamed prostate is usually somewhat enlarged, but may be natural or diminished in size. The gland is less firm than in health, and its texture is more open and spongy. Upon section the cut surface is red or dusky in hue, and moister than normal. Little points of suppuration may exist, but are usually few and small.

The mucous membrane has an increased vascularity and may be thinned, particularly if the prostatic urethra is dilated in consequence of an anterior stricture. It may, on the other hand, be thick and spongy, denuded partly of epithelium, or much roughened with spots of ulceration; sometimes, in cases of long standing, it is pigmented. The sinus pocularis and dilated gland ducts about it may contain pus. Sometimes an abscess cavity exists in communication with the urethra.

Symptomatology. Patients with chronic prostatic inflammation are troubled with increased frequency of micturition, which in a mild case may be scarcely noticeable, but is often very troublesome—occurring sometimes with intervals of less than an hour.

There is sometimes pain of a dull, heavy character, referred to the perineum and lower rectum. There may also be considerable pain low down in the back, with twinges shooting into the thighs and testicles. A slight, persistent urethral discharge, often most marked in the morning, may be the only symptom. In some cases the symptoms may be almost entirely of a sexual character, such as are often spoken of as sexual neurasthenia.

The bladder, when full, may make its condition known by a feeling of discomfort or actual pain, with intensely urgent call to urinate.

The passage of urine may be accompanied by slight scalding sensations, and there may be a twinge at the end of micturition, when the bladder shuts down upon the sensitive prostate. Occasionally tenderness in the perineum may be felt upon deep pressure.

The urine may be cloudy and contain, more or less abundantly, clumps of muco-pus mixed with epithelial cells. These are little accumulations of secretion washed out of the dilated gland ducts, and differ from the loose threads of mucus so common in chronic urethritis in being smaller, more coherent, and rounded in form. When the urine is passed in two portions, the first part is apt to be more cloudy and to contain these clumps of mucus more abundantly than the second part. Not infrequently, however, even when the inflammation is confined to the prostate, the pus is distributed throughout the urine and both portions are cloudy. The reason for this has been very clearly stated by Ultzmann,* and is as follows. The internal sphincter of involuntary fibres surrounding the vesical orifice of the urethra is comparatively feeble, while the compressor urethræ muscle, just in front of the prostate and surrounding the membranous urethra, is strong and competent, and, being under the control of the will, it forms the voluntary sphincter of the bladder.

As discharges collect in the prostate they cannot force their way forward past the constrictor, but readily escape backward into the bladder, where they diffuse themselves through the urine. Even in these cases, however, when the urine is universally cloudy, the first portion will still be somewhat more cloudy than that which follows, and will contain many more of the mucous prostatic clumps. The urine in mild cases may be clear with a moderate number of "prostatic plugs" which settle rapidly to the bottom of the urine glass.

The urine, when examined microscopically, will often be found to contain, besides the pus, a considerable number of blood cells, and occasionally also a few spermatozoa. The blood may not infrequently be perceived to come at the end of micturition, when the bladder closes down upon and squeezes the congested prostate.

A chemical examination frequently shows the presence of a little albumin, often in larger quantity than the pus and blood would account for. In other respects the urine is usually normal.

If the character of the stream is noticed, it will often be found that its force is decidedly diminished, and that after the completion of urination a few drops dribble away. Sometimes partial or total retention may occur.

This interference with urination is to be partly accounted for by the swelling of the prostatic mucous membrane, but is often largely dependent on a spasmodic contraction of the constrictor urethræ muscle; and if under these circumstances a sound is passed, it will meet with decided resistance when it reaches the voluntary sphincter. This spasmodic stricture may be so close as greatly to aggravate the difficulty and pain of micturition, for, as the bladder forces the urine into the prostatic urethra, if its further escape is prevented, the undue pressure in this sensitive part is productive of very great suffering. Usually the spasm of the constrictor is finally overcome by the accumulating intravesical pressure, and urination, beginning first by drops, presently comes with more or less freedom.

As we have said, the constrictor muscle hinders prostatic secretions from escaping anteriorly and appearing as a urethral discharge. A very slight gleet in the morning is not infrequently observed. Sometimes also in these cases a glairy discharge of prostatic mucus is pressed out and escapes while the patient is at stool; especially is this the case when the bowels are constipated and much straining is required. This is commonly interpreted by the patient as an escape of semen, and he becomes convinced that he is a victim of spermatorrhœa.

Usually the microscope fails to find spermatozoa in this discharge, which consists mainly of mucus, with sometimes a little admixture of pus and blood.

Besides the local symptoms and manifestations that have been described, we see in these prostatic cases often marked changes in the general condition of our patients. They are nervous and hysterical, or may be depressed and despondent, with often a hypochondriacal over estimate of the gravity of their trouble. Sometimes a true neurasthenic condition may be induced in a case of long

* "Pyuria," p. 26.

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standing. Digestive disturbances and palpitation of the heart may occur.

Physical Signs. An examination of the prostate through the rectum shows it sometimes slightly enlarged, but often normal or diminished in size. In consistency it is usually somewhat softer than in health.

If the urethra is explored with an instrument it is commonly very sensitive, but may be anæsthetic, the latter condition being noticed usually in old cases. The urethra should be carefully examined for a possible stricture, and it is to be remembered that the constrictor muscle will often be found to make a spasmodic contraction just behind the triangular ligament. The passage of the sound through the prostatic urethra is almost always painful, and may excite an intense desire to urinate, or an ejaculation of semen.

Diagnosis. The disease which we are considering is peculiar to young and middle-aged men, and is to be kept distinctly separate from hypertrophy of the prostate, which occurs only in the old. Inflammatory symptoms, it is true, are not uncommon in this latter affection, and will be discussed later.

Tuberculosis of the prostate offers many points of resemblance to chronic prostatitis, and a differential diagnosis is often difficult, and may be for a time impossible. The detection of small nodules in the prostate and a marked tendency of the disorder to become worse as a result of local treatment are suggestive of tuberculosis. The constitutional tendencies of the patient should be taken into consideration, and a careful search should be made for evidences of tuberculosis in other organs. An examination of the urine for tubercle bacilli may help to a solution, but a failure to find them even after careful search leaves the question where it was before, for they are often sought in vain in undoubted cases of genito-urinary tuberculosis.

The discrimination between prostatitis and deep urethritis after gonorrhœa is sometimes almost impossible.

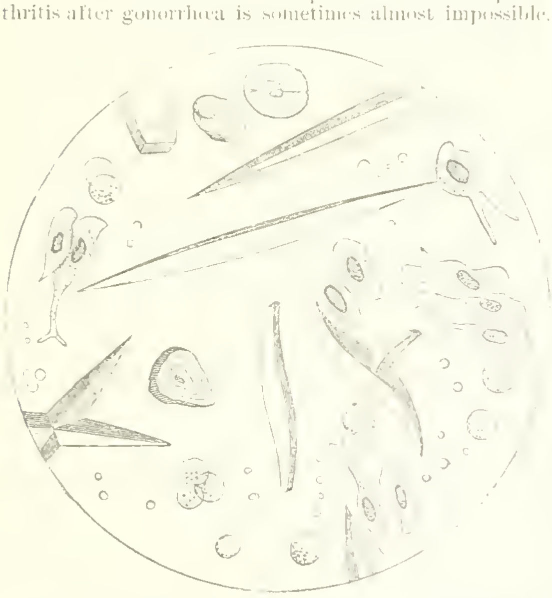

FIG. 3883.—Sediment from Prostatic Discharge, Containing Pus and Epithelial Cells, Granules, Amyloid Bodies, and Böttcher's Crystals.

The rectal examination of the prostate may help to a decision, but not infrequently it gives negative results.

A microscopical examination of the discharge obtained by pressure on the prostate through the rectum may give valuable information but this, too, is often misleading. The discharge in either case contains pus and large and small round epithelial cells. Amyloid bodies and cylinder or caudate epithelium may be found in considerable abundance when the discharge is prostatic.

The formation of Böttcher's crystals upon the addition of a drop of a one-per-cent. solution of phosphate of ammonia to a drop of the secretion shows beyond question that it contains prostatic fluid.

This reaction should be conducted on a microscope slide, under a cover-glass, and within an hour, usually, crystals such as are shown in Fig. 3883 make their appearance. They are composed of a phosphate formed from a base which exists in prostatic fluid, and which is supposed to impart to it its peculiar odor. Unfortunately, the mixture of urine with the secretion prevents the formation of these crystals, and so limits very much their diagnostic usefulness.

It is always to be borne in mind that a combination of urethritis and prostatitis is not uncommon.

Treatment should be addressed to both the general and the local condition.

The general treatment should be tonic, especially in the cases in which much nervous depression exists.

A generous, unstimulating diet, with moderate exercise in the open air, and with cold sponge baths in the morning, when the patient's strength will admit of them, are to be advised.

The laws of sexual hygiene should be carefully explained to the patient, and the importance of their observance made plain to him.

Preparations of strychnine and iron are often of benefit, and they may be advantageously combined with quinine or ergot, both of which seem to exert a soothing influence upon the prostate. Iodide of potassium may be of assistance when the inflammation affects the glandular portions of the organ, and the addition of bromide of potassium is sometimes distinctly useful in quieting sexual excitement.

If the urine is highly acid or otherwise irritating, its character should be modified by demulcent drinks and by alkaline diuretics.

For a more direct local effect, cantharides, turpentine, sandal wood oil, or copaiba may sometimes be administered with advantage, especially when the inflammation is mostly confined to the prostatic urethral mucous membrane.

Various local measures of treatment may be expected to contribute to the cure.

Counter-irritation to the perineum, either with tincture of iodine or with fly blisters, is often of great use. Cantharidal collodion is a convenient blistering medium, and should be applied to a small surface close to the raphe.

Whatever counter-irritant is used, care should be taken that it does not come in contact with the scrotum or anus. After the application is dry, it is a good plan to fix a pad of absorbent cotton in the perineum with a T-bandage. This takes up the perspiration and prevents the blister from spreading to the side opposite to that where it was applied.

When there is much pain in the prostate and rectum, hot injections into the bowel may help to palliate it, and to reduce the congestion in the same manner that hot douches act upon the female pelvic organs.

The most important local treatment, however, is that applied directly to the prostate itself, and consists in the passage of sounds, massage of the prostate through the rectum, and in applications and injections into the prostatic urethra.

The use of sounds in chronic inflammation of the prostate has long been recognized as of advantage, and the benefit from them has been variously explained.

Some surgeons think that they should be used cold, and ascribe their efficiency to the astringent action of the cold. Others consider that their pressure within the prostate exerts some beneficial influence by forcing the blood out of the gland.

While some good may perhaps be attained in either or both of these ways, it is probable that the stretching of the constrictor urethræ muscle, and the consequent relief from spasmodic contraction of the same, will account, in a large measure, for the good results that follow their use. As has been said above, this sphincter is not infre-

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quently put in a spasmodic state of contraction by the proximity of the prostatic inflammation, and in this state of stricture it has a tendency to aggravate the deep inflammation, just as an organic stricture tends to increase and perpetuate a urethritis posterior to it. It can be readily understood, therefore, that the relief of this spasmodic contraction would act favorably upon the inflammation behind it.

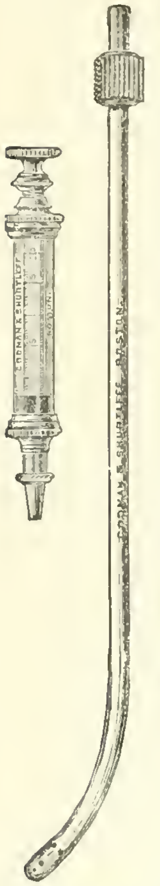

FIG. 3884.—Ultzmann's Prostatic Syringe. A capillary tube and graduated syringe for the introduction of strong solutions. The curve of this and of the irrigating catheter is modified from Ultzmann's instruments. See text.

As large a sound as will pass comfortably through the urethra should be used, and it should be introduced with the greatest gentleness. A sound passed roughly down through the anterior urethra will sometimes find the constrictor tightly closed against it, when, had more care been exercised, the urethra would not have resented its introduction, and it would have readily passed the moderately contracted sphincter.

If the spasmodic stricture is a tight one, it will sometimes be found necessary to precede the introduction of the sound by the passage of a French, olive-pointed, conical bougie; which, insinuating its point through the obstruction, readily dilates it and prepares the way for the larger instrument.

When excessive irritability or an access of inflammation make the application of cold to the prostate desirable, it may best be accomplished by the use of the cold sound. This is a hollow instrument, which after its introduction can be chilled down by passing a stream of water through it. It should usually be kept in place for about five minutes.

We now come to speak of local applications to the prostatic urethra, and in these we recognize the most efficient means at our command for subduing chronic inflammation of this part.

The cases which are particularly suited to this form of treatment are those in which prostatic clumps are present in the urine, with or without a purulent secretion; in short, in which the mucous membrane is distinctly affected. Medication may be conveyed to the pars prostatica urethræ either by the injection of a few drops of a strong solution, or by irrigation with considerable quantities of a weak solution.

The application of soluble drugs to the prostatic urethra is probably best accomplished by the injection of solutions.

The constrictor muscle, situated just in front of the prostate, prevents the penetration of an ordinary urethral injection, and special instruments are therefore needed for medication in the urethra posterior to it. Figs. 3884 and 3886 represent such catheters for prostatic medication.

The curve shown in these instruments has advantages both in the ease of introduction, and in the readiness with which the location of the point can be determined from the position of the handle.

When the instrument is vertical* the point necessarily rests just in front of the triangular ligament; now, upon bringing it down to an angle of forty-five degrees, and at the same time advancing it slightly, the point slips on through the constrictor muscle, but never passes beyond the prostate unless a special effort is made to push it on toward the bladder. Fluid injected through the catheter, when in this position, cannot pass forward through the constrictor, but washes out the prostate and escapes backward into the bladder.

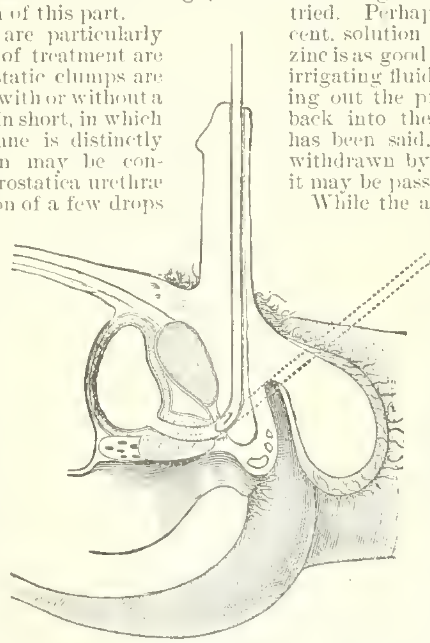

FIG. 3885.—Diagram showing that if a short-beaked instrument is held with the handle vertical, the point rests just at the triangular ligament. The dotted figure shows how the point slips through the constrictor muscle when the handle is brought to an angle of forty-five degrees with the axis of the body.

Of the various drugs used for prostatic application, nitrate of silver is perhaps the most valuable.

Two or three minims of a one- to two-per-cent. solution should be thrown into the prostatic urethra through the capillary catheter (Fig. 3884).

Some pain of a burning character, with often considerable tenesmus, follows the application; but this usually passes off in an hour or two. The injection should be repeated every four or five days, and its effect may sometimes be heightened by the previous passage of a sound. As convalescence is established, the intervals in the treatment should be gradually lengthened.

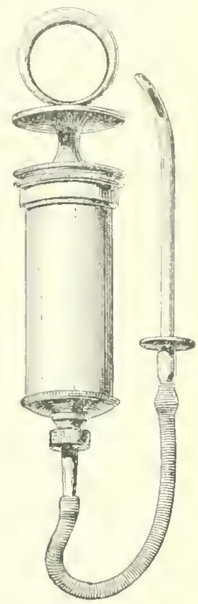

FIG. 3886.—Irrigating Catheter. (After Ultzmann.)

Irrigation of the prostatic urethra may often be practised with great benefit. In case there is much irritability of the neck of the bladder, with considerable muco-purulent secretion, a soothing antiseptic wash is of use. A two-per-cent. solution of borax or boracic acid, with the addition of a little glycerin, is a good injection for this purpose.

If the use of an astringent wash seems indicated, any of the mixtures useful in gonorrhœa may be tried. Perhaps a one-per-cent. solution of acetate of zinc is as good as any. The irrigating fluid, after washing out the prostate, flows back into the bladder, as has been said, and from there it may either be withdrawn by slightly advancing the catheter, or it may be passed by the natural efforts.

While the above-mentioned procedures are addressed to the urethral aspect of the prostate, further relief may be afforded by massage of the rectal face of the prostate. This is done by the forefinger introduced into the rectum, and should aim at expressing the contents of the prostate. The amount of pressure which may be safely used will depend on the acuteness of the inflammation, of which the tenderness will prove a safe guide. Massage should not be given at too short intervals, and is often wisely made to alternate with the other local measures above outlined.

After any manipulation or treatment of the prostate the patient should keep quiet, if possible recumbent, until all serious discomfort passes away, and should

* Throughout this article, when the manipulation of instruments is described, it is supposed that the patient is in a horizontal position.

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avoid any exposure to chill or fatigue for several hours.

HYPERTROPHY OF THE PROSTATE, ENLARGED PROSTATE. — *Etiology.* — The causes of enlargement of the prostate are difficult to establish by any adequate proof.

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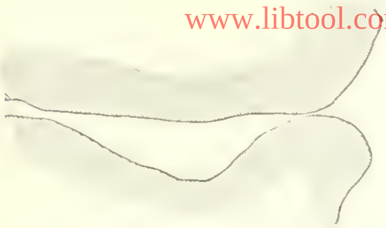

FIG. 3887. — Diagram to show the Shape of the Urethra in a Vertical Section Through a Prostate with an Enlarged Middle Lobe.

The one thing which seems to be essential to the existence of the disease is the advanced age of the patients. Hypertrophy of the prostate is practically unknown before the age of fifty, whereas after that it is extremely common.

Stone in the bladder, stricture of the urethra, irritation by the frequent use of instruments, sedentary habits, gouty or rheumatic diathesis, and exposure to cold and damp, have all been cited by surgical writers as predisposing circumstances; but none of these conditions has ever been positively shown to stand in a causative relation to the disease.

On the other hand, there is no doubt that, when prostatic hypertrophy exists, any of these conditions may greatly aggravate its symptoms; and besides those already named we may mention excesses in drink or in venery, prolonged voluntary retention, and the recumbent posture as familiar causes of increased prostatic congestion.

Pathology.—Hypertrophy of the prostate may occur through hyperplasia of the glandular portions of the organ, of the interstitial tissue, or of both.

As the normal size of a particular prostate can never be known, it may be hard to say, even on post-mortem examination, whether a given specimen is enlarged or not. For approximate determination, however, a prostate weighing six drachms may be regarded as normal in size, and anything over that is to be considered hypertrophied.

Upon section of a prostate which is hypertrophied, the cut surface bulges irregularly above the capsule. It may be grayish-yellow in color or mottled with blotches of red, yellow, and gray, with occasional dark pigmented spots.

FIG. 3888. Diagram of a Horizontal Section through the same Organ, showing how the urethra divides and goes on either side of the middle lobe.

If the glandular element predominates the surface is soft, and exudes a fluid rich in cells. In interstitial hyperplasia the surface is dryer and firmer.

Sometimes little projecting bunches announce the formation of fibrous or glandular tumors within the organ.

Usually the hypertrophy affects all parts of the gland simultaneously, but not all in the same degree.

The shape of the prostatic urethra—a matter of the first clinical and surgical importance—depends largely upon the partial or general character of the hypertrophy. If the enlargement is pretty evenly distributed throughout the organ, the urethra is in the first place considerably lengthened, sometimes measuring even 7 cm. When the hypertrophy is partial the elongation is less, though it is still marked.

Furthermore, in cases of general hypertrophy, as the lateral lobes enlarge they compress the urethra from the sides, until it becomes a slit-like canal with tolerably firm walls in close apposition. As the lateral diameter is thus diminished, the antero-posterior diameter is correspondingly increased.

It will be readily seen that, as long as the enlargement is symmetrical, the direction of the urethra is not materially altered; but, on the other hand, it is equally evident that, if the hypertrophy is partial, and not evenly distributed, the unequal pressure from one side or the other of the canal will cause lateral deviations, and that, if the middle lobe is unduly enlarged, the posterior portion of the urethral floor will be raised, causing a deviation upward or toward the pubis (see Fig. 3887).

The projection upward of this lobe may make the internal urethral opening crescentic in shape, and if the middle coalesces with either of the lateral lobes, this orifice is pushed over toward the opposite side.

Sometimes the middle lobe grows out into the bladder as a distinct tumor, which may be attached by a broad base, or may stand off in a pedunculated polypoid form.

Besides the changes in the prostate itself, there are other alterations in associated organs which we must consider in connection with this disease, as they are instrumental in producing many of the symptoms which we shall have to study.

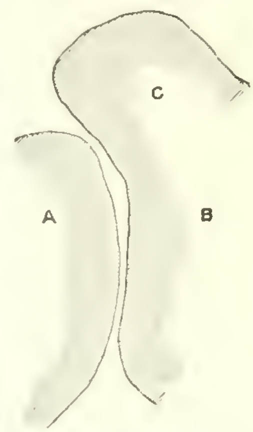

FIG. 3889.—Diagram of a Horizontal Section through a Prostate in which the right lobe, *A*, is moderately enlarged, the left lobe, *B*, somewhat less so, while the middle lobe, *C*, is much enlarged and is joined to the left lobe, causing a deviation of the vesical end of the urethra to the right.

As the prostate enlarges the internal meatus is raised and a pocket is formed in the bladder just behind the enlarged gland. The bladder wall also becomes thickened, partly in consequence of hypertrophy of the muscular coat, owing to the increased resistance against which it has to work, and partly owing to a sclerosis of the interstitial fibrous tissue, like that which has occurred in the prostate.

Interlacing muscular bands often stand out from the vesical wall under these circumstances, forming trabeculæ between which there are, not infrequently, considerable pouches of mucous membrane.

The walls of the ureters and pelves of the kidneys may also be somewhat thickened, and the interstitial renal tissue undergoes frequently a hyperplasia.

As a later result of the prostatic obstruction the bladder, ureters, and pelves of the kidneys may become greatly distended.

Guyon and Launois have laid particular stress upon the fact, already hinted at and partly understood by earlier writers, that coincident with these changes in the urinary tract a general sclerosis, affecting specially the walls of the blood vessels, is going on throughout the body.

When from any cause inflammation of the bladder, ureters, or kidneys has associated itself with hypertrophy of the prostate, we have the familiar pathological appearances of cystitis, pyelitis, and pyelo-nephritis engrafted upon the organs already seriously altered by the prostatic obstruction.

For a full consideration of these complications see the articles on *Bladder of the Male* and on *Kidneys, Diseases of.*

Natural History.—The progress of the disease is slow. The organs affected are not of vital importance, and the changes in them may reach a very advanced state before they seriously threaten life.

Guyon has divided the history of the disease into three

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periods: *First*, that of congestion, affecting mainly the prostate, but also in less degree the bladder and kidneys. *Secondly*, that of partial retention of urine. And, *thirdly*, that of distention of the bladder with usually secondary changes in the kidneys.

This somewhat empirical division gives us perhaps as good a framework as any for the classification of the clinical phenomena.

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In the first stage, that of congestion, we have some enlargement of the prostate and functional disturbances, especially in the matter of urination. This condition may persist for a long time, and in certain cases, in which for any reason the calibre of the urethra is not greatly interfered with, it may exist almost indefinitely without showing any tendency to pass on to the second stage, that of retention.

Usually, however, sooner or later the obstruction to the passage of the urine becomes greater than the force of the bladder can overcome, and a state of habitual partial retention is the result.

When this condition comes on slowly, the accumulation of residual urine may be very insidious, and escape the observation of patient and physician alike; on the other hand, an increase in the prostatic obstruction may occur suddenly, and the unexpected complete stoppage of the urine may be the first announcement of trouble.

When the retention of the second stage of the disease develops gradually, and is not discovered and treated, the point may be finally reached where the bladder has completely lost its tone and is so distended that the urine escapes almost constantly by an overflow (retention with incontinence). This same condition of things may follow also an acute retention which has not been relieved by catheterization and in which nature has finally established a leakage.

The third stage of the disease is now entered upon, and if nothing is done for such a case the distention of the bladder becomes extreme, and a secondary dilatation of the ureter and of the pelves of the kidneys takes place. This is soon followed by atrophy of the secreting portion of the kidney, and an increase of its interstitial tissue (interstitial nephritis).

The secondary changes in the heart and blood-vessels, usually associated with chronic nephritis, are likely to make themselves noticed at this time, if they have not already done so, and the disease becomes a constant and serious menace to life.

It is in this advanced stage of the disease that inflammatory processes, starting in the bladder, rapidly extend backward to the kidneys, and uræmic symptoms presently usher in the closing scene.

Symptomatology.—From what has been said in regard to the history and progress of the disease, it will be seen that the symptoms of the first stage are mainly dependent upon the condition of congestion in the prostate, bladder, and kidneys. And as this congestion is most considerable in the prostate, the most noticeable symptoms caused by it are disturbances of micturition and of sensation, due to the irritated state of the neck of the bladder.

In the second and third stages we have, in addition, a series of symptoms due to the mechanical obstruction to micturition, and to the changes in the bladder and other organs consequent upon this obstruction.

We shall have finally to consider the symptoms arising from various morbid conditions likely to appear as complications in the course of prostatic disease.

The first appearance of symptoms usually announces a morbid condition which has already been coming on for some time. When the enlargement takes place in such direction as not to encroach seriously on the calibre of the urethra, it may reach very considerable proportions before it causes any inconvenience to the patient.

One of the first symptoms to be noticed is an increased frequency of micturition, which is specially marked at night or early in the morning. Guyon regards this as evidence of congestion, which is aggravated during recumbency and sleep. He calls attention also to the frequent existence of erections in these patients, on waking, as further evidence of an increased congestion of the prostate during sleep.

Pain is ordinarily not very noticeable in the early stages of the disease, although a dull aching or heavy dragging sensation in the perineum, rectum, and behind the pubis is not uncommon.

If attention is paid to the manner in which urination is accomplished, it will be found that early in the disease the stream is slow to start and diminished in force. This is due largely to a loss of power in the bladder, but is to be partly explained by the swelling in the prostate, and by a spasmodic contraction and stammering action of the constrictor muscle.

The diminution in the force of the stream in a prostatic patient differs from that seen in cases of stricture, in that, while a strictured patient can, by voluntary effort, increase the force of his stream, a man with enlarged prostate cannot do so.

Second Period. The symptoms which have their origin in congestion continue during this period, and are, indeed, intensified. Added to them we have other symptoms due to the retention, which is the characteristic condition of this stage of the disease.

The retention may be complete or incomplete.

Complete retention may be acute and appear suddenly, or it may be preceded by a period of partial retention which always develops slowly.

The symptoms which accompany a complete retention are easy of recognition, and a physical examination reveals the bladder distended above the pubis. Incomplete retention, on the other hand, comes on very insidiously, and is often overlooked for a long period, at just the time when recognition and treatment of the condition are of great importance.

Although, as has been said, partial retention comes on quietly, still a careful examination of the symptoms will usually elicit evidence of a changed condition of things, at or soon after the time when the bladder begins to fail of emptying itself. The feeling of weight behind the pubis is likely to be increased, and the frequency of micturition, which during the first stage was decidedly more pronounced at night, begins to be almost equally noticed in the daytime. The intervals between the acts of urination become short, and the call is imperative. In short, the bladder being always partly full, it takes but a small additional quantity to distend it to its full capacity.

The only positive means of determining the conditions of the bladder is by a physical examination, and this should be made in every doubtful case.

Sometimes the bladder shows extraordinary tolerance, and the distention becomes so extreme as to cause incontinence from overflow, before the patient feels obliged to call upon a physician; and sometimes also, unfortunately, before the medical attendant recognizes the nature of the difficulty.

This incontinence is evidence of a very great degree of distention, and shows that the disease has entered upon its third stage. Usually, before it appears, the disease has already extended backward and has begun to affect the kidneys.

There is one symptom which may appear and give evidence that the disease has reached the third stage, before incontinence begins. This is polyuria. If the quantity of urine in the twenty-four hours is measured, it will be found considerably to exceed the normal.

Pain, which was an insignificant symptom in the first stage, may assume considerable importance in the second and third stages.

Besides the discomfort in the perineum and back due to the congested and irritated prostate, there is also considerable pain before and during micturition, caused by the distention of the bladder and its unavailing or partially successful attempts to empty itself. The passage of the urine through the prostate is also sometimes painful, and this is especially the case when the occurrence of inflammation has rendered the urine pungently alkaline and has made the parts particularly sensitive.

The examination of the urine may give negative results

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during the early stages of prostatic disease; but when the congestion of the kidneys is considerable there are usually albumin and a few casts. During the last stage of the disease, when polyuria has established itself, the specific gravity is low (1.003–1.006) and there is generally a small amount of albumin, although this may not be present. A few casts will usually be found at this time, too, but they may be absent even when the kidneys are extensively diseased.

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In the presence of inflammatory complications the character of the urine is greatly changed, as we shall see later.

In addition to the more local symptoms which we have been considering, there are also certain general disturbances which are likely to appear in advanced prostatic disease. These are of two kinds, digestive and febrile.

Obstinate indigestion in an old man, especially if accompanied by nausea, should always lead us to take the condition of the prostate into consideration. These patients are also very liable to a low feverish condition, with extremely dry mouth and tongue, and this may announce the extension of inflammation from the bladder back into the kidneys.

We now come to the consideration of the complications which are likely to arise in prostatic cases, and of the symptoms, or variation in symptoms, to which they give rise.

They are cystitis, pyelitis (pyelonephritis), hæmaturia, and stone in the bladder.

Cystitis is so common in prostatic hypertrophy that it may be looked upon almost as a necessary result. It sometimes appears without apparent cause, sometimes in consequence of excesses in drink, or from exposure to cold, and in this case the infection probably comes from the rectum or through the blood. Far more commonly, however, it follows as a consequence of the use of the catheter or other instrument, and when it is once established it is rarely got rid of—but may, as we shall see, by appropriate treatment, be kept within very reasonable bounds.

When the inflammation of the bladder is at all acute, the pain and frequency of micturition are greatly increased. If the prostate shares in the inflammation, a great weight and bearing down pain in the rectum may be felt, with a frequent urgent desire for defecation.

The urine becomes thick from the admixture of pus and mucus, which often settles at the bottom of the vessel in a thick, ropy mass. Presently, in the majority of cases, it undergoes alkaline fermentation, becomes ammoniacal, and has a strong pungent, often fetid odor. The sediment now contains, besides the pus, prostatic cells and abundant crystals of triple phosphates, often associated with finely granular amorphous phosphates.

If the inflammation extends from the bladder back through the ureters to the kidneys, the resulting pyelitis or pyelonephritis makes itself known by pain in the back, high fever, more or less diminution or even suppression of urine, and uræmic symptoms.

This course of things is especially liable to occur late in the disease, when neglect of catheterization has allowed the ureters to become greatly distended. Under these circumstances, any exposure to cold or instrumentation may be sufficient to start the fatal access of inflammation.

Occasionally, when the use of the catheter has been neglected after the time when it should have been begun, the final entrance upon the catheter life, instead of being a conservative measure, gives the final push toward a fatal issue. The existence of polyuria, with urine of a low specific gravity, should always lead us to fear this result.

Stone in the bladder not infrequently occurs in prostatic patients as a consequence of cystitis, in which case the stone is of the soft phosphatic variety; or a stone composed of uric acid, oxalate of lime, or cystin may form, and owe its origin primarily to a constitutional condition.

In either case the prostatic hypertrophy may be regarded as partly responsible for the formation of the calculus.

In the first case, that of the phosphatic stone, the obstruction, by causing the cystitis and fermentation of the urine, stands in a pretty close causative relation to the calculus. In the second case, in which the deposit of crystals from the urine is due to a constitutional tendency, the obstruction at the prostate may be the condition which decides whether a stone shall form or not. For, when the bladder is completely emptied at each urination, the crystals as they form are thrown out and do no harm, whereas when there has been formed behind the prostate a pocket in which there is always residual urine, the sand collects there and soon agglomerates itself into a concretion.

When a stone forms behind an enlarged prostate the pain is usually much increased, and is less amenable to treatment. It is referred often to the glans penis, and is greatly aggravated by motion, especially by riding in a jolting vehicle. It is commonly less marked at night or during rest.

Hæmaturia in case of stone is very likely to appear after exercise or riding, while prostatic hemorrhage from congestion seems to be independent of any jarring of the bladder—in fact, is rather more likely to come at night, when recumbency favors prostatic congestion.

The sudden stoppage of the stream in the midst of urination, by the rolling of the stone against the opening of the urethra, is less likely to occur in case of an enlarged prostate than in a healthy bladder, owing to the lodgment of the stone behind the prostate, below the urethral orifice.

If the presence of the stone affects the frequency of micturition, it tends to increase it rather in the daytime, when motion causes the stone to move about, than at night, when it is at rest.

Hæmaturia, as has been said, may result from the congestion of the prostate with or without ulceration, or from the presence of a stone. We may also have hemorrhage of considerable amount and duration, following the use of instruments; and, lastly, the too sudden emptying of an over-distended bladder may lead to an attack of hæmaturia, from the capillary oozing from the vesical wall.

Sometimes clots of large size may form in the bladder, and cause much pain and discomfort before they are broken up and expelled.

Physical Examination.—After it has been decided from the symptoms that there is a probability that prostatic hypertrophy exists, a thorough examination should be made of the prostate and bladder.

The objects of this investigation are to ascertain the stage at which the disease has arrived, to learn the amount of obstruction and the configuration of the prostatic urethra, and to discover any complicating conditions which may exist.

The patient should first empty the bladder, so far as possible by the natural efforts, and the hypogastrium should then be explored by palpation and percussion, to see whether enough distention of the bladder remains to be detected in this region. The normal variations in the position of the bladder and intestines render this examination often unsatisfactory, especially when the abdominal wall is thick or rigid.

The examiner should then explore with the forefinger the rectum. This is best done with the patient on the back.

If the prostate is enlarged it will be felt pressing down the anterior rectal wall. Its size, shape, and consistency should be noticed.

The relative enlargement of the lateral lobes can usually be well made out, and nodular projections are sometimes felt, caused by irregularities in the hypertrophy of different parts of the gland. Rectal examination, unfortunately, gives little or no information in regard to the condition of the third lobe, which is so often the cause of a serious obstruction to the flow of urine.

Incidentally, the degree of tenderness to palpation will be discovered.

The condition of the prostate itself having been deter-

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mined, the examining finger should be carried up along the posterior vesical wall, if that be possible, and the condition of the bladder should be learned. In this investigation the bimanual manipulation between the finger in the rectum and the hand above the pubes, so commonly practised in examinations of the female pelvic organs, is useful, and by it the amount of distention of the bladder can often be most accurately made out.

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Lastly, the urethra and bladder should be explored.

The existence of a stricture will probably be detected in the passage of instruments for deeper exploration. But in case of doubt the canal may be thoroughly examined with large bulbs. A short-beaked sound should be passed, and as it runs through the prostate deviations of the urethra will often be shown, by the feeling of resistance on one side or the other and by the turning of the handle.

The sound in entering the bladder may sometimes be felt to slip up over a bar, or may turn to one side around a prominent third lobe.

After a proper search has been made for a possible stone, the sound should be depressed until it lies in the axis of the body, and then withdrawn until the concave side of the beak comes against the neck of the bladder; it may then be rotated, and, as the beak sweeps the vesical face of the prostate, any irregular outgrowths or projections will be felt to arrest its movements.

If the sound has been felt to ride over an obstruction at the neck of the bladder and if, after it is in, it rotates freely, this points to a bar rather than to a globular enlargement of the third lobe, which last would arrest the beak of the sound in rotation.

As the instrument is withdrawn slowly through the prostate, the deviations due to projections into the urethra are often felt even more plainly than during introduction.

Finally, the urine may be withdrawn with a catheter and the exact amount of residuum thus discovered. This will be found to vary much at different times, and depends somewhat upon the amount of urine which the bladder contained before the last urination.

When the bladder is full and the urine consequently rushes out with some force in a considerable stream, it will often be found that there is much less water left in the bladder than is the case when urination is attempted before complete distention has been reached.

Diagnosis.—The conditions with which enlarged prostate is likely to be confounded are stricture of the urethra, stone in the bladder, atony of the bladder, cystitis, cancer or other tumor of the prostate, tuberculosis of the prostate, and tumor of the bladder.

The physical examination, if thoroughly made, usually enables us to eliminate the first two of these conditions, and if enlargement of the prostate with residual urine is found we may, in the absence of other discoverable cause, decide that an existing cystitis is dependent upon the prostatic trouble. It may, however, be impossible to demonstrate the absence of stone behind an enlarged prostate except by a thorough examination under ether with the lithotrite.

The decision between a tumor of the prostate and simple enlargement is extremely difficult, unless the tumor has assumed considerable proportions or has begun to invade surrounding parts. The physical examination by way of the rectum gives us our best help in diagnosis, but the irregular growth of a tumor may at first simulate the irregularities sometimes seen in hypertrophy.

The pain attendant upon the growth of a tumor is more severe than that appearing early in hypertrophy, though this is by no means constant.

In case of a cancer the enlargement of neighboring glands may help us to the right solution of the question, and occasionally the microscopic examination of the urinary sediment will show the presence of cells characteristic of a new growth. Not infrequently, however, it will be necessary to wait until the progressive growth of the tumor declares its character.

Tuberculosis of the prostate usually occurs earlier in life than we could look for hypertrophy. In case of doubt, tuberculous deposits must be sought for in other organs (epididymis, seminal vesicles, lungs, etc.).

A tumor of the bladder may give rise to hemorrhages and difficulties of micturition which simulate those caused by enlargement of the prostate. Also a tumor may be present in the bladder behind an enlarged prostate, and so complicate the symptoms.

The hemorrhage from a tumor is ordinarily very much greater than that from a congested prostate. But this is not always the case, and whenever there is persistent or intermittent hæmaturia, however slight, a careful search should be made for villi or other bits of the tumor which may be detached and passed in the urine, and which may be recognized under the microscope.

Examination of the bladder with the sound may, when a tumor is there, reveal a projection somewhere from its wall. But sensations of this sort are very misleading, and it is well, after a thorough sounding, to wash out the bladder with the litholapaxy evacuator, with the object of obtaining bits of the tumor, if one is there.

After definitely settling the diagnosis of prostatic hypertrophy, it is always important to go further and to decide in what stage the disease is, as we shall see that treatment should vary according to the varying conditions.

The steps to this decision have been sufficiently indicated above.

Treatment.—As has been described, the disease under consideration consists essentially in a tendency to congestion of the prostate, bladder, and kidneys, with an accompanying hypertrophy and sclerosis.

For convenience we have divided it into three stages: First, of congestion, with functional disturbances; second, of simple retention; and, third, of retention with distention, often incontinence, and perhaps involvement of the kidneys.

First we will consider those measures of treatment, hygienic and medical, which are applicable to all stages of the disease.

Anything which has a tendency to increase the congestion should be carefully avoided. A chill of the surface should be especially guarded against. The patient should wear flannels next the skin, and should carefully avoid draughts or long exposure to chilly and damp air.

The feet should be kept dry and warm, and if the patient gets up at night to pass water, use the catheter, or for other purpose, he should cover his feet and legs warmly. Neglect of these precautions may at any time bring on an attack of retention, of cystitis, or even of pyelonephritis.

Excesses in eating and drinking are to be avoided. Large quantities of rich or highly seasoned food must not be indulged in, and wine and beer are for the most part better left alone. This caution should be understood to apply only to overeating, as a sufficient quantity of nourishing food is of importance. If the patient has been in the habit of taking a stimulant, a little light claret, or some whiskey and water, may be allowed with meals.

Especial warning should be given against holding the water over the ordinary time, particularly if any call to pass it is felt. An attack of complete retention or of cystitis may result from disregard of this rule.

Venereal excesses are, of course, to be avoided.

The effect of sedentary habits and of horizontal decubitus in increasing the passive congestion must be borne in mind, and moderate gentle exercise is to be advised. The patient will do well, when engaged in any occupation that keeps him long in one position, to take an occasional turn through the room; and at night or in the morning, when he gets up for the purpose of emptying his bladder, a short walk about his chamber will often materially assist him in making his urination thorough and satisfactory.

Constipation should be carefully guarded against. In prescribing for this condition, the violently acting drugs,

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which produce more or less congestion of the pelvic organs, should not be used.

The greatest assistance will often be obtained from rectal injections. These are especially useful when the mechanical obstruction of the prostate, pressing as it does upon the rectum, is largely responsible for the failure of the bowels to act.

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Cold injections are usually to be avoided, though they may sometimes render good service in helping to restore the functions of an atonic bladder. Hot injections (112°–115° F.) will sometimes assist in reducing congestion.

The functions of the skin should be stimulated as far as possible. Rubbing and massage are to be employed to this end, and baths also serve a useful purpose if care is taken against a subsequent chill. A hot bath ending with a sponge off in cold water, and vigorous friction with a rough towel, may be of real benefit, by bringing the blood to the skin and so relieving internal congestion.

In selecting a climate for a prostatic patient, preference should be given to dry inland localities, where sudden changes of temperature are less likely to occur than on the seacoast. Sometimes, however, when the general condition is depressed and a stimulating climate is desirable, the seaside may be tried, special precautions being taken against surface chills.

General medication directed against the disease itself has but little to offer.

The iodides may have a trial, in virtue of their reputation in the treatment of sclerotic conditions of the blood-vessels and other organs. If used they should be persisted in for a long time, with occasional intermissions. They have the disadvantage of sometimes disagreeing with the stomach, and it may be necessary to discontinue them on this account.

Of the medication required in the various morbid conditions which may from time to time need correction, we shall speak in considering the treatment of the various periods.

Local treatment may be divided into palliative and operative.

Palliative Treatment.—Treatment in the first period is almost wholly hygienic and medical.

In the absence of complications, and before there is any retention, the less instrumentation the better, as it only aggravates the congestion, and introduces the danger of infection from dirty instruments.

If the urine is irritating from too great acidity, an alkaline diuretic, such as citrate or acetate of potash, is indicated.

In case of pain, belladonna or hyoscyamus should be administered either by the mouth or by the rectum. Opiates should be avoided, if possible, as they derange the stomach and constipate the bowels. When urgently required, however, they may occasionally be resorted to.

Ergot, strychnine, or nux vomica in some form and quinine are sometimes useful, and act apparently by diminishing the congestion, and perhaps also by stimulating the contractions of the bladder. If the circulation is not good, cardiac stimulants may be of assistance.

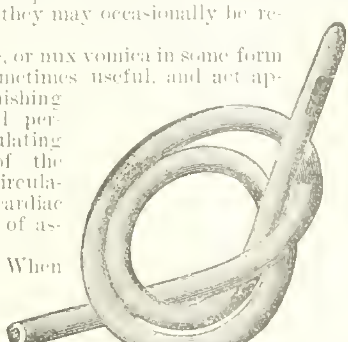

FIG. 3890.—Soft-rubber Catheter.

Second Period. When the stage of partial retention has set in and the patient passes water, but is not able completely to empty the bladder, it is necessary to resort to the use of the catheter. So important is this that every patient who is seen in the first stage and put upon general treatment, should be warned that the time will almost certainly come when catheterization will be required, and that as there is no sure means by which he can tell when he reaches this state, he should occasionally present himself for examination to decide this point.

Sometimes the partial retention is due to some accidental increase of congestion, which may disappear under the use of antiphlogistics. In such a case the patient may be put to bed with leeches to the perineum, followed by hot applications assisted by opiates, if necessary.

FIG. 3891.—Elbowed Catheter (Sonde Coudée of Mercier).

If these measures fail, it will be necessary to draw the water, and it will sometimes be found that, after a short systematic use of the catheter, the bladder will recover itself and again become able fully to expel its contents. Thus the disease may occasionally be moved back from the second period into the first.

When complete retention comes on suddenly the catheter is indispensable, but in this case again its use may perhaps later be given up.

When entering upon the use of the catheter, we may often learn whether it is really needed by noticing the effect upon the symptoms. If these are relieved or ameliorated, we are evidently on the right track.

It is to be remembered, however, that not infrequently, on commencing catheterization, a cystitis develops itself, owing either to the too sudden evacuation of a distended bladder, to the introduction of dirt upon the catheter, or simply to the irritation from the constant use of instruments. It is important that the aggravation of symptoms caused by this inflammatory onset shall not lead the patient or doctor to infer that the catheter is doing harm and should be given up, for it is by continuing its use that the attack of cystitis may be most quickly and surely relieved.

FIG. 3892.—Double-Elbowed Catheter (Sonde Bicoudée).

Let us now consider how and with what instruments the catheterization is to be carried out.

As has been described, the walls of the urethra are pressed together and may be somewhat deviated by the inequalities of the lateral lobes. The posterior part of the urethral floor is also often raised by the projection of the third lobe.

Our object is to reach the bladder through this sinuous passage with the least possible amount of irritation.

If a soft, red rubber catheter will find its way into the bladder, it is, by all odds, the best instrument to use. It requires no skill for its direction, and can do no damage to the urethral walls—a point of great importance, as it enables us to entrust its use to an unskilful patient.

When, owing to the narrowness or tortuousness of the urethra, the rubber catheter will not pass, we must resort to a stiffer instrument, and must adapt its form in reference to the difficulties which it has to overcome.

The obstructions which it will meet project from the lateral walls and floor of the canal, and our effort must be to carry the point of the instrument along the upper or anterior wall.

Mercier devised for this purpose a flexible webbing catheter with the point sharply turned up (sonde coudée), so that it might ride over the obstructions on the floor.

For those cases in which the hypertrophy of the third lobe was very pronounced, he used a catheter with a second bend, designed to lift its point still higher.

In introducing these instruments, care should be taken that the point be kept turned toward the roof of the canal, and after it has passed the triangular ligament the

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penis should be depressed as much as possible between the thighs, so that the catheter may be pushed straight upward in the axis of the body.

The English gum-elastic catheter may often be used with advantage, either with or without its wire stylet. If it is introduced without a stylet it is a good plan to exaggerate the curve of the instrument, as has been suggested by Thompson. When used thus it should be introduced cold and carried as rapidly as possible through the anterior urethra, for as it warms it becomes flexible and loses its form. By passing it rapidly but carefully, its curve often carries it over the obstructing third lobe.

If it meets an obstruction and, warming in the urethra, becomes flexible, the forefinger in the rectum should be used to lift the point of the catheter into the prostate, while at the same time the handle should be brought down to the axis of the body, and the instrument, which is then practically straight, should be pushed steadily into the bladder. This should be done without the exercise of much force, as the point, when properly guided, slips along quite easily and when it catches there is danger of its making a false passage if pushed.

If the gum-elastic catheter is introduced with a stylet it should be curved into the form of a prostatic silver catheter. Sometimes, when the point catches it may be lifted over the obstruction by the simple manœuvre of slowly withdrawing the wire while slightly advancing the instrument. This curls the point upward and often enables it to ride over the obstacle

Occasionally, when other flexible instruments fail, the French conical bougie catheter will succeed in worming its way through the canal. It should be used with great caution, as its comparatively sharp point may catch in and perforate the mucous membrane.

Failing with other instruments, we may have recourse to a metallic catheter of large curve.

The beak of this instrument should be long enough to reach easily through the enlarged prostate, which may be one inch and a half longer than in the normal state. If the curve is too short the point does not reach the bladder, but being engaged in the prostate, runs considerable risk of making a false passage when the handle of the instrument is depressed.

The forefinger in the rectum may give great assistance in guiding the passage of this catheter.

In using any instrument in a urethra with false passages it is a good plan always to withdraw for a considerable distance when the point is caught, and then to try to pass the pocket by carrying the beak down first one wall and then another until the right passage is found. Ordinarily the false passages exist in the floor of the urethra; but this rule has many exceptions.

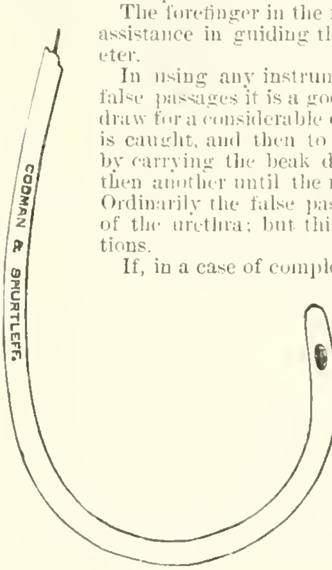

FIG. 3893.—English Gum-elastic Catheter with Exaggerated Curve on Stylet. (After Thompson.)

If, in a case of complete retention, after careful and thorough attempts we do not succeed in reaching the bladder, recourse must be had to puncture with trocar or aspirating needle.

This was formerly done through the rectum with curved trocar, but as this method cannot be used antiseptically the suprapubic puncture is to be preferred. This may be done with a fine needle introduced close above the pubis, and, if necessary, may be repeated two or three times daily for a considerable time. Usually, however, drawing off the urine in this way is followed by such a subsidence of the swelling as presently to allow the introduction of the catheter. Leeching the perineum and the administration of ergot may also be of service in reducing the congestion.

The evacuation of a distended bladder, whether by catheter or by aspiration, should be performed slowly and carefully. When the distention is extreme, the bladder should not be wholly emptied at one time, for if the internal pressure is too suddenly relieved we are likely to have a great congestion of the vesical mucous membrane, with the escape of blood into the urine, followed often by considerable inflammation.

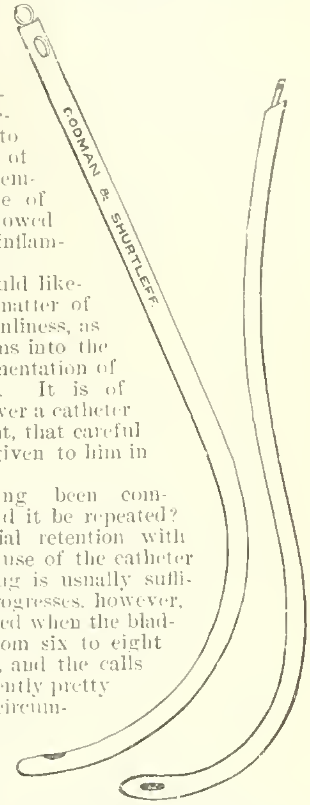

FIG. 3894.—Silver Catheters of Curve Appropriate for Use through an Enlarged Prostate.

The greatest care should likewise be taken in the matter of thorough antiseptic cleanliness, as the introduction of germs into the bladder may start a fermentation of the urine with cystitis. It is of course important, whenever a catheter is entrusted to a patient, that careful instructions should be given to him in regard to this.

Catheterization having been commenced, how often should it be repeated?

In the cases of partial retention with moderate residuum, the use of the catheter each night before retiring is usually sufficient. As the disease progresses, however, a point is presently reached when the bladder habitually holds from six to eight ounces of residual urine, and the calls to urinate are consequently pretty frequent. Under these circumstances the regular use of the catheter is required

If now the patient can get along comfortably while using the catheter four times a day, he is fortunate, and may live for twenty or more years with his artificial urination. Not infrequently catheterization will be required six, seven, or even more times in the twenty-four hours. Especially is this the case when cystitis is present. The water should always be drawn when the desire to micturate is urgent and persistent.

When catheterization is required so often as to become a decided source of irritation, and if the bladder is so irritable as to be constantly liable to painful contractions, it will be found best to tie in the catheter for a time (sonde à demeure). Usually in a few days, after the bladder has had a rest, the catheter can be again left out and the patient can resume regular catheterization.

During the time while the patient is becoming accustomed to the use of the catheter and the bladder is acquiring a tolerance of instrumentation, it is wise to give some urinary antiseptic almost as a routine measure. Of the antiseptics now at our command urotropin and sandal oil are the most useful. Urotropin may be given in doses of five to eight grains two or three times a day, and is a most useful drug, but it will occasionally act as an irritant, especially in the presence of ulceration of the prostate, and in these cases sandal oil is to be preferred. Sandal oil is a more soothing drug, and is especially useful where the tendency to irritability of the bladder exists.

Third Period. In this stage of the disease, systematic emptying of the bladder is as urgently called for as at any earlier time. The serious changes, however, which

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are likely to have occurred in the ureters and kidneys, with the condition of passive congestion which exists throughout the urinary tract, make the use of the catheter a matter of considerable danger, which in some cases may be so great that it will be better practice to leave the bladder undisturbed.

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In these cases the patient's condition of comparative health—troubled, it is true, by frequent and often partly involuntary micturition, but not debarred from ordinary occupations—makes a striking contrast with the state of things which may rapidly develop upon entering on the "catheter life." For a slight added irritation to the bladder may be suddenly followed by a pyelonephritis, or even more abruptly by renal congestion with suppression, uræmia, and death.

These dangers are alarming and imminent enough to make us hesitate, but what is to be hoped from allowing the disease to take its course? Nothing but a certainly fatal issue, which is likely to come in a few weeks or months, and which may be precipitated at any time by an exposure to cold, by fatigue, or by a slight indiscretion in diet.

On the other hand, when catheterization is successfully established, the disease may be moved back from the third to the second stage, and the patient who was in such danger may be put in a state of comparative security.

It is, then, of the first importance to distinguish the cases in which catheterization is so dangerous that the patient had better be left to follow out the natural course of the disease; and in all except these most advanced cases the catheter should be used.

Each case must be decided on its merits, and so much depends on attention to detail that we should sometimes be deterred from commencing catheterization with a careless and slovenly patient, when we should have resorted to it could we have counted on his intelligent co-operation.

Guyon has laid down, for these advanced prostatic cases, a good rule of practice. He puts the patient upon general tonic treatment, and if he finds that he is wanting in strength sufficient to benefit by it, he does not regard him as in a state likely to be helped by interference with his bladder. If, however, he improves decidedly in his general condition, then Guyon regards it as wise to resort to the catheter.

The precautions to be observed in accustoming the patient to the catheter are the same that are required in the second stage of the disease, but they are now even much more important.

Especially should the sudden emptying of a distended bladder be guarded against. It may often require two or three weeks of catheterization before the bladder acquires such tolerance that it may safely be left empty.

During the preliminary period the catheter should always be passed with the patient horizontal, to guard against the too rapid flow of water; afterward, when the complete emptying of the bladder is desired, the vertical position is the best for this operation.

Operative Treatment.—It is impossible in the space at our command here to do more than suggest the outlines of operative treatment and of the more important procedures.

Radical operations aim at a cure; that is, at the complete restoration of the function of urination. While they often fall far short of this ideal, yet many cases are practically cured. Perhaps the main reason why operative treatment has not been more generally successful is to be found in the age of the patients, for in the majority of cases we have to deal with men between fifty and eighty years of age, and it is obvious that severe operations become more dangerous with advancing years. The willingness of the surgeon to operate in any individual case will also often be influenced by the social condition of the patient, for a man of the lower classes who cannot afford the time, trouble, and careful attention to detail necessary to make catheter life tolerable, may wisely be advised to have some operation done, whereas a man in easy circumstances may be kept comfortable by less radical and safer measures.

Operation during First Stage.—As the symptoms of the first stage are largely those of engorgement and irritability, comparatively few patients will be seen at this time, and as it is obviously impossible to decide definitely how long a time may elapse before a patient reaches the second stage, or whether this stage will be reached at all, it is seldom that patients in the first stage are to be advised that an operation should be done. Of course, it must be admitted that the earlier such operations are done, the better, if they are to be done at all, but the progress of this disease is so variable that sound conservatism will rarely be found in favor of operation at this time.

Operation in the Second Stage.—The second stage of prostatic enlargement is, as will be remembered, that of beginning obstruction. At this time, the bladder will usually be in good, or, at least, fair condition, and comparatively little damage will have been done to other parts of the urinary tract. This time is, therefore, in most cases the time of election for radical operative procedures. The patient is usually not too advanced in age, his blood vessels are probably in good condition, and the bladder and kidneys have not been irreparably damaged. If, however, a patient, though in the second stage, be found to have evidences of a chronic nephritis, a damaged heart, or sclerotic arteries, the outlook will be correspondingly less favorable.

Operation during the Third Stage.—The third stage being that of complete obstruction accompanied as a rule by more or less damage to the kidney will be an unfavorable time for radical operation. The mortality at this time is almost prohibitory, and there is little hope of restoring completely, or even in great measure, the function of the bladder. These patients may sometimes, however, by careful catheterization or drainage of the bladder, be so improved that an operation can later be resorted to with reasonable hope of success. Hitherto the rule has been to resort to radical operations only in the more difficult and desperate cases. As a result of this practice the mortality of such operations has been high.

The ideal time to choose for interference is when the obstruction has become considerable, but before it has led to serious changes in the bladder, kidneys, and heart. Could most of the operations be done at this early date, the mortality would doubtless be much lower.

Unfortunately, patients at this stage of the disease are usually too comfortable to be willing to face the risks of operation.

The Various Operative Procedures.—The radical operations may be divided into two general groups: the internal ones, or those done through the urethra or through a small perineal opening, and the external, or those which involve suprapubic cystotomy or a large perineal opening.

Internal Operations.—Of these the so-called Bottini operation is the most prominent. This is done with an electro-cautery, somewhat resembling a lithotrite, though much smaller and more delicately made.

The male blade is connected with an electric battery and acts as the cautery knife. The instrument is introduced into the bladder, and the beak hooked over the prostate, the contour of which is mapped out as accurately as possible. A furrow is then cut with the cautery blade through the prostate in the middle line, the length of the furrow being regulated accurately by a scale in the handle of the instrument. Two lateral furrows are then also cut each at an angle of about forty-five degrees from the median furrow. When the sloughs caused by the cautery have come away, the urethral obstruction is often considerably lessened.

This operation is applicable to some cases which would not stand more radical procedures. The relief is often far from complete, and total failures are not uncommon. The operation may be done under local or under general anæsthesia.

Some operators prefer to introduce the instrument

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through a small incision in the membranous urethra. In this way shorter instruments are required, and they are more easily guided by the hand. The operation does not, however, essentially differ in its results from the regular Bottini operation.

External Operations.—Of the external operations there are three general types, suprapubic, perineal, and combined.

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Suprapubic Operations.—All of the suprapubic operations begin with an ordinary suprapubic cystotomy. The bladder having been opened, two types of operation are at our command. First, the partial operation in which portions of the prostate, such as a projecting third lobe or a prominent bar, are removed, and no attempt is made to remove the bulk of the prostate. This method may be carried further and the prostate may be nibbled away with cutting forceps, until the greater part of the obstruction has been removed. Operations of this type have been practised for a considerable length of time, and while sometimes giving almost or quite perfect functional results, they very frequently fail completely to remove the obstruction. In cases in which only a polypoid third lobe, or a small projecting bar is removed, the operation is of less severity, and carries with it a correspondingly lower mortality than in the cases in which complete removal is attempted, and it may, therefore, occasionally be applicable to cases in which the patient cannot stand a more extensive operation.

Of late years complete enucleation of the prostate by the suprapubic route has been frequently practised, and in selected cases it is an operation giving brilliantly successful results. The prostate is surrounded by a very distinct capsule, formed largely from the layers of the pelvic fasciæ. It is, therefore, possible to shell the gland out from this capsule without excessive hemorrhage, and in these cases the operation can be done rapidly and bleeding readily controlled by packing the cavity with gauze. When the enlargement is very great, and especially when the glandular type of hypertrophy exists, the hemorrhage may be alarming and the raw surface left behind is a great menace on account of absorption of septic materials and extensive sloughing of torn and bruised tissues. The cases likely to prove most favorable under the employment of this method are those in which the prostatic tumor projects chiefly into the bladder, is not of excessive size, and is of the fibrous rather than the glandular type. To avoid the obvious dangers of leaving a large wound upon the floor of the bladder the *perineal operations* have been devised. The underlying principle of all perineal operations is to bring the prostate into view by a free perineal incision, which may be vertical or crescentic; then to separate the prostate from the lower segment of the rectum, and, after incising the prostatic capsule, to proceed to enucleate the gland with the finger much as in the suprapubic operation. In favorable cases this may be done without damage to the floor of the bladder, and is at times also a very successful procedure. The obvious dangers, however, are those resulting from extensive tears of the floor of the bladder and prostatic urethra, and from the not very infrequent accident of tearing the anterior rectal wall in the course of the operation. The cases most suitable for operations of this type are those in which the prostate is well within reach of the finger, and in which the outgrowth has been toward the rectal aspect of the prostate, and in which ulceration of the bladder does not exist. In order more accurately to study the requirements of each case Alexander has devised a *combined operation* in which the bladder is first opened above the pubis, and then if the case be favorable for perineal enucleation, a perineal incision is made and the fingers of one hand in the suprapubic wound push the prostate down while enucleation is done with the other hand through the perineal incision. Some operators do not open the bladder above the pubis, but carry the suprapubic incision down to the bladder wall, and then with the fingers above press down the prostate and make it accessible from the perineum.

It is important to remember that the careful selection of the operation best suited to each case is of the first importance, and it is, therefore, often wise to examine the bladder carefully with the cystoscope before deciding which operation should be undertaken, or whether any operation is likely to give permanent relief.

Orchidectomy and Vasectomy.—The subject of operative treatment of prostatic hypertrophy can hardly be dismissed without making mention of two operations which have been advocated for the relief of the condition, and which may still be done from time to time.

The operation of double orchidectomy, which was ably advocated by White, had many advocates at the time of its introduction. In some cases it appears to give very marked relief in cases of congested prostates, but this relief is likely to prove but temporary, and in the most favorable cases does not result in radical cure. It has been followed in a few instances by very marked mental symptoms, amounting in certain cases to insanity, and this, together with the frequency of total failure to relieve the symptoms, has made it an operation which is very rarely to be advised, and the interest in it at present is largely historical.

Vasectomy.—This operation, which consists of the ligation and division of both vasa efferentia in the region of the external inguinal ring, was strongly advocated by Mr. Harrison. It was hoped that it would have a result equally favorable with that of orchidectomy, but without its unfortunate results. This hope has hardly been justified, and the operation seems to be valuable largely for the relief of those cases in which recurrent attacks of acute epididymitis are a serious cause of discomfort to the patient. It can be done if desired under local anæsthesia, and its technical details present no difficulty.

Treatment of Complications.—Cystitis, which is the most common complication of prostatic hypertrophy, is to be treated according to the rules laid down under *Bladder, Diseases of The*, on pages 795 and 796, in Vol. I. of this Handbook. When it occurs in the first stage of the disease, general treatment is first to be thoroughly tried, and local treatment through a catheter is to be resorted to only when simpler measures fail. In the second and third stages, when partial retention exists, the systematic evacuation and irrigation of the bladder is the most efficient means of treatment at our command.

Nephritis, or pyelonephritis, must be treated on general principles. Mustard poultices over the lower dorsal and lumbar regions are indicated during the acute stage, with, afterward, careful rubbing and friction to keep up the action of the skin; a bland, non-stimulating, but nutritious diet in abundant quantity; and regulation of the bowels. If uræmia threatens, pilocarpine and hot-air baths may be used to promote elimination, and to relieve the congestion of the kidneys.

A stone in the bladder can usually be removed readily by litholapaxy through an enlarged prostate, unless it is of great size and hardness, or unless the careless use of instruments has produced false passages. The pocket behind the prostate often holds a small stone concealed, and makes it hard to seize, in which case the hips may be raised so that the stone rolls back toward the fundus, where it is easily found and crushed.

When micturition is very difficult, it may sometimes be thought wise to remove small stones by perineal incision, in the hope of at the same time relieving the obstruction.

When litholapaxy is impossible on account of the size and hardness of the stone, it is usually necessary to resort to the suprapubic incision. By this operation, too, a prominent middle lobe, or other cause of obstruction, may sometimes be removed.

Atrophy of the prostate may occur as the result of mechanical pressure, or of destruction of portions of the organ by inflammation. It may also appear in the course of an exhausting disease, or as a consequence of old age. It gives rise to no symptoms and calls for no treatment.

Tumors of the Prostate.—These may be classified as follows:

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Cysts	Retention cysts. Hydatids.
Myoma .... Adenoma	Adeno-myoma.
Sarcoma	Round cell. Spindle cell. Lymphoma.
Carcinoma	Scirrhus. Colloid.

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Retention cysts formed from dilated gland acini occur in many old prostates. They are always small, and give rise to no inconvenience. Their contents are sometimes inspissated, forming little concretions.

Hydatid cysts of the prostate are so rare that Thompson could, in 1883, learn of but one; and even in that case it is doubtful whether the cyst started in the prostate or near it. When discovered they should be at once emptied.

Pure myoma is very rare; adenoma is somewhat less so, but adenomyoma is the most common of prostatic growths. Paul thinks ordinary hypertrophy should be ranked under this head.

The universal, symmetrical enlargement can hardly, as it seems, be classified as a tumor, and yet the pathological process is the same in it and in the circumscribed masses which we recognize as new growths. These may project into the urethra, the bladder, and in other directions, or they may be buried in the midst of the gland tissue, from which they can be easily shelled out.

These tumors have sometimes been removed during section of the gland in lithotomy or other operations, and the removal of projections into the urethra has been considered above.

Sarcoma is occasionally observed in the prostate, where it may start primarily, or to which it may transplant itself from the testicle or elsewhere. It usually appears early, but may develop late in life.

Carcinoma is more common than sarcoma, and appears ordinarily after middle life. It may assume a scirrhus or a colloid type.

In either of these last two malignant forms of growth there may be a good deal of pain and considerable hemorrhages, especially after instrumentation.

In carcinoma the neighboring lymphatic glands are likely to be early involved.

Any cyst or tumor of the prostate may give rise to symptoms of obstruction. The difficulty of micturition may reach a point at which some operation for its relief will be required. In opening the bladder for drainage under these circumstances, either the perineal or the suprapubic incision may be used, and the selection would depend somewhat upon the size of the tumor.

If this is large and of a malignant character, which makes its removal evidently impossible, suprapubic drainage would be preferable.

On the other hand, in the case of a smaller or non-malignant tumor the perineal incision should be used, as by it the exact condition of things can be ascertained and possibly benefited. Harrison reports a case in which he removed a cancerous growth as large as the last phalanx of the thumb from the prostatic urethra. The operation was followed by great relief from distress in micturition, and the patient lived for fourteen months.

Tuberculosis of the Prostate occurs often secondarily to tuberculous conditions in other parts of the genito-urinary tract. It probably also sometimes appears primarily in the prostate.

As patients with genito-urinary tuberculosis usually die when the disease is far advanced, it is rarely possible to decide at autopsy where the disease originated; and as the organs are many of them deep-seated and beyond the reach of physical examination, it is likewise impossible during life to be sure that the prostate was primarily affected.

On the other hand, this gland is situated at the junction of the genital and urinary passages, is as it were at the crossroads through which any tuberculous material from the kidneys or testicles must go in its passage from the body. This situation makes it peculiarly liable to secondary infection, and, as a fact, it is almost always sooner or later involved.

The tubercles may appear as little isolated gray granules, scattered throughout the tissue of the organ, or they may be agglomerated into masses which, if they reach a moderate size, ordinarily become cheesy in the centre and finally break down into abscesses.

Sometimes almost the whole prostate is thus destroyed, and its place is occupied by an abscess which usually communicates with the urethra and bladder. It may break through into the rectum, forming a recto-vesical or a urethral fistula directly through the prostate.

The *symptoms* are those of a chronic prostatitis (see above) with a special tendency to hemorrhage. They may be associated with evidences of tuberculosis elsewhere.

Physical examination by the rectum may reveal little or no alteration in the gland. Ordinarily, however, inequalities are felt which may give it a distinctly nodular character. This may be associated with enlargement, or the prostate may preserve almost its normal size.

The ejaculatory ducts and the vesiculæ seminales should be felt for, and if the disease has affected them, they may be found as thickened, resistant, cord-like bodies. This is especially to be observed when the disease started in the testicle and worked its way up to the prostate.

Not infrequently a little shot-like mass is felt between the rectum and the prostate, or it may be a little behind and to one side of the gland. It is not attached to the prostate, rectal wall, or seminal vesicles, but is loose in the tissues between them.

Dr. Bryson, of St. Louis, thought that in one case, in which he had an autopsy, he made it out to be a cheesy mass within a vein. Possibly it is sometimes an infected lymphatic gland.

The testicles, epididymides, and vasa deferentia should also be examined, and the urine should be investigated for evidences of kidney complication and for tubercle bacilli.

These last are very difficult of detection in the urine, and their apparent absence does not argue against tuberculosis. When unmistakably present they are conclusive confirmatory evidence. In all cases of doubt the urinary sediment should be inoculated into a guinea-pig.

The physical investigation should also include the examination of the lungs, which may share in the tuberculous process.

Diagnosis.—The disease may be confounded with chronic prostatitis or cystitis, with stone or tumor in the bladder, or with pyelitis when accompanied by frequent micturition.

While a careful consideration of the symptoms and inherited tendencies of the patient may enable us to form a probably correct idea of the condition, it is only by a careful physical examination that we can reach a positive diagnosis.

Besides the examination described above, an exploration of the bladder, under ether if necessary, will be needed for the detection or elimination of stone and of tumor of the bladder.

There will be a certain number of cases in which a diagnosis is at first impossible, and in which the true interpretation of the condition can be reached only when time has developed characteristic symptoms.

Treatment.—Most important is the constitutional treatment with cod-liver oil, hypophosphites, and iodides. A healthy out-of-door life, with moderate exercise and good food, is to be enjoined.

Thompson advises against local treatment, and it is certainly important to avoid rough manipulation.

In the early stages of the disease, however, gentle local measures may serve rather to allay than to excite irritation, and should be tried.

Irrigation of the prostate and bladder and the introduction of iodoform pencils may be of service. Occa-

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sionally the passage of a sound is useful by removing the contraction of the constrictor muscle. The pain and frequency of micturition may sometimes be much relieved by these means.

While the prognosis is necessarily grave, and the permanence of improvement is always doubtful, still these cases are not always hopeless ones.

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Prostatic Calculi.—In the ducts and dilated tubules of the prostatic glands are found not infrequently little yellowish or brownish bodies, composed of an organic substance allied to protein.

These, if they increase beyond a moderate size, begin to have earthy salts deposited in and around them, and finally become prostatic calculi, which may reach the size of a walnut or even of a larger object.

These calculi are usually multiple, and are facetted from mutual attrition. They are hard, take a high polish like porcelain, and are white or light brown in color.

Chemically, they are composed almost wholly of phosphate, with a slight admixture of carbonate of lime, and are to be distinguished from urinary calculi by the fact that they do not contain any of the triple phosphate of magnesia and lime, which is so large a constituent of vesical calculi.

When prostatic calculi are made out they may be removed by a median or lateral perineal incision. The operation is usually one of no serious danger, as the bladder is not opened.

Arthur T. Cabot.
Hugh Cabot.

PROSTITUTION, REGULATION OF. See *Camp Diseases.*

PROTAN is a tannin nucleo-proteid employed in dose of 1–2 gm. (gr. xv.–xxx.) as an intestinal astringent in diarrhœa. *W. A. Bastedo.*

PROTEINOCHROMOGEN, PROTEINOCHROME. See *Tryptophan.*

PROTHROMBIN. See *Coagulation.*

PROTOGEN. See *Formaldehyde.*

PROTOPLASM. See *Cell.*

PROTOZOA, PARASITIC. See The Appendix.

PRUNE.—*Prunum*, U. S., Br. The partially dried ripe fruit of *Prunus domestica* L., or, according to the British and some other pharmacopœias, *P. domestica Juliana* De C. (fam. *Rosaceæ*). The fresh fruit of the latter variety is oblong, that of others subspherical.

The prune, coming originally from southwestern Asia, is now everywhere cultivated in temperate regions. Probably the best prunes for medicinal uses are those grown in southern Europe, since they are more acid. The prune requires no description. It should not be overdried, should possess a very slight odor and a pleasantly sweet and acid taste. It owes its slightly laxative properties to the presence of acids, chiefly malic, free, and combined with potassium and other bases. There is present also sugar, to the extent of about one-third of the weight. The seed contains amygdalin and yields prussic acid, and should, of course, be removed.

Prunes have no other medicinal value than that of a very mild laxative, similar to many other fruits, but the concentrated juice is useful for administration to small children, because of its pleasant taste. The only official preparation is the confection of senna (see *Senna*). Prunes are very largely consumed upon the table for their laxative effects, as well as for their food properties. As served upon ocean steamers, they usually have some senna boiled with them. *Henry H. Rusby.*

PRURIGO.—Prurigo is a malady *sui generis*. The condition usually appears about the end of the first year, but may appear as late as the thirtieth year. The affection usually starts as a lichen urticatus, the characteristic lesions of prurigo appearing later. There are two forms: prurigo ferox or Hebra's prurigo, and prurigo mitis, but a distinct line cannot be drawn between the two. In prurigo ferox there are repeated eruptions of pale red or skin-colored miliary papules, which itch violently. This eruption is generalized, but it is thickest on the extensor surfaces of the lower extremities. The papules are so small and project so slightly that they often cannot be seen, although they can be felt. Scratching produces excoriated tips, and these become covered with blood crusts. Other lesions appear as the result of scratching, such as excoriations, pustules, crusts, pigmented areas, and a dry, scaly, and thickened skin

During the first few years wheals are frequently found, but they disappear as the papules increase. A secondary eczema in all forms may also be seen. In nearly all cases there is enlargement of the superficial lymphatic glands, the femoral being most marked. The flexures are usually free from eruption. As a rule, the eruption diminishes upon the advent of summer. This form is incurable, but the patient can be relieved to such an extent as to be free from the eruption at times. In prurigo mitis the papules are fewer and the itching is less; consequently the secondary lesions are much milder. Most of the cases met with in this country are of this type. In some of these cases a perfect cure may be obtained by careful and persistent treatment. When untreated, prurigo has a marked effect on the patient both mentally and physically.

Etiology.—In discussing the causation of this affection we can do no more than mention certain conditions with which it frequently occurs. It is usually found in poorly nourished and scrofulous children. Occasionally there seems to be an hereditary predisposition, several children in one family being affected. It is possible that there is some congenital anatomical malformation of the skin as is seen in ichthyosis.

Pathology.—The affection probably starts as a vasomotor neurosis. Microscopically the papules are composed of a round cell infiltration, with œdema of the papillæ. Swelling of rete cells occurs and later there is a hyperkeratosis.

Diagnosis.—The diagnosis is difficult at first, as in the beginning the eruption consists mostly of wheals. The condition is also misleading when large eczematous areas cover the lesions of prurigo. The following points are characteristic, and when they are present the disease cannot be mistaken for any other condition: A constantly recurring eruption of miliary papules, resembling in color the normal skin, appearing in early childhood, and most marked on the extensor surfaces; the enlarged glands; and secondary lesions from scratching.

Treatment.—Very little can be expected from internal medication, unless the patients are scrofulous or poorly nourished; in which case cod-liver oil and general hygienic measures will be beneficial.

Crocker speaks highly of cannabis indica as an effective remedy for controlling the itching, as in pruritus. The dose should be gradually increased to thirty minims of the tincture, well diluted, after each meal. Phenacetin and antipyrin are among the most valuable remedies for the itching. Rest, an even temperature, and alkaline or sulphur baths will make the patient more comfortable. For the local treatment, naphtol, sulphur, and tar are the remedies most likely to relieve the itching and decrease the papular eruption. The usual way of using sulphur is by the application of the official ointment or Wilkinson's ointment. Tar can be used pure or diluted with oil or lanolin. Naphtol should be used as an ointment in the strength of two to five per cent. Whatever local treatment is used, it should be vigorously continued until there are no fresh papules and the skin is smooth and flexible. Occasionally it will be found necessary to use first some bland ointment to cure the secondary eczema which so frequently accompanies this condition.

Howard Morrow.

PRURITUS.—Pruritus is an affection of the skin characterized by itching without any external cause. It is an independent disease, and must be distinguished from

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the symptomatic itching common in such pruritic conditions as eczema, scabies, etc. It is a sensory neurosis due to a functional disorder of the nerves independent of any source of irritation on the skin. The symptoms may be so mild as to produce but temporary discomfort, or so severe as to cause profound misery or even such a degree of nervous depression as may result in insanity. Scratching is the patient's method of relief, and the excoriations produced are often preferable to the itching. Although scratching frequently relieves the itching in a certain place, it usually excites it in other parts. From the scratching we may get excoriations, pustules, wheals, and pigmented areas. A rare result of such chronic scratching is the condition called lichenification, in which the skin is thickened and the natural lines are deepened, leading to the formation of irregularly shiny papules. This condition is usually found in the flexures, and is often mistaken for eczema and lichen planus.

Pruritus is either general or confined to certain areas. The former is frequently spoken of as pruritus universalis, and although the itching is general, it is seldom felt all over at the same moment, and there are frequent remissions from any itching. The most frequent causes of this affection are disorders of the alimentary tract, functional derangement of the liver, cancer of the stomach or liver, uterine disorders, malaria, gout, rheumatism, and Bright's disease. Pruritus is always worse when the sufferer is in bed, and is excited by exercise, forced rest, and sudden changes of temperature.

The itching which accompanies jaundice is not a true pruritus, for it is produced by the mechanical pressure of the biliary coloring matter which is deposited in the skin. Senile pruritus is an accompaniment of senile degeneration of the skin. Although it is general, it is usually most marked on the lower extremities. It is very persistent.

Pruritus hiemalis and pruritus æstivalis are terms given to varieties of generalized pruritus which occur during the cold and hot seasons respectively. Some authors consider these forms distinct affections. Pruritus hiemalis is due to the dryness and brittleness of the epidermis which is caused by the cold of winter. Pruritus æstivalis is occasionally found during the warm weather of summer.

In the *local forms*, although we can have itching in any part of the body, the following varieties are most common: pruritus ani, pruritus vulvæ, pruritus scroti, pruritus palmæ et plantæ. Pruritus ani may be due to fissures, hemorrhoids, ascarides, or pelvic tumors producing local congestion. Pruritus of the vulva may be caused by ovarian or uterine disease, diabetes, or urethritis. Pruritus of the scrotum is usually associated with eczema. Pruritus of the hands and feet is mostly found in the gouty, and frequently is associated with hyperidrosis.

In the different forms of local pruritus it is occasionally impossible to discover the cause. The prognosis of senile pruritus is unfavorable. In the other forms the pruritus will usually cease if the cause is found and removed.

DIAGNOSIS.—All chronic diseases which are associated with itching, such as prurigo, urticaria, scabies, and the irritation from fleas, bedbugs, and lice must first be excluded. It is often impossible to differentiate chronic urticaria, as these two affections frequently occur under the same etiological conditions. Careful investigation must be made as to the presence of any renal, hepatic, or digestive disorders.

The diagnosis of senile pruritus must be made by exclusion. In cases of persistent itching around the anus and vulva, careful examination may show a definite point from which the patient says the itching starts. The skin at this point may appear to be perfectly normal, but it must be treated before the itching will cease.

TREATMENT.—A great deal depends upon the cause, and the sooner this is found out the sooner the patient may be put on appropriate treatment. The internal treatment is dietetic as well as medicinal. The food should be easily digestible and all stimulating liquids should be avoided. The bowels must be carefully regulated. Calomel followed by saline aperients is often necessary at the start. From now on, the internal treatment must be in accordance with the general principles of medicine, and the condition of each internal organ should be investigated. Of the various internal remedies which are used as nerve sedatives, cannabis indica is the best. Ten to twenty minims of the tincture should be given, well diluted, after each meal. Carbolic acid, gr. ij. in each pill, one after each meal, is recommended by Brocq. Antipyrin acts well at times.

External treatment is necessary even if it is not curative, because it enables the patient to abstain from scratching, and this temporarily relieves the irritated nerves. In the mean time other remedies can be directed to the origin of the trouble.

For general pruritus lotions are preferable to ointments. One of the best is composed of liquor carbonis detergens, ʒ iij.; liquor plumbi subacetatis, ʒ iv.; glycerin., ʒ iv.; distilled water, q.s. ad ℥ viij. Another is carbolic acid, two per cent., in camphor water. Bichloride of mercury, gr. ij. to an ounce of fifty-per-cent. alcohol, is a good odorless lotion. A mixture of aromatic spirit of ammonia and water, equal parts, is frequently used.

Five or six ounces of bicarbonate of sodium to an ordinary bathtubful of hot water may be used with advantage. Bran baths are soothing. They should be made by adding from four to six pounds of bran to a tubful of water. After a bath the surface should not be rubbed dry, but should be patted gently with a soft cloth and dusted with some soothing powder.

For pruritus hiemalis alkaline baths and emollient preparations have proved most serviceable. A two-per-cent. solution of salicylic acid in almond oil is an excellent remedy. Similar applications are indicated in senile pruritus.

For local pruritus, dozens of remedies have been recommended, but until the cause is ascertained most of them will give but temporary results. If the patient can locate a definite point from which the itching starts, the destruction of this point by the actual cautery gives immediate relief. Simpler methods, as a matter of course, should be used at first.

For pruritus ani, mercurial applications give the most satisfaction; such are: ammoniated mercury, gr. xx., in zinc ointment, ℥ i.; calomel, ʒ i., in lard, ℥ i. These two are frequently combined. Hot compresses are very agreeable. Carbolic acid in two-per-cent. solution can be used in a compress or in an ointment. A suppository of extract of belladonna, gr. ss. at bedtime, often gives relief; morphine may be added to this. Cocaine, gr. ss. in a suppository, gives temporary relief. On the surface cocaine is frequently used in a boric-acid ointment, or in combination with menthol, two per cent. of each. Camphor-chloral is commonly used. Hydrocyanic acid, naphtol, and ichthyol are useful at times.

For pruritus vulvæ, hot compresses of a saturated solution of boric acid sometimes give relief. Tincture of benzoin painted on the parts daily with a camel's hair brush is also an excellent remedy. *Howard Morrow.*

PSAMMOMA. See *Sarcoma.*

PSEUDOLEUKÆMIA. See *Hodgkin's Disease.*

PSEUDOLEUKÆMIA INFANTUM.—(Synonyms: Anæmia infantum pseudoleukæmica; Anæmia splenica infettiva dei bambini; Anæmia splenica [Splénomegalie primitive]; von Jaksch's anæmia.)

DEFINITION.—A disease occurring in infants, usually in the first two years of life, characterized by great pallor, considerable enlargement of the spleen, moderate enlargement of the liver, a low erythrocyte count, a moderate leucocytosis, consisting chiefly of an increase of the lymphocytes, numerous erythroblasts, low hæmoglobin, the absence of especial enlargement of the lymph nodes, and at times accompanied by hemorrhages (hæmateme-

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sis, hæmaturia, purpura) without any known cause. The course of the disease is usually subacute or chronic.

Historical Notice.—The term "anæmia infantum pseudoleukæmica"* was originally adopted on the ground that the disease was one form of pseudoleukæmia (Hodgkin's disease). Of late years it has been so clearly shown to be different from Hodgkin's disease, in that the condition of the spleen is not the same, that the name "pseudoleukæmia" is evidently a misnomer and, strictly speaking, should not be used in connection with the class of cases under consideration. On the other hand, there are as yet so much dispute and such varying opinions among those who have carefully studied the group of symptoms which are supposed to represent the disease, that there is no other name which at present had better be applied to it, since the evidence is very strong that no such disease exists apart from severe cases of secondary anæmia with enlarged spleen. It is supposed at present to correspond to the so-called cases of splenic anæmia in adults. The same difference of opinion exists as to the recognition of a splenic anæmia in adults as separate from severe cases of secondary anæmia with enlarged spleen. It is thought better, therefore, to describe the symptoms of what has been supposed to be a separate disease by the name under which it was first spoken of, always wishing it to be fully understood that this description merely represents what is known about the subject up to the present time, and does not intend to give the impression that the author necessarily believes that it is a separate disease because he describes a set of symptoms under the term "anæmia infantum pseudoleukæmica." The subject is still *sub judice*, and much further investigation must be carried out before a final decision can be made to give up the idea that there is such a disease separate from severe cases of secondary anæmia.

We wish, however, to have it understood that it is the so-called "splenic anæmia" of adults with which the disease, if such disease exists, is associated rather than with pseudoleukæmia.

Formerly, anæmia infantum pseudoleukæmica was considered a primary disease of the blood, but it was soon differentiated from the different forms of leukæmia, and later from pseudoleukæmia (Hodgkin's disease). It is, however, still believed by some writers to be a primary disease of the spleen.

As far back as 1866 a case of a child suffering from a severe form of anæmia accompanied by an enlarged spleen was reported by Gretsel. Cases have since been described, but in a somewhat indefinite manner, and the next important work which appeared on the subject was that of Banti in 1883. Banti, however, although believing that anæmia splenica was a primary disease of the spleen, considers it also a splenic form of pseudoleukæmia, and it is from Banti's description that the characteristic symptoms of the disease are taken as well as the pathology. Following Banti a number of writers have recorded cases which they considered to represent the disease splenic anæmia; but their cases, in the light of more modern investigation, are so closely allied in their description to those of pseudoleukæmia that they would at the present time scarcely be accepted.

In 1891 Bruhl published an article on splenic anæmia, and suggested the name "splénomegalie primitive." Bruhl's work, however, was very much in the same line as Banti's, and therefore need not be further referred to. Williamson in 1893 reported a case of a boy nine years old who died, and a description of the lesions found in this case will be given under pathology. Later writers, such as Hawthorne in 1895, in the case of a child eleven years old who recovered, and Taylor in 1896, in the case of a girl thirteen years old in whom the symptoms were very similar to those of pseudoleukæmia, have added nothing new to our knowledge of the subject. In like manner Goepel reported the case of a boy eleven years old on whom splenectomy had been performed with recovery, but no histological report was made as to the condition of the spleen, and although he stated that the operation was performed for pseudoleukæmia, no enlargement of the superficial lymphatics was present at the time the operation was performed, and the blood was stated to have been normal.

In 1900 Osler reported fifteen cases which he considered to be cases of "primitive splenomegalie," but his cases occurred in adults. He also reported some additional cases of splenic anæmia at the annual meeting of the Association of American Physicians in Washington, April 29th and 30th, 1902. The opinion of those who discussed Osler's paper gives the impression that splenic anæmia as a primary disease is not universally accepted, and, in fact, most authors consider it to be a form of secondary anæmia.

In 1884 Somma, under the title of "anæmia splenica infantilis," reported thirteen cases in infants and young children. Fedde in 1889 and in 1890 spoke of this disease under the title of "anæmia splenica infettiva," believing it to be an infectious disease of infants. No details of his cases, however, were given.

In 1890 at the Pediatric Congress in Rome, Somma and Fedde presented papers on "Anæmia Splenica Infettiva dei Bambini." Somma's conclusions are that "anæmia splenica infantilis" is a disease which occurs in infancy as a rule, but that adults are not exempt.

It is significant that a number of the cases, reported by various authors, of the disease in early life show a condition of rhachitis.

Cases have also been reported by Senator, Luzet, Baginski, Alt, Weiss, Hock, Schlesinger, Koplik, Monti, Berggrun, Audioud, Glockner, and others, but in all these cases rhachitis or some other condition of malnutrition was present which could produce changes in the blood identical with those which occur in the secondary anæmias of early life.

Pathology.—The pathology of splenic anæmia has mostly rested on the findings in the autopsies described by Banti previous to 1883. The pathological lesions in these cases were not those of leukæmia or pseudoleukæmia, and on this fact Banti laid much stress in his argument that the condition is due to a primary disease of the spleen. In Williamson's case, that of a boy nine years of age, the patient was under observation for four months, and finally died. The pathological lesions as described by Banti were marked fibrous changes in the trabeculæ and the follicles of the spleen, and a great diminution of the cells. There were many large phagocytic cells containing red corpuscles, the bone marrow was red and showed a lymphoid condition, but the lymph nodes were not enlarged. The spleen weighed two pounds seven ounces, the liver weighed two pounds twelve and one-half ounces. The blood showed a diminution of leucocytes, and the red corpuscles were between 2,000,000 and 3,000,000 per cubic millimetre. The temperature varied for four months, sometimes as much as four degrees between morning and evening. There was no history of rhachitis, syphilis, or malaria.

In the reports of the autopsies of Somma's cases of anæmia splenica infettiva dei bambini nothing very definite is added to our knowledge of the disease, nor are the reports satisfactory or conclusive. The spleen is firm and large, sometimes congested, sometimes with a thickened capsule. Various conditions, such as anæmia of the organs, pulmonary congestion, serum in the ventricles of the brain, and enterocolitis, and in one case pneumonia of both lungs, are recorded. Lorenzo reports the autopsy of one case in which there was an increase of the connective tissue of the spleen and sclerosis of the follicles.

Fedde states that the only characteristic lesions are found in the spleen, liver, and blood, that the glands are normal or slightly enlarged, the liver often enlarged from congestion and from a slight increase of the connective tissue, with fatty degeneration and atrophy of the liver

* The title which is placed at the head of this paper was chosen merely for reasons of convenience, *i.e.*, simply because the time had gone by when the article might have been placed under the title which I consider to be preferable.

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cells; the spleen large and firm, with hypertrophy of the connective tissue, and the pulp rich in lymph cells and with the follicles hyperplastic.

Gianturco and Pianese report the pathological findings in a case of Fedde's as a spleen showing no increase in interstitial tissue and with the follicles little developed.

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Mya and Trambusti reviewed the lesions found in the spleen and liver, and came to the conclusion that they were more or less diverse. In one of their cases the lesions in the spleen were similar to those found by Banti in cases of adult splenic anæmia, there being marked increase in the fibrous tissue, together with atrophied follicles and thickened trabeculæ.

Von Jaksch, in his description of anæmia infantum pseudoleukæmica, gives very few and very unsatisfactory reports as to the pathological appearances of the disease; he considers them to be a chronic hyperplasia of the spleen affecting in different degrees parts of the organ, with the liver showing slight increase in the connective tissue.

Hayem and Luzet report in their examination of the blood in anæmia infantum pseudoleukæmica large numbers of nucleated red corpuscles, in some of which there was evidence of karyokinesis of some of the nuclei, and they consider this to be of great diagnostic value. Fowler also lays great stress upon the presence of large numbers of nucleated red cells out of proportion to the diminution of the erythrocytes.

It is very evident that there does not seem to be satisfactory post-mortem evidence to warrant a definite pathological condition representing the splenic anæmia of infants. There seems to be present in most cases a chronic hyperplasia of the spleen, while in other doubtful cases the spleen is not altered.

Etiology.—In regard to the etiology of anæmia infantum pseudoleukæmica nothing definite has been proved. Although pathological micro-organisms, finding conditions favorable for their growth in the spleen, may, according to Somma, find their way into the circulation and thus produce changes which are represented by certain clinical symptoms, yet there is no doubt that the true nature of the disease, if such exists, has not yet been discovered. Nothing has ever been found bacteriologically to show a direct relation between the micro-organisms present and the production of the disease.

Symptoms.—It is difficult to describe the symptomatology of a disease which is so closely identified with cases of secondary anæmia with enlarged spleen, and in which the group of symptoms that are supposed to represent anæmia infantum pseudoleukæmica, are somewhat diverse. Both sexes are equally liable to present these symptoms, and the patients are usually between the ages of ten and eighteen months; one has been reported of seven and one-half months, and one at three and one-half years. The onset of the disease is gradual, the nutrition is poor; there are considerable emaciation, a waxy tint of the skin, at times hemorrhages from the mucous membranes and the skin, a spleen much enlarged, and the liver moderately enlarged. There is no tenderness over the bones, and there are often a venous bruit in the neck and functional cardiac murmurs. The blood shows the characteristics of a secondary anæmia of varying intensity, that is, a diminished number of erythrocytes, low hæmoglobin, variations in the size and shape of the erythrocytes and in the number of erythroblasts present. The leucocytes are not characteristic, being markedly increased in some cases and in normal proportion in others. The lymphocytosis, reported by many writers, may occur under any condition, giving rise to an increased number of white cells.

Diagnosis.—There seems to be no doubt that anæmia infantum pseudoleukæmica and anæmia splenica infettiva are the same condition, and, as there does not seem to be reason for believing that the spleen is primarily affected in either of them, they need not be differentiated one from the other. The differential diagnosis should first be made from leukæmia and pseudoleukæmia. The proportionately low leucocytosis and the absence of either a general lymphatic enlargement or an excess of myelocytes in the blood would differentiate it from the former, while the absence of enlarged lymph nodes would exclude pseudoleukæmia. As there are so few cases in which a thorough and reliable examination of the organs has been made in which rhachitis was not present, the diagnosis between rhachitis with enlarged spleen and secondary anæmia, and this supposed especial group of symptoms, would be very difficult and seemingly impossible.

We know that in infants the same blood changes which have been mentioned above often occur in connection with an enlarged spleen in the course of or following any disease of nutrition. We are therefore in the position of attempting to make a diagnosis between two conditions which may in the future be proved to be practically the same. In making a diagnosis we should limit the term anæmia infantum pseudoleukæmica to those cases in which no cause for secondary anæmia can be found, and in which the clinical symptoms and changes in the blood already described are present.

Prognosis.—The prognosis varies according to the extent and serious nature of the cause which produces the condition. The symptoms run an essentially subacute or chronic course; the large size of the spleen does not necessarily imply a fatal ending. When, however, secondary changes in the blood have occurred to such an extent as to warrant the diagnosis of a severe form of anæmia, and when a spleen of considerable size is detected in connection with these blood changes, the prognosis is very bad, as the infants usually die.

Treatment.—What has just been said of the prognosis in this class of cases may also be said of the treatment, which is, in fact, that of a case of secondary anæmia, and depends upon what is most reasonably supposed to be causing the condition that is present. This may be malaria, rhachitis, gastro-enteric disease, or some unknown cause which, simply representing the conditions of anæmia, calls for the usual treatment of arsenic, iron, proper food, and hygiene.

An extensive bibliography of the subject will be found in an article by Dr. A. H. Wentworth in the "Medical Communications of the Massachusetts Medical Society," vol. xviii., No. 3, 1901. *Thomas Morgan Rotch.*

PSEUDOMYXOMA PERITONEI.—The occurrence of free mucoid or colloid-like material within the peritoneal cavity, as the result of the rupture of an ovarian cyst or cystadenoma, or of the direct secretion of a neoplasm into the cavity, gives rise to a reactive proliferation of the peritoneal surfaces covered by such substance and the more or less complete organization of the latter. As a result of such partial organization the peritoneal surface is found to be covered with a jelly-like layer containing blood-vessels and strands of connective tissue, closely resembling myxomatous tissue. To this condition the term pseudomyxoma peritonei is applied.

The gross appearances vary with the amount of colloid or mucoid material lying on the peritoneal surfaces, and with the degree of organization. In the very early stages the surfaces of the peritoneum are covered with a jelly-like substance of varying thickness, which is easily scraped off, or may even be scooped out of the peritoneal cavity owing to the fact that it lies free therein. If organization has begun, the portion of the colloid material lying next to the peritoneum is not so easily scraped away, appears more opaque, and contains minute vessels, as shown by the fine red lines running through it. The peritoneal surface has therefore a reddish, roughened appearance, and is covered with fine whitish or reddish strands enclosing jelly-like colloid substance. As organization progresses there is developed above the peritoneal surface a zone of fibroblastic tissue which in time becomes changed into fibrous connective tissue, so that the peritoneum becomes greatly thickened, the condition resembling that of a chronic fibroid peritonitis. If the amount of colloid material scattered over the peritoneum is small, it may be completely organized and the peritoneum become more or

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less thickened. On the other hand, a thick layer of colloid (several inches) is but slowly absorbed and organized, and may remain in the abdomen for a long time with but little change except where it comes into contact with the peritoneal surfaces. The reaction on the part of the peritoneum appears to vary greatly; in some cases it occurs immediately, in others it may be delayed for a long time.

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Microscopically, sections cut through the peritoneum and the overlying mass of colloid show a fibroblastic proliferation of the subendothelial layer of the peritoneum, a wandering of fibroblasts into the colloid, and the formation of new blood-vessels which run out into the colloid substance. As organization progresses interlacing strands of connective tissue supporting blood-vessels are formed throughout the colloid substance, enclosing between them masses of the jelly material which have not yet been absorbed. These give the tissue an appearance resembling myxomatous tissue, even under the microscope. It is easily seen, however, that the structure is not that of a true myxomatous tissue, but represents an organization of a jelly-like foreign substance. All stages of organization may sometimes be seen in the same case. The writer has seen a number of cases representing different stages; in one of two years' duration the organization of the colloid was almost complete, the peritoneum being converted into a thick hyaline layer of connective tissue, enclosing here and there bits of unabsorbed colloid. Contraction of the mesentery and matting of the intestinal coils occur in this stage, and the appearance resembles very much the condition of the peritoneum in diffuse scirrhous carcinoma. The surfaces of the liver and spleen are similarly involved, and in the late stages present a picture of marked perihepatitis and perisplenitis.

Localized pseudomyxoma occurs when, from the rupture of a small ovarian cyst or cystoma, a small mass of mucoid substance is distributed in small portions over the peritoneal surface. These show the same stages of organization, hyaline change, etc., and finally come to represent localized thickenings of the peritoneum. This condition occurs most frequently in the pelvis.

If portions of living epithelium or of papillæ are set free into the peritoneal cavity with the mucoid material, after the rupture of an ovarian cystoma, these may proliferate and set up implantation metastases. These may become malignant; if the primary tumor has already undergone carcinomatous change, these implantations are likewise carcinomatous. In the case of the ordinary cystoma the implanted epithelium forms small cysts which become stationary after a while and do not form large growths. When the primary is a papilliferous cystadenoma the implantation metastases are much more likely to develop into larger tumors. It is conceivable that the implantation metastases of epithelium arising from a benign growth may later become malignant.

Small cysts lined with hypertrophic endothelium may also be found in the pseudomyxomatous tissue of the peritoneal covering. These are probably derived from the remains of the surface endothelium. It is also within the range of possibility that these may form centres for the formation of a new growth of malignant character.

Pseudomyxoma of the peritoneum is not in all cases formed by the rupture and discharge into the peritoneal cavity of an ovarian tumor containing mucoid or colloid material. Surface papillomata of the ovary may secrete such material directly into the peritoneal cavity; further, cystic carcinomata of the stomach, intestines, or testicles may give rise to the presence of mucoid or colloid substance in the peritoneal cavity, either from rupture of the primary or from secondaries located in the peritoneum.

In the great majority of cases, however, the mucoid or colloid substance comes from the rupture of a large ovarian multilocular cystoma, in which one chamber has been developed at the expense of the others; or from a primary unilocular cystoma. If the cyst contents are of a thin serous character they may be absorbed by the peritoneum without the production of peritoneal proliferation. The more jelly-like or colloid the contents the more likely the occurrence of pseudomyxoma. In order to excite peritoneal proliferation the substance must be of a fairly firm consistency and not easily absorbed. Pseudomucin may or may not be present in the cyst contents, but in the majority of cases it is a pseudomucin cyst that ruptures. The jelly-like material of the pseudomyxomatous tissue may give both mucin and pseudomucin reactions. Pseudomucin is, however, not necessary to the production of pseudomyxoma. This term should be taken as signifying the formation of a tissue resembling myxomatous tissue. Though spoken of as colloid, the cyst contents in all cases are mucoid, but when firm and jelly-like they may be appropriately designated as colloid or colloid-like.

The cyst contents when poured over the peritoneum act as a foreign body and set up a reactive proliferation which is of the nature of an inflammatory process. The presence of fibrin throughout the pseudomyxomatous tissue may often be shown by Weigert's fibrin stain. Localized collections of leucocytes may also occur throughout the organizing zone. In case of an infected cyst, or following infection as a result of operation, the picture of pseudomyxoma and that of a fibrinous peritonitis may be combined. The writer has seen one case of pseudomyxoma in which the cyst contents were scattered over a peritoneum showing a marked subacute fibrinous peritonitis. The colloid material was deposited on top of a thick fibrinous exudate which was undergoing organization. Organization of the colloid from the new fibroblastic tissue had begun in some areas.

To recapitulate, the writer holds that pseudomyxoma peritonei is a condition of the peritoneum due to a partial organization of a mucoid or colloid material, which has been deposited over the peritoneum as the result of the rupture of an ovarian cystoma or of other cystic tumor containing such material, or from the secretion of certain tumors directly into the peritoneal cavity. This view, however, is not held by all authors. Netzel, Wendeler, and others regard the condition as due, at least in part, to a chronic productive inflammation of the peritoneum associated with myxomatous degeneration. This view may be explained by the presence of pseudomucin in the lymph spaces of the peritoneum, following an absorption from the peritoneal cavity. Westermark and Annell regard the jelly masses on the peritoneum as the product of a specific form of peritoneal disease. Alshauser, Strassmann, Pfannenstiel, and others regard the process as due essentially to an implantation metastasis of tumor cells over the peritoneum. On the other hand, Werth (to whom we owe the designation *pseudomyxoma*), Veit, Kretschmar, and others hold practically the same view as the writer, namely, that the colloid masses are not metastases but are to be explained as the non-absorbable mucoid contents of a ruptured cyst, which, scattered over the peritoneum, act upon it as a foreign body, become enclosed in inflammatory adhesions, and undergo organization after the manner of a thrombus, finally being replaced by hyaline connective tissue.

The prognosis in pseudomyxoma is not necessarily bad. Large masses of colloid material may be kept within the peritoneal cavity for a long time without especial symptoms. Small amounts may be completely absorbed and organized, and the resulting condition of the peritoneum may give rise to the same sequelæ as those which follow chronic adhesive peritonitis. In operations for the relief of pseudomyxoma after the rupture of ovarian cysts, it should be borne in mind that the peritoneum, after the removal of the overlying colloid material, represents a more or less denuded, hyperæmic surface, through which infection may easily take place, giving rise to a fibrinopurulent peritonitis. The general resistance of the peritoneum appears to be lowered as the result of the presence of the foreign substance in the cavity. The danger that a malignant growth will arise from the implantation metastases is not very great in the case of a simple multilocular cystoma, but in the case of a papilliferous cystoma the danger of such an occurrence is much greater.

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Such metastases may occur in the operation wound. On the whole, the safest procedure is to operate as soon as possible after the rupture of the cyst, before organization has begun. A more or less marked ascites, which complicates the diagnosis, is often associated with pseudomyxoma; this is particularly true in the case of associated infection. It may occur, however, as the result of the irritation produced by the presence of the foreign body. Recurrence takes place when the primary tumor or the metastases which produce the mucoid or colloid are not removed; or when the implantation metastases become active, and either burst or secrete into the cavity. Recurrence is much more likely to take place in the case of papilliferous growths. *Aldred Scott Warthin.*

PSEUDOPEPSIN.—When the gastric mucosa is allowed to digest for some time in a slightly alkaline medium and in the presence of an antiseptic like toluol, some of the proteids enter into solution and the tryptophan reaction (see *Tryptophan*) can be demonstrated with the latter. According to Glaessner this self-digestion is due to a specific proteolytic enzyme, to which he has applied the name *pseudopepsin*, and which in some respects resembles the trypsin of the pancreas and the autolytic enzyme of the liver. Pseudopepsin is characterized: (1) By acting in alkaline solutions, in which pepsin is destroyed; (2) by forming tryptophan as a product of its activity; (3) by acting in the presence of free acid even to the extent of 0.3 per cent. HCl, and in the presence of pepsin which destroys some enzymes. This behavior toward acids distinguishes it from trypsin. Pseudopepsin occurs in both the fundus and the pyloric portions of the gastric membrane, and in about equally small amounts. According to Glaessner the proteolytic action of the pylorus mucosa is probably entirely due to pseudopepsin. It is also apparently the characteristic proteolytic enzyme of the glands of Brunner—an observation which is of interest in view of the assumed histological resemblance between these glands and those of the pyloric portion of the stomach. It is not unlikely that pseudopepsin, or a similar enzyme, occurs in the pyloric appendages of many fishes. Pepsin can be obtained free from pseudopepsin by appropriate chemical methods. In ordinary commercial preparations the writer has found evidences of tryptophan-forming enzymes in very few instances. The existence of pseudopepsin as a specific enzyme of the stomach has been denied by Klug. *Lafayette B. Mendel.*

Glaessner: Hofmeister's Beiträge zur chemischen Physiologie, 1902, i., pp. 26, 28, 31, 111.
Klug: Pflüger's Archiv f. die gesammte Physiol., 1902, xci., p. 280.

PSEUDOTUBERCULOSIS.—It seems that the word pseudotuberculosis was first used by Eberth in 1885 as a name for a disease in rabbits, which, although it resembled ordinary tuberculosis of these animals somewhat, was not caused by the bacillus tuberculosis Kochii. Later, the term has been used in a broader sense for all conditions which resemble genuine tuberculosis, but which are produced by organisms other than the tubercle bacillus. Baumgarten and others have objected to the use of the term, and it certainly is not a very good one. If we use the word tuberculosis in an etiological sense, meaning a disease produced by the tubercle bacillus, pseudotuberculosis might be interpreted as meaning a disease caused by pseudotubercle bacilli, that is, by those bacilli which resemble the tubercle bacillus more or less closely; which, at least according to the common acceptation of the term, it does not, altho pseudo-tubercle bacilli sometimes may produce pseudotuberculosis. If, on the other hand, we prefer to use tuberculosis in its anatomical sense, meaning a disease in which there is a production of tubercles, that is, nodules in the tissues, even then the term "pseudotuberculosis" is not very fortunate. The nodules in this disease also are certainly present and not in any way spurious, coinciding, in some instances at least, with true tubercles in all respects, even down to the least histological detail. Nevertheless, despite all these objections, the word will have to be retained for the want of a better one until, perhaps, medical nomenclature is revised and put on a scientific basis, a revision of which it certainly is very much in need.

Taking the word in its broadest sense as meaning a disease with the production of tubercles, that is, nodules of some sort, but not caused by the tubercle bacillus, we find that such a condition may be produced by many different etiological factors.

There is first the pseudotuberculosis of the rodents (the tuberculose zoogléique of the French authors). This form of pseudotuberculosis occurs chiefly among rodents (guinea-pigs, rabbits, hares, mice), but also among birds, particularly chickens, in the form of epizootics. Occasionally it has been produced by the inoculation of the most varying materials—*e.g.*, tissue from a hypertrophied tonsil (Bettencourt), cotton through which the air of the rooms of phthisical patients had been filtered (Chantemesse), material from a case of suspected tuberculosis of the elbow, and also from a nodule from a cow with pearl disease (Courmont), material from a caseous nodule from a child (Malassez and Vignal), pus from a cow suspected of suffering from tuberculosis (Nocard and Masselin), and milk (Parietti). The disease runs a more rapid course than ordinary tuberculosis. At the post-mortem examination one finds small caseous nodules in the spleen, liver, often in the kidneys, more rarely in the lungs, heart, brain, peritoneum. Quite frequently the Peyer's patches in the intestines are diseased and the mesenteric lymph nodes show large irregular areas of caseation and suppuration. On microscopical examination the nodules show more the appearance of chronic abscesses than that of typical tubercles, but at times nodules with large giant cells and typical caseation have been found. Woronoff and Sineff report that giant cells are very numerous in the lesions in chickens, whereas in rodents they found them occasionally only. Apostopoulos found nodules with all the characteristics of genuine tubercles in the liver of rabbits which he had inoculated by way of the anterior chamber of the eye. The disease is produced by a short, rather coarse, non-motile or very slightly motile bacillus, which does not stain with Gram's method, does not form any spores, and does not liquefy the gelatin. It grows luxuriantly except on potato. It does not ferment sugar, does not coagulate milk, does not produce any indol. Some authors describe irregular polar staining. At times the bacilli are arranged in short chains. It is difficult to stain them in the tissues. Tartakowsky has announced recently that in beef tea they form growths resembling stalactites, like those of the bacillus of bubonic plague. The cultures have an unpleasant odor, which is variously described by different authors. The organism seems to belong to the group of bacteria called by Kruse in Flügge's text-book "bacteria of hemorrhagic septicæmia," although Kruse himself classifies it with the bacillus mallei, to which it certainly does not show much similarity. Lehmann and Neumann put it with the bacilli of hemorrhagic septicæmia.

There are two cases on record purporting to be cases of infection with the bacillus pseudotuberculosis rodentium in the human being. One of these was published in 1891 by Hayem and Lesage. The patient suffered from Addison's disease. At the necropsy the left adrenal was found destroyed by caseation. Tubercle bacilli could not be demonstrated, nor were there any typical tubercles or giant cells in the sections. From the blood and the caseous areas the bacillus pseudotuberculosis rodentium was obtained. The other case is that of a child suffering from bronchopneumonia and empyema. In the pus from the empyema, Massa and Mensi (1895) claim to have found the bacilli. We might also cite a case of Courmont, who inoculated a guinea-pig with material from a case of what was suspected to be tuberculosis of the elbow. The guinea-pig developed a typical pseudotuberculosis. In view of the small number of cases recorded, and the possibility of error in the bacteriological diagnosis of the organism, and also in view of the fact that the bacillus pseudotuberculosis rodentium seems to be quite common, and therefore frequently

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found as a contamination in all sorts of material. I believe we are justified in being a little sceptical about the nature and importance of the bacteria found in these cases, until more abundant and absolutely conclusive evidence shall have been furnished.

Then, besides, we find reported in literature isolated cases in which a similar disease was caused by other bacteria. Some of them are more or less closely related to the bacillus pseudotuberculosis rodentium. In Du Cazal's two cases, for instance (both in man, one with caseous nodules on the surface of the peritoneum and similar nodules of the size of a nut in pancreas and liver; the other with large caseous nodules in brain, in pleura, along spinal column and in both kidneys), he found a bacterium which differed from the bacillus pseudotuberculosis rodentium largely only by the fact that it liquefied gelatin. Legrain found a similar organism in the pseudotuberculous lesions of a rabbit that had been inoculated with sputum from a case of pulmonary phthisis.*

In other cases the bacteria encountered were quite different. Preisz, for instance, and also Kutscher found organisms which resembled diphtheria bacilli. Still other and even more uncommon bacterial forms of pseudotuberculosis in animals have been reported by Cherry and Bull, Galli-Valerio, Vallée, and others but we cannot very well enter here into a fuller consideration of these forms.

Again other forms of pseudotuberculosis are caused by certain filamentous bacteria. In Eppinger's case of this kind there were a cerebral abscess, a very chronic tuberculosis with calcification of lungs and peribronchial lymph nodes, and tuberculosis of the pleura. The disease was caused by a form of cladothrix (asteroides), which when inoculated into rabbits and guinea-pigs produced pseudotuberculosis. Flexner reports a case which clinically had all the symptoms of pulmonary phthisis. At the necropsy he found pulmonary cavities and tubercle-like nodules in the lungs, omentum, peritoneum, liver, and spleen. Although histologically the nodules were identical with tubercles, no tubercle bacilli were found, but instead branching threads which stained well with Gram's method. Cultures could not be obtained. An inoculated guinea-pig died, but not of tuberculosis.

Infection with certain mould fungi is also one of the many causes of pseudotuberculosis. By intravenous injection of the spores of certain moulds in rabbits, for instance, one can produce a most beautiful disseminated pseudotuberculosis, as Grawitz has demonstrated long ago. An interesting form of pseudotuberculosis, produced by mould infection, is described by Chantemesse and others as occurring in pigeons. The disease starts with a caseous ulcer in the mouth, which is later followed by the formation of nodules in lungs, liver, more rarely œsophagus, intestines, kidneys. Histologically the lesions resemble tubercles very closely. The cause of the disease is the aspergillus fumigatus. The disease seems to be communicated at times to breeders of pigeons, who stuff young pigeons by introducing food into the mouth of the animals directly from their own mouths, in imitation of the parent birds.

Nodules which resemble tubercles very closely are produced in the skin in certain forms of blastomycetic dermatitis, and even more regularly are they found in another rarer form of fungus disease, which has been first described by Wernicke in Buenos Ayres, and has since then been observed several times in California. The disease generally begins as a chronic cutaneous trouble resembling hypertrophic lupus; later, a disseminated pseudotuberculosis of nearly all the internal organs except the heart and gastro-intestinal canal develops. I have seen cases, however, which did not show any cutaneous lesions, but in which the primary infection seems to have taken place by inspiration into the lungs. The fungus which causes the disease in the tissues multiplies by endogenous sporulation, only without formation of mycelia or budding, and was on that account first described as a protozoan by Wernicke and Rixford and Gilchrist, who studied the earliest cases in California. I succeeded, however, in cultivating the organism in artificial culture media, and in these it grows out into long spore-bearing hyphæ. The classification of the fungus is as yet doubtful, and until our knowledge of it is more complete I have proposed the name fungus coccidioides. I can only confirm the reports of earlier investigators that the similarity in the histological structure of the lesions produced by this fungus to typical tubercles at times is truly remarkable. A histological differential diagnosis between them, apart from the difference in the causative factor, is in these instances absolutely impossible. With such typical tubercles one finds simultaneously in the lesions numerous submiliary chronic abscesses, very much like those which commonly occur in glanders.

With this long list of vegetable parasites our list of producers of pseudotuberculosis is by no means exhausted. Among the animal parasites we find quite a few of the smaller parasites or their eggs, which when accidentally disseminated in the tissues can cause the formation of tubercle-like nodules around them. De Jong, for instance, describes cases of pseudotuberculosis in sheep and goats produced by intestinal worms (strongylus rufescens), and claims that to the naked eye the differential diagnosis from ordinary tuberculosis is difficult. Marsden also reports cases of large, more or less tubercle-like nodules in lungs, liver, and kidneys of sheep, hogs, and goats, due to the eggs of filaria strongylus. In 1884 Laulanié entertained the Société Biologique in Paris with the account of pseudotuberculosis of dogs produced by demodex folliculorum, and in 1899 Helbing read a paper at a meeting of the Freie Vereinigung der Chirurgen Berlins, in which he describes a case of pseudotuberculosis of the peritoneum in man caused by the dissemination of the eggs of a tapeworm. The nodules had the typical histological structure of tubercles; the eggs or fragments of them were enclosed in giant cells, but there was no caseation.

Even small dead foreign bodies, particularly when they are of a somewhat irritating nature, will cause the formation of nodules in the tissues. As early as 1869 Waldenburg proved this by experiments, which he relates in his monograph on "Tuberculosis, Pulmonary Phthisis, and Scrofulosis" (Berlin, 1869), a piece of work which is not so well known as it deserves to be; and even before him Cruveilhier ("Traité d'Anatomie pathologique générale," iv., 1862) had attempted to produce, and to his own satisfaction succeeded in producing, tubercles in the lungs by injection of small droplets of metallic mercury into the trachea of dogs. Only recently Meyer described a case, observed in Hanau's laboratory, of pseudotuberculosis produced by foreign bodies. In this instance a gastric ulcer had perforated and small particles of food had been scattered through the peritoneal cavity. Around these small particles of food a development of tubercles had taken place. A similar observation was made in another case in which an ovarian cyst had ruptured and a large number of cholesterin masses were disseminated through the peritoneum.

When we consider the great variety of causes which have just been enumerated, the question seems natural, Are we really justified in calling all these conditions, which are so manifold *ætiologically*, by the one name pseudotuberculosis? We shall be all the more inclined to ask this question when we learn that in many instances the lesions histologically do not resemble one another entirely. In the pseudotuberculosis of the rodents, for instance, the nodules on microscopical examination usually present the appearance of chronic miliary abscesses, such as they are observed, for instance, in glanders, and not that of typical tubercles. The same is true of the lesions caused by infection with certain pathogenic moulds. In these lesions giant cells and caseation which are considered to be the more important

* In the last issue of Ziegler's Beiträge (1902, xxxii., 526) Wrede reports an interesting case of pseudotuberculosis in an infant. Pharynx, œsophagus, intestines, liver, and adrenals were full of gray submiliary nodules. The condition was caused by a bacillus which closely resembled the bacillus pseudotuberculosis rodentium, but which differed from it in staining with Gram's method.

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characteristics of true tubercles, are often absent. Yet under other conditions the same parasites may produce nodules which in histological structure resemble ordinary tubercles very closely. In chickens, for instance, we learn from Woronoff and Sineff that the nodules produced by the bacillus pseudotuberculosis rodentium contain many giant cells. One must also not forget that in ordinary tuberculosis the nodules show remarkable differences in histological structure according to the age of the nodule and the number and virulence of the tubercle bacilli present. Tubercle bacilli also at times may produce chronic miliary abscesses. Since my attention has been called to this occurrence by some observations made while studying the ependyma of the ventricles of the brain in tuberculous meningitis ("Ueber Ependymveränderungen bei tuberculöser Meningitis," *Virch. Arch.*, cl., 1897, 305), I have seen chronic miliary abscesses produced by tubercle bacilli—and by tubercle bacilli alone without associated infections—quite frequently in other parts of the body in man and animals. In infections with the fungus coccidioides the simultaneous occurrence of "typical" tubercles and chronic miliary abscesses in the same organ, produced by the same parasite, is very bewildering; indeed one is finally forced to recognize that the difference between these two conditions is not a fundamental one—as a matter of fact, I have seen transitional forms of otherwise typical tubercles with central abscess cavity filled with pus cells,—and that whether the tissues respond in one way or the other depends only on the amount of irritation to which they are subjected. If the irritation is less marked, a "typical" tubercle develops; if it is more intense, a chronic miliary abscess is produced. It seems, therefore, that in spite of the variety of causes, and in spite of the varying appearance of the nodules under the microscope, it is advisable to group all these conditions which are closely akin to one another under one name, "pseudotuberculosis," provided we keep in mind that in so doing we use the word "tubercle" in its broadest sense for a nodule, without assuming anything too definite about its exact histological structure.

William Ophüls.

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PSEUDOTUMOR.—The term *pseudotumor* is applied to certain enlargements or swellings of non-neoplastic character which clinically present features by which they may be mistaken for true neoplasms. In the majority of cases such false tumors are found in the abdominal region. They may be produced by a great variety of causes. When the swelling cannot be constantly felt, but comes and goes, it may be designated as a *phantom tumor*. Such enlargements have no organic pathological foundation, and are dependent upon temporary conditions. On the other hand, enlargements or swellings of the abdominal organs due to organic disease may also simulate neoplasms; these conditions should be included under the designation of *pseudotumor* or *apparent tumor* proper. When caused by inflammatory masses of granulation tissue which later contract and disappear, the condition may be spoken of as *vanishing* or *disappearing* tumor.

Phantom tumors may be caused by a contraction of the abdominal muscles or by meteorism. Those caused by muscle contractions are found usually in the upper part of the abdomen. The right rectus near its costal margin is most frequently the part contracted, but the contraction may affect any segment or portion of the abdominal muscles. The contractions are often spasmodic. The entire rectus may be rigid. Usually, however, but a single segment is affected, the contraction being almost always unilateral. The patients are usually hysterical females who present marked stigmata of hysteria; there are usually coexisting constipation and enteroptosis. The contraction may sometimes be made to disappear in a hot bath; but in cases of marked hysteria anæsthesia or hypnotic suggestion may be necessary for the differential diagnosis. The superficial character of the tumor, its flat, horizontal shape, slightly rounded and indistinct edges, etc., in connection with the stigmata of hysteria, make the diagnosis easy.

Phantom tumors due to meteorism or localized distention of the intestines with gas, are of frequent occurrence in the same class of patients as described above, and are often found in connection with the muscle contraction. The character of the swelling, the percussion signs, etc., make the diagnosis easy. The swellings occur usually in the lower portion of the abdomen, particularly in the appendix region, and above the pubis. They are found frequently in women who either pretend or believe that they are pregnant (pseudocyesis). The associated stigmata of hysteria, and the characteristic physical signs render the diagnosis of slight difficulty.

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Apparent tumors of the epigastrium are, according to Einhorn, of infrequent occurrence. He reports forty-two cases, eight occurring in men and thirty-four in women. The tumors presented in the epigastrium or in the left or right hypochondrium, and formed in the majority of cases smooth masses of the size of a hen's egg or a man's fist. They were frequently pulsating, could not always be distinctly felt, and on light percussion yielded a dull sound. They ran a long course, and there was usually a history of a long-continued malnutrition. The tumors remained unchanged or diminished in size. They were caused by prolapse of the left lobe of the liver, exposure and thickening of the abdominal aorta, hypertrophic conditions of the muscles of the abdominal walls, and probably adhesions around the lesser curvature of the stomach. If the tumor is caused by the prolapse of the left lobe of the liver, it is found usually in the median line below the ensiform; it is of large size and gives a dull tone on percussion. Between the dulness of the tumor and the ensiform there may be an area of tympanitic tone. If the tumor is the aorta, it is deep, usually about two inches long, and one to two thumbs in breadth, and pulsates. Hypertrophic conditions of the abdominal muscles are superficial, usually horizontal, and not globular, and are located at one side of the median line.

In very thin individuals the head of the pancreas may be felt and mistaken for a tumor. Likewise floating kidney, liver or spleen, rolled-up omentum, excessively fat mesentery, fæcal impaction, distended urinary or gall bladder, tuberculous thickenings of omentum or mesentery, hydro- or pyosalpinx, cystic dilatation of the appendix, etc., may sometimes be regarded as presenting the clinical appearances of malignant tumors of these regions.

Inflammatory thickenings, tuberculous and syphilitic nodules, encapsulated hæmatomata, encysted parasites, infective granulomata of unknown origin, localized hypertrophy of muscle, local œdema, etc., are also often mistaken clinically for malignant tumors.

The term pseudotumor is also applied to the nodules of a chronic inflammatory nature caused by the experimental injection of blastomycetes and other fungi. Similar nodules may be produced by the introduction of foreign bodies or the injection of certain chemical substances into the tissues.

Disappearing tumors of the abdomen are usually the result of acute inflammatory tumors of the omentum, following appendicitis or salpingitis. The absorption of exudates and the contraction of the granulation tissue lead to the diminution in size or total disappearance of the tumor. Similar disappearing tumors occur in the skin, subcutaneous tissues, periosteum, and intermuscular connective tissue as the result of the formation of granulation tissue following trauma or hemorrhagic extravasation. These may sometimes be mistaken for sarcomata, both clinically and microscopically. The presence of numerous plasma cells, the character of the blood-vessels, and the general appearance of the granulation tissue are points upon which the differential diagnosis should be based. (See also *Omentum* and *Abdominal Tumors.*)

Aldred Scott Warthin.

PSITTACOSIS.—An infectious disease occurring in birds, particularly in parrots, and transmissible to man. The disease in parrots is of the nature of a chronic enteritis, characterized by diarrhœa, wasting, loss of appetite, and falling of feathers. In man the symptoms are those of a grave typhoid, with diarrhœa and a malignant atypical pneumonia. The disease may be transmitted directly from parrots to man or through intermediate objects, and, according to some observers, from man to man. The period of incubation is from seven to twelve days; the symptoms begin with malaise, epistaxis, and digestive disturbances, followed by bronchitis and pneumonia. The urine contains a small amount of albumin. There is high fever lasting for from three to four days, and falling by crisis. These symptoms then recur in this order several times, defervescence finally taking place by lysis. During the attack the spleen is enlarged. Sometimes there may be seen a roseolar or petechial eruption. The disease lasts about thirty days. The mortality is about thirty-seven per cent. The prognosis is good if complications do not occur. In the majority of fatal cases, death is due to pneumonia.

Eberth in 1880, and Wolff in 1883, observed the occurrence of a fatal mycosis in parrots which had been imported in great number from the west coast of Africa during 1880. Transmission to man was not observed. In 1879 Ritter saw a house epidemic of severe pneumonia which he thought was referable to a contagion from parrots, or rather from the cages in which the birds had been transported. The clinical and anatomical picture of the disease was that of an atypical pneumonia. Similar cases were observed in 1882 by Ost, and by Wagner in 1882 and 1886. The disease was introduced into Paris in 1891 by some parrots from South America. In 1892 there was an epidemic of the disease in this city, in which fifty persons were affected. Cases of the disease were also observed in Paris during the next four years, and advantage was taken of the opportunity to study the disease closely. The relation of the disease in man to the affection of the parrot was clearly proved. Cases have been observed also in Italy and Germany.

According to Nocard, the cause of the disease is a specific bacillus resembling that of typhoid fever. The organism is short, rather thick, with rounded poles, is motile, and is a facultative aërobe. It does not stain with Gram's method, does not ferment sugar, does not coagulate milk, and does not form indol. The bacillus is very virulent; subcutaneous injections in rabbits, mice, and pigeons kill within from fourteen to forty-eight hours. In the Paris epidemic this bacillus was not found in the human body; but, three years later, Gilbert and Fournier found it in one case, in the heart blood of a woman dying from the disease. Palamidessi observed an infectious disease transmitted from parrots which he regarded as resembling chicken cholera. The organism obtained by him was regarded as identical with that observed by Nocard. Other observers have failed to find the Nocard bacillus; and Leichtenstern and others believe that the disease of the parrots known as psittacosis may be caused by various bacteria (staphylococcus, streptococcus, pneumococcus, colon bacillus, and proteus), and that house epidemics of atypical pneumonia in man may occur without such diseases of the parrot playing any etiological rôle therein. These writers, however, admit the probability of such a relation in certain cases, as in the Paris epidemic of 1892.

On the other hand, Nicolle reports an epidemic attacking eight persons (four dying), in which the Nocard bacillus could not be found; but the serum from these cases produced a typical agglutination of a culture of the bacillus furnished by Nocard, in dilutions of 1 to 50 and 1 to 60. The blood of one of the cases also agglutinated typhoid bacilli, although the patient had never had the disease.

Widal and Sicard claim that typhoid and psittacosis can be differentiated by the Widal reaction. In dilutions of 1 to 10 the reaction occurs with both; but the masses of psittacosis bacilli are smaller and more crowded. In dilutions of 1 to 40 there arrives a moment when the bacilli of psittacosis no longer react.

The bacteriology of psittacosis and the true relations of the parrot disease to the atypical pneumonia in man remain yet to be determined definitely. Further, it should be observed that in the popular mind psittacosis is regarded as a form of avian tuberculosis, and that cases have been reported of a supposed transmission of tuberculosis from the parrot to man, whence the origin of the error.

Aldred Scott Warthin.

PSOAS ABSCESS is a *cold abscess* located in the psoas muscle. The purulent material gains entrance into the muscle after destroying the vitality of a portion of the sheath by pressure and infiltration.

The iliac fascia which ensheaths the whole muscle con-

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fines the pus and directs its course through the substance of the muscle, the result of such burrowing being extensive destruction of tissue. The infiltration may involve the muscle on either or both sides of the body. The purulent material may accumulate until the sheath becomes a mere pus sac with the lumbar plexus of nerves crossing its cavity, the muscular tissue being destroyed.

The cavity is irregular in shape, bulging laterally, and constricted, sometimes closed at the diaphragm and beneath Poupart's ligament.

An abscess resulting from tuberculosis of the bodies of the lower dorsal or upper lumbar vertebræ will, as a rule, perforate the psoas sheath.

The pyriform pus sac so formed lies along the sides of the dorsal vertebræ, this lateral position being determined by the presence of the anterior and posterior common ligaments.

When the source of the pus is situated above the diaphragm, its entrance into the psoas is facilitated by the intimate connection of the iliac fascia with the ligamentum arcuatum internum.

In the lumbar region the entrance of pus into the psoas is aided by the formation of pouches between the heads of origin of the muscle (body of the vertebra and intervertebral substance and front of the transverse process of the vertebra). These pus pouches rupture into the body of the muscle.

Abscesses resulting from tuberculosis of the sacrum, from sacro-iliac disease or from tuberculosis of the lumbar glands, may also perforate the sheath of the psoas muscle.

Rigidity or contraction of the affected psoas muscle and perhaps neuralgia of the anterior crural nerve are the most frequent symptoms. The contraction of the muscle may lead to great deformity, demanding weight-and-pulley extension, or even tenotomy for its correction.

Frequently the distended psoas sheath can be detected by palpation, and if the pus has reached Scarpa's triangle it can be pressed up and down under Poupart's ligament, following the course of the psoas muscle.

This is the usual course taken by the pus, which is directed by the sheath toward the insertion of the psoas and iliacus muscles; but it may burrow farther, pointing lower down on the limb.

The pus on reaching Poupart's ligament may enter the iliacus muscle, or may leave the psoas sheath along its external border and burrow to the surface in the loin; or it may invade the gluteal or the ischiorectal region.

The direction taken by the abscess is determined by the usual position of the body. If the dorsal position is most constant, the pus may point in the loin or may even sink upward into the pleural cavity. Other organs and tissues are occasionally invaded, and the pus may open into the lungs, bladder, intestines, blood-vessels, or peritoneum.

An early diagnosis will often allow of a successful operation through an incision in the loin. The abscess cavity should be made aseptic and any diseased bone scraped away. The drainage must be free and into an antiseptic and elastic dressing.

Curetting the sac wall should not be attempted unless the whole cavity is accessible.

Although a large collection of pus may become cheesy or encapsulated, yet its presence is a possible focus for the development of miliary tuberculosis or cerebrospinal meningitis. Then, besides, it is a well-known fact that amyloid changes are likely to take place in the viscera when suppuration continues for a prolonged period. Consequently, early operative interference is to be recommended in the hope that it may prevent the development of such changes in the viscera.

When the pus approaches the surface, especially in the groin where antiseptic treatment is difficult, and when the sac is known to be large, aspiration is to be preferred to incision and drainage. The trocar should be passed in a slanting direction, piercing the tissues about an inch before entering the pus sac. The lumen of the trocar should be frequently cleaned with a plunger or wire hook, as the pus contains much semi-solid necrotic granulation tissue, cheesy matter, and often small particles of bone.

After the sac has been washed out with a weak boracic-acid or tincture-of-iodine solution, it should be injected with twenty or thirty grains of iodoform dissolved in ether or suspended in glycerin.

The trocar should then be withdrawn, its retiring point being followed by the finger from the sac to the exit so as to prevent the entrance of any purulent material into its track. The wound should then be sealed with collodion.

During the process of aspiration and flushing of the abscess cavity the entrance of air must be prevented by pressure upon the sac. The quantity of flushing fluid should not exceed that of the pus withdrawn. Compresses should be applied in such a way as to insure the apposition of the walls of the sac, in order to promote healing and to lessen the oozing of serum or blood because of the diminished pressure within the cavity.

Aspiration aseptically performed gives good results, although it may require to be repeated several times. The pus becomes more viscid, and the semi-solid masses of necrosed tissue and fibrin disappear as the healing progresses.

If the abscess has opened spontaneously it should be protected with dressings which promote drainage by capillarity, such as jute or lambs' wool. At each daily dressing two grains of carbolic acid in about fifty parts of water should be injected into the sinus.

The treatment may extend over weeks or months, but the danger from infection becomes less as healthy granulations form in the cavity. Sometimes a counter opening becomes necessary in order to allow of better drainage and more thorough disinfection of the sac.

Pus from an inflamed appendix, a perinephritic abscess, or an empyema may invade the psoas muscle, but a study of the constitutional disturbances will facilitate the differential diagnosis in such cases. The differential diagnosis of diffuse abdominal aneurism may be made by its impulse and perhaps bruit.

The diagnosis from iliac abscess rests chiefly on the age of the patient, for psoas abscess occurs generally in the young with tuberculous history, and iliac abscess in the adult.

The impulse transmitted to the swelling by coughing must be carefully distinguished from that present in hernia; a diagnosis may be made by observing the manner in which the tumor can be reduced and in which it reappears after reduction, and also by the fulness of the iliac fossa, apparent on palpation.

Varicose veins, cysts, undescended testicle, and glandular swellings in Scarpa's triangle must also be differentiated. *Jasper J. Garmany.*

PSORIASIS.—Psoriasis is a disease of the skin which possesses three characteristics that should render its diagnosis easy. These are: 1. The formation of dry, papery, thin, silvery-gray scales, mica-like in their arrangement, and as a rule easily detached, is a constant phenomenon. 2. Dryness is an absolute characteristic of the disease at all stages and in every situation. There is never, in a pure type of the affection, the slightest moisture, greasiness, or tendency to ulceration. 3. The development of points or discs of a color varying from pale red to a red of a brighter hue, and showing a certain degree of inflammatory thickening—sometimes quite marked, but usually only moderate or slight—is another characteristic of the disease. These lesions are always well defined at their borders and tend to enlarge peripherally, sometimes with evidence of greater activity at the border than in the centre. Contiguous lesions often meet, forming irregular, map-like figures, the points of confluence becoming like the centre of the original patch or disc.

At the onset of the disease there is noticed, commonly at some part of the surface of the body where the skin is

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thicker than elsewhere, a well-defined spot or patch of a pale red color (but of a somewhat brighter red in an acute outbreak of the disease) and of variable size (from the head of a pin to a half-dime silver piece). At the affected spot the skin is a little thickened, and its surface consists of one or two layers of thin, dry, easily removable scales which are quite small in proportion to the size of the lesion. This lesion gradually enlarges—as a rule, symmetrically—and in the part newly involved the characteristic slight thickening of the skin and the formation of loosely attached scales may be observed. When the loose scales are removed it will be seen that the natural lines of the skin, which under normal conditions are quite faint, are now accentuated by the upraising of the intermediate areas through the products of inflammation. When the lesion attains the full limit of its growth, it may be as large as a silver half-dollar and of about the same thickness. Through coalescence two or three adjacent lesions may eventually form quite a large area, of irregular shape. I have known an apparently single lesion, on the extensor surface of the forearm, to attain an area of about four by six inches. At no time in the course of its development did this patch fail to show the pathological alterations which are so characteristic of the affection and which have already been enumerated.

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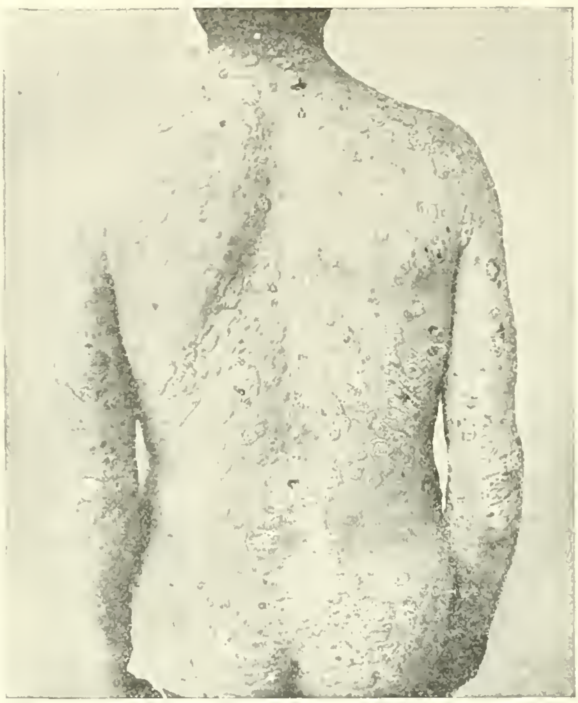

FIG. 3895.—Psoriasis. (From the collection of photographs of skin diseases belonging to Dr. John A. Fordyce, of New York.)

If the scales are allowed to accumulate they form dry, mortar-like masses. In some cases the central parts of the large lesions will remain relatively quiescent for a considerable period of time; the thickening process and the formation of scales being confined to a narrow border (from one-twelfth to one-fourth of an inch wide).

"Punctate hemorrhage" constitutes another and thoroughly characteristic distinguishing feature of the disease. If, in the younger or thinner lesions, the scales are removed down to and including the basal layer, bleeding will take place from a number of isolated spots, not larger than the point of a pin and corresponding to inflamed papillæ, the blood-vessels of which have been torn.

Upon the scalp, when covered with the natural growth of hair, the disease presents an appearance somewhat different from that which it generally does on other parts of the body. There is less infiltration, as a rule, although quite characteristic discs and patches, like those observed on other parts of the body, may occur. The scaling is often excessive, forming piled-up masses of the dry, silvery, papery, and quite easily removable scales. Along the margin of the hairy region, especially on the forehead, there often appears a gyrate band of the disease, one-half of it being located on the hairy surface and the other half on the natural skin surface. Then again, in other cases, the disease develops in the skin of the forehead and extends to a greater or less extent upon the hairy surface of the scalp. In this extended area of the disease the affected skin is red and slightly thickened, and upon it are seated the irrepressible dry, gray scales.

Wherever the disease assumes a somewhat acute character there we may be sure of finding more marked redness and a more rapid formation of scales of varying size, but always of marked thinness.

Although itching is not a characteristic symptom of psoriasis, my records show that it was present in some degree in nearly all my cases. In some of these cases the symptom appeared in connection with an acute outbreak of the disease—either simultaneously with or just preceding the outbreak,—but in others it appeared to be due simply to the accumulation of scales.

While it is generally held that the disease shows a predilection for the regions of the knees and elbows, my own experience does not give any very strong support to this belief. It certainly has a preference for the scalp and for the extensor or thick-skin surfaces, but in a general outbreak the disease respects no limits. In one case, for example, its manifestations were to be seen on practically every part of the surface of the body save the scrotum and feet.

Exfoliative dermatitis may occur as the result of an acute outbreak of psoriasis, the entire skin being involved in the attack. Such an attack is characterized by general redness of the skin (although there may be free or partially free areas) and by the rapid and constant formation and throwing off of paper-like, thin, dry scales; often surprising quantities being exfoliated in a day. The skin is not much thickened, the redness varies from a bright red to a red of a dull lustre, and the inflammatory action is of moderate degree. Itching in some measure may be present. These extensive outbreaks usually subside, thus differing from pityriasis rubra, which ends only with loss of hair and nails, wasting away, involvement of vital organs, and, finally, death.

Psoriasis has been called a disease of the healthy. While this is to some extent true, my observation leads me to amend this statement by saying that the people who have it are in as good average health as their less afflicted fellows, while some of them even deserve the appellation of robust.

I have been unable to trace this disease to heredity, and have seen but slight evidence in favor of the belief that it affects the members of certain families. It develops, according to my experience, in the more vigorous years of life—that is, from infancy to middle age; my cases being mostly adults and under the middle decennium of life. The duration of the disease in these cases has varied from a short time to a period of a few years. Furthermore, males have preponderated over females in the proportion of two to one. On the other hand, it must be remembered that psoriasis is quite a rare disease in this latitude, and that there have been too few cases to justify us in formulating any statistics.

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Prosperity and poverty, sobriety and intemperance, cleanliness and filth, seem to exert no appreciable influence in warding off the disease or in favoring its development. These influences, however, when once the disease has become established, may turn its further course toward the better or toward the worse.

The disease does not appear to have any depressing influence upon the general health. Often it constitutes simply a bodily discomfort, with perhaps, in addition, a certain amount of mental worry consequent upon its presence.

Etiology.—As to the cause of psoriasis, we know nothing positively. There are many theories. In some respects the disease behaves as if it were due to germ influence, the manifestations resembling somewhat those of an exaggerated action of the ringworm fungi—as, for example, the peripheral extension, the frequent clearing up at the centre, and the persistent activity at the border. Psoriasis presents a further resemblance to a parasitic disease in the character of its relapses; it being an easy matter to ascribe them to re-infection from small uncured points, such as can always be found on some part of the body.

Course of the Disease.—Recurrences are the rule; often the central parts of the pale patches left after the subsidence of an outbreak are the sites of a new eruption. These relapses often occur immediately or very soon after the subsidence of an acute outbreak. It is probable that a person affected with psoriasis is never absolutely free from the disease after the first onset. I have been able to follow one such case for a period of over ten years—that is, from the time when the patient was only three and a half years of age to that when he was fourteen years old. It is interesting to note that this patient has always been strong and robust and that he has been in no way retarded in his development.

Diagnosis.—The diagnosis of psoriasis should offer little difficulty, if the features already described are kept in mind. In the following paragraphs I will mention briefly the characteristics which should enable the physician to distinguish it from the various affections with which it is most likely to be confounded.

Dry seborrhœa of the scalp shows little if any inflammation or thickening. The scales in this affection are smaller than those observed in psoriasis, and if they are present in a mass the latter is usually more friable; often, too, these scales form sheaths around the hairs at their insertion in the follicles. Removal of the masses of scales may show a reddening beneath and a slight moisture.

Seborrhœic eczema of the scalp usually shows fewer scales; if there are patches they are thinner and slightly moist, and the scales are greasy. When the disease extends from the scalp upon the forehead it may resemble psoriasis, but there is little infiltration, the scales are not dry and papery, and the inflamed surface presents a somewhat more moist appearance.

Syphilis of the scalp may show the so-called corona or frontal extension. The color is, however, of a deeper shade, the infiltration more marked, and the scales are smaller, more adherent, less papery looking and less abundant. Syphilitic patches on the scalp lack the features which have already been described as characteristic of psoriasis.

Ringworm of the scalp is dry, scaly, not infiltrated in any marked degree, has fewer, finer scales, and shows a well marked, not greatly elevated border which bears evidence of slight exudation. The hairs in the patch are broken or lustreless from the growth of the microorganism.

Eczema of the scalp does not occur in the form of sharply limited patches; then, besides, there is a peculiar stiffening and thickening of the parts affected, and there is either a frank, sticky exudation upon the surface or there are points and lines of broken epidermis where the exudation is just beginning to break forth. Upon drying, the exudation assumes the form of gummy, brownish, or yellowish crusts.

Seborrhœic eczema on the body shows scarcely any infiltration, the scales are few and often greasy, and the affected surface has not the absolute dryness of psoriasis.

Syphilitic patches of the dryest form, when located elsewhere than on the scalp, often show a tint of lividity, and they have a less regular shape than the patches of psoriasis; the scales also are smaller and less plentiful, and they are formed at a less rapid rate than in the latter disease.

In none of the diseases enumerated above can the punctate hemorrhage be produced.

When compared with psoriasis even the dryest eczema of the body shows less symmetry of lesions, more thickening, a less well-defined border, fewer scales, and these not like the scales of psoriasis. Furthermore, the patches have a stiffer look and feel, and itching is more marked.

Ringworm of the body shows fewer scales, and less, if any, thickening of the part affected. On the other hand, the lesion has a sharply defined border, which appears to be the seat of an exudative inflammation. At the centre of the lesion the skin is generally found to be nearly free from inflammatory action.

When psoriasis is associated with other morbid conditions of the skin the physician will have to base his diagnosis upon the presence of certain features which are characteristic of this disease.

Prognosis.—The prognosis of psoriasis is unfavorable as regards a cure, and doubtful as regards the removal of the eruption. In all my experience I have seen but one case of psoriasis—at least so diagnosed—in which recovery was perfect; but even in this case it is not perfectly clear that an error in diagnosis may not have been made, for upon reading my notes of the case again at the present time I find that it may possibly have been one of a slightly atypical seborrhœic eczema. Recovery followed the use of treatment administered on the supposition that the case was one of psoriasis. This patient was a woman in good circumstances who died of alcoholism.

It is best to promise a patient with psoriasis nothing more than a certain amount of relief.

Treatment.—The treatment of psoriasis is both external and internal, the former being the more efficacious of the two. Arsenic has been for years the chief reliance in the internal treatment of the disease, it being often pushed to large dosage and continued for long periods of time. Its effects show such a mixture of good and evil that I seriously question whether the benefits of the remedy are not more than offset by its disadvantages. Some people reach the limit of tolerance (conjunctival irritation, puffiness of lids, gastric irritation) very early. If they escape these, they may, under a long-continued use of the drug, acquire other dermatoses scarcely preferable to psoriasis. However, it is well to give arsenic a trial, but only in cases in which there is but a small degree of cutaneous irritation. It is usually employed in the form of Fowler's solution (liquor potass. arsenit.); the dose being, for an adult, five drops after each meal. This dose should be gradually increased (an additional drop at the end of every twenty-four hours) until the limit of tolerance is reached.

Another arsenical preparation is what is called "Asiatic pills," the formula for which is as follows: ℞ Acid. arseniosi, gr. i.; piper nigris, gr. xx.; pil. mas. q.s. M. ft. pil. xx. Sig.: Begin with one after each meal; increase by one every day. As a result of taking these pills, some patients have complained of stomachic irritation which they, quite reasonably, attributed to the black pepper, this irritation preventing in itself the object sought—viz., to obviate irritation by the arsenic.

Iodide of potassium administered in large doses has acquired considerable renown as a means of relief for psoriasis, but my experience with this drug has been of such a discouraging character that I have given it up in the treatment of this disease.

Thyroid extract, in the form of tablets (gr. ij.–x. t. i. d.), has seemed, by actual comparison with other remedies, to be decidedly beneficial; it constitutes, perhaps, our best remedy for use internally in the treatment of psoriasis. This opinion is at variance with that of excel-

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lent authorities, but is entirely sustained by my observation. All depends upon obtaining the pure, and therefore not inert, substance. As thyroid extract is capable of inducing depression of the heart's action and possibly dizziness, the dose must be small at first, the effect watched, and it may even be necessary to attempt to neutralize these effects by the administration of strychnine.

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As is self-evident, the patient's general condition must be kept at its best by such internal treatment as the symptoms may require, just as if there were no psoriasis.

Faithful following of directions as to external treatment, while onerous, must be required. The first requisite is the removal of scales to permit the action of remedies. Naturally, the treatment generally outlined below is to be much modified if the skin is found to be abnormally irritable.

Hot baths at night, in combination with the liberal use of soap, greatly assist in removing the scales. Sapo viridis may be used in full strength for removing scales, or an alcoholic solution (sap. vir., ℥ ij.; alcohol, ℥ i.) may be employed; but any strong soap will do quite as well. As alkalies exert a special effect upon epidermic scales it is easy to understand the beneficial action of soaps in removing them in psoriasis. Hot tar baths or tar well rubbed into the patches before an ordinary hot bath is taken will often be found helpful.

To aid in the removal of accumulated scales from the scalp, it is advisable to apply freely a mixture containing salicylic acid and olive oil in the proportion of one part of the former to eight of the latter. After the mixture has been well rubbed in, it should be allowed to soak into the parts for some time before it is finally washed away. The addition of formalin to this mixture (two and a half minims to each ounce) seems to heighten its beneficial effect. If a milder application is desired, the addition of twenty grains of salicylic acid to one ounce of simple ointment will be found to answer satisfactorily.

In my own experience with the treatment of psoriasis of the scalp, the ammoniate of mercury, preferably in salve form, has proven the most useful remedy. The following are some of the formulæ used: (1) ℞ Hg. ammoniat., ʒ ss.–i.; Ung. simp. (seu. Ung. aq. ros.), ℥ i. M. Rub well in at night. (2) ℞ Ung. hg. ammon., ol. oliv., āā ℥ ss. M. Sig.: Use at night. If there is not much irritation, Ung. hg. ammon. (U. S. P.) may also be used.

These mercurial preparations can be employed only on a limited portion of the general cutaneous surface, as there is always some risk of inducing salivation if the drug is too extensively applied.

I have used the following, but it produced slight ptyalism: ℞ Hg. ammon., gr. xl.; acid. salicyl., ʒ i.; Ung. zn. ox., ℥ i. M. Sig.: Apply well morning and night. This ointment may be considered perfectly safe if it is applied over a limited area.

When there is a more general involvement of the skin, chrysarobin in salve form is the best local remedy. Chrysophanic acid is much weaker in its action, and I have abandoned its use. Chrysarobin usually exerts its best action when its characteristic dermatitis is produced. Under its action the skin becomes deep red, almost lilac in color, hot, and itches. The subsiding, clearing patches stand out as gray-white and uninflamed upon this reddened surface. The proneness of chrysarobin to cause irritation precludes its use on the scalp or face, for fear that this irritation may involve the eyes.

The most useful salve is the following: ℞ Chrysarobin, ʒ ss.–ij.; Ung. zn. ox., ℥ i. M. Sig.: Rub well in patches freed of scales at night—leave some on. To this may be added acid. salicylic., ʒ ss.–i., which often increases its effect.

The varnishes so frequently employed in affections of the skin seem to interfere with the action of the drugs contained, but occasionally a varnish containing chrysophanic acid has proved somewhat beneficial in the treatment of psoriasis.

The following formulæ have been found useful: (1) ℞ Chrysarobin., gr. xv.–ʒ i.; liq. gutt. perchæ, ℥ i. M. Sig.: Shake. Paint on patches freed of scales. (2) ℞ Acid. chrysophanic., ʒ i.; collodii flex., ℥ i. M. Sig.: Paint on. (3) ℞ Chrysarobin., ʒ i.; collodii, ℥ i. M.

Lanolin, when used as the base, makes a more adhesive ointment, but the zinc oxide salve seems to prevent severe irritation. It is customary to suspend the chrysarobin treatment upon the appearance of marked dermatitis, but if this is not severe the use of the drug may be continued. To relieve this dermatitis, one of the following preparations may be employed after suspending the chrysarobin: (1) ℞ Zn. ox. pulv., ʒ iv.; phenol. (ninety-five per cent.), ʒ i.; amyli pulv., ʒ ij.; aq., ℥ iv. M. Sig.: Shake; apply often. (2) ℞ Zn. ox. pulv., ʒ ij.; amyli pulv., ʒ i.; ol. oliv., ℥ ij. M. Sig.: Shake; apply.

Pyrogallic acid at one time was considered a good second to chrysarobin as regards its efficacy in the treatment of psoriasis; and it may still be found an efficient remedy. The following is a suitable form in which it may be employed: ℞ Acid. pyrogallic., ʒ ss.–ij.; Ung. zn. ox., ℥ i. M. Sig.: Use in the same manner as the chrysarobin ointment, and in those cases in which the chrysarobin ointment proves too irritating.

The tar preparations have proven useful in some cases, especially where the skin will not bear stronger treatment. The following are convenient formulæ: (1) ℞ Ol. cadenii, ʒ ij.; acid. pyrogallic., ʒ i.; ether. sulphuric., alcohol. āā ℥ i. M. Sig.: Apply night and morning. (2) ℞ Picis liq., ʒ i.–ij.; Ung. zn. ox., Ung. diachyli., āā ℥ ss. (or omit the diachylon). M. Sig.: Rub well in once or twice a day. Leave on. (3) ℞ Picis liquid., ʒ iij.–iv.; acid. salicyl., ʒ i.; Ung. zn. ox., ℥ iv. M. Sig.: Apply in the usual manner.

In the employment of these different remedial procedures it is well to remember that a lotion must be re-applied so often that the parts will be kept constantly covered with the fluid; that a varnish must be re-applied as soon as it peels off; that a salve must be well rubbed in, and a sufficient quantity must always be left on to keep the drugs in continuous action upon the skin; and, finally, that soap and baths and other scale-removing measures must be employed often enough for the attainment of the object desired. Then, when all this has been done, the patient will probably still have some psoriasis, or a new attack will supersede the old one, and the only certain hope of an end to the disease is such as is offered by his decease.

M. B. Hutchins.

PTERYGIUM. See *Conjunctiva, Diseases of.*

PTOMAÏNS.—Ptomaïns are basic, nitrogenous organic substances produced by bacteria.

The first writer to suggest the probability of the formation of a poison coming within the above definition during putrefaction seems to have been Kastner (*Arch. f. gesam. Naturlehre*, 1824, Bd. i., 448, 488; Bd. ii., 499), who advanced the hypothesis that poisonous sausages contained an "alkaloid of decay" (*Moderalkaloid*) combined with an organic acid.

In 1852 Schlossberger, in an extended paper upon the sausage poison (*Arch. f. physiol. Heilk.*, Ergänzhft., 1852) supposed "the poisonous substances occurring in sausages and cheese to be organic bases, which have their origin in the decomposition of the protein materials rich in nitrogen, under certain conditions." He supported this hypothesis by the following observations: (1) When ammonia is produced in considerable amount by the decomposition of animal or vegetable substances, it is accompanied by volatile bases; (2) by the action of dilute potash upon poisonous sausages, much ammonia, accompanied by a peculiar repulsive odor, is given off; (3) the physiological action of the putrid poison is very similar to those of the known volatile alkaloids nicotin, coniïn, sparteïn, and to those of the artificial amid, imid, and nitril bases of Hofmann; (4) one of these bases, trimethylamin, is contained in herring pickle.

Four years later (1856) Panum was probably the first to obtain a ptomaïn, although in an impure condition, and to demonstrate that the putrid poison is a chemical

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substance and not a living organism ("Bibl. for Laeger.," 1856; *Schmidt's Jahrb.*, 1859, ci., 213, *Arch. f. path. Anat.*, 1874, lx., 328–352). This substance was described by Panum as being soluble in water, from which it was precipitable by alcohol; capable of extraction from putrid meat, and not identical with any of the known odorous products of putrefaction. It is capable of withstanding a boiling temperature, evaporation, and the influence of absolute alcohol, conditions inconsistent with the presence of organized life.

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In 1866 Bence Jones and Dupré obtained from animal matters a substance which they called "animal chinoidine," which gave precipitates with the general reagents for the alkaloids then known, and whose solution exhibited a blue fluorescence (*Med. Times and Gaz.*, 1866, 163). In 1868 Bergmann and Schmiedeberg obtained from putrid blood a small quantity of a crystalline substance, which was poisonous to dogs and to frogs, and to which the name "sepsine" was applied (*Med. Centralbl.*, 1869, 497). In 1869 Zuelzer and Sonnenschein obtained from cadavers a crystalline substance having physiological actions resembling those of atropin (*Berl. klin. Wochenschr.*, 1869, vi., 121).

Between 1872 and 1878 Selmi published an extended series of observations upon the reactions and properties of putrid products, without, however, having determined their chemical composition, and in 1875 proposed the name "ptomaïn," written by some recent German authors, "ptomatine," derived from the Greek, πτῶμα, *i.e.*, that which is fallen; a corpse. The contributions of Selmi and his Italian followers—Mortigia and Battistini, Trottarelli, Raffaele, Ziino, Albertoni and Lussana, Paterno, Spica, Brugnatelli and Zenoni, Bocci, Guareschi and Mosso, and Monari—have been numerous and important. It remained, however, for Nencki and his pupil Brieger to determine the chemical character of these compounds. The former was the first to establish the composition of a ptomaïn by the analysis of a base having the formula $C_8H_{11}N$, probably α-phenyl-ethylamin, in 1876. The latter, in the most important researches upon the chemistry of the ptomaïns ("Ueber Ptomaine," i., 1885; ii., 1885; iii., 1886; *Berl. klin. Wochenschr.*, 1890, xxvii., 241, 267, 1133), established the constitution of a number of the putrid bases.

The ptomaïns have been, and still are, frequently referred to as "animal alkaloids," a designation which is misleading and improper for two reasons: They are not necessarily produced from animal substances, but many are formed by putrefaction of vegetable proteins; nor are they usually the products of animal metabolism, as are their relatives, the leucomaïns. Only a few of them are known to be alkaloids in the present acceptation of the term, *i.e.*, basic substances derived from heterocyclic nuclei containing but one nitrogen atom in any nucleus. The great majority, and those best known, are of much simpler molecular structure, and are monamins, diamins, guanidins, hydramins, betaïns, or amido-acids. It will be observed, therefore, that the designation "ptomaïn" applies, not to the individuals of a distinct class of chemical compounds, but rather to the bacterial origin of members of several different chemical functions, which may also be produced by synthetic methods, having in common only the two qualities that they contain nitrogen and are basic. Strict regard for the derivation of the name would limit its applicability to ptomaïns produced by saprophytic bacteria, either outside of the living body or within it, as in intestinal putrefaction or in gangrene; but it is now applied also to the basic products of parasitic bacteria, the "toxins" of Brieger.

Some of the ptomaïns, as the diamins and the lower terms of the monamin series, are either non-poisonous or poisonous only in very large doses. Others, and notably those formed by pathogenic bacteria, are actively poisonous. When it had been found that pathogenic bacteria produced in culture media and in the living body definite basic substances, such as Brieger's tetanin, which, when injected into animals, produced symptoms similar to those caused by the bacteria themselves, it was inferred that the manifestations of the disease were caused by these ptomaïns. It has been shown, however, that the basic substances obtained from cultures of the tetanus bacilli, for example, are vastly inferior in toxic potency to the bacteria-free cultures themselves. The inference is plain that the bacteria produce other substances more actively toxic than the ptomaïns, and it is now considered as proven that the basic bacterial products play but a secondary part in the production of the manifestations of disease caused by bacteria, while these other substances, the "toxins," concerning whose chemistry but little is known, beyond the facts that they are non-basic, and that some are possibly proteins, while others are certainly not, are the essential bacterial poisons.

While the toxins are in all probability synthetic products, the ptomaïns are undoubtedly decomposition products derived from the proteins or from complex phosphorus-containing organic substances, either by simple cleavage or by hydrolysis, and many of them are thus produced from the parent substances by agencies other than bacterial life. Cholin is thus produced from the lecithins by hydrolysis by barium hydroxid; the amido acids and indole and skatole are similarly formed from the proteins; the pyridin bases are found in oil of Dippel, produced by the dry distillation of bones; and arginin, the most abundant of the hexon bases, formed by the action of hydrochloric acid and tin chlorid upon the proteins, yields putrescin on further decomposition.

As the process of putrefaction is a gradual and progressive one, different basic products are produced at different stages, and bases obtainable in considerable amount during the first days of putrefaction will have more or less completely disappeared at a later stage, when other bases, not previously present, will have made their appearance. The nature of the bases (as well as of other products) produced varies also with those conditions which modify the progress and nature of putrefactive changes, viz.: (1) The kind of bacteria, particularly whether aërobic or anaërobic, and, consequently, the access or non-access of air; (2) the nature of the protein undergoing decomposition; (3) the temperature; (4) the degree of moisture. It is also probable that in cadaveric putrefaction the nature of the ptomaïns produced is influenced by the results of the simultaneous changes which the carbohydrate and fatty constituents undergo; as, for example, in the formation of adipocere.

As the ptomaïns represent several different classes of chemical compounds, no general characters other than those above indicated can be ascribed to them. Nor can it be expected that they should exhibit any qualities or reactions which could serve to distinguish them as a class from other compounds.

Although the chemical constitution of many of the ptomaïns remains to be determined, that of quite a number has been established, sufficient to warrant their classification, so far as possible, according to chemical function. Such a classification is here attempted.

MONAMINS.—*Methylamin*, $CH_3.NH_2$, and *dimethylamin*, $(CH_3)_2:NH$, gases, and *trimethylamin* $(CH_3)_3:\,:N$, a liquid, boiling point 9°, have long been known to exist in herring brine, and together constitute the greater part of the commercial "trimethylamin," prepared by distillation of beet sugar vinasse. They are also formed during the decomposition of fish and of a number of other animal and vegetable substances. Trimethylamin occurs naturally in, or is easily liberated from, cod-liver oil, ergot, chenopodium, yeast, guano, human urine, the blood of the calf, and many flowers. It probably originates from the decomposition of cholin (see below), from which it may be obtained, along with glycol, by the action of caustic potash: $CH_2OH.CH_2N:\,:(OH)(CH_3)_3 = CH_2OH.CH_2OH + N(CH_3)_3$. All three of these bases have the odor of stale fish, are very soluble in water, forming strongly alkaline solutions of hydroxids, and soluble, deliquescent hydrochlorids. Each forms a platinochlorid, easily soluble in hot but sparingly soluble in cold water, and a readily soluble aurochlorid. They are practically non-poisonous.

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Ethylamin, $C_2H_5.NH_2$, *diethylamin* $(C_2H_5)_2$: NH, and *triethylamin* $(C_2H_5)_3N$, are strongly alkaline, oily liquids, boiling points, 18°, 56°, 89°, which accompany the methylamins in herring pickle, beet-sugar vinasse, and the products of putrid fish, yeast, and gluten. Their hydrochlorids and platinochlorids are easily soluble in water. They are practically non-poisonous.

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Propylamin, probably the iso-compound $(CH_3)_2:CH.NH_2$, boiling point 32°, *butylamin* (iso?), $(CH_3)_2:CH.CH_2.NH_2$, boiling point 68°, *iso-amylamin*, $(CH_3)_2:CH.CH_2.CH_2.NH_2$, boiling point 95°, and a *hexylamin* $(CH_3)_2:CH.(CH_2)_3.NH_2$, are colorless, strongly alkaline liquids occurring in cod-liver oil, beet-sugar vinasse, and decomposing yeast. The amyl compound is actively poisonous.

Nencki's base, $C_8H_{11}N$, obtained from a mixture of pancreas and gelatin after five days' putrefaction at 40°, seems to have been β-phenyl-ethylamin, $C_6H_5.CH_2.CH_2.NH_2$, boiling point 197°. The free base is oily, has a peculiar, not disagreeable odor, absorbs carbon dioxid from the air to form a crystalline carbonate, and forms a sparingly soluble platinochlorid, crystallizing in long flat prisms. Its aurochlorid is a yellow oil, which is rapidly decomposed by reduction. A base, probably identical with this, is formed by decomposition of β-phenyl-α-amido propionic acid, or phenyl alanin, $C_6H_5.CH_2.CH(NH_2).COOH$, itself a product of putrefaction (see below).

Mydin, $C_8H_{11}NO$, is a base obtained by Brieger from human cadaveric matter which had been in putrefaction four months at a temperature from + 5° to − 9° in closed vessels. The free base is strongly alkaline, has an ammoniacal odor, and is a strong reducing agent, and therefore forms no stable aurochlorid. Its platinochlorid is very soluble. This base is believed to be β-oxyphenylethylamin, $HO.C_6H_4.CH_2.CH_2.NH_2$, derived from the decomposition of tyrosin, which is p-oxyphenyl-alanin, $HO.C_6H_4.CH_2.CH(NH_2).COOH$, by loss of CO_2.

Diamins.—*Tetramethylenediamin*, $H_2N.CH_2.CH_2.CH_2.CH_2.NH_2$; *putrescin*—is one of several diamins which were found by Brieger to be products of putrefaction. It is formed, along with penta- and hexamethylenediamin, during the putrefaction of fish, muscular tissue, gelatin, and other animal tissues, appearing about the third day and increasing in quantity for two to three weeks. It is found in the urine and fæces in cystinuria, in amounts proportionate to the quantity of cystin eliminated (diaminuria), and also in cholera stools. Putrescin has been shown to be a diamin, and to be identical with the tetramethylenediamin synthetically prepared by Ladenburg's method, although with methyl iodid it yields only a tetramethylated derivative, but no hexamethylated derivative. The origin of putrescin from the proteins occurs through the hexon base arginin (δ-guanidin-α-amido valerianic acid: $HN:(NH_2):C.NH.CH_2.CH_2.CH_2.CH(NH_2).COOH$, which is formed from the proteins by tryptic digestion. Arginin is split by hydrolysis into urea and ornithin (δ-α-diamido valerianic acid), and ornithin has in turn been converted into putrescin, by loss of carbon dioxid, by bacterial action: $CH_2(NH_2).CH_2.CH_2.CH(NH_2).COOH = H_2N.CH_2.CH_2.CH_2.CH_2.NH_2 + CO_2$. Putrescin and other diamins may be separated from most other substances by taking advantage of the formation of the insoluble dibenzoyl compounds which they form with benzoyl chlorid in presence of alkalies; a property which they share with polyatomic alcohols and aldo- and keto-alcohols. Its dibenzoyl compound crystallizes in plates or needles, difficultly soluble in alcohol, insoluble in water.

The free base is a clear, rather thin liquid, boiling point 156°–157°, having a disagreeable, seminal odor, strongly alkaline, and absorbing carbon dioxid from the air. Its hydrochlorid crystallizes in colorless needles, soluble in water, insoluble in absolute alcohol, not hygroscopic. Its platinochlorid and aurochlorid both form hexagonal plates, difficultly soluble in cold, more soluble in hot water. Its picrate crystallizes in needles, sparingly soluble in water or in cold alcohol, soluble in hot alcohol. It is practically non-poisonous.

Pentamethylenediamin, $H_2N.(CH_2)_5.NH_2$, *cadaverin*, is another diamin found by Brieger to accompany putrescin as a product of putrefaction of muscular tissue, heart, lung, liver, and other animal protein material, from the third day to four months. It also accompanies putrescin in the urine and fæces in cystinuria, and in cholera stools. It has been found in the intestinal contents in a case of intestinal fistula, and is probably a normal product of tryptic digestion, although it is not found in normal fæces. It has been shown to be identical with the normal pentamethylenediamin (formula above) prepared by Ladenburg's method. Cadaverin originates through the hexon base, lysin (probably α-ϵ-diamido caproic acid, $CH_2(NH_2).(CH_2)_3.CH(NH_2).COOH$, from which it is produced by putrefaction, as putrescin is formed from arginin. Cadaverin is a thick, transparent liquid, having a very disagreeable odor, somewhat resembling that of coniïn; boils at 175°; fumes, and absorbs carbon dioxid rapidly when exposed to air, being converted into a crystalline compound. With methyl iodid it forms a dimethylated derivative. Its hydrochlorid is crystalline, deliquescent, readily soluble in water and in dilute alcohol, but insoluble in absolute alcohol and in ether. On dry distillation it splits off hydrochloric acid and ammonium chlorid and forms piperidin: $C_5H_{14}N_2.2HCl = HCl + NH_4Cl + C_5H_{11}N$, an instance of the pyrogenic origin of a cyclic from an acyclic compound, of an alkaloid from an amin. Its platinochlorid forms needles or short rhombic prisms, soluble in alcohol, difficultly soluble in water. Its aurochlorid crystallizes in cubes, needles, or plates, easily soluble in water. Its picrate forms plates, soluble in hot water, sparingly soluble in cold water or in alcohol. Its dibenzoyl compound crystallizes in needles, soluble in alcohol, insoluble in water. With potassium chromate and sulfuric acid it gives a reddish-brown, evanescent precipitate. It is practically non-poisonous.

Neuridin, $H_2N.(C_5H_{10}).NH_2$, another of Brieger's diamins, is isomeric with cadaverin, but of unknown constitution. When heated with caustic potash it yields dimethylamin and trimethylamin, a decomposition which shows it to be not identical with amylamin, with which it is also isomeric. Indeed, there are twelve possible isomeres of this amin. Neuridin is produced, along with cholin, during the first stages of putrefaction, particularly of gelatinoid substances, and increases in quantity as putrefaction advances, while the quantity of cholin diminishes. It is no longer present after fourteen days. The free base is gelatinous, and decomposes even during evaporation of its solution. It has a disagreeable, spermatic odor, and is insoluble in absolute alcohol and in ether, difficultly soluble in amylic alcohol, readily soluble in water. It forms white precipitates with mercuric chlorid and with neutral and basic lead acetate. Its hydrochlorid crystallizes in long needles, and is very soluble in water, insoluble in alcohol, ether, chloroform, petroleum-ether, benzene, or amylic alcohol, except in presence of other animal substances, when it dissolves in the immiscible solvents mentioned. Its platinochlorid forms flat needles, soluble in water, insoluble in alcohol. Its aurochlorid crystallizes in short needles, difficultly soluble in cold water. Its picrate forms needles, almost insoluble in water, sparingly soluble in alcohol. When pure it is non-poisonous.

Saprin is another diamin, formed along with putrescin, cadaverin, and mydaleïn, during the putrefaction of glandular tissues. Brieger assigned to it the formula $C_5H_{16}N_2$, but it is now believed to be isomeric with cadaverin and neuridin, $C_5H_{14}N_2$. It is distinguished from cadaverin by the greater solubility and different crystalline form of its platinochlorid, by the absence of an aurochlorid, by the permanence of its hydrochlorid in air, and by its failure to give the reaction with potassium chromate and sulfuric acid. It is non-poisonous.

Hexamethylenediamin, $H_2N.(CH_2)_6.NH_2$, is formed during putrefaction of muscular tissue and pancreas. It

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is a crystalline solid, fusing at 40° and boiling at 195°. Its platinochlorid forms rhombic needles, soluble in water, sparingly soluble in alcohol.

Brieger's base, $C_2H_8N_2$, isomeric but not identical with ethylenediamin, $H_2N.(CH_2)_2.NH_2$, and supposed to be *ethylidenediamin*, $CH_3.CH(NH_2)_2$, was obtained from putrefying fish. Its hydrochlorid crystallizes in long, brilliant needles, easily soluble in water, insoluble in absolute alcohol. It does not form an aurochlorid. Its platinochlorid crystallizes in small scales, sparingly soluble in water. This base, administered hypodermically in small quantity to mice and guinea-pigs, produces in a short time increased secretion of the nasal mucus, saliva, and tears, which are subsequently temporarily arrested, to begin again later. The pupils are dilated and the globes protruded. There is marked dyspnœa, which continues until the death of the animal, within twenty-four hours.

Another base was obtained by Brieger in very small quantity from cultures of the comma bacillus, which may possibly be *trimethylenediamin*, $H_2N.(CH_2)_3.NH_2$.

Mydalein was obtained by Brieger in small quantity after seven days' exposure to air of putrefying viscera, and increased in amount up to three weeks. The amount obtained was insufficient to determine its composition further than that its platinochlorid contained Pt 38.74, C 10.83, H 3.23 per cent., from which the inference is drawn that it is a diamin, probably containing four or five carbon atoms. Its hydrochlorid crystallizes with great difficulty, and is very hygroscopic. Its platinochlorid forms needles, very soluble in water.

This base is actively poisonous. In small doses in rabbits and guinea-pigs it causes greatly increased nasal and lachrymal secretion, dilatation and insensibility of the pupils, increased body temperature, acceleration of respiration and cardiac action, a tendency to sleep, and increased peristalsis. With larger doses (less than 0.005 gm.) the increased secretions become very profuse, the pupils are widely dilated, and the eyes protruded. The animal falls, the posterior extremities being first paralyzed, then the anterior, and there occur fibrillar spasms of various groups of muscles. Sometimes the animal springs up and immediately falls, making faint movements of the legs. The respiration, at first very frequent, becomes slow and labored. The body temperature diminishes gradually, the movements become more and more faint, and the animal dies in a condition of sopor. The heart is arrested in diastole, and the intestines and bladder are found contracted after death.

Spermin, $C_2H_5N(?)$, a base of uncertain composition, but probably an imin, has been obtained from semen, testicles, ovaries, thyroid, pancreas, and spleen, and from cultures of the comma bacillus. Its phosphate forms crystals, known as Leyden, Böttcher's, or Charcot's crystals, which are met with in anatomical preparations preserved in alcohol, in dried semen, in sputa and nasal secretions, in the blood, spleen, and other organs of leucocythæmics and anæmics, and in fæces. These crystals are insoluble in alcohol, ether, or chloroform, difficultly soluble in water, easily soluble in dilute acids or alkalies. The free base forms crystals, which rapidly absorb carbon dioxid from the air, are readily soluble in water and in alcohol, insoluble in ether, and strongly alkaline in reaction. Its hydrochlorid crystallizes in hexagonal prisms, very soluble in water, insoluble in absolute alcohol or ether. Its platinochlorid crystallizes in plates, its aurochlorid in prisms. It is non-poisonous.

TRIAMINS.—Guanidin or carbotriamin, $HN:C:(NH_2)_2$, is formed by oxidation of guanin, but is not a ptomaïn. Its methyl derivative, *Methyl-guanidin* or *methyl-uramin*, $HN:C:(NH_2)(NH.CH_3)$, which is a product of oxidation of creatin and of creatinin, was obtained by Brieger from horseflesh which had undergone putrefaction at a low temperature and without exposure to air for four months, and it has since been obtained from the cultures of several species of bacilli. It is undoubtedly derived from creatin, to which it is closely related. It is a colorless, imperfectly crystalline, highly hygroscopic and strongly alkaline base. Its hydrochlorid crystallizes in prisms, insoluble in alcohol. Its platinochlorid forms very soluble needles. Its aurochlorid crystallizes in short rhombic prisms, soluble in ether, sparingly soluble in water and in alcohol. Its picrate crystallizes in needles, sparingly soluble in water, which fuse at 192°.

In guinea-pigs methylguanidin causes copious diarrhœa and increased secretion of urine. The pupils are dilated and insensible to light. The animal remains in one position, even when irritated, but soon becomes restless and seeks to move the anterior extremities, while the posterior are paralyzed. The respiration becomes progressively deeper and more labored, and there is marked dyspnœa. The legs become paralyzed, and the animal falls on its side and dies, after short, general clonic convulsions. After death the heart is found in diastole the intestine filled with fluid, the bladder contracted, the cortical portion of the kidneys hyperæmic, and the papillary portion pale.

HYDRAMINS (*Oxyamins*).—These are derivatives of the dihydric alcohols, retaining one hydroxyl, and containing one amido group, more or less modified by substitution. The ptomaïns of this class are trimethylated quarternary ammonium hydroxids.

Cholin, $(CH_2OH).CH_2.N::(CH_3)_3(OH)$, *trimethyloxethylammonium hydroxid*, was originally obtained by Strecker from ox bile in 1849, and was subsequently shown by Diakonow to be derived from the lecithins, which, when hydrolyzed, yield cholin, phosphoglyceric acid, and fatty acids. It is now known to be very widely distributed in both animal and vegetable organisms, and it is one of the first of the ptomaïns to be produced by a number of bacteria, having its origin undoubtedly in the decomposition of the lecithins, which occur in almost all animal tissues, and are very prone to decomposition. As putrefaction advances, cholin gradually disappears, partly by conversion into neurin, or possibly into muscarin, and partly by more complete decomposition, with formation of trimethylamin, until after seven days it is no longer present. Cholin is a syrupy, highly alkaline liquid soluble in all proportions in water, which absorbs carbon dioxid rapidly from air, with formation of a crystalline carbonate. Its chlorid forms highly deliquescent needles, very soluble in water and in alcohol, insoluble in ether, chloroform, or benzene. Its platinochlorid crystallizes in prisms or in plates, readily soluble in water, insoluble in alcohol or ether. Its aurochlorid crystallizes in prisms, soluble in hot water or in alcohol, almost insoluble in cold water. Its picrate forms needles, soluble in water and in alcohol. It is not poisonous except in large doses, when it produces effects similar to those of muscarin.

Neurin, $CH_2:CH.N::(CH_3)_3(OH)$, *trimethylvinylammonium hydroxid*, an unsaturated compound, differing from cholin by H_2O less, was obtained by Liebreich from protagon, and has been obtained from brain tissue and suprarenal capsule, and by the action of boiling baryta water upon cholin. It was found by Brieger, along with neuridin, in the products of putrefaction of horseflesh for five or six days at the temperature of incubation. It may originate by dehydration of cholin or by decomposition of lecithins, in whose constitution it replaces cholin, the existence of which is probable. The free base is a syrupy, highly alkaline liquid, soluble in water in all proportions, and decomposed by boiling of its aqueous solution, with liberation of trimethylamin. Its chlorid crystallizes in needles, hygroscopic, and very soluble in water and in alcohol. Its platinochlorid forms octahedra, almost insoluble in water. Its aurochlorid crystallizes in prisms, difficultly soluble in water. Its picrate forms long needles, sparingly soluble in water and in alcohol.

It is actively poisonous, producing effects resembling those of muscarin. When administered to rabbits it causes movements of mastication, accompanied by profuse secretion of saliva, which is at first thick and viscid, then thin and alkaline. The increased secretion of saliva continues until the terminaton of the poisoning, and varies

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in degree with the magnitude of the dose. Subsequently there is increased secretion from the Schneiderian mucous membrane and the lachrymal glands, the latter of short duration. The respiratory movements are at first more frequent and deeper than normal; the extraordinary respiratory muscles are brought into action, the head is thrown back, and the nostrils are dilated. These symptoms of dyspnœa alter in character as death approaches, in that the movements become irregular, superficial, and less frequent. The heart's action immediately after the injection is accelerated, so that the pulse cannot be counted; in a short time it becomes slower, and diminishes constantly in frequency. The pulsations are at first very strong, but subsequently become progressively weaker until the heart is arrested in complete diastole. The heart's action continues after cessation of respiration. Section of the vagi has no influence, and the heart responds to artificial stimuli. Occasionally contraction of the pupils occurs, an effect which almost always follows an application of a strong solution of the poison to the eye. Powerful peristalsis is an early symptom, causing an uninterrupted voiding of matters, at first consistent, subsequently watery. Ejaculation and dripping of urine also occur. If the abdomen be opened at this stage, tetanic contractions of greater or lesser portions of the intestine are seen. The spleen is also strongly contracted. Only when lethal doses are given do strong clonic convulsions occur, in which the animal soon dies. These convulsions are partially controlled by artificial respiration, but they soon recur. Locomotion is interfered with, the posterior extremities being first paralyzed, then the anterior, before the beginning of the convulsions. In cats there is an increased secretion of alkaline perspiration. Atropin is a powerful antidote; but atropinized animals are still subject to the action of the poison. When taken by the mouth this alkaloid produces the same effects as when administered hypodermically, but ten times the dose is required.

Muscarin (?), $C_5H_{15}NO_3$, a base having the above composition, and corresponding in physiological action to the muscarin which occurs in toadstools (agaricus, boletus, amanita), was obtained by Brieger from putrefying fish. It forms a deliquescent, difficultly crystallizable chlorid; a platinochlorid which crystallizes in sparingly soluble octahedra; and an aurochlorid which forms needles, also difficultly soluble in water. It is not certain that this base is identical with the muscarin of fungi, or that either is identical with the "synthetic muscarin" obtained by oxidation of cholin. The last named undoubtedly has the constitution sometimes assigned to oxycholin, and expressed by the formula $CH_2OH.CHOH.N::(CH_3)_3(OH)$, from its derivation from cholin: $CH_2OH.CH_2.N::(CH_3)_3(OH)$.

Brieger's ptomaïn, administered in very small quantities to frogs, causes total paralysis, and arrest of the heart in diastole. The administration of atropin to frogs under the influence of this base revives the action of the heart, and the effects of the ptomaïn are not observed in atropinized animals. Minute doses, administered to rabbits, cause greatly increased salivary and lachrymal secretions, contraction of the pupils, profuse diarrhœa, ejaculation, voiding of urine, and death after convulsions of short duration.

BETAÏNS.—These compounds, closely related to the hydramins, are anhydrids, or, more properly, lactams, derived from acids corresponding to the hydramins, such as $(COOH).CH_2.N::(CH_3)_3(OH)$ (see cholin), by elimination of H from COOH and OH from the ammonium hydroxid group. Thus:

Betaïn or *trimethylacetic betaïn*— $\begin{array}{l} COO \\ | \quad \diagdown \\ CH_2.N:.(CH_3)_3 \end{array}$, is ranked as a ptomaïn because of its occurrence in fresh poisonous muscles (which undoubtedly owe their toxicity to bacterial action) and among the products of putrefying gluten. It was first obtained from beet root (whence its name), and also exists in malt, in cotton seed, and in a number of other vegetables; and is formed by several synthetic methods, as by the interaction of monochloracetic acid and trimethylamin.

It forms large, deliquescent crystals, with one molecule of water of crystallization, very soluble in water and alcohol. It is strongly basic and forms crystalline salts. Heat decomposes it, with evolution of trimethylamin. Its chlorid forms non-deliquescent plates, insoluble in absolute alcohol. Its platinochlorid forms soluble prisms; and its aurochlorid sparingly soluble plates or needles. It is non-poisonous.

Mydatoxin, $C_6H_{13}NO_2$, which may be *trimethylpropionic betaïn*, $\begin{array}{l} COO \\ | \qquad \diagdown \\ CH_2.CH_2.N:.(CH_3)_3 \end{array}$, or the corresponding iso-compound, was obtained by Brieger from decomposing horse-flesh under the same conditions as mydin. The free base is a strongly alkaline syrup, which crystallizes *in vacuo*, insoluble in alcohol and ether, decomposed by distillation. Its chlorid is a thin, colorless syrup, which forms no double salt with auric chlorid, and with platinic chlorid a very soluble double salt which fuses and is decomposed at 193°.

Mydatoxin is not very actively poisonous. Administered subcutaneously to guinea-pigs, the chlorid of this base causes increase in the frequency of the respiration; at first contraction, and later dilatation and insensibility, of the pupils; and diminution of temperature with short chills. Clonic convulsions, frequently of such intensity that the animal is involuntarily projected forward, recur at short intervals. The secretions of the salivary and lachrymal glands become more abundant. The body temperature falls, and the respiration becomes less frequent. The ears, at first injected, become pale and cold. The extremities are paralyzed. The cardiac action becomes irregular and less frequent. Convulsions are provoked by striking upon the table supporting the animal. Shortly before death the convulsions become less strong, the extremities are extended, the animal falls upon its side and dies. After death the heart is found arrested in diastole, the intestines are strongly contracted, and the bladder is empty and contracted.

Mytilitoxin $C_6H_{15}NO_2$, a base of undetermined constitution but also possibly a betaïn, was obtained by Brieger from the poisonous mussels which caused the poisonings at Wilhelmshaven. The free base has a disagreeable odor which it loses on exposure to air and at the same time becomes non-poisonous. It is decomposed by heating with caustic potash. Its chlorid crystallizes in tetrahedra and is intensely poisonous, causing the same symptoms as do the mussels (see Vol. IV., p. 189). The aurochlorid crystallizes in microscopic cubes which fuse at 182°.

AMIDO ACIDS.—The amido acids, formed by substitution of one or more amido groups (NH_2) for hydrogen in the hydrocarbon groups of other acids, are not usually considered as ptomaïns, probably because they were known as products of the decomposition of proteins, by putrefaction or otherwise, long before Selmi suggested the name "ptomaïn" for substances which he considered to be alkaloidal. Thus tyrosin was found to be a product of decomposition of casein by Liebig in 1846; and Proust discovered leucin as a product of putrefaction of gluten and of cheese in 1819. But these bodies contain nitrogen, and although they are acids by virtue of their carboxyl groups (COOH), they are also distinctly basic, by virtue of their amido groups. They therefore come within the limitations of the class of ptomaïns as given above. Among the diamido acids are included substances, such as lysin and ornithin, and among their guanidin derivatives substances, such as arginin and probably histidin, which, although not ptomaïns, so far as is known, are products of the earlier steps in the decomposition of the proteins, and intermediate in the generation of some, at least, of the ptomaïns.

The amido acids of the acetic series may be obtained synthetically, either by the action of ammonia upon the monochloro derivatives of the acids, or by the action of nascent hydrogen upon the cyano derivatives, as well as

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by other methods. Thus glycocoll, or amido-acetic acid, may be derived from monochloracetic acid: $CH_2Cl.COOH + NH_3 = CH_2(NH_2).COOH + HCl$, or from cyanoformic acid: $CN.COOH + 2H_2 = CH_2(NH_2).COOH$. They appear to be practically non poisonous.

Deltaamido-n-valerianic acid, $CH_2(NH_2).(CH_2)_3.COOH$, one of the butalanins (Salkowski's base), is the lowest term of the series which is known to be a putrid product, and is formed by decomposition of fibrin and of muscular tissue. It is a solid, fusing point 156°, very soluble in water. Its hydrochlorid crystallizes in stellate bundles, and is very soluble in water and in alcohol. Its platinochlorid is soluble in hot water, difficultly soluble in cold water and in alcohol. It is not identical with the amido-valerianic acid obtained by Gorup-Besanez from ox pancreas, or produced synthetically from monochloro-valerianic acid, as it does not form precipitates with ammoniacal silver nitrate or with cupric acetate.

Inactive-a-amido-isobutyl-acetic acid, $(CH_3)_2.CH.CH_2.CH(NH_2).COOH$, *animal leucin*, is one of the twenty-nine isomeric amido caproic acids, or leucins, whose constitution is demonstrated by its formation from isovaleric aldehyd, $(CH_3)_2:CH.CH_2.CHO$. It is produced, along with tyrosin, in the decomposition of proteins with dilute acids or alkalies, by putrefaction, and by tryptic digestion. It is found in the cultures of the bacillus of malignant œdema, and, along with tyrosin, in those of anthrax and comma bacilli, and in the products of decomposition of fibrin by streptococci. It appears to exist also as a normal constituent of the pancreas, spleen, thymus, lymphatic and salivary glands, liver, and kidneys. Pathologically the quantity of leucin is much increased in the liver in diseases of that organ, in typhus and in variola; in the bile in typhus; in the blood in leukæmia, and in yellow atrophy of the liver; in the urine in yellow atrophy of the liver, in typhus, in variola, and in phosphorus poisoning; in choleraic discharges; in pus; and in the fluids of dropsy and of atheromatous cysts. It is probable that leucin exists as a constituent factor of the proteins, and is split off during their decomposition, as is the case with the hexon bases, arginin and lysin, both of which are related to it, the former being the guanidin compound of a diamido-valerianic acid, and the latter a diamidocaproic acid

Leucin crystallizes from alcohol in pearly plates; but is more usually met with in rounded masses of closely grouped, radiating needles. It is sparingly soluble in water, almost insoluble in alcohol and ether, but readily soluble in hot water or alcohol. It is odorless and tasteless, and its solutions are neutral. It dissolves readily in acids and in alkalies, forming crystalline compounds with the former. It fuses without decomposition, and sublimes at 170°. Hydriodic acid under the influence of pressure and heat decomposes it into caproic acid and ammonia. Its hot solutions form precipitates with hot solutions of cupric acetate; and they dissolve cupric hydroxid, but do not reduce it on boiling. When heated with mercurous nitrate solution it liberates metallic mercury

Amidostearic acid, $C_{18}H_{35}(NH_2)O_2$, has been found by Schutzenberger among the products of putrefaction of muscular tissue. The amido acids, $C_{11}H_{22}N_2O_6$ and $C_9H_{20}N_2O_4$, obtained by the same experimenter, are probably mixtures. The former, on decomposition by caustic potash, yields, besides ammonia, potassium carbonate, valerate and butyrate, while the latter under like treatment yields caproate, caprylate, and acetate.

Schutzenberger has also described a class of substances to which he has given the name "leuceins," differing from the leucins by containing two hydrogen atoms less, possibly amidoacrylic acids. Of these he found butyric leucein, $C_4H_5(NH_2)O_2$, and valeric leucein, $C_5H_7(NH_2)O_2$ among the products of putrefaction of muscular tissue.

Aspartic acid, or amidosuccinic acid, $COOH.CH(NH_2).CH_2.COOH$, and glutamic acid, or amidoglutaric acid, $COOH.CH(NH_2).CH_2.CH_2.COOH$, although known as products of decomposition of proteins by the action of acids and in tryptic digestion, have not been found to be products of putrefaction. Schutzenberger obtained an amido acid having the formula $C_9H_{15}NO_4$, which yielded an isomere of allylamin, $C_7H_{15}N$, on decomposition, from putrefying muscular tissue, and Guareschi obtained a base, $C_{14}H_{20}N_2O_4$, from putrid fibrin. These two bases appear to be amido derivatives of dicarboxylic acids, although they are not homologues of the aspartic series.

Tyrosin, or *p-oxyphenylalanin* $(HO)_{(4)}C_6H_4.CH_2.CH(NH_2).COOH$, is one of the earliest known products of decomposition of the proteins, and is formed from them by the action of proteolytic enzymes, by putrefaction, and by the action of acids or of alkalies, always accompanied by leucin. It also exists normally in the intestinal contents, and pathologically in the urine. It has been obtained synthetically from phenyl-acetaldehyde, $C_6H_5.CH_2.CHO$. It crystallizes in silky needles, arranged in stellate bundles, difficultly soluble in cold water, soluble in 150 parts of hot water, insoluble in alcohol or in ether, rather soluble in the presence of acids or of alkalies. It is not poisonous. Tyrosin is a phenolic derivative of *β-phenyl-a-amidopropionic acid*, $C_6H_5.CH_2.CH(NH_2)COOH$, or *phenylalanin*, which is also a product of putrefaction.

ALKALOIDS.—There are nine ptomaïns known which may, with more or less reason, be called alkaloids. Of these seven are pyridin or dihydropyridin derivatives, related to the bases which occur in bone oil. The other two are benzopyrrole derivatives.

De Coninck's base, $C_8H_{11}N$, (*a collidin?*) was obtained, along with the base $C_{10}H_{15}N$, from putrid jelly-fish after one to two weeks. It is a yellowish, mobile liquid, having an acrid odor, very sparingly soluble in water, soluble in ethylic and methylic alcohols, ether and acetone. Spec. grav. 0.9865. Boils without decomposition at 202°. Turns brown, and absorbs water rapidly from air, but dose not appear to absorb carbon dioxid. Its hydrochlorid forms a fine, yellowish, crystalline, deliquescent mass, very soluble in water. Its platinochlorid is an orange-colored powder, almost insoluble in cold water, soluble in hot water, and is moderately stable. It forms a modified platinochlorid $(C_8H_{11}N)PtCl_4$, with boiling water. Its aurochlorid is a yellow precipitate, permanent in the cold. It forms two crystalline mercurochlorids. Its iodomethylate crystallizes in needles, and is colored red by caustic potash. When oxidized by potassium permanganate it yields nicotinic, or β-picolinic acid, also formed by oxidation of β-picolin, which by distillation with lime yields pyridin (C_5H_5N). This base is isomeric with Nencki's base, β-phenyl-ethylamin (see above), and appears to be one of the twenty-two possible collidins, the third superior homologues of pyridin. It is not α-propylpyridin, or conyrin, a product of the action of zinc chlorid and heat upon coniïn, which boils at 165°–166°, but is said to be either β-propyl- or β-isopropylpyridin. If it be the former, $C_5H_4N(C_3H_7)_{(3)}$, it is that ptomaïn which most nearly approaches the constitution of the most simply constituted of the vegetable alkaloids, coniïn, which is α propylpiperidin, $C_5H_{10}N(C_3H_7)_{(1)}$.

Gautier and Étard's base, $C_9H_{13}N$, (*a parvolin?*) was found, along with the base $C_8H_{13}N$, among the products of the prolonged putrefaction of fish and of horseflesh. It is an amber-colored liquid, having the odor of hawthorn, sparingly soluble in water, turning brown and resinous in air, and boiling above 210°, at which temperature it also decomposes into ammonia and a substance having a phenolic odor. Its platinochlorid is crystalline, flesh colored, sparingly soluble in water, and decomposed by light. Its aurochlorid is rather soluble in water. Whether or not this base is one of the fifty-seven possible parvolins of which five only are at present known, remains to be determined.

Guareschi and Mosso's base, $C_{10}H_{15}N$, (*a coridin?*) was obtained from fibrin after five months' putrefaction. It is a brownish oil with a faint odor of pyridin and of coniïn, sparingly soluble in water, strongly alkaline, and resinifies rapidly in air. Its hydrochlorid crystallizes in thin, colorless plates, slightly deliquescent, resembling cholesterin. Its platinochlorid is flesh-colored, crystal-

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line, insoluble in water, alcohol, or ether, not decomposed at 100°, and does not resinify. The same base was also extracted from fibrin after eight to nine months' putrefaction. The quantity of hydrogen obtained in all analyses of this base caused the authors to doubt whether its formula should not be $C_{10}H_{13}N$, in place of $C_{10}H_{15}N$, which would make it an isomere of tetrahydromethylquinolin. On dry distillation the base yields ammonia and a liquid boiling at 200°, which had a composition neighboring to that of Gautier's hydrocollidin. Gautier and other chemists called this base corindin, or better, coridin, a name already given by Thenius to the base $C_{10}H_{15}N$ which he extracted from coal tar. It is not demonstrated that this base is identical with Thenius' base, which boils at 211°, spec. grav. 0.950; whose platinochlorid is dark orange, sparingly soluble in water, alcohol, and ether; and whose aurochlorid is dark yellow. Guareschi and Mosso's base has a poisonous action resembling that of curare, but much less intense.

De Coninck obtained from jelly-fish, after one to two weeks' putrefaction, a base having the same composition as the above, which forms yellowish needles, which becomes viscid and resinous in air, has an odor which is not disagreeable, spec. grav. 1.18, boiling at 230°, sparingly soluble in water, soluble in alcohol, ether, and acetone. Its hydrochlorid crystallizes in yellowish, very deliquescent needles. Its platinochlorid forms a reddish powder, insoluble in water, but forming a modified platinochlorid $(C_{10}H_{15}N)\ PtCl_4$, which fuses at 206°. Gautier considers this as identical with Guareschi and Mosso's base. It does not seem, however, to be identical either with that or with Thenius' base. It is probable that each of the three is one of the one hundred and five possible coridins. The formation of the modified platinochlorid is strong evidence that de Coninck's base is a pyridin homologue.

Gautier and Mourgues' base, $C_7H_{11}N$, (*a dihydrolutidin?*) constitutes about one-ninth of the bases obtained by them from brown cod-liver oil. It is a colorless liquid, oily, alkaline, not disagreeable in odor, absorbs carbon dioxid from the air, lighter than water, boiling point 199°, and sparingly soluble in water. Its hydrochlorid crystallizes in flat needles, bitter in taste. Its nitrate reduces silver nitrate. Its platinochlorid forms a silky, yellow precipitate, and yields the modified platinochlorid $(C_7H_{11}N)\ PtCl_4$, when boiled with water. Its aurochlorid crystallizes in needles or in lozenges. The base unites with methyl iodid, forming a colorless iodomethylate, $C_7H_{11}N.CH_3I$, soluble in water and in ether, and having a disagreeable, nauseous odor. Caustic potash separates from it a colorless, highly alkaline oil, which is said to be dihydromethyllutidin. When oxidized by potassium permanganate in boiling solution it gives off an agreeable odor of coumarin, and, on continuing the heating at 100° in sealed tubes, a methyl-carbopyridic acid, $C_5H_3(CH_3)N.COOH$, is obtained. That this base is a hydropyridic compound is shown by the action with silver nitrate, the formation of the modified platinochlorid, and the composition of the iodomethylate. The formation of the methylcarbopyridic acid shows that it is not one of the three ethyldihydro derivatives, but one of the six dimethyl compounds.

It is very poisonous. In small doses it diminishes the general sensibility. In larger doses it causes localized tremors, particularly in the head, deep depression, with periods of extreme excitement, paralysis, beginning with the posterior extremities, and death.

Gautier and Etard's base, $C_8H_{13}N$, (*a dihydrocollidin?*) was obtained from the products of the prolonged putrefaction of fish. It is an oily liquid, having a tenacious odor of lilac, spec. grav. 1.0296, boiling point about 210°. In air it absorbs carbon dioxid, and resinifies rapidly. It has an energetic reducing action. Its hydrochlorid crystallizes in needles, soluble in water and in alcohol. Its platinochlorid is flesh-colored, sparingly soluble, and is decomposed by light or heat. Its aurochlorid is soluble and reduces easily. It was supposed by Gautier and Etard to be identical with the dihydrocollidin obtained by Cahours and Etard by the action of selenium upon nicotin, but as that base boils at 205°, and is lighter than water, it is more probably an isomere. It is actively poisonous. Even in small doses it causes vomiting, staggering, tetanic spasms, followed by paralysis and death, with the heart in diastole.

The existence of the base $C_{10}H_{17}N$, described by Griffiths, requires confirmation. The composition is that of the dihydrocoridins.

Morrhuic acid, $C_9H_{13}NO_3$, was obtained by Gautier and Mourgues, along with the bases elsewhere referred to, from brown cod-liver oil. It is oily or resinous, but crystallizes in flat prisms, or lozenges on standing. It has an odor resembling that of seaweed. It is both acid and base, and decomposes the carbonates. It forms no precipitate with cupric acetate, even on boiling. Distilled with lime, it yields an oily, alkaline base, which forms an iodomethylate with methyl iodid. It is a pyridin derivative, and is supposed by Gautier and Mourgues to be a monocarboxylic oxyacid, $C_5H_5N(OH)(C_3H_6.COOH)$, derivable from a dihydropropylpyridin. It is said to yield a monobasic acid on oxidation, but it is such itself.

Indole, C_8H_7N, is benzopyrrole, theoretically formed by fusion of a pyrrole ring, C_4H_5N, upon a benzene ring, C_6H_6, with loss of C_2H_4, the nitrogen atom occupying a position vicinal to the benzene ring. It is one of the products of putrefaction of the proteins by anaërobic bacteria, occurs in the cultures of the comma bacillus and of that of tetanus, and is formed in the intestine. When produced by intestinal putrefaction it is partly discharged in the fæces, and is in part reabsorbed, appearing in the urine in combination with sulfuric and glucuronic acids as the so-called urinary indican. It crystallizes in large, shining, colorless plates, having the disagreeable odor of naphthylamin, sparingly soluble in water, soluble in alcohol and in ether, fuses at 52° and distils with vapor of water. It is weak base, and its salts are decomposed by boiling water. Its aqueous solution, acidulated with hydrochloric acid, is colored rose-red by potassium nitrite. By fusion with caustic potash it yields anilin. Its alcoholic solution, acidulated with hydrochloric acid, colors a pine shaving red. With picric acid it forms a compound crystallizing in red needles. With sodium nitroprussid and alkali it produces a red-violet color, which changes to blue with acetic acid (Legal).

Skatole, C_9H_9N, is β-methyl-indole. It accompanies indole in the intestinal contents and in fæces, in which it is the more abundant of the two, and is also formed during putrefaction of the proteins, or by the action upon them of caustic potash in fusion. It crystallizes in brilliant plates, fusing point 95°, insoluble in cold water, less soluble than indole in boiling water, soluble in alcohol and in ether, has a strong fæcal odor. Its solution in concentrated hydrochloric acid is violet. Its solution in sulfuric acid is colored deep purple when heated. It forms a red, crystalline compound with picric acid. It does not give the pine-shaving reaction, nor the red color with acid and nitrite, and with Legal's reaction the alkaline solution is yellow, and turns violet with acetic acid and heat. Like indole, it is in part reabsorbed from the intestine and eliminated with the urine in combination with sulfuric and glucuronic acids. Neither indole nor skatole has any notably toxic action.

PTOMAÏNS OF UNKNOWN CONSTITUTION.—*Morrhuin*, $C_{19}H_{27}N_3$, and *asellin*, $C_{25}H_{32}N_4$, are two of the six bases obtained by Gautier and Mourgues from brown cod-liver oil, the former constituting about one-third of the total, and the latter a small fraction. *Morrhuin* is a thick, yellowish liquid, having the odor of hawthorn and of lilac, lighter than water, in which it is sparingly soluble, strongly alkaline and caustic, and absorbs carbon dioxid from air. Its hydrochlorid is very deliquescent. Its platinochlorid crystallizes in needles, soluble in water, and is decomposed by heat. Its aurochlorid is soluble in water. It is non-poisonous, but is an active diuretic. *Asellin* is an amorphous, white solid, odorless in the cold, but fusing and giving off an aromatic odor when heated. It is almost insoluble in water, soluble in alcohol and in ether, alkaline, and bitter in taste. Its

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salts are soluble in water. Its hydrochlorid is crystalline; its platinochlorid and aurochlorid are unstable. In small doses it produces disturbances of respiration and stupor, and in larger doses convulsions and death. Possibly the former, or both, of these bases may be complex amido acids.

Scombrin, $C_{17}H_{38}N_4$ (not to be confounded with the protamin of the same name obtained from the milt of the mackerel) was obtained in very small quantity by Gautier and Etard from the mother liquors of their alkaloidal bases, above referred to. Its hydrochlorid crystallizes in needles, soluble in water, which decompose slowly at 100°, giving off an odor of lilac. Its platinochlorid crystallizes in light yellow needles, and is soluble in water.

Brieger's base, $C_6H_{13}NO_2$, isomeric with mydatoxin and with leucin, and probably a betaïn, was obtained from tetanus cultures, and is formed by decomposition of tetanin, $C_{13}H_{30}N_2O_4$. Its platinochlorid crystallizes in plates, soluble in water and in alcohol, fusing point 197°, at which temperature it decomposes.

Brieger's bases, $C_7H_{17}NO_2$. Brieger has described three bases having this composition: *Gadinin*, from putrid fish, after five days; *typhotoxin*, from cultures of the Koch-Eberth bacillus; and an unnamed base from horseflesh after prolonged putrefaction at low temperature with limited access of air.

Gadinin (not to be confounded with the brown substance of the same name obtained by De Jongh from codliver oil), obtained from the mother liquors of Brieger's "muscarin," forms a hydrochlorid which crystallizes in thick needles, soluble in water, insoluble in alcohol. Its platinochlorid crystallizes in scales, sparingly soluble in water. It forms no aurochlorid. It appears to be non-poisonous.

Typhotoxin is a strongly alkaline base. Its hydrochlorid is deliquescent. Its platinochlorid crystallizes in needles, easily soluble in water. Its aurochlorid crystallizes in prisms, difficultly soluble in water, fusing point 176°. It forms a difficultly soluble picrate. With Ehrlich's reagent (sulfodiazobenzene) it immediately gives a yellow color, which is discharged by bases. In moderate doses typhotoxin causes increased flow of saliva, and acceleration of respiration. Later there is loss of control of the muscles of the extremities, without true paralysis, the animal falling upon its side. The pupils gradually dilate widely, and become insensible. Convulsions do not occur. The frequency of the heart's action and respiration gradually diminishes. During the entire poisoning there is copious diarrhœa. After death the heart is found contracted in systole, the lungs are highly hyperæmic, the other organs pale. The intestines are strongly contracted, and their walls pale.

The unnamed base, $C_7H_{17}NO_2$, crystallizes in very deliquescent plates, and has a faintly acid reaction, but it does not form salts with bases, and does not respond with Hofmeister's reaction with ferric chlorid. It is not an amido acid. Its hydrochlorid crystallizes in needles, insoluble in absolute alcohol. Its aurochlorid crystallizes in plates or in needles, difficultly soluble in water, fusing point 176°. It does not react with Ehrlich's reaction, and forms no picrate. It has the physiological action of curare. A base having this composition has also been obtained by Baginsky and Stadthagen from cultures of a bacillus allied to the Finkler-Prior spirillum.

Tetanin, $C_{13}H_{30}N_2O_4$.—Brieger, in his earlier experiments with cultures of an anaërobic bacillus found by Nicolaier in earth samples, and capable of producing symptoms of traumatic tetanus in animals, and with cultures of the same bacillus bred by Rosenbach from the wound of a man who died with tetanus, obtained two bases with a similar physiological action—tetanin and tetanotoxin.

Tetanin is a yellow, strongly alkaline syrup, which gives no blue color with ferric chlorid and potassium ferricyanid. Its hydrochlorid is deliquescent, and forms an easily soluble, crystalline compound with phosphomolybdic acid. Its platinochlorid crystallizes from alcohol in light yellow plates, very soluble in water. The free base, or its hydrochlorid, when injected into mice or guinea-pigs, soon causes clonic or tonic convulsions of the greatest intensity, which terminate in death. The course of the poisoning is divisible into two stages: In the first the animal is depressed and lethargic, then it suddenly becomes uneasy, and the diaphragm contracts energetically. The second is marked by convulsions, usually tonic, but occasionally clonic. Death occurs frequently in a violent convulsion. Frogs withstand the action of the poison better than warm-blooded animals, but when they succumb they become perfectly rigid in a position of pronounced opisthotonos. Guinea-pigs, when thoroughly under the influence of the poison, exhibit very clearly the characteristic spasms of tetanus in the human subject and marked opisthotonos.

Tetanotoxin, $C_5H_{11}N$(?), is a volatile substance, boiling at 100°. In relatively large doses it produces in animals fibrillar contractions of diverse groups of muscles, particularly those of the neck and face. Motion is more or less interfered with, until paralysis is established. Convulsions increase in intensity, attacking groups of muscles very violently. The animal lies with the head thrown back and the extremities extended, and, when pressed upon, makes movements as in swimming. Finally the animal falls upon its side, and dies in a violent convulsion.

Two other bases have subsequently been obtained by Brieger from cultures of the tetanus bacillus, both of unknown composition.

Spasmotoxin, which forms a soluble platinochlorid, fusing point 210°, causes violent tonic and clonic convulsions in animals. The other base, unnamed, forms a very deliquescent hydrochlorid; a platinochlorid which crystallizes in scales, decomposed at 240°; and a very soluble aurochlorid and picrate. It produces complete tetanus, salivation, and lachrymation in animals.

It is not surprising that when the physiological action of these bases was first recognized they were considered to be the specific poisons produced by the bacillus of tetanus. But it has been shown that the filtered culture is vastly more active than the combined bases, and that the culture contains a non-basic, non-albuminous toxin, which, still in an impure condition, has a lethal toxicity estimated at 0.23 mgm. for the human subject. Therefore, while the bases above mentioned undoubtedly have some action in producing the manifestation of tetanus, such action is greatly subordinate to that of the toxin.

Lepierre's base, $C_{10}H_{23}N_2O_4$, obtained in small amount from poisonous cheese, is crystalline, odorless, bitter, faintly acid, and sparingly soluble in water. Its hydrochlorid crystallizes in needles, very soluble in water. Its platinochlorid and aurochlorid are crystalline. It causes diarrhœa in guinea-pigs.

Delézinier's base, $C_{32}H_{31}N$ or $C_{34}H_{33}N$ (?), whose composition is quite uncertain, is an almost colorless, oily liquid, very sparingly soluble in water, soluble in alcohol, ether, and benzene, rapidly oxidized in air, and forming deliquescent salts. It is supposed to be identical with a base obtained by Brouardel and Boutmy, which bore some resemblance to veratrin.

Susotoxin, $C_{10}H_{26}N_2$ (?), a base whose hydrochlorid was obtained by Novy from cultures of the hog-cholera bacillus. The free base was not isolated. The hydrochlorid is a light yellow syrup which does not crystallize, somewhat hygroscopic, and soluble in water and in alcohol. It gives off an amin odor when heated with fixed alkali. Its platinochlorid is granular and light flesh colored, or crystallizes in long, thick needles, soluble in water, from which it is precipitated by alcohol. It is toxic only in large doses. It is said to be identical with the *sucolotoxin* of von Schweinitz.

Pyocyanin, $C_{14}H_{14}NO_2$ (?), is the coloring matter of blue pus, first obtained by Fordos. It crystallizes in blue prisms or scales, soluble in water, alcohol, and chloroform, less soluble in ether. Its blue aqueous solution is neutral, and is changed to cherry-red by acids, and back to blue by alkalies. It is oxidized in air to the yellow *pioxanthose*, which also accompanies it in the pus. Ac-

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cording to Kunz, it contains sulfur. It is supposed to be an anthracene derivative.

Anthracin is the name given by Hoffa to a base, $C_3H_6N_2$ (?) obtained from cultures of the anthrax bacillus.

The following bases are of unknown composition:

A base obtained by Brieger from human livers and spleens after two weeks' putrefaction with free access of air. Its hydrochlorid crystallizes in small, deliquescent needles; and its platinochlorid in fine needles, containing 41.30 per cent. of platinum. It causes long-continued diarrhœa in rabbits and guinea-pigs.

Another base obtained by Brieger from the same source; fluorescent, boiling point about 284°, whose hydrochlorid crystallizes in long needles, soluble in absolute alcohol. Its platinochlorid crystallizes in fine needles, very soluble in water, or in plates, containing 30.36 per cent. Pt.

A base obtained by Brieger from putrid fish. Its hydrochlorid and platinochlorid crystallize in small needles; the latter containing 36.03 per cent. Pt and 7.81 per cent. N.

A base obtained by Bocklisch from herring after twelve days of putrefaction, whose platinochlorid crystallizes in large, thin plates, easily soluble in water, and containing 28.57 per cent. Pt.

Peptotoxin is the name given by Brieger to a toxic substance (or mixture of substances) having some of the characters of the nitrogenous bases, obtained from peptone, produced by the action of pepsin from the pig upon fresh fibrin. The same body was obtained from Witte's peptone, and from putrefying fibrin, casein, and brain, liver, and muscular tissues. If putrefaction has continued for eight days, it is no longer obtainable. It crystallizes with difficulty, passes from both acid and alkaline solutions into amylic alcohol, is insoluble in ether, benzene, or chloroform, but very soluble in water. Its solutions are neutral. It is quite stable, and is not decomposed by boiling, or by treatment with hydrogen sulfid or with caustic alkalies. With Millon's reagent it gives a white precipitate, which turns bright red on the application of heat. It precipitates with many of the general reagents for alkaloids, and gives the blue reaction with fœric chlorid and potassium ferricyanid. It is actively poisonous in small doses, causing paralysis of the posterior extremities, sopor, and death.

Phlogosin is the name given by Leber to a substance which is probably not a base, obtained from cultures of staphylococcus aureus. It crystallizes in needles, soluble in alcohol and in ether, sparingly soluble in water, and may be sublimed. It forms no compound with platinic or auric chlorid, and does not precipitate with phosphotungstic, phosphomolybdic, picric, or tannic acid. It appears to contain sulfur and no nitrogen.

Tyrotoxicon is the name given by Vaughan to a material extracted from poisonous cheese, whose chemical characters are not well defined.

The individual existence of the numerous bases described by Griffiths requires confirmation.

Nitrogenous bases are also formed during alcoholic fermentation. These are not properly ptomaïns, being produced by yeast fungi, which are not bacteria.

Morin's base, $C_7H_{10}N_2$, is the best known of these. It was obtained from the fraction of crude fusel oil, distilling at 171°–172°. It is a colorless, mobile, oily liquid, having a nauseous odor, spec. grav. 0.9826, not alkaline in reaction. Its hydrochlorid forms needles, soluble in water and in alcohol, very sparingly soluble in ether. Its platinochlorid is crystalline, soluble in water and in alcohol, very sparingly soluble in ether. It is decomposed by hot hydrochloric acid, with formation of ammonia. It combines with ethyl iodid to form a yellow, crystalline compound, very soluble in alcohol and in water, very sparingly soluble in ether. Its aqueous solution does not precipitate with Mayer's reagent, but on acidulation with hydrochloric acid there forms a flocculent, yellow precipitate, which unites into long, brilliant, yellow needles—a reaction which is not given by the pyridic or quinolinic bases. It is poisonous, and in rabbits causes stupor and paralysis, beginning with the posterior extremities, diminished sensibility, dilatation and insensibility of the pupils, diminution of the temperature and cardiac action, and death in coma. This base is probably identical with Tanret's *glucosin*, obtained by the action of ammonia and ammonium salts upon glucose.

Oser's base, $C_{13}H_{20}N_4$, is produced during the fermentation of pure saccharose by yeast. It is not volatile, and is decomposed when heated with acids. Its hydrochlorid is very hygroscopic, very unstable, and turns brown in air. Its aurochlorid is a yellow, flocculent precipitate, which becomes crystalline, and is very sparingly soluble in water.

A base, said to be pyridin, has been found in commercial alcohol by Haitinger and by Guareschi and Mosso to the amount of 0.4 to 0.5 in 1,000. Schrötter has described two bases, $C_7H_{12}N_2$ and $C_{10}H_{16}N_2$, obtained from the fraction of molasses-fusel distilling at 180–233°. Krämer and Pinner obtained bases, which they considered to be pyridic, from commercial alcohol. Other imperfectly defined bases have been described as existing in beer or in distilled spirits by Surgères, Lindet, Modermann, Lermer, von Geldern, Dannenberg, Meyer, and Fassbender and Schoepp.

Pouchet's bases, $C_5H_{12}N_2O_4$ and $C_7H_{14}N_2O_6$, cannot be regarded as ptomaïns, as they were obtained from the liquid residues of an industrial process of treatment of bones, flesh, and other animal refuse by sulfuric acid, and the action of the acid was undoubtedly a factor in their production.

The ptomaïns and basic products of yeast fungi above described are split products of protein material, eliminated by the organisms producing them, and not constituents of those organisms. The distinction between constituent and excretory bacterial products is one of importance biologically and pathologically, but is one which is undesirable from the point of view of analytical toxicology, because the bacteria, as well as their elimination products, are present in materials submitted to analysis, and, although the entire bacteria do not give up their constituent substances to solvents by any means as readily as they do after comminution by Koch's method, they do so to a certain extent.

The only instance of the formation of a protamin by bacteria of which we have knowledge, is the *tuberculosamin* of Ruppel, which he obtained from the tubercle bacilli, but not from their cultures. It is, therefore, a constituent of their organism, in which it exists in combination with a nucleic acid, and not an elimination product. Tuberculosamin has the properties of the protamins: it is extracted by cold, dilute sulfuric acid (one per cent.), is precipitated from neutral solution of the sulfate by sodium picrate, forms an alkaline solution in water, is strongly basic, does not give the color reactions of the proteins except the biuret reaction, contains no phosphorus, and precipitates the proteins from ammoniacal solutions. The protamins form precipitates with phosphotungstic acid, Mayer's reagent, and other general reagents for alkaloids. They are actively poisonous, causing at first acceleration, then slowing of the respiration, marked diminution of the blood pressure, and death.

Chemico-Legal Considerations.—The ptomaïns are now mainly of interest in connection with forensic toxicology. From the first discovery of these substances, and until their chemistry and that of the vegetable alkaloids became better known, it was feared that their existence might seriously interfere with or entirely prevent the detection of vegetable alkaloids, with sufficient certainty for the purposes of justice, in cases of criminal poisoning. The ptomaïns were called "putrid alkaloids," were considered to be of the same chemical class as the vegetable alkaloids, and almost all were found to respond to many of the general tests for the alkaloids. In short, everything seemed to point to a much closer rela-

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tionship between the ptomaïns and the vegetable bases than that which actually exists. But the development of the chemistry of the ptomaïns has shown that those of them which have the most complex molecular structure are more simple in constitution than their nearest relatives among the vegetable alkaloids, and very much more simple than the ester-alkaloids, such as atropin, or the still more complex polynuclear alkaloids, such as morphin.

While the parasitic bacteria probably cause synthetic combinations, as in the generation of the toxins, the function of the saprophytic bacteria, which alone are of interest in this connection, is essentially analytical. It may be considered to be within the limits of possibility that, starting with the complex protein molecule, a substance having the constitution of a vegetable alkaloid might be produced during the series of hydrolytic decompositions caused by the saprophytes. But all observations are against such an hypothesis, no such substance has been found among all of the putrid products which have been obtained. Moreover, the known products of decomposition of the proteins by other means, through the protamins, the hexon bases, the nucleins, the purin bases, the amido acids, and the amins, lead in a direction not tending to the formation of the alkaloids, except in the case of the formation of the pyridic bases by the action of heat. The formation, however, of pyridic and, particularly, of hydropyridic ptomaïns as late products of putrefaction indicates the possibility that the analytical processes of the saprophytes may be followed by the transformation of certain of the acyclic products into heterocyclic compounds, in a manner similar to the conversion of pentamethylene hydrochlorid (cadaverin) into piperidin: $H_2N.(CH_2)_5.NH_2:HCl = NH_4Cl + C_5H_{11}N$.

No ptomaïn has been discovered which corresponds in all of its characters with a vegetable alkaloid. Two substances alike in all respects are two samples of the same substance, and no vegetable alkaloid is known which is also a product of putrefaction. But there are certain vegetable alkaloids which resemble certain ptomaïns in several of their properties, while differing in others, and, at the same time, exhibit no known well-marked and distinctive chemical reactions. Probably the closest resemblance is that between the so-called cadaveric coniïn and true coniïn. Both are liquid, oily, volatile, intensely alkaline, similar in odor, soluble in water and in petroleum ether, and form precipitates with platinic chlorid, auric chlorid, mercuric chlorid, and several of the general reagents. They differ in that coniïn is actively poisonous, while the ptomaïn has been found to be inert, except in one case in which Otto obtained a poisonous substance, which probably owed its toxicity to the presence of another ptomaïn. The "cadaveric coniïn" is, however, not coniïn (α-propyl piperidin) but cadaverin (pentamethylenediamin). Therefore, while it must be admitted that we have no method to separate coniïn from a putrid cadaver, and, in the minute quantity in which it would probably be obtained, distinguish it from cadaverin, or from a mixture of ptomaïns containing cadaverin; it may also be anticipated, the two substances not being identical, that distinguishing characters of sufficient delicacy will be found to exist.

Attempts have been made to find a characterizing reaction common to all ptomaïns, whereby they might be distinguished from the vegetable alkaloids. Among those suggested were the reactions of Brouardel and Boutmy, and of Trotarelli. But no such reaction can exist, because the ptomaïns do not constitute a distinct chemical class, but include among their number representatives of several chemical classes of tolerably diverse character; and for the further reason that, while the great majority of ptomaïns are non-alkaloidal, some are pyridin or hydropyridin derivatives, as are also the alkaloids. As the "general tests" for the alkaloids for the most part form precipitates with ptomaïns, albumins, and nitrogenized bases other than alkaloids, they are only of negative value in the rare cases in which they fail to react, or of confirmatory value by reason of peculiarities in the qualities of the precipitates which they produce with certain alkaloids.

The ptomaïns which are frequently referred to as "strychnin-like" or "morphin-like" are quite as noticeable because of the differences from those alkaloids which they present, as by reason of their resemblances thereto.

The bases obtained by Brieger from the cultures of the tetanus bacillus, while resembling strychnin in the production of tetanic spasms, differ from the alkaloid in not giving the color reaction, in not being bitter, and in crystalline form. Amthor's product was neither bitter nor crystalline, nor did it give the color reaction of strychnin, but an entirely different one. In Ciotto's case the material supposed to have been strychnin appears to have given the color reaction, as Selmi, who differed from Ciotto in his conclusions from the observed facts, concedes this much. But the colors obtained are not described beyond the statement that they were "the colors proper to the reaction of strychnin," and Selmi, in the course of the same paper, says that aspidospermin "behaves with bichromate as does strychnin," while in fact there are marked differences between the color reactions of strychnin and of aspidospermin under like treatment. But Ciotto's substance was not shown to be either crystalline, alkaline, or distinctly bitter, and when administered to frogs in quantity sufficient to kill them it did not cause tetanic spasms. Lombroso and Dupré obtained from the spoiled maize which is regarded as the cause of pellagra a mixture of bases (pellagrozeïn) which is bitter in taste, causes tetanus in frogs, and is said to give the color reaction of strychnin, but whose reaction only resembles that of strychnin in its initial stage. It also differs from strychnin in its crystalline form, and in that its sulfuric-acid solution assumes a permanent violet color when exposed to vapor of bromin. But pellagra is confined to a comparatively narrow strip of territory (six degrees) in the south of Europe. Moreover it is not proven that the constituents of pellagrozeïn are bacterial products; certainly they are not cadaveric ptomaïns.

We find reference in toxicological literature to alleged "morphin-like" ptomaïns in three cases. In the Sonsogno case, in Italy, the substance mistaken for morphin did not give either the Pellagri reaction, the ferric-chlorid reaction, the nitric-acid reaction, or the Erdmann reaction; and it only resembled morphin in that it behaved as a reducing agent toward iodic acid, auric chlorid, and certain other reducible substances. In the Portuguese case of Urbino de Freitas not one of the three most nearly characteristic of the tests for morphin, the Pellagri, the Husemann, and the ferric chlorid was even tried, and the experts erred in asserting the presence of morphin in a cadaver upon the evidence of a not entirely satisfactory Fröhde reaction, the iodic reaction, and the formation of a green color with the Lafon test, the last a reagent whose merits had been insufficiently tested. In the Buchanan case in New York, Vaughan makes the unwarranted assertion that "all the tests obtained by the experts were duplicated with putrefactive products." This alleged duplication was attempted in open court, in the presence of the author, with the following results: The ferric chlorid gave a brilliant grass-green, not a blue color. The Husemann was improperly applied, and failed, as it would have done had morphin been present. The Pellagri was also improperly applied, and failed, as it would have failed with morphin in the manner in which it was used. The Fröhde gave a distinct orange color, passing to yellow, in place of the purple, passing through blue, dirty green, and yellow to pink as it gives with morphin. The nitric acid gave an immediate yellow, but not the orange-red changing to yellow of morphin. The iodic acid gave a faint reaction similar to that obtained with morphin and with many other reducing agents. The six "duplications" therefore consisted of five failures to produce similarity, and one faint resemblance.

Whether a vegetable alkaloid is detectable in cadaveric material or no depends now, as it did before our knowledge of the existence of the ptomaïns was gained, upon the existence or non-existence of a sufficient number of

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well-marked physical qualities, chemical reactions, or physiological actions of that alkaloid. If such exist, and are not duplicated or interfered with by ptomaïns, the alkaloid may be detected with certainty. If they do not, it cannot be, ptomaïn or no ptomaïn. In the frequently cited case of General Gibbone in Rome, it was shown by Selmi that the substance which was claimed to have been delphinin could not be that alkaloid, because it did not have its physiological action. But this affirmative proof was simply confirmative of the already convincing argument that delphinin has no physical characters and gives no chemical reactions which are sufficiently distinctive to permit of its identification when present in the minute quantity obtainable in such an analysis.

That the presence of ptomaïns may militate against the detection of a vegetable alkaloid, both by interference with its reactions and by similarity of its physiological action, is well shown in the case of atropin. From the viscera of a woman, after nine months' burial, the author obtained a residue (which would have contained atropin had it been present) which caused wide dilatation of the pupil and insensibility to light, persisting for several hours, gave the peculiar crystals with bromin in hydrobromic acid, and reddened phenolphthalein; but did not produce Kratter's crystals, or respond to the Vitali reaction. But portions of the same residue, to which atropin sulfate was added in notable proportion, also failed to give the Vitali reaction.

While, therefore, the presence of ptomaïns may interfere to prevent the detection of certain alkaloids which may be actually present in the materials examined, we know of no instance in which a ptomaïn or mixture of ptomaïns has given reactions which would cause it to be mistaken for an alkaloid possessed of sufficiently distinctive characteristics to permit of its certain identification in the assured absence of all ptomaïns. A survey of the reactions manifested by the reputed "alkaloid-like" ptomaïns shows that their similarities to those of the vegetable alkaloids consist chiefly in resemblances of physiological action, and in their behavior toward "general reagents" and toward iodic acid. We have stated above that the general reagents play only a very secondary rôle in the identification of vegetable alkaloids, and iodic acid is merely a test for reducing agents, which is used for morphin because the reducing action of that alkaloid is one of the characters which differentiates it from most of the other vegetable bases. If we except one veratrin reaction obtained by Brouardel and Boutmy, the somewhat doubtful case of Ciotto mentioned above, and the statements of Vaughan, there is no reference in toxicological literature to a ptomaïn which has given a well-characterized reaction of a vegetable alkaloid.

Rudolph A. Witthaus.

PTYALIN. See *Saliva.*

PTYALISM. See *Mouth, Diseases of,* in THE APPENDIX.

PUBERTY.—DEFINITION.—The term puberty was formerly used to designate the whole period of sexual development, and is still occasionally so used. Jules Voisin[1] refers to the age of puberty as the time between the ages of fourteen and twenty two years. In general, however, writers now confine the term puberty to the initiatory and formative period of sexual development, while to the entire period of sexual development is applied the broader term adolescence.

The Age of Puberty.—The average age of puberty in the male is 14.3 years; the average age of first menstruation in the female is about 13.7 years. The period differs according to race and climate, and may be hastened by the reading of erotic literature, by suggestion, and by an early participation in social life.

The pubescent period begins in girls at least a year and a half before the first menstruation. This preliminary period is, according to Armand Delpeuch,[2] the time when the child needs the greatest care, for at this time the trunk is relatively the shortest, the thorax relatively the narrowest, and the heart relatively the smallest, and at the same time the child is doing his most rapid growing. The female makes the most rapid growth from twelve to fourteen, and the male from fourteen to seventeen. The pubescent child should, therefore, be guarded against too violent exercise, and yet should be provided with much pure air.

Physical Changes.—A general physical disturbance takes place, shown by the rapid bodily growth, the elongation of the vocal cords, increased pilosity, a change in the size and condition of the reproductive organs, and a profound disturbance of the nervous system. Indeed, muscles, blood-vessels, glands, and all organs share in the general disturbance.

Psychical Changes.—The psychical no less than the physical being is affected by puberty. Marro of Turin[3] says that "puberty exercises a notable influence upon the psychical life, which is manifested, in some instances, by giving to mental symptoms qualities which they did not have before or which they had only to a slight degree, and in others by preparing a way for the invasion of psychoses. Hereditary predisposition is the prominent cause of the affection."

Periodic Phenomena.—The most notable accompaniment of puberty in the female is *menstruation* (which see). In the male there is throughout sexual life and beginning with puberty a periodicity which is probably analogous to that of the female. The seminal vesicles possess glandular walls and retain the secretion of these walls for periods varying from one to four weeks normally.

The retained secretion distends the walls, and through pressure stimulates nerves which pass to the erection centre, which is in turn excited.

By day erotic emotions are easily aroused; at night when the subject sleeps he may experience an erection accompanied by an erotic dream and culminating in an emission ("nocturnal emission"). In this way is the pressure of accumulating vesicular secretion relieved and the subject should pass another period free from sexual impulses. After the period of pubescence is established, the testes of the male form spermatozoa rapidly under sexual excitement and slowly during periods which are free from excitement. In neither case do the spermatozoa pass into the seminal vesicles; they are retained in the testes, the vasa deferentia, and ampullæ. The testes form not only the spermatozoa but a milky fluid in which the spermatozoa float. The secretion of the testes contains a mysterious principle whose reabsorption gives to the male those characteristics which we recognize as distinctive of virility. In the nocturnal emission coming without sexual excitement no spermatozoa are lost; hence these emissions cause no depletion. *J. W. Hall.*

[1] St. Louis Med. Review, October 13th, 1901.
[2] La Presse méd., August 17th, 1898.
[3] St. Louis Med. Review, October 13th, 1901.

PUERPERAL INFECTION.—(Puerperal fever, puerperal sepsis, puerperal septicæmia, childbed fever.)

DEFINITION.—An acute contagious disease of the puerperium characterized by an inflammation of some part of the genital tract, and frequently associated with a variety of systemic manifestations. It is caused by a number of pathogenic and saprophytic micro-organisms.

HISTORY.—The disease has been known from the earliest times. Hippocrates, Galen, Avicenna, and others of the early writers, as well as many in the sixteenth, seventeenth, and eighteenth centuries, have described cases. In the first half of the nineteenth century there were many frightful epidemics of the disease.[1] It was the scourge of the great lying-in hospitals of Europe, and patients were decimated regularly by its ravages. Oliver Wendell Holmes in his essay, "The Contagiousness of Puerperal Fever," published in 1843, logically proved the contagious nature of the disease; and Ignaz Philipp Semmelweiss, who recognized the identity of the disease with wound infection and devised a practical method

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of hand disinfection, published, in 1861, his monograph, "Die Etiologie des Begriffs und die Prophylaxis des Kindbettfiebers." He introduced hand disinfection in the great Maternity Hospital in Vienna, and immediately the mortality fell from ten per cent. to about one per cent. The teachings of these classical essays were bitterly opposed, however, and it was not until after Lister had introduced antisepsis in surgery that its importance in obstetrics was generally recognized. The ancients attributed the affection to a retention of the lochia, and this has been the most common explanation until recent times. After the introduction of antiseptic and aseptic methods in obstetrics, there was a marked reduction in the mortality from puerperal infection in hospital practice. At the present time, in the better maternity hospitals, the mortality is a small fraction of one per cent. In private practice, however, cases are frequently seen, especially in the hands of untrained midwives and careless or ignorant physicians.

Etiology.—Puerperal infection is essentially wound infection. As Semmelweiss and others have shown, the *materies contagii* is carried to the parturient woman on the hands of those who have made recent autopsies or dissections, or who have dressed suppurating or inflammatory cases of any kind. With the advance of our knowledge of the causal relation of bacteria to disease in the last fifty years, the infectious nature of the disease has been clearly established. Puerperal infection, however, is not a specific disease, but like wound infection in general may be caused by a variety of micro-organisms. Among these the streptococcus is found most frequently, and is present in nearly all the fatal and most serious cases. The gonococcus comes next in frequency of occurrence, but causes much less serious infections, and few fatal cases have been caused by it alone. The staphylococci, the colon bacillus, and a number of putrefactive anaërobic bacilli are frequently found. Among the rare forms are the gas bacillus (aërogenes capsulatus,[2] Welch), the pneumococcus,[3] the diphtheria bacillus[4] (Bumm, Nisot, Williams), and the typhoid bacillus[5] (Williams). In addition to these a number of unidentified aërobic bacilli have been found.

Mixed infections, as the streptococcus with the colon bacillus, the staphylococci with anaërobes, etc., occur more frequently than infections with a single organism.

The recently emptied uterus with its lacerated bleeding surface presents a peculiarly favorable field for the invasion and growth of micro-organisms. The retention of blood clots and fragments of the placenta or membranes favors infection. Incomplete contraction of the uterus with consequent dilatation of the lymphatics and the formation of large thrombi in the venous sinuses is also a factor, for it is along these vessels that infection most readily extends.

Source of Infection.—Bacteria must either be present in the uterus or vagina or be introduced from without. The doctrine of auto-infection has been advanced by a few observers. Albert[6] attributes to a latent microbic endometritis, which does not prevent conception, many cases of abortion and premature labor as well as some cases of puerperal infection.

The normal uterine cavity, however, is generally conceded to be sterile,[7] but there has been a long controversy over the bacterial flora of the vagina. Bacterial examinations of the vaginæ of a large number of pregnant women have led to contradictory results. Döderlein,[8] Winter, and others found pathogenic bacteria in a varying percentage of cases; while Krönig,[9] Menge, and others, found none, with the exception of the gonococcus. Döderlein,[10] made further studies and divided his cases into two classes: (*a*) Those with "normal" acid vaginal secretion in which he found no pathogenic bacteria; and (*b*) those with an "abnormal" weakly acid, neutral, or alkaline secretion, in ten per cent. of which he found streptococci. Later Krönig,[11] with improved technique by which he avoided contamination from the vulva, found no streptococci in either normal or abnormal cases. These results have been confirmed recently by Williams.[12]

The bulk of the evidence is now in favor of the view that infection comes from without in practically all cases. Experiments have shown that the normal vaginal secretion has distinct bactericidal power. Cultures of streptococci and other pathogenic bacteria, introduced into the vagina of a pregnant woman, have been destroyed, and disappear in from twenty-four to forty-eight hours. The gonococcus forms an exception; as far as known, it is the only pyogenic coccus which can live and thrive in the vaginal secretion.

Morbid Anatomy.—Any part of the genital tract may be infected, and accordingly we may have, primarily, puerperal vulvitis, vaginitis, endometritis, metritis, metro-lymphangitis, metro-phlebitis, or salpingitis. Extension of the infection to adjacent structures may give rise to parametritis, peritonitis, oöphoritis, or phlegmasia alba dolens. Further, with any of these conditions varying degrees of toxæmia and bacteriæmia may occur.

Puerperal vulvitis and vaginitis present no characteristics differing materially from those of ordinary infections of lacerated wounds. The so-called diphtheritic forms are usually due to mixed streptococcus infection, although true diphtheritic inflammation has been reported in a few rare cases (Bumm, Nisot, Williams).

Endometritis, or an inflammation of the uterine mucosa, is the most common form of puerperal infection.

It is a help in the study of the lesions to divide the cases into those which are due to the streptococcus, the septic cases, and those which are due to putrefactive bacteria, the putrid cases.

In the pure streptococcus cases the walls of the uterus are comparatively smooth, there is little or no accumulation of necrotic material, and the discharge is correspondingly small in amount and devoid of offensive odor.

In the cases in which putrefactive bacteria (colon and anaërobic bacilli) are present at the same time with the streptococci, and in the simple putrefactive cases the walls are rough, the cavity of the uterus is filled with masses of foul-smelling necrotic material, and the discharge is profuse, offensive, and frequently contains gas bubbles.

Microscopically there is in general a typical inflammatory reaction in the endometrium. The cavity of the uterus is lined by a surface layer of necrotic tissue which is filled with bacteria; beneath this is a layer of leucocytes, the so-called "protective wall" of leucocytes. In the virulent streptococcus cases the necrotic layer is slight or absent, and the protective wall of leucocytes is poorly developed; the streptococci invade the wall of the uterus along the lymphatics or veins, and can be traced to the peritoneum, the parametrium, and the ovary, and, in many cases of peritonitis, parametritis, oöphoritis, and phlegmasia alba dolens, to the veins of the pelvis and of the leg.

Infected emboli from thrombosed veins may be carried to distant organs and there set up secondary septic inflammations, or they may cause a general systemic infection.

In the milder streptococcus and staphylococcus infections the inflammation may be limited to the endometrium, with little or no invasion of the protective wall of leucocytes, and the general symptoms may be due largely, as in the simple putrefactive cases, to absorption of toxins.

In the simple putrefactive infections the necrotic layer and the protective wall of leucocytes are well developed, and the bacteria are confined to the necrotic layer.

In the mixed infections of streptococcus with putrefactive bacteria we may have a more or less composite picture of the conditions above described.

Since the discovery of the gas bacillus (aërogenes capsulatus) by Welch, in 1891, it has been found in a number of puerperal infections. These include cases of emphysema of the fœtus, puerperal endometritis, physometra, emphysema of the uterine wall, and puerperal gas sepsis. Many of the patients recovered. The fatal cases were characterized by an extraordinarily rapid development, post mortem, of gas in the tissues and blood channels of the fœtus and mother. It seems probable that

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most of the fatal cases of air embolism previously reported were cases of gas-bacillus infection.

Symptoms.—Cases differ greatly in their character according to the variety and virulence of the micro-organisms, the site of the primary infection, and the degree of extension of the disease. As has been noted, the infection usually takes the form of an endometritis.

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In general, the symptoms are those of a wound infection with more or less toxæmia. A chill, fever, general malaise, rapid weak pulse, restlessness, and headache are most frequent.

The patient will have done well during the first few days of the puerperium, and then on the third or fourth day she will have headache and malaise, followed by a chill and a rapid rise of temperature to 103° F. or higher. In the simple cases there is but one chill, while the fever remains high for some days and then subsides. The lower abdomen is tender on pressure. The uterus also manifests increased tenderness, and is larger and more "doughy" in consistency than normal. The character of the lochia is changed. There is apt to be constipation and the urine is scanty and highly colored.

Clinically, the cases may be divided into the septic and the putrid forms. The well-known variation in the virulence of cultures of the streptococcus explains the not infrequent mild cases due to streptococcus infection.

The severer streptococcus cases are characterized by rapid onset, often with early delirium, or great mental prostration and apathy, although some show a remarkable absence of mental symptoms. With the invasion of the lymphatics and blood-vessels come the symptoms of general septicæmia, recurring chills, and high, irregular temperature; in such cases death usually follows within a week.

In the milder septic cases, if the infection is limited to the endometrium, the initial chill and rise of temperature are followed by a gradual decrease of the fever. The lochia are purulent but not profuse, and they are devoid of marked odor. The general symptoms subside after the uterus is washed out, and recovery usually follows, but a condition of subacute or chronic endometritis may persist for a long time.

If the infection is not limited to the endometrium, but extends along the lymphatics, it may give rise to abscess formation in the walls of the uterus, in the broad ligament, in the retroperitoneal tissues, or in the inguinal region; or it may extend to the peritoneum and set up a local or a general peritonitis. The latter is usually fatal. Again, there may be a direct extension of the infection to the Fallopian tubes with development of salpingitis or an abscess. Such extensions are accompanied by chills and a fresh access of fever. The abscess may rupture into the bladder, the rectum, through the skin in the inguinal region, or into the peritoneal cavity. If the abscess is drained satisfactorily the symptoms rapidly subside and recovery follows. Rarely an abscess may undergo gradual resorption.

Extension of the infection along the thrombosed veins of the uterus may give rise to pyæmia. In such cases the initial chill may be delayed, the temperature does not remain constantly high, but instead there is a typical hectic fever with alternating chill, fever, and remissions. The symptoms vary according to the number and size of the infected emboli, the organs to which they are carried, and the virulence of the micro-organisms. These emboli frequently give rise to an often fatal bronchopneumonia, or less frequently to destructive inflammations in various joints. In a few cases the thrombosis extends to the femoral veins and causes phlegmasia alba dolens. This usually occurs in the second week and is characterized by severe pain and swelling of the leg, with fever. The pain and swelling may persist for a long time, but uncomplicated cases end in recovery. The symptoms of thrombosis of the femoral vein may be the first evidence of an infection, the primary inflammation in the uterus having been so slight as to escape notice.

Putrid endometritis differs somewhat in its symptoms and course from the septic forms. The onset is usually on the third or fourth day, and the initial chill and rise of temperature may be as marked or even higher than in the septic cases, but the general condition is not so serious. The main difference is in the character of the lochia, which in the putrid form are profuse, offensive, and frequently have a frothy appearance owing to the presence of large numbers of gas bubbles. The cases improve rapidly after the masses of necrotic material have been removed and the uterus has been washed out. Nearly all of the putrid cases terminate in recovery.

Diagnosis.—Typical cases give no difficulty in diagnosis. In distinguishing between the septic and the putrid forms of endometritis the changes in the lochia are important. The profuse malodorous discharge and the roughened surface of the uterine mucosa are very distinctive in the putrid types; while a smooth uterine surface with scanty purulent discharge and high fever suggests a streptococcus infection.

In the mixed streptococcus cases, however, the uterine wall may be rough and the discharge profuse and offensive. Here the value of a bacteriological examination of the uterine lochia is particularly evident.

Fever, during the puerperium, may be due to diseases other than puerperal infection. Angina, acute pulmonary affections, influenza, acute inflammatory conditions of the breasts, typhoid fever, and malaria occasionally occur.

Some cases of puerperal infection are undoubtedly diagnosed as malaria. But we are not justified in attributing the fever to malaria unless we find the plasmodium in the blood, and even then we cannot exclude puerperal infection until we have proved that the uterine lochia are sterile.

"We might say that every rise in temperature in the puerperium should be regarded as due to puerperal infection, unless we can clearly demonstrate some other infection to be its cause" (Williams).

Fever due to auto-infection from the intestinal tract is promptly reduced by the effective action of a strong laxative. Certain mental disturbances, such as emotional excitement, fright, or grief, may be attended with a sudden rise of temperature, which falls to normal in a few hours.

The absorption of sterile exudates and blood clots is usually associated with a rise of temperature often to 100°, but rarely above 101° F., and this rise occurs in the first thirty-six hours.

Prophylaxis.—Puerperal infection is wound infection. Therefore in order to avoid infection scrupulous care, according to the principles of surgical technique, must be taken from the beginning of labor to the end of the puerperium.

Vaginal examinations in the last days of pregnancy should be made with antiseptic precautions. During and after labor they should be reduced to a minimum. Preliminary antiseptic douches in normal cases are to be avoided, since they decidedly decrease the bactericidal power and resistance of the vagina and its secretion. The use of the ordinary douche and the making of a vaginal examination by the nurse should be prohibited. If the vagina is known to contain pathogenic bacteria, the obstetrician himself should cleanse it with the utmost care; but such conditions should be corrected, if possible, long before the onset of labor.

Since the hands are the chief carriers of infection, they should receive careful attention. The following is one of the most satisfactory methods of hand disinfection:

1. Scrub the hands and forearms up to the elbows with a sterile brush, green soap, and hot water for three minutes, paying especial attention to the finger nails and palmar surfaces of the fingers—change the water at least once.
2. Trim the finger nails with a sterile knife or scissors, and clean the finger nails with a nail cleaner.
3. Repeat the washing for five minutes by the clock, using a fresh brush.
4. Rinse in fresh water.

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5. Soak hands in a hot saturated solution of potassium permanganate until they are of a deep mahogany color.

6. Decolorize completely in a hot saturated solution of oxalic acid.

7. Soak forearms and hands in a 1 to 1,000 solution of bichloride of mercury for three minutes by the clock, or until the patient is ready for operation.

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It should not be forgotten that sterile hands may be contaminated readily at the bedside.

The patient also should be carefully prepared. At the onset of labor she should be bathed and given a rectal enema. The external genitals frequently harbor streptococci and various pathogenic and putrefactive bacteria. They should be carefully washed, before each vaginal examination, first with soap and hot water, and then with a 1 to 2,000 solution of bichloride of mercury; afterward they should be protected, with a towel soaked in the bichloride, until the physician is ready to make his examination.

During the second stage an antiseptic towel should be kept over the vulva and sterile sheets and towels should be arranged in such a manner as to prevent contamination.

In operative procedures rubber gloves may be worn to give added protection. They should be thoroughly boiled and then drawn over the sterilized hands.

Perineal tears offer ready entrance to bacteria and should be repaired. The sutures may be placed during the third stage and tied after the expulsion of the placenta.

Operations for the repair of lacerations of the cervix greatly increase the chance for infection, and should not be done unless imperatively demanded for the control of hemorrhage.

After the birth of the placenta the patient should be cleaned and the vulva covered with an ample sterile dressing, which is held in place by a T-bandage.

Ergot may be used to secure better contraction of the uterus, but should not be given until the placenta has been expelled.

During the puerperium the external genitals should be kept clean by frequent irrigation with a 1 to 4,000 solution of bichloride, and the vulval pads frequently renewed. Vaginal douches should be used only in exceptional cases, and then with the utmost regard for surgical cleanliness. Infections have been caused by the careless use of the vaginal douche, even in the later stages of the puerperium.

Treatment.—General treatment alone often gives the best results in the severe streptococcus cases. Strychnine, gr. $\frac{1}{30}$, may be given every two hours with half an ounce of whiskey every hour, but the quantity should be reduced promptly when the pulse shows improvement. The patient should be kept on the verge of strychnine poisoning and a state of drunkenness, if necessary. Mild cases require little medicine. The bowels should be kept open and good food given in all cases.

Antistreptococcus serum has given very unsatisfactory results. Laboratory experiments have shown that serum prepared from a given culture is protective for that particular culture and no other. Recent reports by Labusquière,[13] Savor, Blumberg, and Scharfe show results of doubtful or no value.

The cases of true diphtheritic infection reported by Bumm, Nisot, and Williams showed rapid improvement and recovery following the use of diphtheria antitoxin.

Salt solution enemata every six hours, given through the long rectal tube, are often of value in relieving symptoms and promoting diuresis. The subcutaneous injection of sterile decinormal salt solution has been of apparent benefit in some cases. Tincture of ferric chloride in large doses is of value.

Local treatment in the streptococcus cases should be limited to douches, preferably of hot sterile decinormal salt solution. These may be repeated every six hours if necessary. Dilute bichloride douches, 1 to 10,000, immediately followed by the salt solution, may be used. But antiseptic douches are dangerous and should be used with great care. Forty cases of death from bichloride poisoning have been reported.

Clots and fragments of the placenta may be removed with the finger or the dull curette. Curetting on the whole is dangerous, especially if streptococci are present, for by it we may break down the protective wall of leucocytes and expose fresh areas to infection, the very thing we wish to avoid.

Hysterectomy has been advocated for severe cases, but the results reported by Rochard, Bazy, Terrier, and Tuffier, with a mortality of from thirty-three to one hundred per cent., hardly justify a resort to the operation. Leopold[14] and Fehling do not favor it. As they show, to be of value it must be done early, before the infection has extended through the uterine wall. But at present we have no means of determining in which cases the infection will extend, and in which it will remain limited to the uterus. Ricard has collected eight hundred and fifty-one cases with fever at 102.2° F. and higher, showing a mortality of thirteen per cent. under general treatment.

Abscesses and dense areas of cellulitis in the parametrium should be opened through the vagina or through the abdominal wall.

Putrefactive cases with abundant foul discharge are greatly helped by cleaning out the masses of necrotic material with the finger or curette, and following this by a large douche of salt solution, the douche to be repeated every six hours. *Otto G. Ramsay.*

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PULLER SPRINGS. — Madison County, Montana. Post-Office.—Puller Springs. Hotel.

This resort is reached by a good wagon-road, and has semi-weekly mails. The location is in a beautiful valley, having an elevation of 5,530 feet above the sea-level. The springs are two in number, the temperature of the water being 95° F. for the larger and 105° F. for the smaller spring. No analysis. The waters have been found beneficial in rheumatism and allied disorders. The beautiful location of these springs, coupled with the potential therapeutic properties of the water, will undoubtedly bring them into extensive use as the State becomes more thickly settled. *James K. Crook.*

PULSATILLA.—U. S. *Pasque Flowers.* The dried herb of *Anemone Pulsatilla* L. and *A. pratensis* L. (fam. *Ranunculaceæ*), collected soon after flowering, carefully preserved and kept not longer than one year. Both are low, hairy herbs and among the earliest and most beloved of spring flowers. For medicinal purposes the plant should be dried in the shade and stored in a cool and dry place. The drug is thus described: Silky-villous; leaves radical, long-petioled, the petioles usually purplish, the blades twice or thrice deeply three-parted or pinnately cleft, the lobes linear and acute; flowers long-peduncled, subtended by an involucre of three pinnately parted sessile leaves; calyx of (usually six) large, dull purple, hairy sepals; petals obsolete; stamens numerous; pistils several, be-

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coming in fruit long, plumose-tailed akenes; inodorous and very acrid.

CONSTITUENTS.—Pulsatilla yields upon distillation with water a very pungent, volatile, oil-like principle, from which ether or chloroform extracts a peculiar camphor, which has been called *Anemone camphor*, and which possesses the acridity of the oil to such a degree that it is capable of blistering the skin. This camphor is divisible into anemonin and iso-anemonic acid. The former is a colorless, crystalline, neutral substance, of but little taste when cold, but intensely pungent when melted. It is but slightly soluble in cold alcohol, ether, or water, more so in those liquids when hot, and is readily soluble in chloroform. *Iso-anemonic acid* is a white, amorphous, insoluble substance, without odor, taste, or medicinal property.

ACTION AND USE.—The clinical investigation of pulsatilla has been greatly neglected by physicians, apparently with little better reason than that it is a favorite medicine with homœopaths and eclectics. That it possesses powerfully active properties is sufficiently proven by its action upon the skin and the mucous membrane. Its action is fairly well described in a general way by saying that it resembles that of aconite, but its special field of usefulness is well worthy of careful determination. It is a fairly active counter-irritant, and is frequently so employed. Although capable of blistering, if applied with friction, such a use of it is not wise, since the blister is rather uncontrollable. Applied to the mucous membrane, it produces a burning and tingling, followed by numbness, much as does aconite. In the stomach it acts as a stimulant, or in larger amount as an irritant emetic. Systemically, it reduces both the rate and the force of the heart and of the respiration. It is therefore an antiphlogistic, and is somewhat used as a respiratory sedative. Among the homœopaths and eclectics its sedative action is largely utilized in the treatment of inflammatory conditions of the genitals, although it is also a favorite emmenagogue.

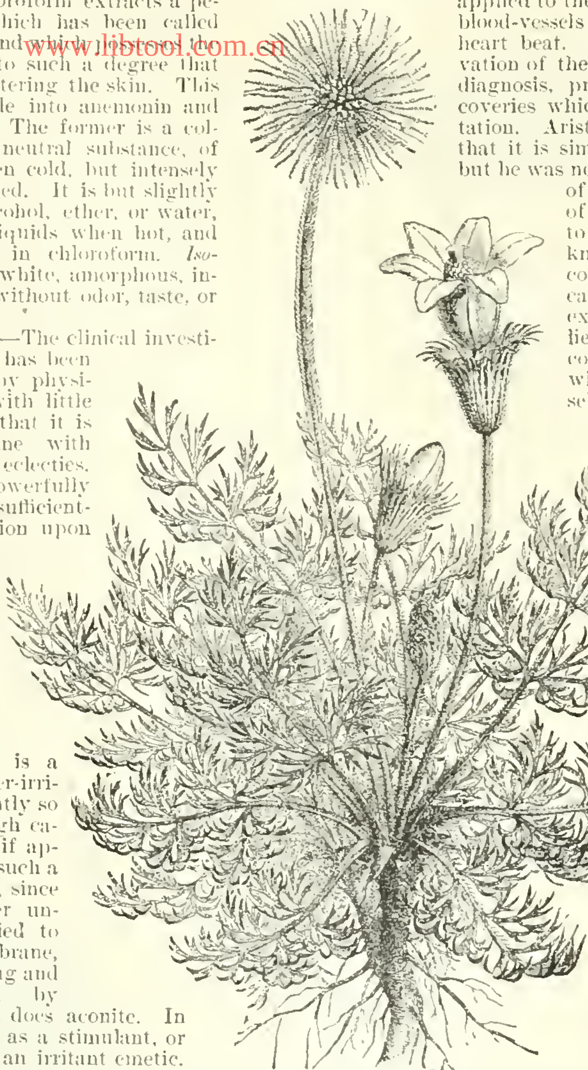

FIG. 3896.—Anemone Pulsatilla. (Baillon.)

There is no official preparation. The powdered drug may be given in doses of 0.06–0.3 gm. (gr. i.–v.) or the fluid extract in an equal number of minims. The tincture is probably more used than all other of its preparations combined. It is commonly made of twenty-per-cent. strength, and the dose is 0.5–1 c.c. (♏viij.–xv.). The extract is used in doses of one-half to two grains and anemonin in doses of one-fifth to one-half a grain.

ALLIED DRUGS.—*Anemone nemorosa* L., the common wind-flower, and various other anemones, have a similar composition to that of pulsatilla, and are similarly used. Various species of *Ranunculus* or buttercup, and of *Clematis* or virgin's bower, also exhibit resemblances in the same direction, as does Hepatica or liver-leaf. All these pertain to the family *Ranunculaceæ*. *Henry H. Rusby.*

PULSE, THE.—INTRODUCTORY AND HISTORICAL.—The pulse, literally a beating or throbbing, may be broadly defined as periodic movements caused by the rhythmic action of the heart. The term is commonly applied to the changes in size and tension of the blood-vessels which may be seen or felt at each heart beat. In the history of medicine the observation of the pulse, and also its employment in diagnosis, preceded by many centuries the discoveries which opened the way for its interpretation. Aristotle refers to the pulse, and states that it is simultaneous in all parts of the body; but he was not aware of its relation to the activity of the heart. Galen, equally ignorant of its origin, devoted much attention to it, but his lack of physiological knowledge led him to form many false conceptions, and he attached a significance to minor variations which later experience has not justified. He believed that the arteries expanded and contracted actively by some force which they possessed within themselves. In China medical science, like other things, has changed little in thousands of years. The native physicians there have very crude ideas of both anatomy and physiology, and yet they describe and even graphically depict the pulse in great detail. They imagine they find indications in it of the exact seat no less than the nature of nearly every disease.

A more reasonable claim, where the indications given are better supported by other symptoms, is ascribed by the poet Browning to Paracelsus, that erring Moses who in the sixteenth century began to lead the profession out of the Egypt of tradition.

"When we would thoroughly know the sick man's state
We feel awhile the fluttering pulse, press soft
The hot brow, look upon the languid eyes
And thence divine the rest."

The foundation for the scientific study of the pulse was laid by William Harvey, who discovered and described the circulation early in the seventeenth century. Among his conclusions we find that "the heart is the organ of propulsion for the blood" and that "the pulsation of the arteries is nothing else than the impulse of the blood within them." In 1707 Sir John Floyer states a little more definitely: "The pulse is that sensible motion which is given to the artery by the blood which the heart injects into it." Still fuller is the account given in Haller's "Elements of Physiology," published in 1760: "The arteries are, in a living person, always full of blood, since the jet or stream that starts from an artery is not interrupted by alternate stops, while the heart rests or relaxes itself, but it flows on in a continued thread. . . . Since, therefore, a new wave or column of blood is sent into the arteries already full, although it bears but a small proportion to the whole mass contained in the arterial system throughout the body, . . . yet by its immediate contact with the precedent wave or column, which

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moves slower as it gets farther from the heart, it consequently drives the same forward, lengthens the artery, and makes it assume a cylindrical form, augments its diameter, etc. This dilatation of the artery, whereby its light or capacity is changed from a less to a greater circle, is called the pulse." In 1767 Henri Fouquet described in

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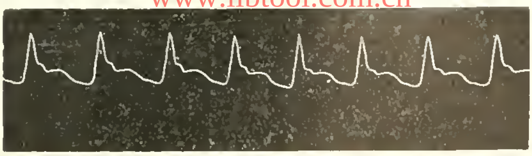

FIG. 3897.—Normal Pulse Tracing.

detail the sensations imparted to his finger by the pulse and was the first in Europe (the Chinese were before him) to represent the pulse by drawings. In 1855 K. Vierordt describes a rough means of recording the movements of the arteries automatically, thus laying the foundation of modern sphygmography. On this foundation a host of modern investigators, both laboratory and clinical, have raised a substantial structure of useful knowledge.

ARTERIAL PULSE. — *Description and Explanation.* — The arterial pulse comprises a succession of waves initiated in and near the heart and propagated through the arteries. As the contents of the left ventricle are forced through the semilunar valves, room is made for the blood, partly by the distention of the aorta, and partly by a pushing on of what is already there into the smaller arteries, causing the latter to be distended in turn. This distention slightly increases the calibre of the arteries; but what we recognize as the pulse, when we lay our finger on the wrist, is rather the increase of tension or pressure within the vessel which occurs at the same time. In some cases an artery may become more tortuous as the wave of increased tension is passing over it. With the finger on the pulse, it is sometimes possible to recognize more than one impact or wave. It is difficult, however, and often impossible to be sure of these so-called secondary waves by the sensation imparted to the finger, and we should know very little about them were it not for the assistance furnished by the sphygmograph. By means of this instrument it is possible to communicate the movements of the artery to a lever supplied with a writing point. This is brought to bear upon a piece of smoked paper moved by clockwork. The result is a graphic representation of the variations in pressure occurring within the artery. Some of the many forms of instrument and the method of employing them will be described in the article on *Sphygmography.* Fig. 3897 represents the tracing obtained by one of these instruments (Dudgeon's sphygmograph) from the radial pulse of a healthy man.

If it be examined it will be seen that each pulse beat is represented by a sudden rise followed by a more gradual fall. The sudden rise is known as the *primary or percussion wave* and can be traced to the contraction of the ventricle. The descent is broken by two secondary waves, of which the second, known as the *dicrotic wave*, is in this case the largest and most distinct. This wave is very constant, being found in almost all pulse tracings. It is preceded by a depression known as the *dicrotic notch*. There has been much controversy as to the cause of the dicrotic wave, one view being that it is due to a rebound of the blood from the aortic valves at the moment when they close, and the other that it is a wave reflected back from the small peripheral vessels. While a very few still hold the latter view, it has been discarded by most physiologists as a result of overwhelming evidence that has been advanced in favor of the rebound theory. If the wave were due to a reflection of the percussion wave from the periphery, it would occur earlier in the peripheral than in the central vessels, which is not the case. Moreover, a number of physiologists, notably Karl Hürthle, have shown that the dicrotic notch which marks the beginning of this wave follows immediately the closure of the aortic valves. He has invented the so-called differential manometer to record the time of closure of the valves. This instrument records the relation of the pressure in any two cavities. If connected with the aorta and left ventricle through a Hürthle's heart catheter, it indicates the moment when the pressure in the ventricle falls below that in the aorta. This moment corresponds of necessity with the beginning of a back flow into the ventricle, and must be directly followed by closure of the valves. In Fig. 3898 from Hürthle's "Beiträge zur Hæmodynamik" *A* is the curve of pressure at the root of the aorta, that of the left ventricle, and *D* the curve of the differential manometer showing the relation between the pressure in the ventricle and that in the aorta. When the curve *D* rises above the base line the pressure is higher in the ventricle, and blood begins to flow into the arteries; when it falls below the line, there is a tendency for a back flow to take place and the semilunar valves close. The vertical lines 1, 2, 3, 4, 5 show corresponding points of time in the three tracings. The aortic valves close directly after the line 3, which marks the beginning of a backward flow into the ventricle. This corresponds in time very closely with vertical line 4, indicating the commencement of the dicrotic wave. The close agreement in time between these two events is strongly suggestive of a causal relation. The correspondence between the closure of the aortic valves and the dicrotic wave has also been successfully demonstrated by Martius, Karl Schmid, Jr., and others by marking the time of the second sound of the heart as heard with a stethoscope upon the pulse curve.

The rebound from the semilunar valves may be explained as follows: The blood is thrown out of the ventricle at a certain speed and with a certain momentum. When the ventricle has emptied itself the momentum of the blood in the aorta tends to carry it forward away from the ventricle. This cannot actually take place, or a vacuum would be left at the root of the aorta, but the tendency in that direction causes a low pressure and consequent suction action at the aortic orifice. This lower pressure or suction leads to a wave in a backward direction, completing the closure of the semilunar valves. This is reflected forward again as the dicrotic wave. The dicrotic wave is most pronounced when the smaller arteries are dilated and the peripheral resistance is low. In this case the column of blood, meeting with little opposition, is thrown out of the ventricle with greater speed and momentum, and the recoil against the semilunar valves consequently occurs with greater force.

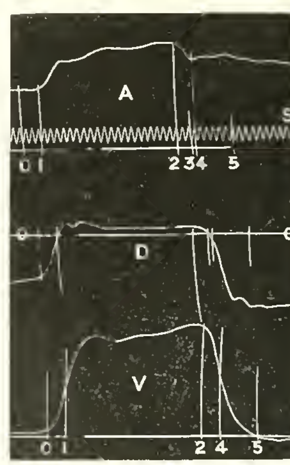

FIG. 3898.—Shows Relationship between the Pressure in the Ventricle and that in the Aorta. (From Hürthle.)

Immediately preceding the dicrotic wave another, and in this case (Fig. 3897) smaller, wave may be seen which is known as the *predicrotic* or *tidal wave*. The cause of this is more doubtful than that of the dicrotic wave. It is found in the curve of intraventricular pressure, and may even be present under certain conditions in the tracing of the transverse diameter of the frog's ventricle (Marey), so that it is frequently ascribed to a peculiarity in the contraction of the ventricular walls, "the systole not being equally sustained" (Foster) or "the outflow remainder wave" (Roy and Adami). There are those who ascribe this wave entirely to inertia and recoil of the instrument

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used. The instrument may, and often does, exaggerate it, but there is little doubt of another factor being present. The most plausible explanation is perhaps something like this: both the percussion wave and the predicrotic originate within the ventricle during its systole; the reason of there being a depression or notch dividing them into two is that a slight fall of pressure occurs when the semilunar valves open and afford a passage for the blood into the aorta; the physical laws here exemplified may be studied in the mechanism of the hydraulic ram as has been pointed out by Karl Schmid, father and son. If the pressure in the arteries is low, the ventricle nearly empties itself with one effort, and the predicrotic wave is scarcely seen; but if the pressure is high, only part of the blood is forced out at first, and after a slight fall in pressure at the opening of the semilunar valves, the continued contraction of the ventricle raises it again up to or beyond its original height, forming the predicrotic wave. It is certainly a practical rule that where the predicrotic wave is pronounced and reaches a high level the blood pressure is high relatively to the strength of the ventricle.

Other secondary waves are sometimes seen upon pulse tracings and are probably due to oscillations taking place within the vessels, or in some cases they may be instrumental in origin. A multiplicity of secondary waves points to high blood pressure and consequent tension of the arterial walls. Elevations or depressions occurring upon the descending limb of a tracing are called katacrotic, those more rarely seen upon the ascending limb are called anacrotic. A tracing with interruptions upon the ascent is called an anacrotic tracing, and we may also speak of an *anacrotic pulse*. Similarly, where there are interruptions on the descent we speak of a katacrotic tracing and *katacrotic pulse*. A pulse may be both anacrotic and katacrotic. The normal tracing in Fig. 3897 is katacrotic only. The tracing shown in Fig. 3899, taken from a case of aortic stenosis, could be classed as both anacrotic and katacrotic. The predicrotic wave forms the summit of the tracing and indicates resistance to the outflow of blood from the ventricle; the primary or percussion wave forms an anacrotic crest or angle on the ascent, and the dicrotic wave is seen as an elevation on the descent (katacrotic).

Factors Contributing to the Character of the Pulse.—The exact character of the pulse depends on three principal factors: the force of the ventricular contraction, the degree of elasticity of the arteries, and the resistance offered to the outflow of blood from the arteries into the capillaries and veins. The quantity of blood in the body naturally occurs to one as a modifying factor, but its influence is difficult to trace, and in any case it probably acts chiefly by modifying the ventricular contraction. An additional factor that does, without doubt, however, exert a modifying influence in special cases is the condition of the aortic and to a much less extent of the mitral valves. Of the three principal factors mentioned *the ventricular contraction* determines the rate and combines with the other two factors to give the pulse its other qualities. *The elasticity of the arteries* modifies the pulse in the direction of less abruptness. The more elastic the larger arteries are, the less sudden is the increase of tension in the smaller ones. The diminished elasticity of age tends to make the rise of the pulse wave steeper. In cases of low blood pressure the same effect is noted, because the elasticity of the arteries is not fully brought into play. *The peripheral resistance* depends largely upon the degree of activity of the muscular coats of the arterioles. When these are relaxed the blood pressure falls, the ventricle empties itself easily, and the pulse is large and soft. When the arterioles are contracted the blood pressure rises, the work of the ventricle is increased, and this is indicated in the pulse by hardness and a prominent predicrotic wave. Advancing age tends to raise the peripheral resistance by the withering of many of the capillaries and consequent narrowing of the channel by which the blood must flow from the arteries into the veins. Age also affects the force of the ventricles and the elasticity of the arteries so that the pulse in old people varies according to the part of their vascular system where degenerative changes have been most active. As the thoughtful observer notes in the pulse the modifications brought about by ventricular activity and peripheral resistance, he will find there suggestions of many possible influences acting through the cardiac and vasomotor nerves.

Rate of Propagation.—It takes a certain measurable time for the effect of the ventricular contraction to make itself felt in increased tension of the peripheral arteries. In other words, the pulse waves travel at a certain rate. This "rate of propagation" varies somewhat, but is usually given as between three and ten metres a second. It is considerably influenced by variations in blood pressure and by the degree of rigidity or elasticity of the arteries; the more rigid the vessels the more rapid the propagation of the pulse.

Fig. 3899.—Anacrotic Pulse (aortic stenosis).

Further information on some of the subjects treated of above will be found in the article on *Circulation*.

The Examination of the Pulse and What it Shows.—One should not make any direct examination of the radial pulse until he has obtained what information he can by inspection of the visible parts of the body. A glance is often sufficient. In the face one can find indications of the condition of the capillary circulation in the glow of health or in pallor or lividity. In the neck there may be violent throbbing of the arteries or distention and pulsation of the veins. In the fingers one may find lividity and clubbing or a capillary pulse. The pulsation of the temporal and radial arteries may be visible.

It is important to choose for the examination of the pulse a time when the patient is as little excited as possible. It is well to distract his attention by conversation. To obtain the best results the patient should lie or sit in a comfortable position. The observer should be in front of the patient or to his right side. The patient's right arm should be supported with the elbow flexed and the forearm half pronated. Two or three fingers of the observer's right hand should be laid upon the radial artery where it passes over the lower end of the radius between the styloid process and the flexor tendons. The fingers are to be moved up and down the artery and across it, first with light pressure and then with sufficient to flatten out the vessel so as to bring out *the condition of the arterial wall*. If the artery can be felt and rolled beneath the fingers when flattened out it indicates the thickening of arteriosclerosis or the rigidity of atheromatous or calcareous degeneration. If the latter change has taken place to a marked degree, one can often feel the arterial wall to be uneven and ribbed. If the artery can be felt to be tortuous, one is justified in inferring that the patient has been the subject of relatively high blood pressure extending over a long period. In examining the wall, as described above, an impression will often be received of *the calibre or fulness of the artery*. One is very apt to be misled on this point, according to Leonard Hill, by the fact that the venæ comites accompany the artery and contribute to the sensation of size given to the finger.

The arterial pressure may be roughly estimated by the amount of pressure which must be exerted by the finger to obliterate the pulse in the portion below. The artery should be pressed directly backward against the radial bone, and it is well to compress it below as well as above the examining finger so as to exclude any "anastomotic pulse" from a communicating vessel. A correct judg-

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ment as to arterial pressure can be acquired only by much practice. One is very liable to confuse the sensation given by high arterial pressure with that of a thickened or calcareous artery.

Low arterial pressure is found in fevers, especially the later stages, in most wasting diseases, and in many forms of heart disease. High pressure occurs especially in nephritis, lithæmia, and lead poisoning.

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The pulse proper should be examined with reference to its rate, regularity, size, and quickness. The so-called *hardness or softness of the pulse* is practically identical with the arterial pressure which has just been discussed. *The rate of the pulse*, whether frequent or infrequent, is to be determined by counting the pulse beats by a watch for not less than half a minute. It is well to note the number of beats in each period of five seconds so as to determine whether or not the rate is variable.

When the pulse is too frequent to be successfully counted in the ordinary way it is sometimes possible to calculate its rate by counting every second beat and doubling the result. When some or all of the beats are too feeble to be distinguished, the rate can be obtained by auscultation of the heart. A record of the variations in the pulse rate from day to day is often valuable. Before drawing conclusions from the rate of the pulse, due weight must be given to the fact that it may be modified by very slight influences such as the position of the patient or slight mental excitement. If the rate be abnormally high it should be counted again when any excitement has had time to subside. The rate of the pulse varies much within the limits of health. *Age* has a very great influence. The average rate is something over 130 in the first year of life, about 90 in the tenth year, 70 in adult life, and 75 or 80 in those who have passed the allotted span. *Sex* has little influence, the average in females being only a few beats per minute more than in males of the same age. What little difference there is in the two sexes may with reason be attributed to *size*, for, as a rule, the larger the body the less frequent the pulse. Tables showing in more detail the effects of age, sex, and size on the rate are given in the article on *Circulation*. *The time of day* has a slight influence on the pulse rate, which is usually five or ten beats higher in the afternoon and evening than in the morning. *Meals*, especially if hot, may increase the rate for one or two hours. *Change of position* from lying to sitting raises the rate from two to five beats per minute. On standing a further increase of four to eight beats may result. *Exercise* has a still greater influence, very slight exertion sending the pulse up twenty or thirty beats, and violent exercise may more than double the rate. An increased frequency out of all proportion to the effort made is commonly seen in the debilitated and the diseased.

Pathological frequency of the pulse may be conveniently divided into three groups (Mackenzie). First, those in which the heart responds to an extra call upon it by an excessive increase of rate; second, those in which the pulse rate is continuously increased; third, those in which periods of increased rapidity take place in irregular paroxysmal attacks.

To the first group of *abnormal excitability* belong all cases in which the reserve power of the heart is impaired. This may be the result of some general disease or of valvular or other heart affection. When no other sufficient cause can be found, one may suspect a neurotic temperament or the abuse of some stimulant or narcotic (alcohol, tea, or tobacco).

In the second group of *continued frequency* we may place (*a*) most febrile diseases. In fever the pulse usually bears some relation to the temperature. It is commonly increased about ten beats per minute for each degree Fahrenheit of pyrexia. Marked exceptions to this rule are found in typhoid fever where the increase in the pulse rate is usually small for the amount of pyrexia, and in meningitis where the rate is very variable, but may be lower than normal in spite of considerable fever. (*b*) Diseases of the heart. Increased frequency of the pulse is a common but by no means an invariable symptom of valvular disease. In disease of the aortic valves, especially aortic stenosis, the pulse rate is less likely to be increased than in mitral disease. In degeneration of the heart muscle the pulse rate is very variable, and may be either higher or lower than normal. The rate is usually increased in pericarditis and in overstrain from excessive work. (*c*) Exophthalmic goitre. (*d*) Numerous other conditions such as incipient tuberculosis, exhausting diseases, neuroses, pregnancy, hemorrhage, alcoholism, great anxiety, severe pain.

The third group of *paroxysmal attacks* embraces palpitation and paroxysmal tachycardia. In *palpitation* we have a sudden onset of rapid, violent heart action accompanied by throbbing of the larger arteries. This excessive throbbing does not extend to the smaller arteries, "the radial pulse, for instance, being rapid but having no excess of force" (Balfour). True palpitation occurs in weakly anæmic individuals, and is induced by psychical and gastric reflexes of various origins, "never by exercise." The patient is usually painfully conscious of the violent action of his heart.

In *paroxysmal tachycardia* the subjective symptoms are less pronounced. The heart may be beating even more frequently than in palpitation, and yet the patient be unconscious of the fact. The attacks are variable in duration, but may last several days. During the attack the heart frequently dilates as a result of incomplete emptying by the rapid feeble beats. Mackenzie looks upon the disease as caused by some local heart stimulation giving rise to a prolonged series of premature systoles.

Diminished frequency of the pulse must always be carefully distinguished from those cases of missed beat in which only every second pulse is strong enough to be felt at the wrist. It is a safe rule to count the heart sounds before diagnosing an abnormally slow pulse. An infrequent pulse is sometimes present in individuals who show no other signs of disease. It is said that the pulse of Napoleon Bonaparte was never over forty. An infrequent pulse is most common in the latter half of life. It may sometimes be a symptom of degeneration of the myocardium. It is often seen in diseases accompanied by high blood pressure, such as chronic nephritis, and as a result of poisons produced within the body, as in jaundice, or introduced from without, as digitalis. The most marked instances of infrequent pulse, or *bradycardia*, as it is called, are those following injury to the spinal accessory nerve. This nerve arises from the spinal cord as far down as the fifth or sixth cervical vertebra, and may be implicated in fracture of the spine or inflammatory compression of the cord in this region. In such cases the pulse may fall to thirty, twenty, or even lower. A pulse rate of eight per minute has been recorded. In such cases syncopal attacks and epileptiform seizures are common.

Regularity of the Pulse.—In healthy people who are not suffering from any disturbing influences, the pulse beats are usually regular in rhythm and volume. This may be recognized by the examining finger. In some cases, however, we find variation in the intervals between the beats or in their volume or both. Such departures from the normal present themselves in a great variety of types which are often referred to by different names in the various books on the subject, so that considerable confusion of terms exists. The following table is suggested as a classification of the different kinds of irregularity, although I am quite aware of its imperfections and recognize the fact that there is some overlapping so that the same pulse might be put under more than one heading:

- Allorrhythmia (Greek, another rhythm).
  - P. alternans.
  - P. bigeminus.
  - P. trigeminus.
  - P. paradoxus.
- Arrhythmia (without rhythm).
  - P. intermittens (dropped beat).
    - P. deficiens.
    - P. pseudo intermittens (hemisystole).
  - P. intercidiens (premature systole).

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P. irregularis.
Diastolic.
Systolic.

In *allorrhythmia* the variations in rhythm are themselves rhythmical. Thus in the first subdivision, *pulsus alternans*, we have alternately a strong pulse beat and a weak one. This is sometimes ascribed to a strong beat of the left ventricle and a weak beat of the right ventricle alternating with a weak beat of the left side and a strong beat of the right side. In *P. bigeminus* the beats are in pairs, two beats with a short interval between and then a pause. P. bigeminus must be carefully distinguished from *P. bisferiens* which is a pulse where the predicrotic wave is well marked so that each single pulse has a double crest. In *P. trigeminus* there are three beats and then a pause. Cases are reported in which there are two beats and a pause followed by three beats and a pause. *P. paradoxus* is where the pulse becomes extremely feeble or fails altogether at the end of each inspiration. When pronounced this form of pulse usually indicates adhesive pericarditis or great obstruction of the respiratory passages. A slight variation in the pulse at different stages of respiration may be present in healthy people.

Arrhythmia includes those forms of pulse irregularity which have no rhythm of their own. *P. intermittens* is where from time to time the finger misses a beat. It is sometimes spoken of as dropped beat. Where the ventricle misses a contraction altogether we speak of a *P. deficiens*. Where there is a beat of the ventricle which, while it can be heard over the heart, is too weak to propagate a pulse to the wrist, we speak of a *hemisystole*, causing a false intermission. In *P. intercidiens* instead of a beat being dropped out we have one occurring before its proper time. We may refer to this event as a *premature* systole. Such a premature systole is often too feeble to be felt at the wrist, and is then a hemisystole also. At other times it is distinctly felt, and when it occurs at regular intervals may give rise to a pulsus alternans or pulsus bigeminus. Where there are one full beat and two premature systoles regularly repeated we get a pulsus trigeminus. Under the heading simply of *pulsus irregularis* we may put any irregular pulse that cannot be classified in any other group. This and pulses of the other groups as well, may be separated into two divisions of some practical importance. In the first of these the irregularity is due to a variation in the length of the pause (*diastolic*). Such irregularity is frequently found in the healthy, and is of little importance. In the other division the irregularity is due to variation in the force and duration of the ventricular contraction (*systolic*), and the pulse beats are felt to vary in strength. Pulses of this kind are more apt to indicate danger and should be carefully considered after thorough examination of the heart. Diastolic irregularity is frequently seen in children, and Mackenzie proposes to call it *the youthful type* of irregularity, although it is often seen in adults too, especially as the pulse is slowing down during convalescence from a fever. For systolic irregularity Mackenzie proposes the term *adult type* of irregularity. The terms systolic and diastolic seem to the present writer less open to objection.

In looking for the *cause of pulse irregularity* we first turn to the heart and find that sometimes the lack of normal rhythm is due to independent action of the ventricle and sometimes may be traced back to the auricle. To determine which chamber is primarily at fault may best be complished by taking simultaneous tracings from the radial and jugular, as will be further explained shortly in connection with the venous pulse and also in the article on *Sphygmography*. Irregularity is frequently a result of the strain put upon the heart by valvular disease, but is not often seen in pure aortic cases. It is especially in cases of advanced mitral disease in which the auricles are overworked and distended, perhaps paralyzed, that we get the most pronounced forms. Among other causes of irregularity are myocarditis and fatty degeneration, anæmia, strain, and digitalis poisoning. The latter is said to be often characterized by a pulsus trigeminus.

One cause of pulse irregularity that requires special discussion is vagus inhibition. Some writers go so far as to make influences reaching the heart through this nerve almost the sole cause. Such a statement is doubtless an exaggeration, and yet many influences act reflexly through the vagus in such a way as to cause irregularity. Among these we may include emotional shocks, such as sudden joy, sorrow or fear, mental strain and worry, gastro-intestinal disturbance, pain, injury, cold, either external or internal.

Fig. 3900 is a tracing from a patient in whom the heart appeared quite normal. She had suffered much from domestic trouble for several months and it is possible that that was the cause of the irregularity.

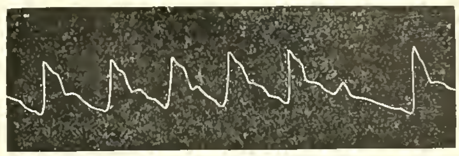

Fig. 3900.—Pulse showing Premature Systole.

To the finger on the wrist it seemed as though there were an occasional intermission. The pulse tracing shows that this was not a pulsus deficiens but merely a weak beat (hemisystole). If careful measurements be made it will be seen that the weak pulse beat comes a little before it is expected (premature systole). One frequently finds irregularities of this kind in people without any other symptoms of disease. An instance which came under my notice recently would suggest that it may sometimes be an hereditary peculiarity. I had the opportunity of examining a father and son, both of whose pulses were irregular. In the father's pulse there was a weak premature systole at intervals varying from a few beats up to thirty or more. In the son they occurred every four or five beats if he kept very quiet, but slight exertion caused the entire disappearance of the irregularity. Both of these men have hearts rather below than above the average size, and neither of them has any symptoms of disease.

As to *prognosis in cases of irregularity*, such cases as those just mentioned in which the heart appears quite sound need not excite any alarm, especially if the irregularity be known to be of long standing. If the heart is dilated the case should receive more consideration. Cases of diastolic irregularity in the young or convalescent need not excite any alarm. It is a totally different thing when an irregularity develops in a case of old heart disease or in the course of a fever. In both of these cases it suggests overloading or paralysis of the auricles, and is a symptom of danger. Cases of pneumonia in which the pulse becomes intermittent before the crisis are usually fatal. As a rule, where people have an intermittent pulse during health the onset of fever causes the intermission to disappear. When this does not occur, it may be taken as a danger signal. Generally speaking, the more rapid the pulse the more serious is the occurrence of intermission or other irregularity. Irregularity can be given its proper importance only when considered with other symptoms. If there are no other serious symptoms and the heart can respond well to extra calls upon it, then irregularity is of little importance. When, on the contrary, there are other symptoms that the heart is laboring under stress of work, then irregularity may be taken as an additional bad sign, and the more so the higher the temperature and the more frequent the pulse.

Size or Excursion of the Pulse.—Pulsus magnus or parvus, large or small pulse. These terms are used to describe the sensation that the finger has of being lifted as the pulse wave passes. When the sensation is very considerable we speak of a large pulse, when it is slight of a small pulse. One naturally explains this sensation by supposing that the artery expands as the result of increased tension. Many writers, however, among whom

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Sir William Broadbent is prominent, minimize the effect of arterial expansion or deny its occurrence. According to them the finger pressing upon the wrist pushes in or flattens the artery between the beats, but feels a tendency of the vessel to resume its cylindrical shape under the increased tension of the pulse wave. This latter view seems very reasonable, but some slight expansion must certainly take place.

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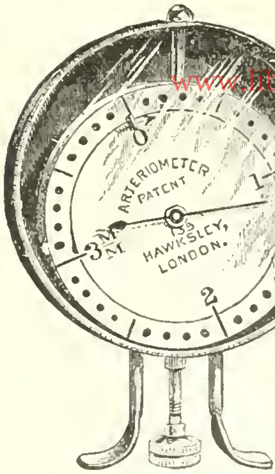

FIG. 3901.—Oliver's Arteriometer.

A large pulse means that a large quantity of blood is being forced into the arterial system at each heart beat and points to a powerfully acting ventricle and unobstructed vessels.

A small pulse may be present in a variety of conditions. It may be from the presence of some disease of the valves of the heart putting the ventricle at a disadvantage. It may be from some obstruction between the ventricle and the wrist, such as aortic stenosis, aneurism, or tumor. Or the artery being examined may be abnormally small on account of some other artery like the ulnar being larger than usual. The most obvious cause of all is a heart beating feebly.

If we get a small pulse in a contracted artery we call it a wiry pulse, if the arterial tension is still considerable; if the tension is low and the pulse very small, we speak of a thready pulse, which is seen in cases of severe shock or where a patient is in extremis. A small pulse in a relaxed vessel is sometimes spoken of as a trembling or a running pulse.

Quickness of the Pulse.—Pulsus celer or tardus, quick or slow pulse. These terms are properly applied not to the rate of the pulse, but to the suddenness with which the expansion of the vessel takes place. In the quick pulse the sensation imparted to the finger is that of a sudden tap. In the slow pulse there is a sensation of more gradual lifting or heaving, and the feeling of pressure lasts for an appreciable time. A quick pulse is seen when the ventricle empties itself easily. It is usually present when the blood pressure is low, but not in aortic stenosis, for then there is obstruction to the work of the ventricle. The most characteristic form of quick pulse is the Corrigan's or water-hammer pulse of aortic regurgitation. The character of a slow pulse differs according to the position where the obstruction to the outflow of blood from the ventricle may be. If the obstruction is at the aortic valves the pulse is slow and of low tension, as in aortic stenosis. If the obstruction be in contracted peripheral vessels, then the pulse is slow and of high tension, as in chronic nephritis.

A dicrotic pulse is one where the dicrotic wave can be felt as well as the primary wave It is characteristic of relaxed vessels with a fairly strong heart action. It is most common in fever where the arterial tension is usually rather low. When the blood pressure falls very low, as in a failing heart, the dicrotic wave tends to disappear. It will be more fully discussed in connection with pulse tracings.

Symmetry of the Pulse.—An examination of the pulse is not complete without comparing the corresponding arteries on the two sides of the body. When there is a difference on the two sides, it is necessary to trace up the course of the vessel on the side where the pulse is weakest. Somewhere in its course from the heart to the wrist one may find a tumor or aneurism or deformity causing pressure and partial obstruction. Dr. Allison, of Edinburgh, made the claim in a clinical lecture some seventy years ago that he had observed in a severe case of fever that the pulse had a fuller character on the side on which the patient was lying. He ascribed this to the influence of gravity acting on weakened relaxed vessels much as it would do after death. I do not think there is anything in Oliver's recent experiments to render this unlikely.

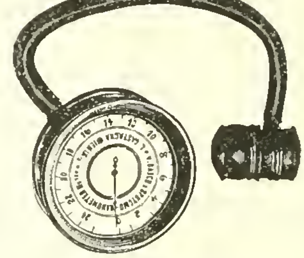

FIG. 3902.—Von Basch's Sphygmomanometer.

Field of Response.—This is a term suggested by Mackenzie for the ability of the heart to rise to occasions. We may also speak figuratively of the heart's "bank account." This may be investigated by noting the effect upon the pulse of various degrees of exertion. Sometimes a pulse which seems good when the patient is resting changes its rate and character to such an extent on slight exertion as to indicate serious weakness. The breathing should be noted and may furnish confirmation of the opinion formed from the pulse. This is a method of considerable value in estimating the seriousness of an irregular pulse. The less dangerous forms of irregularity tend to disappear on slight exertion, whereas cases due to a failing heart may be expected to show increase of irregularity and breathlessness.

INSTRUMENTAL AIDS in the examination of the pulse. *The calibre of the vessel* may be approximately measured by *Oliver's arteriometer* of which an illustration is given in Fig. 3901. The principle is that a pointer on the graduated dial marks the distance which the central foot has to be pushed down from the time it begins to press on the artery till it quite obliterates it. The readings of this instrument may not be absolutely reliable, but it is sufficiently accurate for comparing the size of the same artery under different circumstances. In this way it has been used by the in-

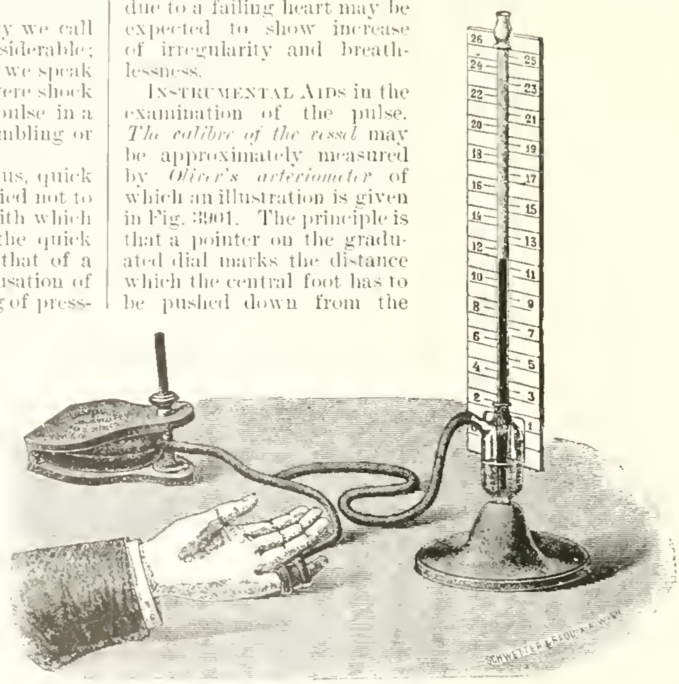

FIG. 3903.—Gaertner's Tonometer.

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ventor for working out the effect of various influences on the vaso-motor tone and the distribution of the blood in the body.

Arterial Pressure.—A number of instruments are on the market for measuring the arterial pressure in man and several different principles are represented. The best known instrument for this purpose is perhaps the *sphygmomanometer of von Basch.* This is shown in Fig. 3902. It consists of a capsule which is pressed upon the radial artery until the pulse is obliterated below, and a dial and pointer which indicate how much pressure has been exerted. It is only moderately accurate. Leonard Hill claims that errors as great as from 30–70 mm. of mercury are made with it. Much would doubtless depend upon the man using it. *The tonometer of Gaertner* (Fig. 3903) seems to be a very good instrument. Dr. Orr, of Montreal, reported at a recent meeting of the Canadian Medical Association an exhaustive study of the pressure in different diseases in which this instrument was used. The most striking results were the high pressures obtained in many cases of nephritis, and the fact that in cases of valvular disease of the heart the pressure average was not very different from that found with sound hearts. With this instrument we measure the amount of pressure which must be exerted around a finger to prevent the blood flowing through its vessels. The instrument as shown is well adapted for the office, and a more portable modification may be obtained for carrying about.

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Other instruments for measuring blood pressure depend upon the principle that the excursion of the pulse is greatest when the pressures inside and outside the artery are equal. The *sphygmometers of Hill and Barnard*, the *sphygmomanometer of Riva Rocci*, and the modification of it used in the Johns Hopkins Hospital, and the *hæmodynamometer of Oliver* are all of this type. Of all these the simplest is one of the two forms invented by Hill and Barnard (Fig. 3904). It consists of a vertical glass tube five inches in length which expands above into a small bulb and is closed at the top by a glass top. A small india-rubber bag partly protected by a metal cup is fixed to the tube below. The bag is filled with colored fluid, and on pressing it down upon an artery the fluid rises in the tube and compresses the air in the bulb. The more one presses the more the fluid rises; at a certain height the meniscus of the fluid exhibits more pulsation than at any other height. At this point the top of the meniscus indicates the arterial pressure. This instrument has been described at length because it is cheap, simple, and fairly accurate if carefully used.

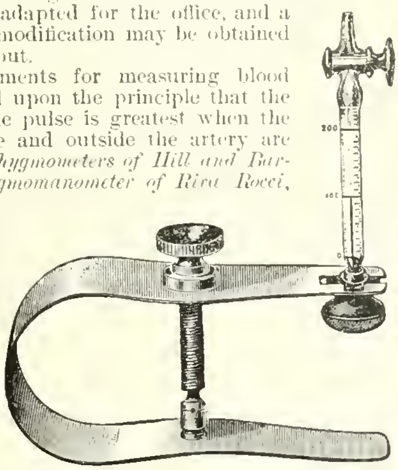

FIG. 3904.—Sphygmometer of Hill and Barnard.

The pulse waves may be made to record themselves automatically by one of the various forms of *sphygmographs.* These instruments, as already said, are contrivances by which movements of a blood-vessel are transmitted to a lever, which records them on smoked paper. For the various forms of instrument and the method of using them the reader is referred to the article on *Sphygmography.* The product is a tracing, of which a normal example has already been given in Fig. 3897.

Criticism and Appreciation of the Sphygmograph.—It was thought for a time that the sphygmograph would indicate, so that he who ran might read, the pressure, size, and quickness of the pulse, as well as the peculiarities incident to various diseases; these hopes have proved vain, and we now know that the sphygmograph is inferior to the finger in most of these points. One great difficulty in the interpretation of the sphygmogram is that a great variety of tracings may be obtained from the same pulse by simply varying the pressure of the

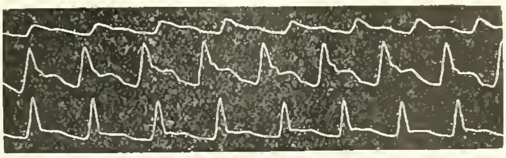

FIG. 3905.—Pulse Tracings which show Effect of Varying Pressure.

instrument or by employing different makes. Fig. 3905 shows three pulse tracings taken within a few seconds of each other from the radial artery of the writer. The differences are due to the pad being pressed down upon the artery with varying force. Fig. 3906 shows tracings taken, the upper from the carotid, and the lower from the radial of the same subject, within a few minutes of one another. In this case the carotid was recorded by air transmission and the radial by transmission through a spring. Features are sometimes found in pulse tracings which do not represent anything in the pulse at all, but are dependent on inertia or rebound of the instrument.

In spite of all these pitfalls that beset us, however, it is possible to take sphygmograms that will afford us much information about the pulse and the conditions which determine its character. In tracings we can see the principal events of the pulse in their proper time relations. They show us what to feel for, and corroborate or controvert the opinions we have formed of the pulse from our tactile examination. The sphygmograph is very useful as a guide to those who are learning to feel the pulse and in whose finger tips the tactile sense is not fully educated. There are points about the pulse, too, that even the most highly trained "thumb and finger fail to plumb" which are shown with ease by this instrument. The dicrotic wave and the predicrotic wave usually belong to this category. In irregular pulses we often have premature systoles or other weak heart beats causing pulse waves too weak to be felt by the finger, but not too weak to be shown by the instrument. Then tracings enable us to compare the time relations of the waves in different arteries or to compare the time of the arterial pulse with the heart beat or with the venous pulse. Such tracings are of value in working out the rate of propagation of the pulse and the direction in which the waves travel. The venous pulse very often can only be safely interpreted in the light of such simultaneous tracings.

It is doubtful whether sphygmography will ever be a routine method in general practice, but for the specialist, the teacher, and the investigator it is very valuable, and, when the elements are mastered, becomes an interesting and instructive practice.

Normal Pulse Tracings—High and Low Pressure.—The four tracings shown in Fig. 3907 are all taken from people in good health without any circulatory or general disease.

As far as tracings can do so, the first of these four sphygmograms indicates rather high blood pressure and

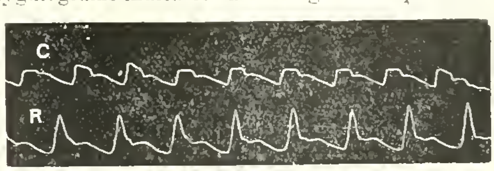

FIG. 3906.—Pulse Tracings Taken from the Carotid (*C*) and the Radial (*R*).

the last one low pressure, while the two between represent intermediate conditions. One is safer in trusting the finger for indications of the arterial pressure than in

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trying to read it from a tracing, but attention to the following points usually enables one to form a fairly correct opinion from a tracing. In the first place the tracing must be taken by a person of experience. A poorly

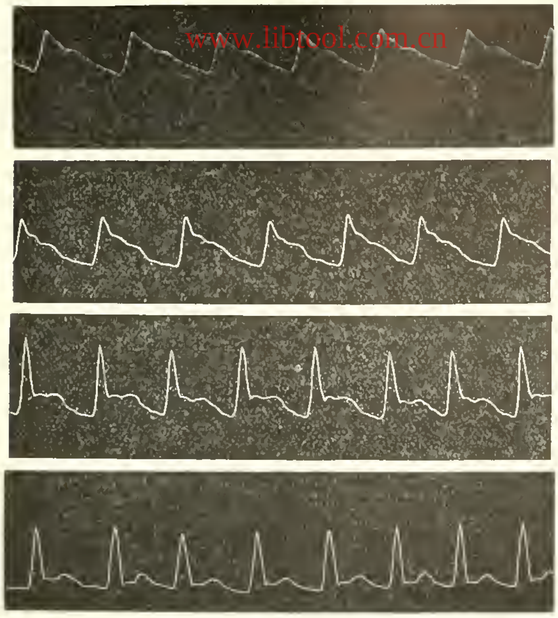

FIG. 3907.—Normal Pulse Tracings, Indicating Different Arterial Pressures.

taken tracing is very misleading. Where the blood pressure is high the rise and fall of the waves are more gradual, in low blood pressure quick or steep. In high blood pressure the dicrotic wave is small and high up on the descent. As the blood pressure becomes lower this wave becomes more distinct and approaches nearer to the base line, and may appear as a wave rivalling the primary wave in size and separated from it by a distinct interval. If the blood pressure becomes very low indeed, as in cardiac failure, then the dicrotic wave becomes smaller again and may quite disappear. A well-marked dicrotic wave is a sign of relaxed peripheral vessels and not of a weakly beating heart. It is seen best developed at the beginning of fevers when the skin is hot and the blood distributed to the surface, but the heart still beating strongly.

The predicrotic wave is most pronounced in cases in which there is most resistance to the outflow from the ventricle, and therefore usually indicates high blood pressure. It is also seen, however, in aortic stenosis (see Fig. 3899). A practical rule for judging of the predicrotic wave is given by Gibson: "Draw a line from the top of the primary wave to the lowest point of the dicrotic notch." If the predicrotic wave fails to reach this line the pulse is of low or medium pressure. If the predicrotic wave rises higher and crosses this line the pulse is of high pressure (better, the resistance to outflow of blood from the ventricle is great). Another peculiarity often

FIG. 3908.—High-Tension Pulse. (Hutchison and Rainey.)

seen in high-pressure pulse tracings is the presence of several oscillation waves on the descent such as those seen in parts of Fig. 3908.

When interpreting tracings it is well to bear in mind that the part from the beginning of the primary wave to the bottom of the dicrotic notch corresponds to the time when the blood is being driven out of the ventricle into the arterial system. This almost corresponds with the ventricular systole, and may conveniently be called *the systolic portion* of the tracing. From the bottom of the dicrotic notch to the beginning of the next primary wave the aortic valves are closed and no blood is leaving the ventricle. This may be called the *diastolic portion* of the tracing.

Any peculiarities in the systolic portion may usually be traced to the ventricle; but the diastolic portion cannot depend directly upon the ventricle, as during this time the aortic valves shut off the arteries from the heart. Variation in the rate of the pulse is brought about principally by shortening or lengthening of the diastolic por-

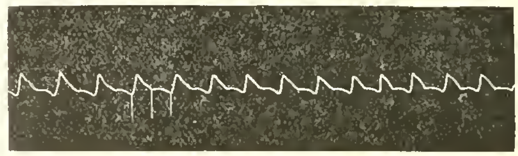

FIG. 3909.—Frequent Pulse.

tion. Thus in an infrequent pulse like that in Fig. 3908 the diastolic portion which I have marked *D* is about twice as long as the systolic portion *S*, whereas in Fig. 3909 where the pulse was 130 as the result of a fever, the two portions are of about equal duration.

In some cases the shortening of the diastolic portion takes place to such an extent that the next percussion wave commences before the dicrotic wave is complete and cuts into the descending limb of the latter. The result is a tracing like that shown in Fig. 3910. *S* is the percussion and *D* the dicrotic wave. It will be noticed that the dicrotic notch *N* is the lowest part of the tracing. Such a tracing is called *hyperdicrotic* or *superdicrotic*.

THE PULSE IN VARIOUS PATHOLOGICAL CONDITIONS.—*Affections of the Aortic Valve.*—The pulse of aortic regurgitation is one of the most typical, and is known as *Corrigan's pulse*, from Sir Dominic Corrigan, who was one of the first to describe it, or as the *water-hammer pulse* from a toy of that name that gives a sudden shock to the

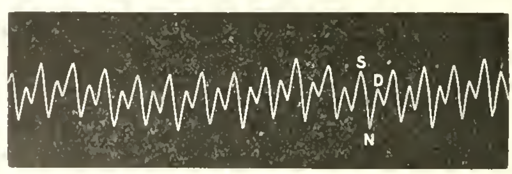

FIG. 3910.—Hyperdicrotic Pulse. (Mackenzie.)

fingers. Corrigan's pulse may be described as large and quick, usually infrequent and regular. It is sometimes described as collapsing because the vessel seems to become empty between the pulse beats. The impression given to the finger is that of a momentary tap.

The peculiarities of Corrigan's pulse are best made out by raising the patient's arm high above his head while feeling his radial.

The statement made by Henderson, Balfour, and others that the rate of propagation is slower in aortic regurgitation than where the heart and vessels are normal has been shown by François Frank, Keyt, and Mackenzie to be without foundation. A prominent feature of aortic regurgitation is the violent throbbing of the vessels of the neck. A capillary pulse may also usually be seen. In some cases the pulse wave passes right through the capillaries into the veins and may be observed in the veins of the back of the hand, and, sometimes, a tracing may be obtained of this rare form of venous pulse. Such a tracing is figured in Gibson's book on the heart.

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Tracings from the radial in aortic regurgitation are characterized by a steep rise and fall of the percussion wave and by the fact that the predicrotic wave is usually more pronounced than the dicrotic. The tracing shown


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FIG. 3911.—Aortic Regurgitation.

in Fig. 3911 is from a case of moderate severity and illustrates these points. In a more pronounced case the dicrotic wave would be still less marked or even absent altogether, and the percussion wave might be even steeper in its rise and fall. The presence of a fairly pronounced dicrotic wave does not, be it noted, exclude a moderate degree of aortic regurgitation.

The pulse of *aortic stenosis* is not so characteristic as that of regurgitation. It usually feels slow and sustained to the examining finger, is of normal or diminished frequency, and, like that of aortic regurgitation, regular in rhythm and volume. The tracing is usually anacrotic (see Fig. 3899). The predicrotic wave rises higher than the primary, indicating the difficulty the ventricle has in emptying itself. The details vary in different cases. Sometimes the primary and predicrotic waves form two well-marked crests separated by a distinct depression, forming the so-called *pulsus bisferiens.* In other cases instead of the tracing being anacrotic we may simply have a primary wave with a gradual rise and a rounded crest, followed by a poorly marked dicrotic wave.

In *mitral regurgitation* and *mitral stenosis* the pulse may be quite indistinguishable from the normal. As one or other of these diseases progresses, however, dilatation of the ventricle, and especially of the auricle, takes place; then the pulse tends to become weak, rapid, and markedly irregular in both rhythm and volume, constituting the so-called "*mitral pulse.*" This pulse varies so much in its details in different cases that it is useless to figure any one form as typical.

Affections of the Heart Muscle.—There is nothing uniform or typical about the pulse in these conditions. It may be abnormally slow or fast or irregular. The cardiac field of response is diminished. Any departure of the pulse from the normal rate or rhythm should lead one among other things to consider the probability of the heart muscle being diseased, but other considerations besides the pulse will have to be depended on for the solution of the question.

The presence of the pulsus paradoxus in certain cases of *adhesive pericarditis* has already been referred to.

In *aneurism* of the transverse part of the aorta the left radial pulse is often smaller and slower than the right. It sometimes feels delayed too, but this is questioned by some writers. The exact character of the radial pulse varies greatly in cases of aneurism according to the situation of the disease, the degree of degeneration of the vessels generally, and the condition of the aortic valves. Fig. 3912 shows simultaneous tracings from the aneurism and the right radial in a case in which a large pulsating aneurism extended from the chest up the right side of the neck. The exaggeration of the predicrotic wave seen in this tracing seems to be very common in aneurism, as it is in both forms of aortic valvular disease.

In fever we have to distinguish between the effect of the pyrexia as such upon the pulse and the effect of the disease causing the pyrexia. Moderate pyrexia tends to modify the pulse through both the heart and the peripheral resistance. The heart is made to beat more rapidly, partly by a direct action of the increased temperature on the heart tissue itself, and partly indirectly through the cardiac centres in the medulla. The superficial arteries are dilated and an increased amount of blood is carried to the skin. The effect of these changes is to cause a pulse of increased frequency and diminished pressure with exaggeration of the dicrotic wave. To the finger such a pulse feels frequent, large, and soft. It is often referred to as bounding. A tracing would more or less approach the type shown in Fig. 3913.

If the pyrexia runs high or lasts long the heart suffers and becomes feeble and often irregular. In such cases the pulse is very frequent and is small, soft, and compressible. Tracings taken at intervals, when the heart is failing, show gradual disappearance of the dicrotic wave, the absence of which in a case of fever is usually a very bad sign. Irregularity of the pulse in the early stages of a fever or increase of rate in an adult beyond 140 per minute are symptoms which usually indicate great danger. During convalescence slight irregularity is common and of little significance. The character of the pulse in fever may be much modified by other influences, such as specific poisons or mechanical interference.

SUMMARY OF THE DIAGNOSTIC VALUE OF THE PULSE.—The pulse furnishes the best single indication of the state of efficiency of the circulation. In it we find indications both of the condition of the vessel walls and of the strength of the heart beat.

Very important information may be obtained by observing the changes in the pulse during bodily activity.

The discovery of high tension may direct our attention to the presence of nephritis or lithæmia.

In aortic valvular disease a quick collapsing pulse or a

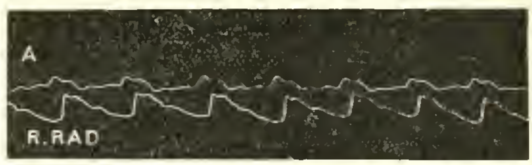

FIG. 3912.—Simultaneous Tracings from a Thoracic Aneurism and from the Right Radial Artery.

slow, small pulse will indicate the predominance of regurgitation or stenosis.

In mitral valvular disease a rapid irregular pulse is suggestive of loss of compensation and dilated or paralyzed auricles.

In pericarditis with effusion, where the heart sounds are faint, the pulse is of especial value in indicating the degree of cardiac failure.

In fever the rate, the tension, and the presence or absence of irregularity are of great prognostic value. A sudden change in the pulse may be the first indication of a crisis or a fresh complication. In many diseases the pulse is of value in furnishing indications for treatment (stimulants) and in exhibiting the effect of the remedies used.

In the search for all these indications the finger is the best means to employ. In special cases some of the more elaborate instruments may furnish additional or confirmatory information.

THE VENOUS PULSE.—*Introductory.*—The term venous pulse is applied to changes in size and tension occurring in the veins as the result of the action of the heart. The

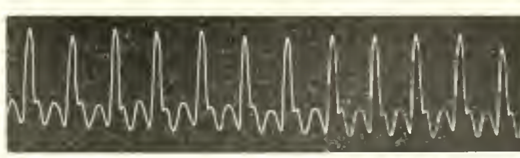

FIG. 3913.—Pulse in Sthenic Fever. (Mackenzie.)

distention and collapse of the veins caused by the alternate phases of respiration are not included. A true venous pulse in a healthy animal seems to have been first described by Wedemeyer of Hamburg, in 1828. He made his observations on a horse. Since that time numerous physiologists have seen and recorded the venous

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pulse in healthy dogs, cats, rabbits, and other animals. It has been noted in the veins of the thorax, neck, abdomen, and limbs. Mosso obtained the first venous pulse tracing from a human subject in 1879. Since then those who have looked for it in man have found it to be very common. In the writer's experience it may be seen and recorded in the majority of people by those who make the examination under suitable conditions. It is most frequently seen in the jugular veins, external and internal. In the case of the external jugular one can usually see the blue vein through the skin; in the case of the internal jugular one can see the movements imparted to the skin over it. Sometimes one vein can be seen best, sometimes the other. For the observation of the venous pulse two conditions are usually necessary, viz., that the veins be reasonably distended with blood, and that the neck be not too fat. Probably in the majority of people the recumbent position is necessary for it to be recognizable. For the method of taking tracings of the venous pulse see *Sphygmography*.

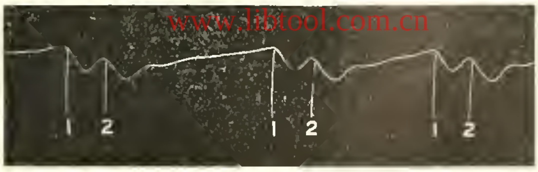

FIG. 3914.—Negative Venous Pulse (dog).

VARIOUS FORMS OF VENOUS PULSE. — The venous pulse is seen in many different forms. This renders its study more difficult than that of the arterial and has discouraged many from undertaking it. Its modifications, however, may be traced with considerable confidence to their respective causes, and are replete with indications of the condition of the heart for those who will take the trouble to familiarize themselves with them. James Mackenzie, who has written more exhaustively on the venous pulse than any other English writer, claims that it "gives us far more information of what is actually going on within the chambers of the heart" than the arterial pulse.

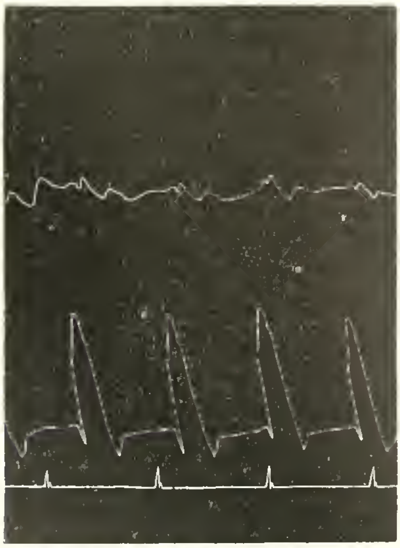

FIG. 3915.—Curves of Auricular (above) and Ventricular Pressures, from a Dog. Time in seconds.

The principal forms met with may be designated according to their place of origin as:

1. Auricular, negative, or normal.
2. Ventricular, positive, or pathological.
3. Arterial.
4. The modified negative of auricular paralysis.

The auricular or *negative* venous pulse follows very closely the curve of pressure in the right auricle. It is obtained in its most complete form when the pulse is not too frequent. Fig. 3914 is taken from the internal jugular of a dog under the influence of morphine with a pulse rate of 45 per minute.

It will be observed that the down strokes in the tracing which denote the collapse of the vein (negative pulse) are far steeper than the rises which indicate refilling. The fall beginning at 1 is called the *systolic collapse*, and is due to the diastole of the auricle drawing in blood from the veins during the ventricular systole. The fall beginning at 2 is the *diastolic collapse* due to the diastole of the ventricle. The ascending portions of the tracing, which indicate filling of the veins, are caused principally by the blood flowing in from the capillaries faster than the heart can receive it. Just before the systolic collapse (1), however, we may in some cases observe two small elevations, the *presystolic* and the *systolic rise*. These may be traced back to their origin in the systole of the auricle and of the ventricle. We speak of the long ascent leading up to these waves as the *diastolic rise*. The irregularities at the beginning and in the middle of this diastolic rise are unexplained. The interpretation given above of the systolic rise as due to an impact propagated backward through the auricle and veins by the ventricular systole is disputed by some writers (Mackenzie), who ascribe it entirely to a shock imparted to the vein by the pulse in the carotid. This view is doubtless partly true, as there is often a wave in the venous pulse due to the carotid impact; but it is equally true that there is quite frequently a wave at the top of the diastolic rise that can be found both in the venous pulse and in the curve of auricular pressure, and that may be shown to be synchronous with the ventricular systole. In Fig. 3915 simultaneous tracings are shown of the pressures in the right auricle and ventricle of a dog taken with Hürthle's catheter. Corresponding points of time are marked by the vertical lines. It will be noted that there is a very distinct wave in the auricle synchronous with the ventricular systole. This is no doubt due to the rise of pressure in the ventricle pushing the tricuspid valves back and thus imparting a shock to the auricle.

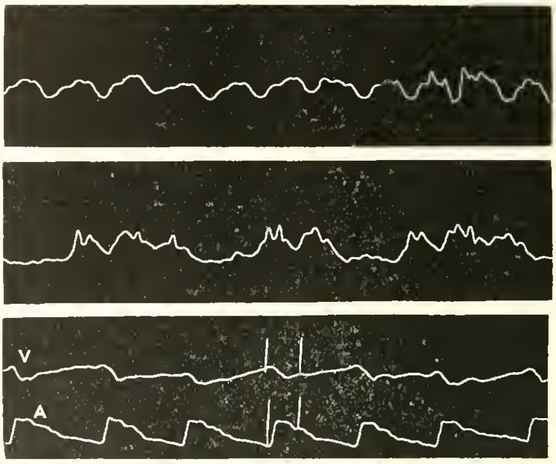

FIG. 3916.—Three Types of Negative or Auricular Venous Pulse (human).

For the rise in the tracing (Fig. 3914), leading up to 2 there is, so far as I know, no satisfactory name. Some writers call it the first diastolic rise, but it is systolic in time. Others call it the ventricular rise, but it is not caused by the ventricle but by the blood flowing in from the periphery. A rational term to apply to it would be the *prediastolic rise*, for it leads up to and is interrupted by the ventricular diastole.

When the pulse is frequent the waves are crowded together, and some of those described are not seen at all or cannot be identified. Take, for instance, Fig. 3916 where three examples are given of venous pulse tracings from human subjects. It is very difficult to distinguish the different waves described above in these three tracings. In the last of the three a method is shown by which the difficulty may be partially solved. In this, simultaneous

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records are taken from the external jugular vein (above) and the radial artery (below). Corresponding points of time are marked on the two tracings, and by these it can be seen that synchronous with the rise of the radial pulse tracing there is a fall in the venous, the systolic collapse.

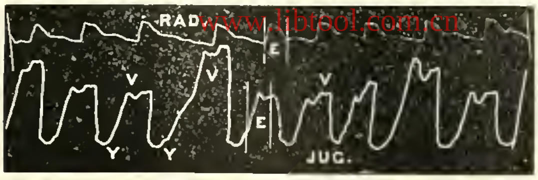

FIG. 3917.—Ventricular Venous Pulse (below); Radial Pulse (above). (Mackenzie.)

This systolic collapse alone is sufficient to prove the venous pulse to be of the auricular or negative variety. Using the radial pulse as a guide, it is possible to find traces of the other waves described as typical, although they are not very distinct. Be it noted here that the systolic and diastolic portions of the jugular pulse correspond very closely in time with the systolic and diastolic portions of the radial pulse, because, as has been pointed out by the writer, the greater distance of the radial from the heart is compensated for by the fact that the rate of propagation of the venous pulse is only about one-third that of the arterial.

As a rule, the auricular venous pulse can be readily recognized without taking a tracing. It is characterized by a sudden collapse of the veins of the neck followed by a more gradual filling. Where the pulse is infrequent the collapse is double, corresponding to the systolic and diastolic collapse seen in a tracing (Fig. 3914). The proper organ for the examination of the venous pulse is the eye, and it is best seen with the patient reclining with the head on a level with the body (no pillow). The finger is of little use as the changes in tension are too slight to be appreciated by it. It is a good plan to have the finger on the radial as a guide to the time relations. In cases of doubt, as when the pulse is frequent, simultaneous tracings must be taken of the jugular pulse, and either the apex beat, or the carotid, or the radial.

The presence of the auricular venous pulse has little significance. I have seen it at all ages from infancy to old age, and have recognized and recorded it in healthy and athletic young men as well as in a variety of diseased conditions. It is practically never absent from healthy dogs, and I believe that when it cannot be observed in a human subject, who is in a proper position for observation, it is because the tissues of the neck are too thick for it to show through rather than because it is not there. It is more marked than usual when the tissues of the neck are specially thin or when the veins of the neck are distended. For it to be seen at its best the heart must still be beating with fair vigor. Among the conditions in which the auricular venous pulse is pronounced are nearly all forms of emaciation and general debility, diseases in which the entrance of blood into the chest is interfered with, such as rickets and chronic coughs, conditions in which there is slight dilatation of the heart as at the end of long continued fevers or in the various forms of anæmia.

The ventricular or positive venous pulse is seen where the high pressure existing in the ventricle during systole is transmitted to the veins so as to prevent the usual systolic collapse. In a typical ventricular venous pulse the only collapse we have in the veins is the diastolic collapse caused by the blood being sucked in by the diastole of the ventricle. In these cases the veins of the neck can usually be seen to be distended, and the pulse can be seen in them even with the patient standing or sitting up. Moreover, the filling or distention of the veins is seen to take place, or, at least, to be completed suddenly, and the finger can detect a positive impact corresponding in time with the carotid pulse. Simultaneous tracings from the jugular vein and the radial artery show absence of the usual systolic collapse. Instead, we see a continued rise or a sustained elevation of the tracing during the ventricular systole, succeeded by a sudden diastolic fall. These points may be very well seen in Fig. 3917. In this figure simultaneous points of time in the radial and jugular pulses are marked by vertical lines including between them the systolic period *E*. It will be noted that the venous pulse consists of a single large wave with a divided crest, and that the only pronounced collapse is after the systole is over. A somewhat less typical case observed by the writer is shown in Fig. 3918. This was taken from a case of tricuspid regurgitation in which compensation had been partly restored by digitalis.

The ventricular venous pulse is found in three conditions. By far the most usual cause of it is *tricuspid regurgitation*, but it cannot quite be called pathognomonic of this lesion, as there are two other rare conditions in which it is found. One of these is mitral regurgitation with patent foramen ovale, of which a case was recently reported in "The Johns Hopkins' Hospital Bulletin" by W. S. MacCallum. The other is adhesive pericarditis, in which the contraction of the ventricle draws in the thoracic wall and causes compression of the thoracic viscera; sufficient pressure is thus exerted on the great veins to initiate a positive wave which is propagated into the veins of the neck.

The ventricular pulse may in some cases be confounded with the pulse of auricular paralysis which will be described shortly.

The arterial venous pulse includes four different forms of pulsation in the veins, of which none call for more than a mention.

1. A pulse may be transmitted from the arteries through the capillaries in aortic regurgitation or where there is great dilatation of the peripheral vessels.

2. Cases are on record in which there has been an anastomosis between a peripheral artery and vein with consequent transmission of a pulse.

3. Pulsations which are arterial in origin are sometimes seen in the veins of closed cavities like the eyeball.

4. Veins may have a pulsation transmitted to them from arteries as a result of mere juxtaposition. This last fact must be remembered in interpreting the tracings obtained from the veins of the neck, especially the internal jugular, as frequently one of the waves seen is due to the impact of the carotid upon the vein. Such waves are best identified by comparing the tracing with a simultaneous one from an artery.

The Venous Pulse of Auricular Paralysis.—When the auricle is paralyzed the presystolic (auricular) wave is absent and so is the systolic collapse (auricular diastole). The tracings obtained are very similar in form to those of tricuspid regurgitation, as the tracing continues to rise until the ventricular systole is complete, and then a fall due to the ventricular diastole occurs. The venous pulse of auricular paralysis with competent tricuspid valves can be distinguished from the systolic pulse of tricuspid regurgitation better by the finger than from a tracing. In a tracing, it is true, the rise is more uniform and gradual in auricular paralysis than in the ventricular pulse where a systolic elevation may be made out; but in some

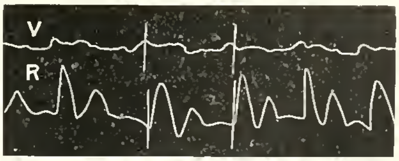

FIG. 3918.—Venous Pulse from External Jugular (above); Arterial Pulse from Radial (below).

cases it is difficult to decide from a tracing which we have to deal with. The finger, on the contrary, can recognize a distinct positive impact in the veins in the case of a ventricular venous pulse, whereas in the pulse of auricular paralysis no such positive impact is felt. Fig. 3919

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shows a tracing such as we sometimes meet with. This is from an old woman with a dilated and irregular heart, but no murmurs. The venous tracing shows, as a rule,

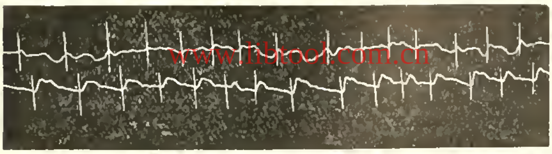

FIG. 3919.—Jugular Pulse (above), Radial (below). Corresponding points are marked.

the most pronounced collapse during diastole and resembles somewhat the ventricular pulse shown in Fig. 3918. There was no positive beat in the veins of the neck, however, and there were no heart murmurs, so I ascribed the condition to dilatation and threatening paralysis of the auricles without any serious amount of regurgitation. In this tracing a presystolic rise and systolic collapse are occasionally seen, so that the paralysis of the auricles was not absolute.

THE VENOUS PULSE IN IRREGULAR HEART ACTION.—A number of observers have recently been making use of the venous pulse as a means of deciding the primary seat of irregularity in the rhythm of the heart. One example will have to suffice. Fig. 3920 is a tracing taken from one of the cases referred to, in discussing the arterial pulse, of a father and son, both in good health and both with irregular pulses. This tracing is taken from the son. The venous pulse is small, as is usually the case

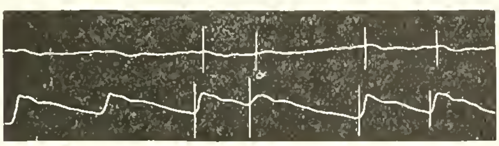

FIG. 3920.—Jugular Pulse (above); Radial (below). Corresponding points are marked.

in a healthy adult, but suffices for the purpose. An irregularity may be seen in both the arterial and the venous pulse of the nature of a premature beat. In the ordinary beats preceding and following the premature one, a faint wave may be detected in the venous pulse synchronous with the primary wave in the radial. This is the systolic wave. Just preceding the systolic wave a fainter one which is presystolic and due to the auricular systole may be seen. In the venous beat corresponding to the premature wave in the radial a systolic wave may also be seen, but the auricular wave follows it instead of preceding it, showing that the auricle in this case contracts after the ventricle, and therefore the anomalous stimulus causing the premature beat must have acted on the ventricle. If measurements be made it will be found that the pulse intervals on either side of the premature beat are together equal to the preceding and succeeding ones, or to two average pulses. This, according to Hering, Cushny, and

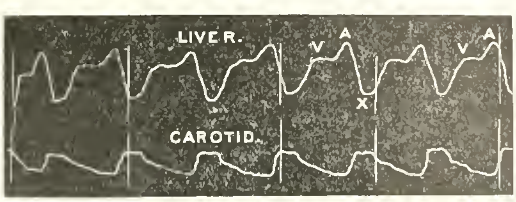

FIG. 3921.—Auricular Liver Pulse.

others, points to the auricle not being implicated in the irregularity. When the auricle is the primary seat of the disturbed rhythm, such a correspondence is not usually found. This rule is said by Gerhardt, however, to be not without exceptions. The full importance of thus differentiating the seat of the irregularity is not fully worked out, but on the whole those cases in which the irregularity is confined to the ventricle are less serious than those in which the auricle is also irregular in its rhythm.

THE LIVER PULSE.—A pulsation can be felt and recorded in the liver in certain cases in which the right side of the heart and the veins are much distended. In some cases the tracing has the form corresponding to the auricular venous pulse. In these cases, according to Mackenzie, there are usually tricuspid stenosis and auricular hypertrophy, as the normally weak auricular waves have not force enough to make themselves felt in the liver.

In other cases the liver pulse has the characters of the ventricular venous pulse, and then we may be reasonably

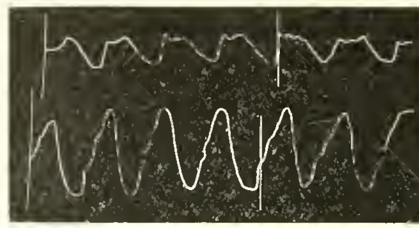

FIG. 3922.—Ventricular Liver Pulse. (Carotid above; liver below.)

certain of the existence of tricuspid regurgitation. Tracings of these two forms of liver pulse taken from Mackenzie's book are shown in Fig. 3921 and Fig. 3922.

CAPILLARY PULSE.—This consists in alternate reddening and paling of an area of the skin with each heart beat. It is most frequently looked for in the bed of the finger nails, and may be brought out most distinctly by raising the arm. Quincke, who first described the capillary pulse, recommends rubbing gently a spot upon the forehead and looking for it there. The capillary pulse may be taken as an indication of aortic regurgitation with a strongly acting ventricle (hypertrophied).

William S. Morrow.

REFERENCES.

I desire to acknowledge my special indebtedness to the book on the pulse, by James Mackenzie, and warmly to recommend it to those desiring to read something more exhaustive than this article.

I have also received help from the following: The physiologies of Schaefer, Halliburton, Howell and Hall; Vierordt's "Medical Diagnosis"; Hutchison and Rainy's "Clinical Methods"; Gibson's "Diseases of the Heart"; Balfour's "Diseases of the Heart"; Fagge's "Practice of Medicine"; Green's "Examination for Life Insurance"; Ewart's "Heart Studies"; Hürthle's "Beiträge zur Hæmodynamik" in Pflüger's Archiv, vol. xlix.; D. Gerhardt's "Klinische Untersuchungen über Venenpulsationen" and "Einige Beobachtungen an Venenpulsen" in Archiv für experimental Path. u. Phar., vols. xxxiv. and xlvii.; Karl Schmidt, Jr., "Herz-Kammer Systole und Pulsecurve," Pflüger's Archiv, 1902, Heft 5 u. 6; W. S. MacCallum, Johns Hopkins Hospital Bulletin, March, 1900; Cushny, "On Intermittent Pulse," British Med. Journ., September 29th, 1900. A good bibliography will be found in Gibson's "Diseases of Heart and Aorta."

PUMPKIN SEEDS.—*Pepo,* U. S. P. *Semen Peponis.* The dried ripe seed of *Cucurbita pepo* L. (fam. *Cucurbitaceæ*).

The nativity of the pumpkin is not certainly known, though it was probably North American. It presents numerous varieties, and the squashes, at least some of them, have been regarded by some botanists as pertaining to the same species. Although squash seeds appear to possess similar properties, they are not included, as a drug, under the above title.

Pumpkin seeds are about 2 cm. (⅘ in.) long, broadly ovate, flat, white, or whitish, nearly smooth, having a shallow groove near to and parallel with the edge; containing a short conical radicle and two flat cotyledons; inodorous; taste, bland and oily.

The active constituent is supposed to be a small amount of a soft, green, acrid, and bitter resin, which possesses the same properties as the entire drug. With this there

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exists a yellow or somewhat reddish-yellow, bland fixed oil, to the extent of about thirty-five per cent., a little sugar, crystallizable albumin, and other unimportant constituents. The oil, which consists of glycerides of palmitic, myristic, and oleic acid, portions of which acids also exist in a free state, has been credited with the properties of the drug, but possibly, if pure, does not possess them.

Pumpkin seeds are markedly diuretic, but their medicinal use is as a pleasant and moderately certain tænicide. Only the kernel should be used, and it is commonly given in the form of an electuary or emulsion, the dose amounting to from 25 to 50 gm. (℥⅞ to ℥iss.). Fifteen grains of the resin is an equally efficient dose, though not so pleasant.

Throughout the West Indies, Mexico, Central America, and many other countries, pumpkin seeds, as well as squash seeds, are largely consumed as food.

Henry H. Rusby.

PURGATIN.—Purgatol, anthrapurpurin diacetyl ester, is an odorless, tasteless, yellowish-brown powder recommended by von Hösslin as an agreeable laxative. It acts slowly, requiring thirteen to twenty-four hours, and produces a copious, non-liquid stool. The urine is colored red. Dose, 0.5–2 gm. (gr. viij.–xxx.).

W. A. Bastedo.

PURGATIVES, OR CATHARTICS, are medicines which are used to produce alvine evacuations. According to their activity and power, they are divided into laxatives and mild and drastic purgatives.

Purgatives which act very gently, producing soft, feculent stools without notable irritation, are called *laxatives*. This term is also applied to more powerful purgatives when they are given in small doses, so as to act mildly. (See *Laxatives* in Vol. V.)

Purgatives which operate briskly, usually producing more or less fluid evacuations, sometimes with griping and tenesmus, but without serious irritation, are called *mild* or *simple purgatives*. To this group belong some of the salts of magnesium, sodium, and potassium, which, from their resemblance in chemical and physical properties, and in physiological action, are termed *saline* purgatives.

The term *drastic* is applied to those purgatives which operate energetically, producing numerous evacuations, and, in excessive doses, more or less gastro-intestinal irritation.

Purgatives which produce watery stools, especially the salines and some of the drastics, are called *hydragogues*, and those which cause the evacuation of large quantities of bile, *cholagogues*.

Mode of Action.—All purgatives accelerate the peristaltic movements of the intestines. Radziejewsky carefully observed the rapidity of peristalsis in dogs, both before and after the administration of purgatives. In the normal state the movements of the small intestine were rapid, those of the large intestine very slow. After the administration of purgatives, the movements of both became much accelerated, but most markedly those of the large intestine.

It was assumed that purgatives, especially the hydragogues, also induce a discharge of fluid from the intestinal mucous membrane. Experiments on animals at first seemed to show that this was an error. Thiry completely separated a portion of the small intestine from the rest of the bowel, without dividing its vessels and nerves, sewed up one end, which was returned into the abdominal cavity, and attached the open end to the wound in the abdominal wall. Into the cul-de-sac thus formed he introduced croton oil, senna, and Epsom salt. No accumulation of fluid took place. Schiff experimented in a similar manner with aloes, jalap, and sulphate of sodium, and Radziejewsky with croton oil and sulphate of magnesium, both with the same negative result. Radziejewsky also analyzed the fæces before and after the administration of purgatives. The evacuations produced by purgatives contained more water and sodium salts than normal fæces, and sometimes products of pancreatic digestion, but never as much albumin as should have been present if transudation of fluid from the intestinal blood-vessels had taken place. It was therefore concluded by these investigators, and is still maintained by some recent authors, that purgatives do not induce either transudation or increased secretion, and that the watery character of the stools results only from the greatly accelerated peristalsis, which interferes with the absorption of the fluid normally secreted.

But subsequent investigations yielded different results. Moreau introduced sulphate of magnesium into a portion of intestine isolated by means of two ligatures, and after some hours found a decided accumulation of fluid. Brunton, experimenting in a similar manner, found that croton oil, gamboge, elaterin, and Epsom salt caused a decided accumulation of fluid. That the accumulated fluid was not a transudation was evident from the fact that it contained very little albumin. Brieger injected into an isolated portion of intestine very small quantities of colocynth. No accumulation of fluid took place, but the bowel was contracted and slightly reddened. Larger quantities of colocynth, as well as croton oil, caused an accumulation of bloody fluid, with decided inflammation of the mucous membrane. After injecting calomel, senna, rhubarb, aloes, and castor oil, Brieger found the bowel empty and firmly contracted. Sulphate of magnesium in very dilute solution caused no accumulation of fluid, but concentrated solutions of this salt, so also Glauber salt, caused very decided accumulation. That the fluid was a secretion, and not a transudation, was evident from the fact that it readily converted starch into sugar and dissolved raw fibrin.

Thus it has been found in experiments that sulphate of magnesium, sulphate of sodium, croton oil, gamboge, colocynth, and elaterin, not only accelerate the peristaltic movements of the intestines, but also induce a secretion of watery fluid from the intestinal mucous membrane; and that castor oil, rhubarb, aloes, senna, calomel, and minute quantities of colocynth accelerate peristalsis, but do not notably increase secretion.

Hess, in experiments on dogs, endeavored to determine the manner in which purgatives increase the peristaltic contractions. He made gastric fistulæ a short distance from the pylorus, so that he could easily introduce purgatives into the duodenum. After having determined the quantity of the purgative (sulphate of sodium, castor oil, croton oil, senna, colocynth, gamboge, and calomel) which would act briskly, he introduced into the duodenum a small, empty india-rubber ball, to which was attached a long, fine india-rubber tube. After this had been carried by the normal peristaltic contractions a certain distance, which varied in the different experiments, he filled it with water to such a degree as to obstruct the bowel. The purgatives which previously had acted briskly then completely failed. Hess therefore concluded that the peristaltic movements excited by purgatives are probably not propagated through long distances by means of nervous apparatus, or, according to Engelmann, from muscle to muscle, but that they are reflexly excited in each part of the intestine by direct stimulation of its mucous membrane.

Mild Purgatives.—Of the purgatives which act vigorously, without causing severe irritation of the intestines, the following are commonly employed: aloes, rhubarb, senna, castor oil, salines, and mercurials.

Aloes.—In large doses, from five to twenty grains, aloes produces semi-liquid or liquid stools. The first evacuation rarely occurs before six hours, and often not before ten or twelve hours. Some griping usually precedes the evacuations, and they are often attended by a feeling of heat in the anus, and by straining, especially if the medicine be repeatedly taken. From the slow action and the tenesmus, it is supposed that aloes influences the rectum more than other parts of the intestines.

In experiments on rabbits, Kohn found that aloes caused moderate hyperæmia of the stomach, intestines,

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and kidneys. In various animals large doses of aloin, injected into the subcutaneous tissue, were followed by gastritis, sometimes with hemorrhage and ulceration, and in rabbits by degeneration of the epithelium of the kidneys.

According to the experiments of Rutherford, aloes increases the secretion of bile and renders it more watery. Various observers have found that it does not act when bile is absent from the intestines.

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Aloes was formerly employed in large doses to produce brisk purgation, when acute disorder of any organ of the body supervened soon after the cessation of an habitual hemorrhoidal discharge. It was sometimes given to produce a revulsive effect in cases of congestion of the brain, apoplexy, hemiplegia, and insanity. At the present time it is rarely used, except in small doses as a laxative. According to G. B. Wood, it sometimes quickly cures jaundice when other remedies have failed.

Aloes is contraindicated in inflammatory affections of the intestines and kidneys, in irritable and bleeding piles, in uterine hemorrhage, and during menstruation.

It is generally administered in pillular form, and the official *pills of aloes* are preferable to other preparations. Each pill contains two grains of aloes.

Rheum.—In dose of thirty to forty grains, taken at one time, or ten to twenty grains, repeated several times at short intervals, rhubarb produces semi-liquid stools in from five to ten hours, usually with griping, but without severe irritation. Some constipation generally follows. Recent experiments have confirmed the ancient opinion that rhubarb increases the secretion of bile.

Rhubarb is a suitable purgative when the bowels require thorough evacuation in patients who are occasionally subject to diarrhœa. Sometimes it is preferred to other purgatives in catarrhal jaundice.

It may be given in the form of powder, fluid extract, tincture, or wine. Aromatics are generally associated with it to prevent its griping effect. ℞ Pulv. rhei, ℈ij.; pulv. aromatici, ℈i. M. Div. in pulv. iv. Sig.: One powder every two hours. They may be conveniently taken in syrup or molasses, or in wafers. The fluid extract is given in doses of fifteen to thirty minims, mixed with syrup and an aromatic water. ℞ Extr. rhei fluid., ℥ iss.; syr. zingiberis, ℥ ss.; aq. cinnam., ℥ iss. M. Sig.: One tablespoonful every two hours till the bowels move. The tincture and wine are suitable for feeble patients, especially if they are accustomed to alcoholic beverages, and may be given in doses of half an ounce, repeated, if necessary, at convenient intervals.

Senna.—Senna operates gently and slowly in doses of fifteen to thirty grains, producing one or two pultaceous stools in from five to ten hours. Large doses act more briskly. Two or three drachms usually produce semi-fluid discharges in three or four hours. The evacuations are preceded by pretty severe tormina, and sometimes by nausea and eructations. Borborygmi and occasional small fluid stools often continue for from twelve to twenty-four hours.

Though it acts vigorously, and produces quite liquid stools, containing about eighty-five per cent. of water, senna never causes severe irritation or inflammation of the intestines. It is supposed, however, that large doses may influence the uterus, and, given during pregnancy, induce hemorrhage and abortion.

The watery character of senna stools is generally regarded as evidence of increased intestinal secretion; but in careful experiments Brieger found no accumulation of fluid in an isolated loop of intestine with which senna had been in contact some hours. That it greatly accelerates the peristaltic contractions of the small intestine appears from Radziejewsky's experiments. This investigator found that in dogs, normally from seven to nine discharges took place from a fistula in the ascending colon in three or four hours after a feeding; but when senna was administered the discharges began in ten or fifteen minutes, and numbered about thirty in four hours.

Cathartin, the active principle of senna, in doses of gr. iss.–iiss., produces thin stools with colicky pains in from three to fourteen hours. An amount equal to two grains, injected into the subcutaneous tissue, was followed by copious evacuations in from eight to twelve hours.

As senna acts rapidly and efficiently, it is suitable when the contents of the intestines require speedy removal. Combined with Epsom salt, as in the official compound infusion of senna, it is frequently employed in the early stage of inflammatory diseases, except those of the alimentary canal. It is better adapted than rhubarb and some other mild purgatives for patients disposed to costiveness.

Senna, in large doses, is contraindicated in inflammation of the intestines, hemorrhoids, menorrhagia, threatening abortion, and prolapse of the uterus or rectum.

It is generally given in the form of the *infusum sennæ compositum*, which, in quantities of about two ounces, repeated several times at intervals of one or two hours, soon produces copious watery discharges. The fluid extract of senna may be given in doses of half a drachm to two drachms with syrup and an aromatic water. ℞ Extr. sennæ fluid., ℥ ss.; syr. zingiber., ℥ ss.; aq. cinnam., ℥ iij. M. Sig.: A tablespoonful every hour until the bowels act. The syrup of senna is a convenient preparation for children in doses of from one to four drachms.

Oleum Ricini.—Castor oil, in doses of half an ounce to an ounce, usually produces semi-fluid evacuations in from three to six hours, generally with little or no griping or other symptoms indicating irritation of the intestines. Nausea and vomiting may occur in very susceptible persons, especially if the oil is rancid or the stomach disordered.

From its efficient and speedy operation, castor oil is well adapted to all cases requiring a thorough cleansing of the alimentary canal, as when the presence of poisons, undigested food, or products of decomposition in the intestines indicates the use of a brisk purgative. Its gentle, unirritating action renders it suitable when a purgative is required in inflammation of the intestines, inflamed hemorrhoids, fissure of the anus, metrorrhagia, and after parturition. For methods of disguising its taste, see article on *Laxatives.*

Saline Purgatives.—The following saline purgatives are commonly employed: Sulphate of magnesium, sulphate of sodium, citrate of magnesium, tartrate of potassium and sodium, and bitartrate of potassium.

Large doses of saline purgatives produce copious watery stools. This peculiar action was explained by chemists as resulting from osmosis, the dense saline solutions within the intestines causing the less dense fluid of the blood to pass through the walls of the blood-vessels. But the fact that large doses of salines, when given in very dilute solution, so as to be less dense than the fluid of the blood, act as efficiently and often more speedily than concentrated solutions proved that this theory was untenable. Subsequently it was shown, by Buchheim and others, that only salts of low diffusibility are efficient purgatives, and that this property impedes their absorption in the intestines, causing them to pass nearly entire into the lower part of the large bowel and to excite purgation.

For a time it was supposed that the accelerated peristalsis resulting from the presence of saline solutions was sufficient to explain their rapid and peculiar action. But the investigations of Moreau, Brunton, Brieger, Hay, and others, have conclusively shown that dense saline solutions produce an active secretion of watery fluid from the intestinal mucous membrane. Brieger and Hay found that very dilute solutions, although they may purge rapidly, do not cause an increase of secretion; and Hay observed that when concentrated solutions are given, the quantity of fluid secreted depends upon the degree of concentration. Solutions containing less than five per cent. of a salt, produce little or no secretion, but stronger solutions always have this effect. Under ordinary circumstances, the amount of fluid secreted corresponds very nearly to the quantity required to form a five-per-cent. solution of the amount of salt administered. In consequence of the secretion of a large quantity of fluid,

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when concentrated saline solutions are given, the fluid of the blood becomes proprotionately diminished. This continues only a short time, as the blood absorbs fluid from the tissues until it has nearly regained the quantity lost by increased secretion.

Thus the mode of action of saline purgatives depends upon the quantity and the degree of dilution. Very dilute solutions excite no intestinal secretion, but rapidly produce watery stools; while concentrated solutions cause a decided increase of secretion, diminish the fluid of the blood, excite absorption of fluid from the tissues, and in a short time produce watery evacuations.

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Saline purgatives are preferred to other mild cathartics for evacuating inspissated fæcal masses. As a rule, they should be given in very dilute solution. In the early stage of inflammatory diseases, salines are often employed for the purpose of lowering temperature and blood pressure, and thus diminishing the inflammation. They are of little use in such cases unless given in concentrated solution, so as to excite a decided increase of the intestinal secretion. The utility of salines is most conspicuous in cases of ascites and general dropsy. Administered in very concentrated solution, they often in a short time produce a very notable effect, especially if the patient have entirely abstained from food and drink for some hours before taking the saline.

Magnesii Sulphas.—Epsom salt is generally preferred to other saline purgatives. In doses of half an ounce to an ounce it usually produces watery stools in several hours, the first discharge sometimes taking place in one hour. This rapid action is rarely attended by severe griping. As it is readily soluble in water, it may be given in very concentrated solution, a method strongly recommended by Hay in cases of dropsy. It is frequently associated with senna, as in the compound infusion of senna.

Its taste is somewhat improved and its activity increased by sulphuric acid. ℞ Magnesii sulph., ℥ i.; aq. destill., ℥ ij.; acid. sulph. arom., ʒ ss.; syrupi, ℥ i. M. Sig.: One or two tablespoonfuls every hour. The bitterness of Epsom salt may be disguised by strong coffee and aromatics, especially cinnamon water. ℞ Magn. sulph., ℥ i.; aq. cinnam., ℥ iij.; syr. aurant., ℥ i. M. Sig.: A tablespoonful every hour.

Sodii Sulphas.—Glauber's salt has a still more repulsive taste than Epsom salt. It is therefore rarely employed when saline purgatives are indicated. According to recent researches, it causes a decided increase of the secretion of bile and renders it more watery. In all other respects its action closely resembles that of Epsom salt. The following substances have been employed to correct its disagreeable taste: Lemon juice, aromatic sulphuric acid, carbonated water flavored with syrup, and extract or fluid extract of licorice.

Sodii Phosphas.—This salt, although an effective purgative in doses of ʒ ss.–i., is rarely employed in the diseases of adults. It is sometimes used in laxative doses, ʒ ss.–ij., several times daily in catarrhal jaundice and other diseases supposed to indicate a cholagogue. On account of its not unpleasant taste, it is frequently used as a purgative in the diseases of children. The following is an agreeable mixture: ℞ Sodii phosphatis, ʒ ij.; syr. rubi idæi, ℥ ss.; aq. destill. q.s. ad ℥ iij. M. Sig.: One teaspoonful every hour.

Liquor Magnesii Citratis.—The solution of citrate of magnesium has an agreeable taste, and is therefore often preferred to other saline purgatives for unloading the bowels in simple constipation. It is, however, less efficient than the sulphates of magnesium and sodium, sometimes operating briskly, sometimes producing no purgative effect. Usually a whole bottle, containing twelve ounces, taken in several portions at short intervals, is required. In cases of dropsy and inflammatory diseases other saline purgatives are preferable.

Potassii et Sodii Tartras.—In doses of half an ounce to an ounce, Rochelle salt usually produces liquid stools in a few hours. As it has a less disagreeable taste than Epsom salt, generally agrees well with the stomach, and acts gently, it is often employed when a mild purgative is indicated in the diseases of children, females, and delicate persons. It somewhat increases the secretion of bile. From two to four drachms, dissolved in sweetened water, may be taken at intervals of two hours till the bowels respond.

Potassii Bitartras.—Large doses of cream of tartar, half an ounce to an ounce, are followed by watery stools, which are often preceded by flatulence and griping. It is rarely used alone, but frequently in combination with jalap. When given in large doses, it should be suspended in an aromatic water to prevent griping.

MERCURIAL PURGATIVES.—Of the preparations of mercury which produce catharsis, calomel and blue mass are frequently used. Metallic mercury is sometimes employed in obstruction of the bowels.

Hydrargyri Chloridum Mite.—Calomel, in doses of from five to ten grains, usually acts in about six or eight hours, producing copious semi-liquid, dark brown or green evacuations. As a rule, no marked incidental effects are observed; but sometimes, especially after the larger quantity, the evacuations are preceded by griping, nausea, and depression. Smaller doses, one to three grains, act more slowly and very gently. Accurate chemical analyses have discovered in calomel stools bile pigments, leucin, tyrosin, peptones, sulphide of mercury, and unchanged calomel, but no skatol and indol.

The presence of bile in the stools was formerly regarded as a certain evidence of an increased secretion of bile. But in numerous careful experiments on dogs, and in some observations made on patients having accidental biliary fistulæ, it was found that purgative doses of calomel notably lessen the secretion of bile. To explain the presence of bile in the stools notwithstanding diminished secretion, it was then assumed that calomel greatly increases the peristaltic contractions of the small intestine, especially of the duodenum, and thus hurries the bile already secreted downward so rapidly that reabsorption cannot take place. The presence of leucin and tyrosin in calomel stools rendered this view very plausible. But the fact that some purgatives, which act more rapidly than calomel, and doubtless strongly accelerate the peristaltic contractions of all parts of the intestines, do not produce markedly bilious discharges seemed to show that this assumption was incorrect.

The recent experiments of Wassilieff show conclusively that calomel produces bilious stools, by arresting decomposition in the intestines. He divided fresh oxgall into three portions, each weighing 200 gm.; to one portion was added 3 gm. of calomel, to another 2 gm., and to the third none. They were kept in a warm room, and occasionally agitated. The portions containing calomel at once became green, and retained this color as long as the experiment was continued, which was six days. They readily responded to Gmelin's test for bile pigment, and showed no trace of decomposition. The portion not containing calomel had become brownish-yellow in one day, did not exhibit the reaction of bile pigment, and was soon putrid. Doubtless calomel exerts the same antiseptic influence in the intestines. Under ordinary circumstances the bile pigments, bilirubin and biliverdin, become converted into hydrobilirubin, and hence cannot be detected in the fæces. Calomel prevents this decomposition, and by increasing peristalsis causes the unchanged bile pigments to be evacuated. In the same manner it prevents further changes of leucin and tyrosin, and the formation of skatol and indol.

Calomel is a very effectual purgative in the morbid state called biliousness—marked by a sallow complexion, yellowness of the white of the eyes, a bitter taste, defective appetite, and sometimes nausea; by headache, mental dulness, and depression; and sometimes by light-colored stools and sedimentary urine. By arresting decomposition and removing bile and other substances before they can be absorbed, it thoroughly relieves both the intestines and the liver.

In small doses calomel has been found useful in the

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gastro-enteritis of children. Its utility is probably due chiefly to its antiseptic action.

Administered in doses of from five to seven grains, for one or two days, in the first week of typhoid fever, calomel somewhat lowers the febrile temperature and renders the disease milder. As other purgatives are less useful, it probably exerts a destructive influence upon the micro-organisms which cause the disease.

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As a rule, calomel is indicated as a purgative in all acute affections of the intestines resulting from fermentation and putrefaction.

Together with jalap or rhubarb, calomel is sometimes administered in the early stage of inflammatory disorders of the internal organs. Though not useless, it produces very much less effect on the quantity of fluid in the blood-vessels and on the blood pressure than large doses of the saline purgatives.

Calomel should not be used in habitual constipation.

It is usually ordered in powder with sugar, or with jalap, rhubarb, or bicarbonate of sodium. ℞ Hydrarg. chlor. mitis, gr. v.; sacch. albi, gr. x. M. Sig.: Take at once. ℞ Hydrarg. chlor. mitis, gr. iij.; pulv. jalapæ, gr. x. M. Sig.: Take at once in syrup or molasses. ℞ Hydrarg. chlor. mitis, gr. v.; sodii bicarbon., gr. xv. M. Sig.: Take in molasses or syrup. In all cases, if calomel have failed to act after eight or ten hours, a saline purgative or castor oil should be given.

Massa Hydrargyri.—Blue mass is a somewhat uncertain purgative when given in doses of from five to ten grains. It is, therefore, usually combined with rhubarb, aloes, podophyllin, or compound extract of colocynth, or, if given alone, a dose of castor oil, Rochelle salt, Epsom salt, a senna draught, or a seidlitz powder, is administered after eight or ten hours. It is held to be efficient in biliousness, and is usually given in the evening.

Hydrargyrum.—Metallic mercury in large doses quickly passes through the alimentary canal in consequence of its great weight. Probably the dragging and stretching of the mucous membrane, resulting from the presence of large quantities, excite very powerful peristaltic contractions, which rapidly carry the metal through the intestines.

Metallic mercury has been employed in intestinal obstruction when all other ordinary means had failed to give relief. Bettelheim (*Deutsches Archiv f. kl. Med.*, Bd. 32, p. 53) carefully studied seventy cases of obstruction, reported during the last fifty years, in which mercury was used. In fifty-seven cases a cure resulted, that is, the obstruction was relieved either temporarily or permanently. In no case did it cause rupture, inflammation, or gangrene of the bowel, while in some instances it saved life. Bettelheim therefore considers it proper to administer mercury in cases of obstruction due to fæces, ascarides, and even to intussusception or torsion, if other ordinary means have failed to give relief.

The dose of metallic mercury varies from one to ten ounces.

Drastic Purgatives.—Of the cathartics which operate violently and produce serious irritation of the intestines, when given in excessive doses, only the following are commonly employed: jalap, scammony, colocynth, podophyllum, gamboge, croton oil, and elaterin.

Jalapa.—Jalap is the mildest drastic, and resembles senna in its action. In doses of fifteen to thirty grains it usually soon causes a feeling of discomfort in the epigastrium, and sometimes nausea. After two or three hours tormina and several liquid stools occur. Smaller doses, five to ten grains, act gently, producing one or two pultaceous evacuations. In very excessive doses jalap causes vomiting and profuse rice-water discharges, with great depression.

The resin of jalap, in doses of from one to three grains, acts as a laxative, but in larger doses, from five to fifteen grains, it produces watery stools in a few hours.

According to recent investigations, jalap does not act well when bile is absent from the intestines. In experiments on dogs it was found to increase moderately the secretion of bile.

On account of its rapid, safe, efficient, and hydragogue action, jalap is frequently employed when a brisk cathartic is indicated. In cases of acute constipation, and in inflammatory diseases, it is usually associated with calomel, and in ascites and anasarca with bitartrate of potassium. The official *pulvis jalapæ compositus*, consisting of thirty-five parts of jalap and sixty-five parts of cream of tartar, is generally preferred to other hydragogues in dropsy. In doses of half a drachm to one drachm, it usually produces watery discharges in a few hours.

The resin of jalap may be given in doses of from one to eight grains in powder or emulsion. ℞ Resin. jalapæ, pulv. acaciæ, āā gr. viij.; sacch. albi, ʒ ss. M. Div. in part. æqual. iv. Sig.: One powder every two hours till the bowels move. ℞ Resin. jalapæ, gr. viij.; pulv. acaciæ, sacch. albi, āā ʒ i.; aq. menth. pip., ℥ ij. M. Sig.: One tablespoonful every two hours. Sometimes resin of jalap is given in combination with calomel. ℞ Resin. jalapæ, hydrarg. chlor. mitis, āā gr. iv.; sacch. albi, ℈ i. M. Div. in part. æqual. iv. Sig.: One powder every two hours.

Jalap is contraindicated in inflammatory affections of the alimentary canal.

Scammonium.—Scammony resembles jalap in action, but is less certain, sometimes producing little or no effect, at other times acting harshly, with griping and tenesmus. Usually it is followed by watery stools in a few hours. The presence of bile in the intestines is necessary for its action. It is rarely used except in combination with other purgatives, as in the official *compound cathartic pills*. The dose of scammony, to act briskly, is from ten to twenty grains, and of its resin, from five to ten grains.

Colocynthis.—Large doses of colocynth produce numerous fluid evacuations, with griping and tenesmus. Excessive doses cause sanguinolent stools, great abdominal pain, intense depression, and sometimes death.

Small doses, one to three grains, act gently, producing loose stools without notable griping. But if frequently repeated, such doses soon cause tormina and tenesmus, and slimy stools.

According to Brieger, small quantities of extract of colocynth, 0.02 gm. dissolved in 2 gm. of water, injected into isolated portions of intestine, produce slight hyperæmia and peristaltic contraction, but no accumulation of fluid. But larger quantities produce decided inflammation and an effusion of bloody fluid.

In experiments on dogs Rutherford found colocynth to cause an increased flow of watery bile.

On account of its harsh operation, colocynth is rarely employed alone to produce brisk purgation; but in small doses, in combination with other laxatives, it is frequently given in habitual constipation.

The dose of the extract of colocynth, as a laxative, is one-sixth to two-thirds of a grain, and of the compound extract, from one to five grains. The latter preparation is sometimes given in doses of five to fifteen grains, to purge briskly. Usually the extract of hyoscyamus, or the extract of belladonna, is combined with it, to prevent griping. ℞ Extr. colocynth., gr. i.; aloes, gr. vi.; extr. hyoscyami, gr. vi. M. Ft. pil. vi. Sig.: One pill at bedtime. ℞ Extract. colocynth. comp., gr. xij.; extr. bellad., gr. ij. M. Ft. pil. vi. Sig.: One pill at bedtime.

Cambogia.—Gamboge is held to be still more irritant than colocynth. In experiments Rutherford found, after large doses, violent irritation of the duodenum and small intestine generally, with profuse catharsis, but no increase of the bile flow.

It is, perhaps, never given alone, but is sometimes added to other purgatives to increase their action, as in the compound cathartic pills. Very small doses, one-sixth to one-half grain, are said to produce pultaceous stools without much griping. Generally, doses of three to four grains cause some nausea and colicky pain, and several watery stools. Excessively large doses, one drachm, have caused fatal gastro-enteritis.

Formerly gamboge was frequently employed in obsti-

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nate constipation, ascites, anasarca, paralysis, insanity, gout, and skin diseases. Generally it was given together with aloes, jalap, bitartrate of potassium, and calomel. ℞ Cambogiæ, gr. iv.; pulv. jalapæ comp., ʒ ij. M. Div. in pulv. iv. Sig.: One powder every two hours till the bowels act, in cases of dropsy.

Pilulæ Catharticæ Compositæ.—The compound cathartic pills contain small quantities of aloes, scammony, colocynth, jalap, gamboge, and calomel. On account of their complex composition they are supposed to affect all parts of the intestines, and to increase the secretion of bile. One pill usually acts as a laxative, while three or four produce free purgation. They are suitable to acute constipation not complicated with inflammation of the intestines, but should not be employed in habitual constipation.

Podophyllum.—This purgative, even in large doses, usually acts slowly, from six to ten hours elapsing before the bowels move. Doses of ten grains rarely cause marked incidental effects, but twenty or thirty grains are usually followed by nausea, and sometimes vomiting and depression, and severe colicky pain. The evacuations sometimes have a dark color, from which it was assumed that they contain a large quantity of bile. In experiments on dogs Rutherford found that moderate doses of podophyllin cause an increased flow of bile.

The resin of podophyllum, commonly called podophyllin, is used as a laxative. Doses of one-eighth to one-half grain usually produce a gentle movement in eight or ten hours. Large doses, from two to four grains, cause nausea, sometimes vomiting, severe griping, and numerous stools, which may be slimy and bloody and followed by intense depression.

Podophyllin is not suitable in cases requiring brisk purgation. But in chronic constipation it is much used, because it continues to act for a long time without necessitating an increase of dose. It is frequently employed when symptoms are present which show that the secretion of bile is abnormal. Usually it is given in pillular form, with extract of hyoscyamus or extract of belladonna. ℞ Podophyllini, gr. ij.; extr. hyoscyami, gr. viij. M. Ft. pil. No. viij. Sig.: One pill at bedtime. It has also been given in solution as follows: ℞ Podophyllini, gr. ij.; alcohol. dil., ℥ ij.; tinct. zingiberis, ʒ ij. M. Sig.: A teaspoonful in a wineglassful of water.

Podophyllotoxin is said to act more regularly than the official resin. It has been given to adults in doses of one-sixth to one-fourth of a grain, and to children in doses of one-sixtieth to one-twelfth of a grain. Brun employed it in alcoholic solution as follows: ℞ Podophyllotoxini, 0.5 gm.; spir. vini rectif., 7.5 gm. M. Sig.: From five to fifteen drops in sweetened water.

Oleum Tiglii.—Croton oil is a very energetic drastic, a drop sometimes producing from five to fifteen watery evacuations. Often the first evacuation occurs in one or two hours.

The susceptibility of different persons to its action varies, in some one drop acting intensely, while in others it produces only a few semi-liquid stools. In rare instances purgation does not result from the dose mentioned, but there takes place general disorder, marked by palpitation of the heart, pain in the extremities, severe headache, giddiness, and prostration.

Frequently the action of croton oil is attended by symptoms indicating irritation of the stomach and intestines—a sensation of heat in the epigastrium, more or less nausea, sometimes vomiting, borborygmi, colicky pain, and tenesmus.

Excessive doses quickly induce vomiting and purging, and great prostration. Twenty drops have proved fatal.

Croton oil is used when a powerful purgative is indicated, and milder medicines have failed to act or cannot be administered. Sometimes this is the case in obstinate constipation, lead colic, and diseases of the brain and spinal cord. When brisk purgation is necessary, and swallowing is very difficult, the oil is preferred to more bulky cathartics, a drop being mixed with a little sugar, or a little bread crumb, and placed on the back of the tongue.

The oil has been strongly recommended for the removal of tapeworm—one drop mixed with one drachm of chloroform and one ounce of glycerin, to be given early in the morning.

Croton oil is usually given in pillular form. ℞ Ol. tiglii, gtt. i.; micæ panis, q. s. M. Ft. pil. iv. Sig.: One pill every hour. It is said that the oil acts more gently when combined with compound extract of colocynth and extract of belladonna. ℞ Ol. tiglii, gtt. i.; extract. colocynth. comp., gr. viij.; extr. bellad., gr. i. M. Ft. pil. iv. Sig.: One pill every two hours. Sometimes it is given mixed with sugar. ℞ Ol. tiglii, gtt. i.; sacch. lactis, ʒ i. M. Div. in part. æq. iv. Sig.: One powder every hour. It may also be mixed with castor oil, or made into an emulsion, as follows: ℞ Ol. tiglii, gtt. i.; pulv. acaciæ, ʒ ij.; syr. amygdalæ, ℥ ss.; aq. destill., ℥ iiiss. M. Ft. emuls. Sig.: One tablespoonful every hour.

Elaterinum.—Elaterin is the most powerful and drastic of all purgative medicines. The twentieth of a grain, given to an adult, will generally produce watery stools in one or two hours. Sometimes this speedy action is not attended by marked incidental effects; but often, especially if it is given alone, nausea, severe griping, borborygmi, and some prostration are produced. Excessive doses may cause intense gastro-enteritis and fatal collapse.

Elaterin is employed in ascites and anasarca, when gentler hydragogues have failed to act efficiently. As a rule, it is given only every other day, and not continued longer than a week or ten days, lest it excite serious intestinal inflammation. After an interval of a week its use, if necessary, may be resumed. It is contraindicated in dropsies complicated with intestinal irritation, and must be used with extreme caution in very young, aged, and feeble patients.

It may be ordered in solution, pill, or powder. ℞ Elaterin, gr. ss.; alcohol., ℥ ss.; acidi nitrici, gtt. ij. M. Sig.: From twenty to forty drops in an aromatic water. ℞ Elaterini, gr. ½; extr. hyoscyami, gr. vi. M. Ft. pil. vi. Sig.: One pill every hour till stools take place. ℞ Elaterini, gr. ¼; sacch. albi, ʒ i.; ol. menth. pip., gtt. ij. M. Div. in part. æqual. vi. Sig.: One powder every hour until the bowels act.

General Indications.—Purgatives are used (1) to evacuate the intestines; (2) to diminish hyperæmia of remote parts or organs; (3) to promote the absorption of exudations and transudations; and (4) to eliminate noxious substances.

1. *All purgatives evacuate the contents* of the intestines; but when this is the sole indication for their use, only laxatives and mild purgatives should be given. In chronic or habitual constipation those laxatives are most suitable which act slowly, producing normal or nearly normal fæcal evacuations, without losing their activity in small doses after frequent repetition, and without interfering with general nutrition. Experience has shown that aloes possesses these properties in the most eminent degree. Podophyllin, cascara sagrada, rhubarb, and compound extract of colocynth are also eligible. The saline laxatives are sometimes used in habitual constipation; but as their prolonged use is followed by impairment of nutrition, they should not be given to feeble patients unless required by other indications.

In occasional or acute constipation any laxative or mild purgative may be employed. If hardened fæcal masses are present in the intestines, the saline laxatives and castor oil are most suitable. Sometimes all the mild purgatives fail to act in acute constipation, especially when the cause of the constipation is still present, as in lead poisoning. Drastics, if carefully used, are then appropriate, and croton oil is usually preferred. Metallic mercury has been successfully used after all ordinary purgatives had proved ineffectual.

To remove poisons and irritating substances from the intestines, those purgatives which act speedily and gently

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should be preferred, especially castor oil and salines. When irritation of the intestines results from decomposition or fermentation, calomel is the best purgative.

2. *To diminish hyperæmia* of remote parts or organs, purgatives which act rapidly and produce semi-liquid or watery discharges are required. Mild purgatives deplete indirectly by sweeping the intestinal secretions and partially digested food downward so rapidly that absorption is impeded. Saline purgatives, in strong solution, excite a copious secretion of watery fluid, and thus directly deplete the blood. Drastics act in a threefold manner, accelerating peristalsis, increasing secretion, and exciting intestinal hyperæmia. The choice of a purgative will, therefore, depend upon the intensity and duration of the disease to be influenced, the organ affected, and the character of the general symptoms. In congestion of the liver, calomel, followed by a saline laxative, is the most suitable purgative. In congestion or inflammation of most organs, saline cathartics and compound infusion of senna are usually employed; but in very severe congestion or inflammation of very important organs—such as the brain and spinal cord—drastics are preferred, especially croton oil.

3. *To promote absorption of exudations* and transudations, the hydragogues are most suitable. Generally the saline hydragogues, given so as to produce copious watery stools, soon cause rapid absorption. In cardiac dropsy they often diminish the dropsical swelling very notably in a few hours. Of the drastic hydragogues the compound powder of jalap and elaterin are the most useful. Generally the former is preferred on account of its mild action. But when it fails to act efficiently, or when an effusion of serum occurs rapidly, and in such large quantity as to produce extreme distress, such as alarming dyspnœa in pleuritis, elaterin is usually given. Sometimes it so rapidly induces absorption of the effusion as to give decided relief in a few hours.

4. *To eliminate noxious substances*, calomel, salines, and drastics are used. The utility of calomel in biliousness and congestion of the liver is in part due to the rapid removal of irritating and decomposing substances from the alimentary canal. Saline laxatives, especially sulphate of magnesium, are indicated in chronic lead poisoning, to remove the poison from the intestines as fast as it is eliminated by the liver. They are also suitable in cases of uræmia, especially if at the same time it is necessary to induce absorption. In uræmic coma, croton oil is sometimes preferred to milder purgatives.

Contraindications.—All purgatives are contraindicated in peritonitis, intestinal hemorrhage, perforation of the bowels, strangulated hernia, and extreme debility. Brisk purgatives are generally inappropriate during pregnancy, especially if previous abortions have occurred, and during menstruation. They should not be used if there exist severe rectal lesions, or a tendency to looseness of the bowels. Even laxatives are contraindicated in habitual constipation, until all other known means have failed to establish a normal habit of defecation.

Samuel Nickles.

PURPURA.—(Synonyms: *Hæmorrhæa petechialis*; Fr., *Purpura*; Ger., *Blutflecken*.) Purpura is a disease characterized by the extravasation of blood into the skin. In many instances, however, it is not limited to this organ and may be encountered in almost any structure of the body. The parts coming most readily under visual inspection are naturally the skin and mucous membranes, although in severe and fatal cases the autopsy shows that the internal viscera are likewise involved. It may be asked whether purpura is not rather a symptom complex than a well-defined affection *per se*. It occurs under so many apparently varied conditions that one is at a loss to ascribe to it definite limitations. In this connection, however, it will be considered from a dermatological standpoint, the skin being the organ most extensively involved. The clinical manifestations of purpura vary; hence several varieties have been described, although the essential feature is the occurrence of hemorrhage into the structures surrounding the blood-vessels. In severity purpura likewise varies greatly, being in some instances an exceedingly mild affection with extravasation only in dependent parts, as the legs; or it may be an extremely severe and rapidly fatal disease. Between these extremes numerous grades, both in appearance and in severity, occur. Usually purpura is accompanied by constitutional symptoms which to a great extent depend upon the amount of cutaneous hemorrhage.

For convenience of description the various lesions have received distinct names. Thus we speak of *vibices* when the extravasation of blood into the skin assumes a streaked or elongated form. *Ecchymoses* are irregular extravasations of blood involving considerable areas, and giving

Fig. 3923.—Purpura Simplex. (Case of Dr. William T. Corlett.)

the appearance of bruises. *Ecchymomata* or *hæmatomata* are terms used to designate tumors formed by the extravasation of blood, usually occurring when a large vessel wall has given way. The term *purpura papulosa* is employed to designate pinhead-sized extravasations which are usually situated in the upper part of the derma. *Hæmorrhagic bullæ* are extravasations underneath or between the layers of the epidermis, while *hæmatidrosis* is a rare condition in which the sweat glands give forth a bloody exudate. *Petechiæ* are cutaneous areas of extravasation of various shapes and sizes.

The cutaneous lesions of purpura are characteristic in that they are symmetrically arranged, are of a dark bluish color, and do not disappear on pressure. At first they may be of a bright red or claret color, although at an early stage they take on a purplish hue; as absorption goes on the color undergoes various changes from a brown to a greenish-yellow tint, such as may be observed in an ordinary bruise. The cutaneous manifestations occur in successive crops; hence various shades of color may be seen at the same time. Most cases of cutaneous hemorrhage may be grouped under three heads, which will be treated as varieties of the disease.

Purpura Simplex represents the mildest form of the disease. This is commonly observed in the skin, and is frequently limited to this structure. As a rule, it is unaccompanied by constitutional symptoms. It usually makes its appearance suddenly, and is first seen on the dependent parts, as the legs (see Fig. 3923), although in children the arms, neck, and other parts of the body may be involved. The most usual sites are the inner aspect of the legs, the dorsum of the feet, and the posterior surface of the forearms. In this form the mucous membranes may be involved to a slight extent, that most frequently implicated being the mucous membrane of the mouth, although we have reason to believe that the hemorrhagic process is not limited to these structures, but that, on account of the mildness of the symptoms, it escapes notice when occurring in parts not easily inspected. In this variety the lesions consist of variously sized and shaped petechiæ

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which are at first roundish or oval, and which sometimes extend at the periphery; at other times they remain stationary until absorption takes place. A more infrequent form, in which the lesions are punctate (*lichen lividus* of Willan) and surround the exit of a hair shaft, is also encountered. The lesions in purpura usually continue to appear for several days or weeks, although the disease is self-limited and as a rule terminates in recovery within one or two months. The cutaneous lesions soon undergo resorption and deposition of hæmatin which leaves an indelible stain in the tissue.

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Purpura Rheumatica, Peliosis Rheumatica, Toxic Purpura (*Purpura exanthématique* of the French) is a more severe form of the disease, so called because of its association with vague pains which are usually referred to the joints or muscles, and are supposed by some to be closely related to acute articular rheumatism. In this variety constitutional symptoms are more marked. In some cases distinct swellings occur about the joints, there is a slight elevation of temperature, the tongue is frequently coated, and usually there is anorexia, sometimes with nausea and vomiting. Extravasation of serum alone may likewise take place, giving rise to urticarial lesions in the skin (*purpura urticaria*). In very rare instances the serous exudate occurs in the epidermis, giving rise to bullæ and œdematous plaques. Stelwagon ("Diseases of the Skin," 1902, p. 466) has observed swelling of the lips and throat which he describes as a *febrile purpuric œdema*. Sometimes the eruption becomes associated with symptoms of a multiform erythema, the lesions varying in appearance, although always associated with cutaneous hemorrhage. From the foregoing it may be seen that this form of purpura is closely allied to the exudative erythemata.

This toxic form of purpura is sometimes associated with complications of a grave nature. Thus endocarditis and pericarditis, together with necrosis and sloughing of the mucous membrane of the mouth, have been observed by Osler.[1] It is sometimes recurrent and may appear annually throughout a period of several years. Henoch[2] has called attention to gastro-intestinal symptoms occasioned by hemorrhages into the intestinal mucosa; this has been accompanied by vomiting and diarrhœa, the stools not infrequently being tinged with blood. Hemorrhage may likewise take place to a slight extent into the bladder. This has been most frequently observed in children. In severe cases the kidneys are affected, giving rise to the symptoms of acute hemorrhagic nephritis. In these cases albumin is usually present in the urine. The spleen is sometimes easily palpable.

Purpura Hæmorrhagica, sometimes known as morbus maculosus Werlhofii (which see), and also as land scurvy. This is a more grave affection than the two preceding varieties. The severity of the disease, however, largely depends upon the cause as well as on the extent of the cutaneous hemorrhage. The onset of this variety varies; it may be insidious, appearing as a mild attack with few or no constitutional symptoms; soon gradual impairment of the health becomes manifest, and the patient becomes weak from loss of blood. The appetite disappears, assimilation is interfered with on account of intestinal hemorrhage, and diarrhœa with bloody stools finally occurs. The gums bleed easily, and there is not infrequently hæmaturia, epistaxis, or hæmoptysis. The lesions usually assume the form of large ecchymoses or ecchymomata, and the mucous membranes are apparently involved to an equal, if not greater, extent than the skin. In the latter the disease may appear on the more dependent parts, although the whole body soon becomes involved. In severe cases symptoms of collapse occur, and the disease may soon terminate in death (*purpura fulminans*). At other times the disease pursues an uninterrupted course for several months, when finally resolution takes place and the patient recovers. At other times extravasation of blood takes place into the brain or spinal cord, giving rise to symptoms referable to a tumor in these parts. There is usually but slight elevation of temperature in this form, although the disease is sometimes noted to be ushered in with a slight fever, the temperature rising one or two degrees.

Cutaneous hemorrhage may also occur as a symptom of other well-recognized diseases, such as variola, the plague, and cerebro-spinal fever, and in cases of poisoning from the bite of poisonous reptiles.

Etiology.—The disease occurs in both sexes, and is met with at all ages. It is a fairly common disease in my experience, and has been most frequently encountered between the ages of sixteen and forty-five. The general health of the cases that have come under my observation, previous to the advent of the cutaneous hemorrhages, has been good, although, as has been stated, there is sometimes a tendency for the disease to recur from time to time during a period of several years. In a series of cases which I had the opportunity of observing a number of years ago, bad hygienic conditions with a defective food supply were undoubtedly the chief etiological factors in the disease. Of these the chief rôle must be given to the withdrawal of green vegetables from the dietary, most notably potatoes, cabbage, and greens; at any rate, on supplying these articles in moderation the disease disappeared from various families in which it had been observed to occur for a long time. Further, in my experience the disease has been met with more frequently in women than in men, the nationality most frequently affected being the Bohemian. It has occurred usually in people in the lower walks of life. Various drugs have been known to produce cutaneous hemorrhage, notably potassium iodide, chloral, belladonna, ergot, phosphorus, iodine, quinine, copaiba. These drugs do not produce the same effect in all people, there being in some individuals an idiosyncrasy by which the ingestion of certain substances, innocuous to others, gives rise to toxic effects. Again, toxic substances or their ptomaïns, by acting on the nerve centres, are thought to be potent factors in the causation of purpura, notably in the erythematous or toxic form.

As malaria undermines the general health, it is thought by some to contribute to this condition. Other diseases contribute in like manner to purpura, most notably those which tend to profound anæmia, such as scorbutus, hæmophilia, pyæmia, sarcoma, nephritis, scarlatina, typhus fever, cerebro-spinal fever, variola, and rubeola, as well as various diseases of the nerve centres, such as locomotor ataxia and hysteria. The venom of serpents must likewise be mentioned in this connection. In new-born infants the sudden change to which the circulation is subjected may give rise to cutaneous hemorrhage, which should be looked upon as purely mechanical. Various micro-organisms have likewise been described as associated with purpura. Martin de Gimard,[3] Letzerich,[4] and Kolb[5] have succeeded in producing the disease in animals by inoculating with pure cultures, and doubtless this accounts for some cases, especially among the severe forms. From the foregoing it will appear that the cause of purpura varies in different cases, and no one condition can be assigned as invariably producing the disease.

Stelwagon, in summarizing the various causes of purpura, believes that the etiological factors may be divided into classes, most conspicuous of which are the vasomotor, toxic, and infectious; and that some of the latter arise from auto-intoxications, which have their origin in the intestinal tract. This latter seems especially true in those cases which are marked by a multiform erythema and urticarial lesions. It is evident, therefore, that we have in purpura a condition of variable appearance and widespread distribution, affecting almost every organ and structure of the body and producing symptoms which vary according to the part attacked. What we know, therefore, is this: purpura is a symptom, in the broad sense of the term, of many conditions, many of which at the present time are wholly unknown.

Pathology.—The most constant findings in purpura are circumscribed areas of blood extravasation, which are usually found in the papillary layer of the derma. Less frequently the epidermis may be invaded, the latter occurring only when the blood extravasation has been

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excessive, as from rupture of an arteriole, or when the disease assumes a toxic form (*peliosis rheumatica*). When the disease is not limited to the skin, the deeper part of the derma or even the subcutaneous structures (purpura hæmorrhagica) may be involved. Again, there may be only a few red blood cells surrounding the vessel (diapedesis), in which case the lesions are usually limited to the superficial stratum of the derma. If the disease has existed for some days the characteristic retrogressive changes are found, namely, the presence of coloring matter from the blood giving rise to a rust-like stain, which gradually fades away, leaving only a slight pigmentation. Frequently these are the only changes found. At other times the vessels in the area involved are markedly dilated (*purpura ectasique* of the French), and red blood cells are found outside the vessel wall. This Leredde regards as due to paralysis of the vaso-motor filaments distributed to the vessel. This form is supposed to be of toxic origin involving primarily the nerve centres. Aside from these changes there have been noted dilatation of the vessels with proliferation of the endothelium, together with an accumulation of blood cells, fibrinous thrombi, and microbic emboli. Furthermore, amyloid degeneration of the vessels has been noted, together with proliferation of the connective-tissue cells and necrosis of the vessel wall. The study of the blood has of late attracted close attention, and Lenoble[6] holds that true purpura (*P. myéloïde*) or the toxic form is invariably due to alterations in the blood. The following, according to this observer, are always present and may be regarded as characteristic:

1. Absence of contraction of the clot and consequent expression of the serum. This is constant, and it is only after recovery that the expression of serum becomes normal. In light cases one can see a certain degree of contraction of the clot, although occurring a little later than usual.

2. The appearance of bone-marrow cells which are always present, sometimes abundant, and are characterized (*a*) by the apparition of nucleated red blood cells, few in the chronic, but more abundant in the acute form; in the latter case, however, they are not permanent. These red cells are in the group of Ehrlich's normoblasts, more rarely megaloblasts or even microblasts (one case); (*b*) by the appearance in the circulation of myelocytes which are usually neutrophilic, more rarely eosinophilic. This reaction is always slight or feeble, and varies from a fraction of one per cent. in the chronic type to six or seven per cent. in the acute form.

3. Marked changes in the blood platelets, which are diminished in number and increased in volume, but whose chief alteration is in the more or less complete loss of their characteristic grouping. This loss of the power of clumping explains the lack of contraction of the clot, the special anæmia, and the profuse hemorrhages which are characteristic of the disease.

These changes, which are constant, may persist indefinitely in the chronic form. In the subacute form the duration is variable, and normoblasts may be found long after recovery is apparently complete.

The following are given as accessory and inconstant blood changes:

1. Leucocytosis with increase of the polynuclear eosinophiles and especially of the lymphocytes. These last are always increased, and were omitted from the primary changes mentioned because they are found in all forms of purpura. Their presence is as important as is that of the myelocytes, whose office it is to repair the constant loss of the large mononuclears which undoubtedly act as macrophages. According to the Dominici these cells also give rise to parent cells of the elements which are destroyed by the circulating toxins.

2. Frequent but inconstant is the appearance in the pure blood of a reticulum either with a coarse or with a fine network.

3. Contrast between the number of red corpuscles, which may be much increased, and the amount of hæmoglobin per cell, which may remain small.

This disease is thus controlled by a double cause, viz., an infection and an anæmia. The intensity of the symptoms varies with the intensity of the infection. The blood shows few changes in chronic, subacute, and transient types, but in the acute form the blood appears disorganized and shows the presence of bone-marrow cells, while the red blood cells have become very vulnerable. This is shown by the large number of pseudoparasites whose importance has been dwelt on by Hayem.[7]

Diagnosis.—Little difficulty need be experienced in recognizing a well-marked case of purpura. In purpura simplex the lesions sometimes resemble flea-bites or the bites produced by other insects (*purpura pulicosa*). In the latter, however, there may be seen a characteristic inflammatory halo surrounding a deep red punctate centre, which is never present in purpura. Erythema nodosum might, late in its course, be mistaken for purpura, especially when the dark-red inflammatory nodules of the erythema have receded, leaving bruise-like areas. The location and history of the affection should enable one to differentiate between them. It should be borne in mind that erythema is an acute affection of two or three weeks' duration, with large, elevated, slightly inflamed and painful nodules, usually limited to the anterior surface of the legs and to the forearms; while the lesions of purpura appear in successive crops lasting from four to twelve weeks, are of a dark color, usually not elevated except in the form of bullæ, and are not inflammatory nor painful. In erythema the redness disappears on pressure, while this does not take place in purpura. Pain has been experienced on pressure in erythema, but pressure does not cause pain in purpura. From trauma purpura may be distinguished by the multiform character and distribution of the lesions, and by the absence of any history of injury.

The late manifestations of syphilis likewise give rise to pigmentation, but they are also preceded by inflammation, and are always chronic, which offers a sharp contrast to the lesions of purpura. Even in the necrotic form of purpura the lesions are smaller, are multiform, and are of comparatively shorter duration than those of syphilis. From the various drug eruptions, noticeably that of cubebs and copaiba, the erythema is of a brighter red and disappears on pressure. In the acute infectious exanthemata cutaneous hemorrhages are not uncommon, notably in variola and rubeola; but in the former we have a grave affection which, as a rule, rapidly advances to a fatal termination, and in measles the coryza and other characteristic features of the rash would enable one to exclude purpura which has a slower evolution and less often terminates fatally.[8]

Prognosis.—This depends on the extent of the cutaneous hemorrhage, the cause of the disease, and the complications present. In simple purpura the prognosis may be considered favorable, whereas in toxic cases, or in those accompanied by marked involvement of the viscera, the prognosis must be guarded. In purpura simplex the majority of patients recover in from four to twelve weeks. In purpura rheumatica the disease is liable to return, although it is seldom from the primary affection that a fatal issue ensues. In severe forms the disease is always grave, if not fatal.

Treatment.—The first consideration is rest in a horizontal position. Except in very mild cases this should be maintained very strictly throughout the whole course of he disease. Many cases are reported in which fresh crops of eruption have appeared after the patient assumed the erect posture. When the lower extremities are mainly involved, it is well to elevate the feet above the horizontal plane by means of pillows. When the extremities are the chief seats of predilection, flannel bandages may be applied so as to give support by gentle pressure. The room should be well ventilated and an abundance of direct sunlight admitted The diet should be simple, nutritious, and easy to digest. In toxic cases diffusible stimulants may be indicated. The drugs which have given the best results are: turpentine, in doses of five drops three times a day, or by inhalation; ergot, or the

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subcutaneous injection of ergotin, which is highly spoken of by Crocker; silver nitrate, gr. ¼ to gr. ½ in pill form; aromatic sulphuric acid; and chloride of lime in doses of from fifteen to thirty grains three times a day. The latter remedy should not be given for a longer period than two or three days, as it acts directly on the coagulation of the blood. Astringents in the form of iron or a four-per-cent. solution of hydrochlorate of cocaine have been resorted to in severe cases. Ice in the mouth, or elsewhere, may be indicated as a local application. Boulloche[9] recommends the injection of artificial serum, and relates a case of fulminating purpura in which death seemed imminent, but which, under this treatment, made a complete recovery. In this case 120 c.c. were given. Absolute cleanliness should be insisted upon, and some mild astringent and antiseptic gargle may be applied to the mouth and fauces. Further than this the treatment depends largely on the cause of the disease and the complications which are encountered.

William Thomas Corlett.

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PUS. See *Inflammation*, and *Exudation, Pathological.*

PUTREFACTION. See *Bacteria*, and *Ptomains.*

PYÆMIA. See *Septicæmia and Pyæmia.*

PYELOTOMY. See *Kidneys, Surgical Affections of.*

PYKNOSIS (also spelled *Pycnosis*) is the term applied to that condition of the nucleus in which, in the early stages of necrosis or just preceding necrosis, it stains more intensely with nuclear stains. At the same time there is usually a contraction of the nucleus; but the nucleus may remain of normal size or even swell. *Karyorrhexis* may follow pyknosis, or there may occur a gradual *karyolysis* without a disintegration of the chromatin elements. In sections stained with hæmatoxylin the pyknotic nuclei may appear almost black. This phenomenon is usually explained as due to a condensation of the chromatin. Pyknosis may be observed in necrosing cells of all organs and tissues; it is seen particularly in necrosing syncytial cells, bone-marrow giant cells, muscle cells, sarcoma cells, etc. Pyknotic cells are sometimes mistaken for newly formed cells; and in some cases the differential diagnosis is difficult. This is particularly the case in striped muscle. Undoubtedly many of the cells regarded as evidences of muscle regeneration have been cells in a condition of pyknosis.

Aldred Scott Warthin.

PYLORECTOMY. See *Stomach, Surgery of the.*

PYOKTANIN.—(*Methyl violet.*) An aniline dye introduced in 1890, by Prof. J. Stilling, as a powerful antiseptic for surgical purposes.

Dr. Stilling summarized its qualities as follows: (1) Pyoktanin is an antiseptic surpassing all others. The bacteriological researches have shown blue pyoktanin to be about three times as strongly antiseptic against anthrax bacilli as sublimate is, and to be quite as efficacious as sublimate toward the staphylococcus aureus. (2) It is an absolutely non-toxic substance. (3) In consequence of this non-toxicity it is a matter of indifference in many cases of wounds, etc., whether somewhat weaker or stronger solutions, or even the pure drug, be used. (4) It does not coagulate albumin—a negative quality of high value physiologically, which pertains to no one of the antiseptics heretofore known. (5) It possesses an extremely high degree of diffusibility, permeates the interior of the eye like atropine, and acts similarly in other tissues.

It was recommended to be used in all inflammatory affections accompanied by the formation of pus. Conjunctivitis, urethritis, and inflammation of mucous surfaces were especially benefited, but it was also used with success in the treatment of ulcers and other suppurating wounds. Methyl violet failed to prove itself of particular value, and has fallen into disuse. In many instances favorable results were not obtained, and it frequently produced marked irritation. Its intense coloring properties also proved particularly objectionable. Probably its most important use has been in the treatment of inoperable malignant disease.

In 1891, Professor von Mosetig reported a number of cases treated by injections of pyoktanin, with very favorable results. For some time he had used the different forms of aniline as an injection, with the purpose of staining the nuclei of the cells and thus checking their growth, but the constitutional symptoms produced had always been a hindrance to the treatment. When Professor Stilling introduced methyl violet he at once began to use it for this purpose. The germ-destroying power of the agent, in connection with its diffusibility in healthy and diseased tissues, made it a very promising agent, especially as it was also harmless and devoid of any injurious effect on the human economy. The first case was in a woman, sixty-six years of age, with a large tumor of the lower jaw which prevented her from swallowing and caused great suffering. After thirty-five injections of 6 gm. of a 1 to 500, and afterward of a 1 to 300, solution, the tumor was so much reduced without ulceration that the patient could eat without discomfort. In the case of a man, fifty-eight years of age, with a cystosarcoma of the chest wall, measuring 13 cm. in width by 18 in length, after twelve injections of 6 gm. of a 1 to 300 solution, the measurements were reduced to 10 by 12 cm. In two cases of adenocarcinoma of the neck, the same treatment proved so effectual that the patients considered themselves cured. Another case was that of a woman, sixty years of age, with papilloma of the bladder; for which 20 gm. of a 1 to 1,000 solution was injected into the bladder every second day. After the injections there was notable improvement, the hæmaturia had ceased, and there was little or no pain. Professor Mosetig also cited a case of a man, sixty years of age, with an enormous sarcoma of the pelvis; colotomy had been performed. After sixteen injections of 6 gm. of a 1 to 500 solution into different parts of the mass, it had shrunk to one-half its former size, and the patient was greatly relieved and able to walk about for a few hours daily.

Since Professor Mosetig's announcement numerous cases have been treated and reported. The results have varied greatly, some surgeons claiming very remarkable cures, while others have failed to observe any signs of benefit, and look upon it as a perfectly useless procedure. The greater number of those who look with favor upon the treatment, including its author, do not claim that it is a curative agent for cancerous diseases, but simply that during its use the progress of the growth is checked, the local condition improved, and a temporary relief obtained. The following directions are given for its employment: Under proper antiseptic precautions the part is to be carefully curetted until all the diseased tissue that is accessible is removed. When there is no ulceration of the surface, the curetting is omitted. After the curetting, a tampon of iodoform gauze is placed in the wound and allowed to remain for forty-eight hours. The surface is then washed and carefully dried and the injections are made into the tissue, to the depth of the needle if necessary, according to the extent of the tissue involved. Other injections are made into the surrounding tissues, as many

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as fifteen punctures being made at one sitting. It is advised to begin with the deeper injections, in order to avoid a discoloration of the tissues on the surface in the early stages. After the injections have all been made, pure pyoktanin powder is introduced into the cavity, or gauze or cotton, medicated with it. The tampon is left in position until the second day, when it is removed and the parts are thoroughly washed and the injections repeated. The introduction of the solution exerts an analgesic action, and also checks the profuse hemorrhage that is frequently present.

Intrapulmonary injections have also been used for the treatment of pulmonary tuberculosis. The liquid employed was a 1 to 500 solution, of which eight to sixteen minims were injected. The injections are reported to have been well borne, but when the liquid penetrated to the bronchi, a violent attack of coughing was provoked. Therapeutically, it is said to have produced a lessening of the hectic condition and reduced the number of bacilli in the sputa. *Beaumont Small.*

PYRAMIDON—dimethyl-amido dimethyl phenyl-pyrazolon, dimethyl-amido-antipyrin, $C_6H_5N.N(CH_3)_2.CO.CH.NCH_3.CCH_3$—is a yellowish-white, tasteless crystalline powder, which is soluble in ten parts of water. With ferric chloride it gives an evanescent deep bluish-violet color, a distinction from antipyrin which gives a red color.

Employed in smaller dosage than antipyrin it has an antipyretic action like that body and a more sedative action on the nerves. Robin et Bardet found prompt relief in trigeminal neuralgia. Laudenheimer praises it in the pains of tabes, alcoholism, chorea, neurasthenia, and hysterical conditions. Pollak notes sweating and some flushing of the face, but reports the drug specially applicable in the hectic fever of pulmonary tuberculosis. Horneffer found it effective in facial neuralgia but not in sciatica. Bertherand ascertained that doses of 0.3 gm. (gr. v.) increased the coefficient of nitrogen elimination ten per cent. in eight days. In a diabetic who was excreting 2–3 gm. (gr. xxx.–xlv.) of sugar a day, pyramidon sent the sugar up to 15–20 gm. (gr. ccxxv.–ccc.); so it is contraindicated in this disease. This investigator found the profuse sweating an objection, especially in tuberculous patients. In sciatica he obtained good results from hypodermic injection. Albrecht was able to shorten and modify severe asthmatic attacks in emphysema by doses of 0.3 gm. (gr. v.) two or three times a day for several days. In pneumonia, typhoid, scarlet and other fevers the drug has been used with asserted good results. The dose is 0.06–0.65 gm. (gr. i–x.), and 3 gm. have been given in one day without ill effects.

The pyramidon camphorates, both the acid and the neutral salts, are preferred by some therapists in tuberculosis. Bertherand recommends these compounds for preventing the excessive sweating of pyramidon. The dose of the neutral salt is 0.5–0.75 gm. (gr. viij.–xij.), the larger dose representing 0.5 gm. (gr. viij.) of pyramidon; the dose of the acid salt is 0.75–1 gm. (gr. xij.–xv.).

Pyramidon salicylate is claimed to be especially valuable in neuralgia and rheumatism in dose of 0.75–1 gm. (gr. xij.–xv.). *W. A. Bastedo.*

PYRANTIN. See *Phenosuccin.*

PYRIDINE (C_5H_5N)—a liquid base present in coal tar and separated by fractional distillation. It is also obtained from bone oil, or Dippel's oil. It is a decomposition product of various alkaloids, and is present in tobacco smoke.

It is a colorless liquid, with a peculiar empyreumatic odor and pungent taste. It is very hygroscopic and mixes freely with water, alcohol, and oils. Its specific gravity at 32° F. is 0.9858. Pyridine resembles alkaloids in its property of forming salts with acids. In toxic doses pyridine is a powerful depressant, causing paralysis and death from failure of respiration. The blood is also altered and destroyed. Germain Sée has studied its action in various forms of asthma and recommends it when the disease is of a nervous origin. One drachm is placed in a saucer in a closed room, at a temperature of 68° to 77° F. In about an hour evaporation will have taken place, and the patient should then inhale the impregnated atmosphere for fifteen or twenty minutes, which may be repeated two or three times a day. The drug may also be inhaled by placing ten or fifteen drops on a handkerchief.

The drug has not, however, established itself as a remedy of much value, and is rarely employed in this country. It must not be confounded with pyrodine, which is a preparation of hydracetine. *Beaumont Small.*

PYROGALLOL: PYROGALLIC ACID.—Pyrogallol is a triatomic phenol, $C_6H_3(OH)_3$, producible by the action of heat on gallic acid, whence the common name "pyrogallic acid." It is official in the United States Pharmacopœia under the title *Pyrogallol*, Pyrogallol. It occurs in long flattened prisms, or in needles; colorless, odorless, but with a bitter taste. It dissolves in 1.7 parts of cold water, and very readily in boiling water and in alcohol. In solution, exposed, it oxidizes, turning brown. Pyrogallol possesses the poisonous property, more or less common to the group of phenols, of affecting the blood and bringing about hæmoglobinuria. Administered by injection to rabbits, this medicine has speedily caused chill, dyspnœa, tremor of the extremities coming on in paroxysms, and death. The urine in such cases has shown the characteristic features of hæmoglobinuria, and the blood has exhibited discoloration and destruction of the red blood corpuscles. In rapidly produced death by large doses, the blood has turned black or, in some cases, of a chocolate color and jelly-like consistence. In the human subject death has resulted, in one instance, from the application, to one-half the body at once, of a ten-per-cent. pyrogallol ointment. In this case a violent chill, with vomiting and collapse, set in six hours after making the application of the salve. The patient rallied, but forty hours later a second attack ensued, ending in coma, with great reduction of temperature. Death occurred on the fourth day. During the illness the urine was much diminished in quantity, and showed, in highest degree, the condition of hæmoglobinuria, being dark brown in color and, upon standing, depositing a thick sediment of amorphous, blackish material. The blood was found, post mortem, disintegrated, and the kidneys bluish-black and stuffed with the same material as the urinary sediment. Pyrogallol has been used in medicine almost exclusively as a local application for the relief of certain skin diseases, notably *psoriasis*—an application often successful when other remedies may have failed. Applied in solution or in ointment, pyrogallol stains the skin somewhat, but the stain speedily disappears. Linen clothing, however, may be permanently injured by the action of the medicine. To avoid this latter effect, a solution of pyrogallol in flexible collodion has been proposed (Elliot). Such preparation, when dried to a film upon the skin, seems still to exert the therapeutic action of the medicine, but, being dried, is without action upon the clothing. Pyrogallol may be applied in ointment or in solution, and strengths are used ranging from five to fifteen per cent. of the remedy. The higher percentages, in ointment certainly, may irritate severely, and should be used with caution. Applications should never be extensive at any one sitting, for fear of enough absorption to bring about constitutional poisoning. *Edward Curtis.*

PYROSAL—antipyrin salicyl-acetate—occurs in colorless crystals of acidulous taste and difficult solubility in water. It contains fifty per cent. of antipyrin and thirty seven per cent. of salicylic acid. Introduced by Riedel, this compound has been used as an antipyretic and analgesic in rheumatism, influenza, migraine, sciatica, etc. The action is prompt, and no untoward effects have been noted. The dose is 0.3–0.7 gm. (gr. v.–x.), repeated frequently. *W. A. Bastedo.*

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QUARANTINE.—The term "quarantine" has its origin from the Italian "quaranta," meaning forty, this being the number of days for which vessels were, in the fifteenth century, held under observation on account of epidemic disease. It is now applied to what should more properly be known as maritime sanitation. In addition to this, it is also applied to restrictions against the advance of epidemic disease on land.

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While it may be fairly assumed that all who are in anywise interested in the subject of quarantine are already fully conversant with the history of such measures as have been taken in the past for preventing the spread of epidemic disease, nevertheless, for the sake of comparison with what is now considered proper, and to set forth more clearly the great strides which have been taken in sanitary science and in the methods employed in the exclusion of exotic disease, a short *résumé* will not be amiss.

It is generally understood that the quarantine which was established by Venice in 1403 for the exclusion of plague was the first systematic attempt to exercise any kind of surveillance over commerce for the conservation of public health. It may be remarked, however, that a species of land quarantine, namely, the isolation of lepers, was certainly existent fourteen centuries before that time, possibly at a much earlier period.

The general idea in the fifteenth century seems to have been that no measures of purification were indicated, but that detentions for a period of forty days would suffice to allow the disease to die out; and in truth this was what frequently happened. The unfortunate individuals comprising the *personnel* of a vessel in quarantine had to take their chances, and these were admittedly slight, of escaping the scourge while they were huddled together with its already stricken victims, the authorities believing that the lives of a few were well sacrificed in the interest of the many, and that their duty ended with providing food for these unfortunates and keeping them within fixed bounds.

The foregoing statement may be said to sum up the maritime quarantine system as it existed five hundred years ago. Of land quarantine there seems to have been none, or, if it existed at all, it was of the same brutal character as that applied to the shipping.

When the bubonic plague swept over Europe with such appalling results in this same fifteenth century, the people fled unrestrictedly from any stricken community and scattered death in their wake. Abject cowardice and sublime courage shone out in vivid contrast to one another.

Coming down to more recent times, we find that as late as 1850 a very nebulous idea held sway in the minds of men as to proper methods for preventing the ingress of pestiferous diseases, and the forty-days detention period which was instituted by Venice four hundred and fifty years before, and which Spain adopted against yellow fever from the West Indies a century later, was still in vogue and constituted practically the sole maritime guard of most states against disease; while, on the other hand, some few advanced communities, in sheer disgust at measures which, while destroying their commerce, gave no adequate protection against the ravages of yellow fever, smallpox, and cholera, the preventable diseases then uppermost in men's minds, had thrown off all restraints and were willing to risk the disasters incident to an epidemic, rather than the ills of ruined commerce. And this indeed was a rational decision; for, however we may view the matter from a theoretical standpoint, the question practically put is this: Can a community better afford to take a slight or even a pronounced risk of disease which will destroy a certain percentage of its population, than to take the risk of commercial death which will annihilate it as a community? The former risk is the more rational, and especially when we bear in mind that all quarantine must of necessity involve a certain feature of necessary risk; for, even were it possible to evolve an absolutely safe system, no community would allow such a system to stand, involving as it would most serious hindrances to commerce.

One of the most talented editors of the American press, some years ago, denounced the then existent system as "sanitary savagery," and we must admit that there is some justification for this appellation.

The sole aim, the very *raison d'être*, of a quarantine is the exclusion of exotic disease. If it does much less than this it fails to fulfil its obligations to the community; and, by doing more than this, it retards commerce, interferes with legitimate vested right, and becomes an object of well-merited aversion.

Quarantine is the sanitary vidette and skirmish line, and it may, and often does, fail to keep out exotic disease even though carefully and scientifically conducted. Nothing short of correct laboratory methods (absolutely inapplicable to practical quarantine) could under all conditions exclude disease. Such being the case, we must view a proper quarantine, to express the matter in homely parlance, very much as a sieve, which will exclude the major part of the solids from a given volume of water passing through. Now, if we apply such a sieve to a river, so long as the water can pass by, leaving behind most of the detritus carried in suspension, all will be well; but substitute for that sieve an impervious dam, and so surely as you do, that dam will be swept away. So, likewise, if we place a quarantine of scientific accuracy at the gateway of any of our large commercial cities, we shall have built practically a sanitary dam, and we shall soon find that commerce, having submitted to what it considers a reasonable amount of obstruction, will refuse to accept further restriction, and our sanitary dam will be swept away by the overwhelming outflow of public opinion, which will, rightly or wrongly, tell us, and tell us in unmistakable terms, that the public is willing to take some slight risks for the sake of commerce, and does take these risks, and will not submit to any system which seriously interferes with the community's means of obtaining a livelihood.

We must bear in mind that while the sanitary aspect of a quarantine is undoubtedly of primary importance, commercial interests demand and should be granted consideration in such matters, and while commercial interests are secondary, they are entitled to careful thought; for we must not forget that the condition brought about by a stoppage or even a slowing of business in any large community means suffering and privation to thousands. When you stop the wages of the breadwinner, you inevitably, though indirectly, produce sickness, the very thing we propose to prevent, and it matters little to the victim whether that sickness be of an epidemic or a non-epidemic character.

When, in the early eighties, the Marine Hospital Service assumed the small quarantine functions previously assigned to the National Board of Health, and with these functions took over the quarantine stations which had been established by the National Board of Health at Ship Island, Mississippi, and Blackbeard Island, Georgia, the system of long-drawn-out detention, plus a fumigation with sulphur dioxide and some spraying with solution of bichloride of mercury, was still in vogue; but there was no clearly defined idea as to how, or why, or when things should be done.

Dr. A. N. Bell, who was at the time an officer in the United States Navy, had indeed in the fifties made a most valuable contribution to sanitary science in the shape of a report of the disinfection done by steam on board a United States man-of-war, which had become infected by yellow fever during a cruise in the West Indies, but no one seems to have taken any particular interest in the matter, and it had been practically forgotten until about 1883, when Dr. Joseph Holt, of New Orleans, the president of the Louisiana State Board of Health, inaugurated a system of disinfection near the mouth of the Mississippi River, the mainstay of which was the application of steam. It is probable, however, that the first really scientific application of live steam to the disinfection of textiles, etc., was made by Dr. H. R. Carter, Surgeon of the United States Marine Hospital Service, at the Gulf Quarantine, Chandeleur Island, Mississippi, in 1888.

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He there demonstrated the principle that steam, to be practically effective, must be diffused through the matter to be treated (must circulate), or else that a vacuum must first be provided to insure the penetration of the steam, as otherwise there would be dead air spaces in which only dry heat of not more than 90° C. would be secured; in other words, these areas would not really be disinfected.

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Dr. Carter, at the Gulf Quarantine, and the writer, at Blackbeard Island, Georgia, were during that year simultaneously working toward the same end, and endeavoring to bring about improvements which establish the following basic principles that are now, it is believed, universally acknowledged:

1. That a suspected ship must—if we wish to make sure that she shall do no harm—be considered to all intents and purposes as an infected ship.

2. That members of the *personnel* must be removed from possible infection as soon as practicable after the ship arrives in quarantine.

3. That so far as the ship itself is concerned, it is as free from danger five minutes after the completion of a proper disinfection as it would be in five years.

4. That the longer the ship lies without disinfection, the more infected, other things being equal, will she become.

5. That the period of incubation of the given disease having elapsed since the person was removed from possible exposure, such person can safely go at large.

These hypotheses all seem very plain and simple. Doubtless they are at the present time, but prior to the time mentioned, as a survey of the then exising state of municipal quarantine regulations will show, it had been at many places the custom to detain a vessel from a yellow-fever port for anywhere from fourteen to forty days, and to disinfect her at some time during this detention, no particular time being stated.

To Dr. Joseph Holt, of New Orleans, belongs the credit for the first real awakening to the fact that quarantine should mean sanitation and not punishment of the unfortunate victims of epidemic disease.

To Dr. H. R. Carter belongs the credit for the enunciation of the principle that detention of persons under observation must be rational, and must of necessity follow their complete disinfection or, to state the matter more clearly, their complete removal from sources of infection; that, scientifically speaking, detention applies alone to *personnel*, and not to inanimate things; that such detention need be only for the period of incubation, and must be for the *full period* of incubation. He worked assiduously to inculcate these ideas, and succeeded.

Another point of interest in quarantine, as it existed in the eighties, is the absolute inadequacy of the appliances for disinfection and for the general handling of vessels. It is true, as above stated, that Dr. Bell had, in the fifties, proved the adequacy of steam disinfection extemporaneously applied, and that Dr. Joseph Holt, president of the Louisiana State Board of Health, had announced and proved his idea of steam disinfection.

These ideas, however, were slow in taking root; and, as late as 1890, there were only three quarantines equipped with steam disinfecting apparatus. It was about 1890 that Dr. Oliphant, of New Orleans, the then president of the Louisiana State Board of Health, and Dr. Kinyoun, of the Marine Hospital Service, promulgated the idea of generating sulphur dioxide by a furnace and obtaining a higher percentage than the 4.5 per cent. (by volume) of the gas obtainable by the pot plan.

The foregoing is an amply sufficient summary of what quarantine was.

The system now in practice under the administration of the United States Public Health and Marine Hospital Service and of the most advanced State authorities is, like almost all institutions which have arisen under the ægis of our race, a conservatively constructed plan, arrived at by slow, steady advances, by careful trial of methods, by rejection of unfit and acceptance of well-proven methods, and with the end constantly in view that every protection must be given to the people, but that nothing should be done which will unnecessarily hamper the commerce of the nation or of any local community.

All methods of disinfection are thoroughly tried in the Hygienic Laboratory, and, if proven acceptable there, are then given what may be termed a field trial, *i.e.*, a test under very practical conditions, but under the eye of scientists who are able to determine their exact value. Careful investigations are made into the nature of the various infectious diseases, and the findings of all scientists regarding their causative agencies and methods of propagation receive thoughtful consideration by those who are working out the problem of how to deal with each upon the arrival of a ship in quarantine infected therewith. These investigations are going on day by day without ceasing, to the end that nothing shall be done that ought not to be done, and nothing left undone that ought to be done.

No other of the great powers has such strong reasons as the United States for the establishment and maintenance of a strict system of maritime sanitation, for the reason that no other nation of prime importance has at its very doors an endemic disease (yellow fever) constantly demanding admission. It is true that cholera and plague do on occasion threaten the nations of Europe, but this is at long intervals. One result of this necessity for vigilance has been a largely increased interest in such matters, and, as the outcome of this interest, there has been established by the United States a system (not as yet perfect or general, but widely distributed) of foreign inspection of vessels and *personnel* bound for the United States. That this foreign service is valuable there can be no denial; but equally certain is it that it can only be an outpost, and must be strongly backed up by a thoroughly efficient service at our own ports.

The United States Public Health and Marine Hospital Service has, at the present writing, inspectors stationed at the principal ports of China, Japan, the Island of Cuba, Mexico, and Central America, and it has also in the past, as occasion demanded, placed inspectors at various other ports. It is the policy of the service to meet, by detailing inspectors to that point, any exigency which arises in the shape of epidemic disease at any given point, and which threatens the sanitary integrity of the United States. As illustrative of the latter statement, it may be said that during the major part of 1893 the service had twelve medical officers stationed at those European ports from which the passenger traffic to this country was heaviest. In addition, the State of Louisiana has inspectors at West Indian and at several Central American ports, which they deem it advisable to watch on account of the large commerce between those ports and their own. As the writer has had no accurate knowledge of State inspection and the work of State inspectors, he will limit this discussion to the subject of national foreign inspection.

At Havana, Cuba, the Marine Hospital Service, for several years before the Spanish War, maintained an inspection service which was of great value to commercial and sanitary interests in that it gave data to the consul-general upon which to issue bills of health, which data, as a whole, formed an abstract of the sanitary condition of the port and vessel, and enabled quarantine officers to decide more promptly than they otherwise could, what treatment should be accorded each vessel upon her arrival in this country. It is well known that the Southern ports and New York placed great reliance upon this Havana bill of health.

At the beginning of the Spanish War this inspection service was, of course, discontinued, but at the close of that war there was established in the whole island of Cuba a regular system of maritime quarantine, providing for the inspection and disinfection of both incoming and outgoing vessels, which system was as near perfect as circumstances would permit; and this was continued until the spring of 1902, when, the Cuban Government assuming charge of its own functions, the quarantine was turned over to them, and the system of inspection which had hitherto existed was resumed.

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The same class of work is now done at other Cuban ports as at Havana, and while the Havana inspection is the most important one in the inland, others are none the less valuable as giving a clean-cut idea of the status of the port and ship on the day of sailing.

The inspectors in Europe in 1893 had the difficult task of endeavoring to prevent, by strict surveillance of ports, ships, and passengers, the introduction of cholera into the United States. Whether or not this effort was worthy of being made may be judged by the facts. Two ships brought each from Europe with them cases of cholera to the United States. While this was all that came to our shores, the non-inspected ships from Europe for South America, Africa, and other continents at times had many victims of cholera, and it is doubtful if there be any sanitarian who has been interested in such matters who does not remember the dreadful state of affairs aboard the unfortunate Neapolitan steamers bound to Rio in 1893. The facts are quoted from a report written at the time from Naples:

"The four for South America, with the result in each case, were as follows: The figures are not official, but are practically accurate in every respect. All were turned back by the South American authorities: *Vencinzio Florio*, about 50 deaths; *Andrea Dorio*, 90 on way out, total not ascertained; *El Remo*, 84 deaths; *Carlo R.*, about 230 deaths.

"To summarize, then, eight ships left Naples. The water supply was the same and the food about the same; the class of passengers identical, and their places of origin similar, in many cases identical. All four leaving [for South America] without precautions became floating pest-houses. Of the four for the United States, the one leaving before cholera appeared in Naples had three deaths; the other three were made to conform to the regulations, and all escaped."

The benefits to be derived from foreign inspection, however, are not by any means comprised in the present statement of what has thus far been accomplished by this agency. An honest and well-trained sanitarian at each port, which by virtue of its unsanitary surroundings menaces our health, if he be provided with the necessary authority, can and will do a great amount of good; possibly, nay probably, not what the general public may expect, certainly not an absolute sanitation of departing ships, obviating all necessity of quarantine at home, but work of great practical value none the less. Under no condition should we accept a bill of health from these inspectors as pratique; such bills should only be construed as information, and, when properly made, as extremely valuable information.

Inspectors should have the several duties of, first, keeping themselves posted, not only as to the health of the city where each is located, but of all the country commercially tributary to that city; second, reporting at stated intervals to the home office any facts bearing on the possibility of the introduction of disease from their ports, and in extra emergencies they should make cable reports of such facts; third, supervising all vessels, cargoes, and passengers for the United States in times of actual epidemic; fourth, collating and submitting for the benefit of the health authorities at home new facts on the subject of State and municipal sanitation independent of epidemic disease; that is to say, new ideas as to drainage, sewerage, irrigation, and ventilation, and all such other matters as may bear upon the public health in any way whatever. In a word, these inspectors should develop, for sanitary purposes, as has already been done for business purposes, a full-fledged system, a medical consular system, if you choose to designate it, which may gather unto itself all matters which may in any way help us to attain to the end we have in view, and let that end be the conservation of the health of this nation. To accomplish this there is only one path open. It is assumed, in the first place, that to enable an inspector to enforce his demands and be something more than a mere spy upon commerce, much authority is needed. This authority can be conferred only by the national Government, and by it only through treaty with the nation whose ports we should inspect, unless we evade this by having our inspectors appointed deputy consuls, or by having them serve in the office of the consuls as, under the law of 1893, was done in Europe, and is now done in the tropics. Inspectors, then, to have authority, must be national inspectors, because even though their reports and their work are public property and would be for the public weal, their work is not intended alone to benefit Louisiana or New York, Massachusetts or Georgia, but every State in the Union. Ohio and Kansas have as much interest in the health of the nation as any seaboard State, and only by national service can the whole nation be fully and equally served at an equal cost to all. It is not certainly known to whom belongs the credit of first using this very valuable adjuvant to an efficient quarantine service, but it is reasonably sure that it was inaugurated by the State of Louisiana, and when we have come to learn the full value of a rightly applied foreign inspection, it is fair to say that the whole nation will owe a vote of thanks to that State.

Let us practically illustrate some of the workings of an inspector abroad, from both a sanitary and a commercial standpoint. In September, 1893, becoming cognizant of the presence of the cholera spirilla in the Elbe River at Hamburg, and consequently expecting an outbreak of cholera, the inspector began to put all emigrants for the United States under observation, and confiscated all foodstuffs whose history was not clearly known. After taking away about twenty-five bushels of such food from a lot of five hundred and seventy-five people bound for New York he permitted the vessel to sail. A case of cholera developed on the second day out. It was afterward clearly shown that this case developed from the eating of a piece of sausage which an emigrant had concealed in his shirt bosom. Now let us suppose that nothing had been done with these people; that they had not been kept under observation; that they had been allowed to take their twenty-five bushels of possibly infected foodstuff along with them, and then let us conjecture how many cases might have developed, if one developed from one joint of sausage. This is cited to show what it is believed any fair-minded man will concede, viz., that even though there are occasional errors of omission (and such will occur in all inspections), an inspection is of immense value. With the exception of the instance just narrated, and one other of a similar character, infection occurred only on one ship out of the hundreds which were given bills of health in Hamburg in 1893, and all ships sailed on time. This result forms a striking contrast with the cases of the vessels bound from Naples to South America.

Now, as to the commercial aspect of the matter. Upon the beginning of the inspection work on April 1st, 1893, it was found that a majority of articles were being subjected to a so-called disinfection—one that was absurd, uncalled for, and in some instances fraudulent, not a true disinfection in any sense; that other articles were being shipped which it was impossible to disinfect and which should not have been allowed shipment. The report of the Chamber of Commerce was promptly obtained, and from that was drawn a full list of all articles ever shipped from Hamburg to the United States. From this list the following classification was made: "A," articles to be shipped free from any inspection; "B," articles requiring a permit from the inspector and possible disinfection; "C," articles which must be disinfected; "D," articles forbidden shipment on account of the impossibility of disinfecting them. Disinfection establishments which did a reliable disinfection were then sought out and specified, and their certificates accepted. At the hour of sailing the ship was boarded and her custom's manifest presented for inspection. This enabled the inspector to see at once of what her cargo consisted. One ship only was held, and compelled to discharge her forbidden cargo; but during the remainder of the year 1893 no other such trouble occurred. The shippers expressed themselves as gratified at the facilitation of their business by, first, an exact knowledge of what they were to do or not to do; second, by the removal of an embargo on

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many articles; third, by a lessening of expenses incurred through unnecessary disinfection. Although the system has been discontinued since December, 1893, the good results of this European inspection have not altogether ceased up to the present moment. One of those results was the establishment, by German authority,—at Spandau and subsequently at Tilsit and Illowa, the latter two on the Russian frontier—of stations for the cleansing of persons and baggage of the hunted and hated Russian Jew. These stations handle nearly all of that class, and, in the event of another outbreak of cholera in Russia, they will be of untold advantage both to the emigrant and to the public. It is not unfair to claim that these stations would not have been established except for the example of American inspection abroad. A system almost identical with that at Hamburg was pursued in Bremen, Antwerp, Rotterdam, Havre, Naples, and in the chief ports of Great Britain, and it is a matter of history that only two very slight infections developed aboard ships, although three hundred thousand people were inspected, kept under observation, and embarked during the period alluded to.

We are compelled to admit that we cannot remedy the sanitary condition of any foreign port except in so far as criticism may serve to arouse a sense of shame in a municipality, just as the same weapon might compel a dirty boy to wash his face.

Of course, after the actual outbreak of disease, we can, by delaying the commerce of the infected town, compel the authorities to remedy, in some measure, the defects; but it is doubtful if we could accomplish this except at such a time, and then it would be too late.

Finally, it is probable that our strongest protection lies in stationing the best available men as inspectors at all such ports, and by this means obtaining timely warning of approaching danger. Then, when the disease arrives, we should be ready to fight it with the most approved appliances known to modern science, operated by the most skilled physicians the Government can assign to this work.

We now come to the discussion of what a maritime quarantine under the best modern conditions actually is, how it should be equipped, and how operated.

The Quarantine Itself.

In the selection of a site for a quarantine station, the following points should be borne in mind: The station should be accessible to incoming vessels, and should deflect them from their regular course, in coming into port, only to the minimum extent. There should be as great a depth of water at the quarantine station as the maximum draft of vessels entering at that port. It should be so far away from the port as not to be in the way of the further growth of the city, thus preventing any necessity for the future removal of the station, and also avoiding antagonism of public sentiment. A quarantine plant, to be complete in all repects, should comprise:

1. Boarding Facilities.—The necessities vary from a small rowboat at some stations to an able seagoing tug at others. It may be stated as a general rule that for a land-locked station, south of the territory in which harbors become icebound, a good, stanch naphtha launch, not only will suffice for boarding purposes, but will be preferable to almost any other type of vessel, because of the ease with which it can be handled.

2. Anchorages.—At a complete quarantine station two anchorages should be provided, one for infected and one for non infected vessels, and they should be sufficiently removed from one another to prevent vessels undergoing inspection at the non-infected anchorage being infected from the other, or infected anchorage.

3. Disinfecting Plant.—The disinfecting plant may be either on a wharf or on a floating platform. It is believed that, other things being equal, a wharf is superior to the floating platform, and that the latter should be resorted to only where natural conditions interfere with the erection of a proper wharf or make such construction too expensive. The disinfecting plant itself should consist of: (1) Steam disinfecting chambers; (2) means for generating sulphur dioxide; (3) machines for generating formaldehyde gas; (4) vats for holding disinfection solutions; (5) large, air-tight wooden chambers for the application of gaseous disinfection to large quantities of material; (6) force pumps for applying disinfecting fluids.

Steam Disinfecting Chambers.—The probably most effective and mechanically as well as scientifically most perfect steam disinfecting chamber in use to-day is what is known as the Kinyoun-Francis steam chamber, devised by Dr. J. J. Kinyoun, with the assistance of Mr. Francis, of the Kensington Engine Works, of Philadelphia. When, as is now generally done, there is attached to this chamber a formaldehyde retort, it becomes a doubly useful appliance. The chamber is provided with an ejector which will produce a vacuum of fifteen inches in the largest-sized chamber—a chamber, for example, approximately five feet in diameter and sixteen feet long—in one minute. This is, according to the observation of the writer, about five times as rapid work as can possibly be accomplished in the production of a vacuum by the ordinary air pump. The chamber is double-jacketed, and by a system of pipes and valves the steam may be forced through the chamber in various directions, causing a circulation of steam, and resulting in increased efficiency in disinfection. When it is desired to use formaldehyde from the retort attached to the side of the chamber, a vacuum is produced, the pressure raised in the formaldehyde retort to about sixty pounds, and the valve leading into the vacuum barely opened. It should not be forgotten that if the valve is opened wide, the fluid contents of the formaldehyde retort will be carried over into the chamber, thus spoiling the articles to be disinfected. Lack of space forbids a more thorough description of this apparatus, which has been exhaustively described by Dr. M. J. Rosenau ("Disinfection and Disinfectants," p. 57, *et seq.*).

Means for Generating Sulphur Dioxide.—The sulphur furnace mentioned above, which was invented by Dr. J. J. Kinyoun, then a medical officer of the Marine Hospital Service, was designed to meet the existing demand for a greater percentage of sulphur than could be produced by the pot method, and in careful hands it is capable of generating a much larger percentage of sulphur dioxide than the pot method does. It has now, however, been very definitely ascertained that such large percentages of sulphur dioxide are not only unnecessary, but are so destructive in their action as to render it inadvisable to use them; consequently, the much simpler method of placing the required amount of sulphur in an ordinary pot, which in its turn is placed in a vessel of water, and the sulphur then lighted by the use of a few ounces of alcohol, has largely superseded the furnace and answers every purpose.

Machines for Generating Formaldehyde Gas.—(1) Autoclave under pressure. (2) Retort without pressure. (3) Generator, or lamp.

The above-mentioned three methods are given, and all of them, within their proper limitations and properly used, are effective. It may be well to say that, as a general rule, formaldehyde disinfection should be confined to small spaces, and not undertaken in such large compartments as the hold of a vessel, something like two thousand cubic feet of air space being the maximum limit wherein efficiency can be attained. In addition to the three appliances mentioned above there is a means, which has previously been mentioned, of applying formaldehyde and dry heat in partial vacuum in a steam chamber.

Tanks should be provided for holding solutions of carbolic acid, bichloride of mercury, permanganate of potash, or other solutions which may be desirable for use at the station.

Air-tight wooden chambers for the application of gaseous disinfectants to large quantities of material consist simply of an ordinary room having but one door, which is adjusted to fit as tightly as possible. The room itself should have a triple lining; it should be ceiled first with wood; then upon this should be placed a lining of tarred

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paper, and finally over this should be fastened a tightly fitting wooden ceiling. In this are arranged racks and hooks for spreading out or hanging up the articles to be disinfected.

Force pumps are simply ordinary Worthington or other pumps of equal force, made to resist, so far as possible, the action of bichloride of mercury.

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Detention Barracks.—There should be provided at every quarantine station adequate quarters for the comfortable housing, without crowding, and for the segregation, if necessary, of such a number of people as may ordinarily be expected to be held in detention at any given time. These quarters should be, as elsewhere stated, very thoroughly screened to prevent the ingress and egress of mosquitoes, flies, and other insects. The plumbing should be of the best and the sewers should be so arranged as to make it possible entirely to disinfect the dejecta. The kitchen, which is to provide food for the occupants of these quarters, should be far enough away to prevent any possible risk of contamination of food; and at the same time arrangements should be provided for the disinfection—before they are returned to the kitchen—of any food carriers which may be used in the barracks or hospital.

A steam laundry is a very useful adjunct to this portion of the station.

Crematory.—The station should be provided with a crematory capable of handling a human body in a decent and proper manner, or of disposing of any contaminated material which is deemed to be beyond the reach of mere disinfection.

Inspection of Vessels.—Experience has demonstrated that, prompted by anxiety to avoid delays and to save expense to owners, the average ship master has no compunctions of conscience regarding deception, and will often deceive the boarding officer if he is not very acute. In view of this fact, many of the ablest officers in the national service make it a custom to indulge in cursory inquiries and to stroll about the ship for a few moments, asking apparently careless questions of subalterns and crew, before beginning the regular inspection. The writer on one occasion found a man in his bunk (convalescent from yellow fever), who subsequently stood in line for inspection and declared himself well.

After such a cursory glance at ship and personnel, it is customary to call for the ship's papers, including the bill of health which, under the law of February 15th, 1893, all vessels entering a port of the United States must bring from the United States consul at the port whence they sailed. The captain, and the ship's surgeon, if one be carried, are then carefully interrogated as to the minutest details of the voyage, and as to the health of the crew and passengers, if the ship has within recent date come from a suspected port. All hands are then mustered and compared with the ship's papers.

This muster is one of the choice occasions for deception by the master. He may report any missing man as being on duty with the engines, and, if told to send a substitute to duty and bring the man, will even endeavor to pass off upon the inspecting officer a man already before him. In dealing with the fire-room force of an Atlantic liner (often one hundred and fifty or more) the inspecting officer must remember that this is a trick easily accomplished.

When the inspection of the *personnel* has been completed, it is then necessary to go through the whole ship, and especially those compartments devoted to the occupancy of crew or passengers. Every hole and corner in every compartment is to be searchingly investigated. If any inspection is needed, an absolutely complete one is an imperative demand. Firemen have been known to put their belongings in the firebox of a boiler which was temporarily disused, and cover them with cinders. In view of the known occurrences of this kind, it is absolutely necessary to use the most stringent care in searching every possible hiding place, and to bear in mind another fact which, while well recognized by most quarantine officers, seems beyond belief, viz., that the article most likely to be so hidden is *always that which with greatest certainty is infected*.

The clothing of a man dead of communicable disease was secreted by his comrades in the furled sails of a bark at the South Atlantic quarantine, and only the large and badly distributed bulk opened the way for its discovery.

Fortunately, cargo is, as a rule, composed of new goods, and it is therefore hardly probable that it contains any infection. Indeed, while I am not as yet willing to subscribe absolutely to the innocuousness of cargo, I must admit that it is likely to come up for serious consideration only as regards one particular; I refer to the question of food-stuffs coming from some cholera centre. These food-stuffs, however, are not, as a rule, of such a character that they would be likely to transport the comma bacillus in a living state across the Atlantic Ocean. An examination of the ship's manifest will, therefore, show fairly well whether there is a necessity for taking any measures regarding cargo, and such measures belong to the disinfection rather than the inspection of the vessel.

Food and water supply should be investigated if such a disease as cholera is aboard, and water supply alone for mosquitoes if yellow fever is found. In the absence of either, no attention need be paid to these supplies.

Ballast has long been a bugaboo at Southern quarantine stations, and the writer confesses to having been at one time a strong believer in the transmission of yellow fever through *infected* ballast, but he is now fully convinced (through the findings of the Army Yellow-Fever Commission) that yellow fever cannot be conveyed through the medium of clean, *dry* ballast, of the character ordinarily used, be it either rock or sand. Nor would there be any danger in sea-water ballast in tanks.

There is probably no doubt that dirty and damp rubbish might convey plague or cholera, and even yellow fever by serving as a brooding place for mosquitoes; but clean, dry rock or sand would almost certainly convey nothing of an infectious nature. Dirty rubbish ballast should be debarred at all ports, and ships which insist on bringing such stuff should pay the penalty of disinfection.

The inspection of ballast and the determination of its character are, as a rule, easy of accomplishment. If the inspection satisfies the quarantine officer that the vessel can be admitted to entry without jeopardy to public health, she is given pratique and concerns him no further. If, however, it is decided that she is infected, measures appropriate for the eradication of the disease with which she is known to be infected must be taken.

In order that we may properly consider what measures are necessary for the correct treatment of a vessel infected with any given quarantinable disease, a brief *résumé* of the salient points of each of these diseases will be in order, such *résumé* to include, so far as is possible in each case, the period of incubation, the actual cause of the disease, the characteristics and viability of the causative micro-organism, when known, and its manner of spread. Symptoms of diseases will not be considered, such being out of place in an article of this character.

Yellow Fever.—Considerable space will be given to the discussion of this disease because, as above stated, it is the one perennial threat against the Southern borders of the United States. Its period of incubation varies from a few hours to five days, and in a few rare instances slightly more than five days. Its cause is as yet undetermined. Its method of transmission has, fortunately, been determined to be through the medium of the mosquito, and that it is most probably not conveyed in any other way. It is now known, therefore, that yellow fever is not a contagious disease in the same sense as scarlet fever or smallpox is contagious. Consequently there is no danger to be apprehended from a yellow-fever patient, provided the presence of the mosquito can be entirely excluded. It is evident, therefore, that our whole effort in prophylaxis against yellow fever must be devoted to the exclusion, and, wherever possible, to the extinction, of this insect.

In view of the recent findings of the Army Yellow-Fever Commission, to the effect that yellow fever is con-

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veyed from man to man solely through the agency of an intermediary host (the Stegomyia fasciata), it becomes at once necessary to inquire what bearing the acceptance of these findings in their entirety will have upon the question of precautions to be taken against the admission of yellow fever into our ports.

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Vessels should be inspected now before they leave the yellow-fever port and all mosquitoes destroyed.

The Public Health and Marine Hospital Service, fully alive to the importance of the facts above stated, has stationed officers at foreign ports to do this work wherever it can be done without conflict with the laws and regulations of the place. It will not do to assume that vessels cannot carry mosquitoes, as some have asserted; as a matter of fact, they do carry them. Thus, for example, one vessel, the *Maria Blanquier*, arrived at Sapelo Sound, Georgia, after a voyage of about forty days from Rio, with myriads of Stegomyia fasciata aboard, and it only needed that she should have had one case of yellow fever in Rio to have had every soul on board stricken en route, and the vessel (short-handed) be perhaps a castaway.

To sum up, then, we find that the disinfection of vessels from a yellow-fever port, and only a few days out from such port, is still necessary, and that such disinfection should compass the *entire* destruction of all mosquitoes on board the ship. The best means to this end will be a gaseous disinfection by SO_2 of not less than four per cent. volume strength for a period of at least six hours, and better twelve. This disinfection should be carried out simultaneously in all parts of the vessel, and scrupulous care should be taken to see that the fumes reach *all* dead air spaces, and particularly all parts of the living apartments.

If a vessel has been away from a yellow-fever port for more than ten days,—*i.e.*, several days beyond the incubative period of yellow fever,—and if at the same time a well-authenticated history of no sickness en route has been obtained, it would be very natural to assume, especially if the Stegomyia had not been found in the vessel, that she was not infected and that consequently she might safely be allowed to pass on without subjecting her to a process of disinfection. The records, however, show plainly that it is not always safe to reason in this manner. Thus, for example, Surgeon H. R. Carter, of the Public Health and Marine Hospital Service, has published in Bulletin IX. of the Yellow-Fever Institute, July, 1902, a report of a number of instances in which yellow fever was apparently contracted on board an infected ship. Owing to the lack of space I shall be able to quote only one of the instances mentioned in this report.

"III. British ship *Avon*, in rock ballast: twenty-two in crew, four immune to yellow fever. Sailed from Rio de Janeiro April 20th. All well in port and en route until thirty-eight days out, when a boy in port watch sickened with yellow fever. Taken to hospital, Gulf Quarantine, on third day, and died on sixth day. Another case developed two weeks later in a quarantine attendant who helped me clean up the room, sail locker, in which the boy was sick aboard ship.

"It is remarkable that there should have been only one case of yellow fever among the crew aboard this vessel. At the time, it was ascribed to the fact that this boy, the only one on the port watch, helped a man, shipped in Rio de Janeiro and immune to yellow fever, overhaul his chest a few days before the boy was taken sick. Whether there was an infected mosquito in the chest which had survived this length of time, or whether there was any relation between the chest and the fever, may be a question. It in no wise affects the present question that the disease was contracted aboard. It was the first case seen at this station that year."

Cholera.—The period of incubation of this disease is from a few hours to five days; more often it is about three days. The cause is the comma bacillus of Koch, now generally known as the Spirillum choleræ asiaticæ. (For details in regard to this disease see the article on *Asiatic Cholera* in The Appendix.)

The manner of spread of this disease, the introduction of which into the human system is by the alimentary canal, is through the medium of dirty hands, polluted food, polluted water. Both food and water may be polluted, and probably are, by flies, which, having come into contact with cholera dejecta, subsequently make their way to the food supply. These insects probably played an important part in the great epidemic of cholera in Hamburg in 1892, after the disease became general in the city, though in the beginning it undoubtedly arose from the presence of the spirillum in the main water supply of the city, the Elbe River, and it was the ultimate correction of this water supply which had more to do, than any other one factor, with the wiping out of the disease. In fact, it appears doubtful whether more than occasional cases of cholera would occur in any community where the water supply is guarded with great care. It is not simply through drinking it, however, that individuals may contract cholera from infected water; they may also acquire the disease by eating fruits and vegetables which have been washed in such infected water.

Bubonic Plague.—The period of incubation of this disease rarely exceeds seven days, and is more generally from three to five days. The cause is the Bacillus pestis, a short rod which is capable of bipolar staining with aniline dyes, and whose viability and general characteristics have been well stated by Dr. M. J. Rosenau in his work on "Disinfection and Disinfectants." It will suffice here to state that it survives in moist and albuminous surroundings for quite a long time, and in test tubes in laboratory work for months and even years. It dies quickly when dried, but retains life longer when dried upon textiles and other similar fomites than in any other form of dryness, especially if the temperature is under 19° C. It is, therefore, to be borne in mind that the colder the climate the greater is the danger to be feared from infected fomites, and the more thorough should be the procedures adopted for effecting disinfection. A dry atmosphere and sunlight kill the bacillus quickly, and inversely, darkness and damp atmospheres promote its vitality. It is not a water-borne infection, though it may live for a time in water. It is largely spread to man through the agency of rats, fleas, flies, and other small animal life. It therefore follows that, to disinfect for plague, it is necessary to use such agents as will destroy this small animal life, as well as the plague organism itself.

The past history of this disease, although it has been written in a very unsatisfactory manner, is nevertheless sufficiently full to indicate that it has probably obtained a foothold in communities, in almost every instance, for a relatively long time before it has been recognized. It may be that it has existed among the rats and other animals for many months before any human being has become infected thereby, and a study of all the great epidemics of plague will indicate that it has existed among men for a very considerable period of time before it has been recognized as plague, and before measures have been taken to prevent its spread. There is little doubt that the great plague in London did not occur within one month or one year after the disease first gained a foothold in that city. It appears very probable that it had already been there for several years, slowly and steadily gaining a foothold for the great outbreak. Again, it is apparent that in the beginning of an outbreak this disease is more mild in character than later on in the epidemic. This characteristic has been observed in the case of yellow fever also. There are apt to be mild, so called ambulatory cases, which would not be recognized as plague under any other condition than that of an active epidemic, and these may spread the disease just as surely as a virulent case; and it is these which doubtless do spread the disease from person to person and from place to place long before there is any general recognition of its existence.

Smallpox.—The incubative period of this disease has been variously stated as being from five to thirty days. These wide limits, however, are exceptional, and most authors agree upon an incubative period of from ten to twelve days in a majority of cases. An experience extending over many hundreds of cases justifies the state-

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ment that in at least ninety per cent. of all cases, the initial fever of the disease will begin in approximately ten days from the time of exposure, and will hardly vary twenty-four hours from this time. The causative agency of this disease is not known. Its mode of transmission is generally through actual contact with a person who has the disease in the eruptive stage. It is not denied that intermediate contact, such as the carrying of the disease by a careless doctor from a smallpox patient to a healthy family at a distance, may be possible, but such occurrences are so rare as to be hardly worthy of consideration in actual practice. In other words, while such carelessness might result in carrying some of the contagium upon the clothing of the person, and thus the question of intermediate fomites be brought into play, it is very much more generally true that when the disease is carried by fomites, it is carried by clothing actually worn and used by a person infected with smallpox, and subsequently taken to a healthy person. There has been much discussion as to the period when smallpox becomes contagious. While, generally speaking, it may be safe to take precautions with regard to an exposure to a smallpox patient in the febrile stage, it has been found that almost without exception—and, so far as the writer is aware, absolutely without exception—no infection has ever resulted from exposure to either the febrile or the papular stage of smallpox. It is only after desquamation has begun that the patient is liable to communicate the disease to others; and this contagiousness will continue until desquamation has thoroughly ceased. Consequently, it is important, before discharging a convalescent from smallpox, to ascertain if every single scale has been cast off from the scalp and from the palmar surfaces of the hands and feet; for it should be borne in mind that the desquamation from the scalp is retarded by the hair, and that this is particularly so with regard to the negro, while the thick epidermis of the palmar surfaces makes them the last to desquamate.

Typhus Fever.—The incubative period of typhus fever is ordinarily stated at about two weeks; it is probably a little less than this, some authors giving it as twelve days. The exact cause of the disease is unknown. It is exceedingly contagious, probably the most pronouncedly contagious of all the quarantinable diseases.

To quote Dr. Rosenau: "Typhus fever is believed to be 'contagious' in the sense that it is communicated by contact between the sick and the well. When the disease exists in epidemic form it is the most highly contagious of all the diseases of man. The nurses, physicians, and those who come in contact with the patient are the first to take the disease. Few escape.

"It is evident that sanitation is much more needed to prevent the spread of this disease than disinfection; in fact, while disinfection is practised for typhus fever, there is nothing to indicate that it is efficacious in preventing the spread of the disease."

Disinfection of Vessels for Various Diseases.

Yellow Fever.—As stated in the discussion of yellow fever, the disinfection of a vessel infected with this disease necessarily involves the destruction of all the mosquitoes aboard such a vessel; and while this is probably all that should be done, it is nevertheless still the custom—and one which probably will continue until all health authorities are fully convinced that there is no other means of transmission than that afforded by the mosquito—to carry this disinfection somewhat further. To compass the destruction of the mosquito, it is simply necessary to introduce simultaneously into each and every part of the vessel—cabin, forecastle, between-decks, hold, and any other compartments in the vessel—sulphur dioxide gas of a minimum strength of four per cent. per volume for each thousand cubic feet of air space of the vessel. In an empty vessel it is desirable to continue introducing the gas for from six to twelve hours; in a vessel containing cargo it will be necessary to provide channels through the cargo, in order that the gas may permeate as far as possible, and to continue the introduction of the gas for twenty-four hours, in order to insure the destruction of all the insects. If the disinfection of baggage and textiles of other kinds is to be undertaken, this is done for the different articles, according to their class, in the manner described in detail in the article on *Disinfection.*

From a sanitary standpoint the vessel and its inanimate contents may now, after such a thorough disinfection, be considered no longer a source of danger, and the owner may be permitted to remove his ship from quarantine.

As regards those who were on board the vessel at the time of her arrival, it will be necessary, before carrying out the measures for disinfection described above, to dispose of them on shore, at the station. The sooner any infected persons are isolated or segregated, in order to prevent a further spread of infection, the better it will be for all parties concerned. The sick should be taken to a hospital so thoroughly provided with screens as to prevent the ingress or egress of mosquitoes; the healthy persons should be placed in barracks similarly provided, in order to prevent the spread, to the remaining healthy patients, of infection from any one of them who may subsequently be taken sick. This screening must be so absolutely perfect in character that it shall not only exclude the most of the mosquitoes, but all of them; and in the event that some solitary mosquito should find access to any of the rooms, steps should be taken to insure its destruction. To prevent the harm which might result from the accidental contamination, by one or two of these insects, of any ward or barrack building, it will be necessary every day to burn a certain quantity of the so-called Persian insect powder in every apartment, and then afterward to sweep up and kill the stupefied insects which will fall to the floor upon the inhalation of the fumes.

Finally, any person effectually isolated from infection, and remaining healthy more than five days, may be released.

Cholera.—Upon the arrival of a vessel at a quarantine station with cholera on board, or having had cholera on board at a recent period during the voyage, it is advisable, when possible, to remove from the vessel all of her *personnel* (both crew and passengers), isolating and segregating these people ashore very much after the method prescribed in dealing with a yellow-fever ship. In addition to the precautions to be taken against insects in the case of yellow fever, it is necessary to provide, in the case of the cholera suspects, recently cooked food which shall not have been contaminated by an insect, and a water supply of undoubted purity. It will also be necessary to make arrangements for either the disinfection or destruction by fire of all the dejecta of all persons kept under observation; for it should not be forgotten that the apparently healthy person may carry within his alimentary canal the cholera spirillum, and may infect sewage, which in its turn may ultimately infect a water supply.

For the ship itself, the measures to be taken are as follows: 1st. A thorough mechanical cleansing, such as is very admirably done by the Hamburg-American and North German steamship companies on their passenger steamers when they arrive at the home port. This consists in washing the vessel with what they know as Seifenlager, a very strong solution of soap and water, plus a certain amount of caustic potash. When every part of the vessel, which may properly be so treated, has been cleansed in this manner, and when the ornamental wood and bright work finish, which cannot be so treated, has been washed with a solution of carbolic acid or other agent which will not damage it, thorough dryness, so far as practicable, should be obtained, and the gaseous disinfection applied simultaneously to every part of the vessel. This gaseous disinfection should be preferably of sulphur dioxide, four per cent. twelve hours' exposure, as elsewhere stated; but, in certain compartments on the finer class of vessels, this style of disinfection would result in damage, which can be obviated by using instead, in such apartments, a six-per-cent. volume of formaldehyde gas for a period of from six to twelve hours. All

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textiles which will not be damaged thereby should be subjected to live steam for a period of thirty minutes; and such as will not bear this treatment should be disinfected by the conjoint use of a vacuum and formaldehyde gas, six per cent. volume, for an exposure of one hour's duration. All textiles which have been polluted by cholera dejecta should without exception be burned, and no attempt should be made to disinfect and re-use such articles. The detained *personnel* may be released when five days have elapsed since their last possible exposure to infection.

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Plague.—Measures to be taken in the treatment of a vessel infected with plague are identical with those used in the case of a cholera-infected ship, except that on account of the peculiar methods of transmission of this disease (partly through small animals), it is necessary to use a germicidal agent which will destroy animal life as well as bacteria; and for this purpose formaldehyde is not strictly reliable; consequently, all gaseous disinfection done on a plague-infected vessel must and should be done with sulphur dioxide. The segregation and careful attention to the individuals, including the adoption of stringent measures capable of preventing the pollution of either dejecta or sewage, apply to this disease as strongly as to cholera; and for the reason that small insect life has a bearing in the transmission of the disease, the screening provided for cholera and yellow fever, while not so absolutely essential, is nevertheless advisable, and, wherever possible, should be used. Manifestly the persons under detention may be released at the expiration of from seven to eight days since their last possible exposure to infection.

Smallpox.—Here we have to deal with a disease which does not require such rigid measures as have been applied to any of the other quarantinable diseases. If a person in any given apartment of a vessel has been afflicted with smallpox, it does not necessarily follow that all the persons on the vessel are to be detained in quarantine, nor that the whole ship is to be disinfected. It will be sufficient if we disinfect with scrupulous care all possibly infected personal belongings, and, in the same manner as is applied for yellow fever, all portions of the vessel which have been invaded by the disease. At the same time it is important to keep under observation those persons who have been in direct contact with the afflicted party, or who have not been vaccinated. The usual custom is to vaccinate immediately all exposed persons and hold them under observation for fourteen days; to release at once all those who have not been exposed and who are vaccinated; and to disinfect such parts of the vessel as have been in touch with the actual case, releasing the vessel at once, and holding only the suspects. Should the infection on the smallpox vessel be so general as to justify the opinion that all on the vessel have been more or less exposed, then it becomes necessary to disinfect the vessel in the same manner in which it would be done for yellow fever, and to disinfect it throughout, holding under observation for fourteen days all of its *personnel*.

Typhus Fever.—In view of the little that is known of typhus fever, *i.e.*, as to its manner of transmission, period of incubation, etc., it is exceedingly fortunate that we seldom or never find a general infection of typhus fever aboard ship. Should such a calamity supervene, all the *personnel* should be immediately segregated ashore, and the groups placed far enough apart, if sufficient ground is obtainable, to prevent the infection of one by the other, it having been claimed that aerial infection plays a part in this disease. The vessel should be disinfected in the same manner as for cholera, and the *personnel* kept under observation for a period of fourteen days from their last exposure to possible infection.

Leprosy.—The quarantine regulations of the United States demand the retention at quarantine of any alien leper, and his replacement upon the vessel when outward bound.

Minor Communicable Diseases.—There are, in addition to the diseases above discussed, several others which at times call for treatment, but which are not generally classed as quarantinable diseases. These diseases—scarlet fever, measles, diphtheria, and even some others—are as a rule passed up to the local board of health for proper handling.

When treated at quarantine, they call for the same measures as are applied to smallpox (except of course vaccination).

Land Quarantine.

Because of lack of space only brief notice can be given this subject, which after all is simply a common-sense application of maritime rules to exactly the same diseases on land. The people are to be handled in precisely the same manner as at a maritime station, and if we simply transfer our disinfecting agents from a ship to a house, the methods remain the same. The difficulties of administration are greater because, while at a maritime station the quarantine officer is practically supreme, in land quarantine he has to meet the whims and foibles of local lay authority, or even of individuals.

Joseph H. White.

QUASSIA.—*Quassiæ lignum* or *Lignum Quassiæ. Jamaica Quassia. Bitter-wood. Bitter-ash.* The dried wood of *Picrasma excelsa* (Swz.) Planch (*Quassia e.* Swz.; *Picræna e.* Lindl.; *Simaruba e.* DeC.—Fam., *Simarubaceæ*), U. S. P.

The Jamaica quassia tree is said closely to resemble a small or medium-sized ash tree. It occurs chiefly in Jamaica, but to some extent in other parts of the West Indies. Quassia was originally derived from a different plant, considered below, but was later replaced by this one. The wood occurs in billets of various sizes, dense, tough, of medium hardness, and of a nearly uniform yellowish-white color; internally porous, with a minute pith, indistinct rings, and medullary rays which, on tangential section, exhibit from two to five vertical rows of cells; inodorous and intensely bitter.

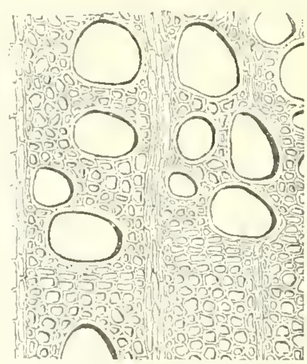

Fig. 3924.- Section of Quassia Wood. (Baillon.)

It is usually met with in the form of chips or raspings.

The powdered wood is devoid of stone cells, contains crystals of calcium oxalate, and exhibits the tangential appearance of the medullary rays described above.

Quassia contains neither tannin nor starch, and, if pure, yields not more than four per cent. of ash. Its bitter principle is the crystalline substance *quassiin*, freely soluble in alcohol and chlorofom. Although it requires 1,200 parts of water for solution, the dose is so very small that water constitutes a satisfactory menstruum. Quassiin is further resolvable into two crystalline bodies, called respectively *α-picrasmin* and *β-picrasmin*. A minute amount of alkaloid has been reported, but is probably of no medicinal importance.

Action and Uses.—Quassia is generally regarded as a pure or simple bitter tonic, like gentian, and is mostly used as such, being given, either alone or in combination with aromatics and stimulants, as a stomachic and appetizer. In debility, in convalescence from fevers, in dyspepsia, it has been, and is still, in considerable use. Its taste is, however, more bitter and disagreeable than that of gentian or quinine.

Quassiin is a powerful irritant and convulsive poison when concentrated or used in overdoses, and is apt after long administration to set up a gastric irritation. Its use is therefore better alternated with that of other medicines.

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It is particularly poisonous to the lower animals, on account of which it is much used as a rectal injection for the destruction of ascarides. For the latter purpose, from a half-pint to a pint of the ten-per-cent. infusion is employed. The death of an infant has followed such use. The freedom of quassia from tannin renders it a desirable bitter for mixing in prescription with the iron preparations. The Pharmacopœia provides an extract (*Extractum Quassiæ*), the dose of which is 0.03–0.2 gm. (gr. ss.–iij.), but this is the least desirable preparation for use, since the patient fails to receive the beneficial effect of the bitter taste. The dose of the official fluid extract is 1–4 c.c. (fl. ʒ ¼–i.) and of the tincture, which is by far the most efficient of all preparations, 2–8 c.c. (fl. ʒ ss.–ij.). The infusion is a popular form of administration, and should be of five-per-cent. strength. Another excellent method is to introduce cold water into cups made of quassia wood. The water becomes almost at once intensely bitter, the patient receiving the full benefit of the bitter taste, with little systemic effect.

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Surinam Quassia.—This, the original quassia, is still the one chiefly employed in Southern Europe, and is official in nearly all pharmacopœias. It is the product of *Quassia amara* L., of the same family, a shrub or small tree of Northern South America, whence it extends up into Central America and into the West Indies. The billets are much smaller, usually from one to three inches in diameter, crooked, and still bearing the bark, which is of an ashy gray color and nearly smooth. The wood is somewhat heavier than that of the Jamaica variety, and exhibits medullary rays only one row of cells wide on tangential section. The bark is full of large stone cells, which are seen in the powder, since bark and wood are usually ground together. The active principle of this variety is practically identical with that of the other, and the properties, uses, and doses are the same.

The same statements may be made concerning East Indian quassia and Japanese quassia, derived from other species of *Picrasma*. *Henry H. Rusby.*

QUEBRACHINOFORM. See *Formaldehyde.*

QUEENS ROOT. See *Stillingia.*

QUERCIFORM. See *Formaldehyde.*

QUINAMINE. See *Cinchona.*

QUINCE SEED.—*Cydonium* (U. S. P., 1880).—The dried ripe seeds of the common quince, *Cydonia Cydonia* (L.) Lyons (*Pyrus Cydonia* L.; *Cydonia vulgaris* Pers. fam. *Rosaceæ*) together with the gum in which they are naturally embedded.

The quince is a native of Southwestern Asia and adjacent Europe, but the seeds are wholly the product of cultivated plants. They occur agglutinated in masses of eight to ten or more, being embedded in a colorless, transparent gum, of which about twenty per cent. is obtainable, and for which they are valued. One part of this gum makes about 100 parts of mucilage. This has little adhesive power, but is excellent for the ordinary medicinal uses of mucilage, such as the making of collyria, demulcent drinks, etc. When the drug was official, it was directed that the official mucilage be made by taking 2 parts of the seeds with 98 parts of water.

Henry H. Rusby.

QUINETUM. See *Cinchona.*

QUINIDINE. See *Cinchona.*

QUININE. See *Cinchona.*

QUININE, NEW COMPOUNDS OF.—In the following preparations, the dose, unless specified, is that of quinine sulphate.

Acetyl-salicylate—for rheumatism.

Arsenite—sixty-nine per cent. quinine. Dose 0.005–0.03 gm. (gr. $\frac{1}{12}$ to gr. ss.).

Bichloride—very soluble. Improvement in recurrent cancer followed daily injections of 0.5–1 gm. (gr. viij.–xv.) by Jaboulay in France and Trible in America.

Borate—a yellow insoluble powder, antiseptic.

Caseinate.

Chloro-carbonate—freely soluble, almost free from bitter taste.

Chloro-phosphate—fifty per cent. quinine; soluble in two parts of water.

Chloro-sulphate—seventy-four per cent. quinine; soluble in one part of water.

Dibromguaiacolate—guaiaquinol.

Dihydrobromate, dihydrochloride, dihydroiodate—all readily soluble and used by hypodermic injection for whooping-cough. Dose, 0.06–0.2 gm. (gr. i.–iij.).

Dihydrochloride-carbamate—muriate of quinine and urea. Seventy per cent. quinine; very soluble.

Ethyl carbonic ester—Euquinine (see Vol. IV.).

Ferri-chlorid—dark reddish-brown crystals used in two-per-cent. solution as a hæmostatic in internal hemorrhage and in uterine hemorrhage.

Glycerophosphate — kinewin, especially employed in neuralgia. Dose, 0.1 gm. (gr. iss.).

Guaiacol bisulfonate—guaiaquin, an odorless, non-caustic substitute for guaiacol.

Hydroquinone-hydrochloride—antipyretic.

Ichthyol-sulfonate—sulpho-ichthyolate, employed in tuberculosis.

Iodo-hydroiodate—insoluble in water. Used as substitute for iodides in syphilis, and in the same dosage.

Lactate—readily soluble.

Lygosinate—antiseptic compound of di-ortho-cumarketone (lygosin).

Methyl-di-hydrazin-perchlorate—compound of quinine hydrochlorate, caffeine, and antipyrin.

Phospho-hydrochloride—soluble.

Phosphoric acid ester—phosphorylquinine.

Salicylic acid ester—salicyl quinine or saloquinine (see *Saloquinine*).

Salicyl-salicylate—(see *Rheumatin*).

Silico-fluoride—soluble in water.

Sulpho-creosotate—used in tuberculosis.

Urethane—very soluble, made by mixing 3 parts of quinine hydrochloride, 1.5 parts of urethane, and 3 parts of water. *W. A. Bastedo.*

QUININE. (TOXICOLOGICAL.)—Any high degree of toxicity can hardly be said to exist in the ordinary use of cinchona and its alkaloids or their salts. There are certainly symptoms very commonly associated with their therapeutic uses, even in most moderate doses, which are characteristic and indicate some functional disturbance of various organs. Such are the sense of constriction about the forehead, the ringing of the ears, and occasionally nausea. In many persons these are not sufficiently marked to attract attention unless the doses given are very large or long continued. Of these the sense of fulness and the deafness are the commonest, and are looked upon as necessary accompaniments of the administration of the drug, not giving rise to uneasiness either in the patient's or in the physician's mind, and expected to disappear promptly when the medication is stopped. They are the physiological evidence of mild cinchonism. The susceptibility of individuals varies greatly as to the amount of the drug which will produce such manifestations. Some persons are occasionally met with who suffer so promptly and acutely from these troubles that treatment to counteract them has to be instituted in order that enough of the required drug may be taken into the system to produce the desired effect upon the primary disease. Many, on the other hand, show so little susceptibility that astonishingly large and rapidly repeated doses may be given with only beneficial results.

Liebermeister (quoted by Kunkel) says: "I have up to this time employed quinine in large doses in more than fifteen hundred patients with abdominal typhus, and also in hundreds of pneumonias and other diseases. The number of single doses, of from 1 to 2, up to 3 gm.,

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which I have prescribed, may run up to ten thousand, and not once have I seen any essential or lasting injury which one might seem warranted in ascribing to quinine." The cause of the disturbances produced by quinine has not yet found a satisfactory explanation.

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Notwithstanding the infrequency of toxic manifestations from the use of quinine, a large number of cases can be found in the periodical literature of the last half-century, some of an acute character after minimum doses, and some in which the most inordinate quantities have been taken. It is these latter which present the most serious symptoms, and are even followed by death. The former must be regarded as due to an idiosyncrasy, which also is not infrequently hereditary, while the latter may properly be classified as cases of poisoning, whatever the action of the drug or whatever organs are specially involved. There is still another class of cases, viz., those in which quinine, given in very moderate doses, especially in certain tropical districts of Africa, to persons who are already the subjects of malarial dyscrasia, quite promptly causes a sharp advance in temperature accompanied by hæmoglobinuria—the Schwarzwasserfieber of German writers. The following may serve as illustrations:

Hare reports the case of a man of fifty-three for whom two grains of quinine, three times a day, was prescribed. It produced an intense erythematous rash, which was subsequently followed by desquamation, including the palms of the hands and soles of the feet. On learning that quinine was contained in the medicine prescribed for him, he said that he had once before had the same experience, an eruption having developed after he had taken a cocktail containing a few drops of elixir of calisaya. This man's daughter, twenty years of age, also suffered from a rose rash followed by desquamation after taking a small dose of quinine.

Husemann reports the case of a soldier in good health who took 12 gm. of sulphate of quinine in a five-per-cent. solution. He died in four hours in an access of heart weakness. A third report is by Guersant. A French physician in a rural district was in the midst of an outbreak of malarial fever. When his wife was taken ill he gave her 240 grains of quinine in the course of a short time, and she fell into a state of stupor with amaurosis, deafness, and difficulty of moving, whereupon he gave her 375 grains more, and the serious symptoms increased. Fortunately for her he was about this time taken ill with the fever himself, and she finally recovered. He administered to himself, however, 900 grains by mouth and rectum, which brought him to a condition resembling that of a man affected with pneumonia terminating in hepatization; but he managed to take in the course of eight or nine days five ounces more of quinine. When at last he came under the observation of another physician he was in a cold sweat, deaf, blind, his respiration difficult and rattling, and in a profound stupor, looking like a drunken man. Delirium and death soon closed the scene.

I. B. Yeo reports his own experience as follows: Fearing that he had taken cold, he administered to himself two doses of two or three grains each of quinine. The next morning he found upon his legs an erythema with much itching, which faded in three or four days. He repeated this experience twice at intervals of two months, the last time taking three grains and the rash appearing in a few hours. Five months later, imagining that the former doses might have contained some impurity, he took pains to get the sulphate of quinine from a druggist of the best repute, and the usual eruption in three and a half hours followed the taking of three grains. Six weeks later, a dose of one fourth of a grain, directly after breakfast, was followed by the rash in five hours.

Not to burden this paper with the details of the action of quinine in disturbance of all the various organs, it will suffice to mention those of special interest and importance, whether such toxic effect is manifested after the introduction into the system of such quantities as would everywhere be considered large if not excessive, or of such minute doses that their poisonous activity is the evidence of an individual idiosyncrasy. Of these the most prominent are the effects upon the skin, upon the eyesight and hearing, upon the kidneys, and upon the pregnant uterus. Some reference should also be made to effects upon the general nervous system.

Cutaneous disorders may arise from the local irritating action of quinine when the skin is denuded, according to Hugounenq, and it has frequently been observed that the operatives in quinine factories suffer from similar local troubles, with also a certain amount of constitutional disturbance, even when the skin is sound.

Authorities differ in their views of the pathogenesis of these eruptions, Lewin saying that no absorption of quinine takes place through the sound skin, and that the eruption occurring in quinine workers is not to be regarded as an occupation disease, but as an idiosyncrasy against quinine, which seems not a very tenable theory in view of the frequency with which such cases occur. He says also on the next page that it is the direct contact of the quinine with the skin, its excretion through the medium of the sweat glands, among other like possibilities, which chiefly furnishes the explanation of this irritation rather than a disturbance of the stomach or bowels producing a reflex irritation of the skin or any action of the drug in solution in the blood acting upon trophic or vaso-motor nerve tissues.

Morrow considers that the theory of the stimulation of the sensory nerves of the gastric mucous membrane, producing reflex dilatation of the cutaneous vessels, is applicable to only the milder and superficial forms of eruption. He also refers to the theory of an elective affinity of the sweat glands for the drug, its attempted elimination through this channel causing local irritation. He says that the toxic action of quinine upon the skin may result from electrolytic action, from its use in pomades or lotions, and from subcutaneous injection as well as from ingestion of the drug.

Writers report many forms of quinine eruption, although that resembling scarlatina is the commonest and most important from the point of view of diagnosis. It is most apt to follow the taking of sulphate of quinine rather than other preparations.

Thus there is pruritus, which is often limited to certain regions, such as the glans penis, the hands, or the legs. Erysipelatous and gangrenous forms are reported, although the latter is very rare. The urticarial form is wont to be accompanied with much constitutional disturbance. Hyde and Montgomery remark that it is hardly to be distinguished from an *urticaria ab ingestis*. The mucous membrane of the throat and fauces may be involved in this form. Eczematous and bullous forms are mentioned, and finally the petechial, which may be accompanied by bleeding from the buccal mucous membrane or by sanguinolent stools, sometimes following very small doses of the drug. Desquamation of greater or less extent is a not infrequent sequela of these various forms of eruption. In the matter of differential diagnosis the greatest interest attaches to the exanthematous form from its likeness to scarlatina. The eruption is of a vivid hue and disappears under pressure. The history of the case, as to whether quinine has been given or not, is of the utmost importance, and Morrow points out that there is usually no fever, and that the eruption subsides when the drug is discontinued. Quinine can also be easily detected in the urine.

With reference to the effects of quinine upon the sight and hearing it is observed that they are wont to be more persistent than other toxic effects of the drug, lasting often for years or permanently, while the others disappear on its discontinuance. The symptoms of its injurious action on the eye are increased lachrymation, itching and œdema of the lids, photophobia (which may be only transient, but may persist), diminished or lost pupillary reaction, and sometimes complete but usually temporary loss of sight, either in one or in both eyes. But the most typical and persistent lesion is concentric limitation of the visual field, which may exist even though the acuity of vision is little impaired, and which may be demon-

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strable even when the acuity of vision is completely restored. At the same time there may be a diminished sense of light, as if a veil were interposed. There may also be color blindness, which but slowly disappears. The changes appreciable by the ophthalmoscope are in the papilla of the optic nerve and the vessels of the retina, the media remaining clear. There is a high degree of constriction of all the vessels, tending to atrophy, and the optic nerve is pale (Lewin and Kunkel).

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Quinine given in even very moderate doses generally causes some hardness of hearing with tinnitus or roaring in the ears. There may even be complete deafness lasting for twelve or twenty-four hours. Existing middle-ear disease may be exacerbated or an otitis externa may develop. Under these conditions may be observed a slight injection of the vessels of the handle of the malleus and some degree of opacity and retraction of the membrana tympani.

It has been observed that what has been called quinine fever sometimes supervenes upon the administration of small doses of the drug in persons who are the subjects of malarial infection, the symptoms consisting in the rather prompt appearance of chill, fever, and sweating, with sometimes disorders of the alimentary canal and bloody urine. No satisfactory explanation has been offered for these manifestations. When it is added that to quinine is attributed an occasional irritation of the urinary passages leading to albuminuria, and that sometimes the urine also contains blood, hæmoglobin, and methæmoglobin, we are very near to the condition known under the German name of Schwarzwasserfieber (black-water fever), which Kunkel describes as follows: "This is a disease of the African tropics, and is so far directly associated with malarial infection that it occurs only in men who have been infected with malarial virus. They are apt to be only apparently in good health, or have a malarial dyscrasia. There is always a chill, followed by nausea, intractable vomiting, and other signs of severe constitutional disturbance, such as diarrhœa, dulness of mind, restlessness, dyspnœa, and irregular febrile movement, as in cases of septic infection. There are indications of serious blood decomposition. The urine is of a dark reddish-black color, and contains pigment granules, renal epithelium, and casts, but no erythrocytes. The symptoms of acute nephritis are always present. The prognosis is bad and death follows with signs of heart failure or of uræmia. In cases that do not succumb kidney lesions remain, and after the seizure the blood corpuscles and hæmoglobin are enormously diminished."

Kunkel enters quite extensively into the discussion of this subject, and cites many authorities who furnish good evidence that in the course of malarial disease, when quinine has not been given, attacks of hæmoglobinuria occur, and that they seem to occur most often in regions where the local perniciousness of the disease is greatest. Thus they occur in Greece more than in Germany, and in Africa more than in India.

Again, in cases in which small doses of quinine are given to the subjects of malarial infection, but who are not seriously ill at the time, bloody urine will quite promptly appear. Thus good authorities agree that in certain persons saturated with malaria the blood corpuscles become very sensitive to the action of quinine and readily break down. The question also comes up, in this connection, regarding the similar action of chlorate of potash, of carbolic acid, and of arseniuretted hydrogen as blood poisons. There seems good evidence also that not only are small doses of quinine not curative in these conditions, but that they excite the disease, which can be cured by large doses only, 4 gm. for example. Welsford, however, is of the opinion that black-water fever is a localized disease, and that some malarious districts in Africa are free from it; also that quinine certainly does cause hæmoglobinuria, but only rarely. He reports a case in which two ten-grain doses on two occasions induced black urine.

The action of quinine as an ecbolic is based on the occasional occurrence of abortion in malarial districts after this drug has been given. It is also reported that in China it is depended on to produce abortion, and that female operatives in quinine factories frequently abort. There is by no means an agreement of good authorities on this subject, however, and the best opinion favors the belief that this action is occasional rather than regular, and should be regarded as an incidental or by-effect rather than an evidence of toxicity.

It remains to consider the poisonous action of quinine upon the central nervous system. It is by no means easy to discriminate between the effects of quinine itself and those due to the disease for which it is given, especially as in severe cases, like pneumonia, intermittent and continued fevers, where large doses might probably be used, the disease itself might present such symptoms as headache, sleeplessness, and a state of collapse with loss of consciousness, delirium, or even tetanic or convulsive manifestations, such as are said to be due to the action of the drug upon the nervous system. Therefore cases illustrative of these effects are the unusual ones in which great quantities of quinine have been rapidly taken into the system when not called for by the existing disease, or far beyond its requirements, such as some already cited in this article, or the following, reported by A. E. Roberts:

"A woman, aged thirty-five, took about 20 gm. of quinine, became insensible in an hour, and this state lasted until the next day. She was cold and cyanotic, with slow and feeble respiration, pulse 45 and very weak, pupils widely dilated and insensible. Still she recovered. Her hearing became normal in a week, but it was two weeks before she had even a slight perception of light, and this was not wholly regained for months."

Such histories are the basis for the opinions of Briquet, A. B. Palmer, and Kunkel, the former of whom says: "If 2 gm. or more are taken and continued for several days, we observe an overwhelming, an exhaustion, stupor, somnolence, weakness of sight, dilatation of the pupils, and tremblings of the limbs. Very large doses lead to complete loss of consciousness, loss of sight and hearing, and complete immobility of the limbs. The delirium or intoxication of quinine is usually gay. He concludes that quinine produces a slight and temporary excitation of the encephalon, then soon a sedative action, which gradually increases, and which may go on to the destruction of nervous power."

Palmer describes as quininism ("cinchonism," Foster's "Medical Dictionary") those disorders of the cerebrospinal functions indicated by headache, giddiness, contraction or sometimes dilatation of the pupil, ringing or roaring in the ears, deafness, partial blindness, abnormal touch and smell, difficulty of controlling muscular acts, somnolency, sometimes delirium, at other times stupor, sometimes a severe sense of stricture about the chest. These effects are for the most part temporary, but sometimes more permanent. Kunkel concludes that with poisonous doses of quinine the central nervous system is progressively paralyzed in all parts. In case of severe acute poisoning death occurs from paralysis of respiration, artificial respiration prolonging life until paralysis of the heart occurs.

When we come to look for the lessons to be drawn in the way of prophylaxis against the possibly toxic action of quinine it is clear that the dangers due to idiosyncrasy are not serious, for its results are so soon in evidence from such small doses, and so very uncomfortable to the subject, that he will be quite apt to remember them, and to avoid the drug in the future. The injurious effects of quinine, Lewin tells us, are more apt to be observed in women and aged people than in others, while persons with delicate skins and those subject to eczema are particularly liable to quinine exanthemata. To these classes then, and especially to persons suffering from eye and ear diseases, quinine should be given most cautiously or not at all.

There is little likelihood that any impurities in the drug are responsible for the toxic effects attributed to quinine. In fact, Lewin declares that there are no dangerous adul-

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terations of it unless salicylic acid is the adulterant. He also warns against prescribing sulphate of quinine and iodide of potassium together, lest iodine should be set free in the intestinal canal.

There is not much to be said about the treatment of the toxic effects of quinine. Usually stopping the administration of the drug is soon followed by relief of the symptoms. When it is esteemed necessary to give the medicine, although unpleasant effects are already present or may be anticipated, several means of counteracting them are recommended. The bromides, and particularly hydrobromic acid, have quite a reputation, while Lewin and others have found ergotin, given in about equal doses with the quinine, efficient. Morrow and others recommend tincture of hyoscyamus. In dangerous cases in which there is collapse, the usual measures for stimulating the circulation by external applications and friction are in order, as well as the internal use of hot tea and coffee, and perhaps the subcutaneous injection of tincture of musk.

MacGregor favors subcutaneous saline injections in treating black-water fever. *J. Haven Emerson.*

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QUINOFORM. See *Formaldehyde.*

QUINOIDINE. See *Cinchona.*

QUINOLINE-BISMUTH-SULPHOCYANATE, or **RHODANATE.** See *Crurin.*

QUINOPYRIN is an aqueous solution of quinine hydrochloride and antipyrin. It is used by hypodermic injection as an antipyretic and nerve sedative in dose of 1 c.c. (♏︎ xv.) several times a day. *W. A. Bastedo.*

QUINOSOL. See *Chinosol.*

RABIES OR HYDROPHOBIA.—Rabies or hydrophobia is an acute infectious disease of the central nervous system which occurs in man as well as in other warm-blooded animals. As a spontaneous disease, as distinguished from that due to intentional inoculation, it is met with in the dog and allied species, the wolf, the fox, the jackal, the hyena. Cats are also more or less often affected. Osler states that the disease is said to prevail among the skunks of the Western States of North America. So far, no species of animal except pigeons has been found to be refractory to intentional inoculation with the rabies virus. In these birds the older individuals are not normally susceptible, but they become so on the deprivation of food, and the young birds are normally susceptible.

From the many points of analogy which exists between rabies and other acute infectious diseases, the conclusion would seem unavoidable that rabies is caused by a specific micro-organism; but all efforts to establish this by experiment and observation have so far proven futile, though several unsubstantiated claims to this effect have been made, it is true. Although the specific infectious agent is not known, it can be propagated in the central nervous system of living animals, not of dead animals. By inoculation of animals it has been shown that the poison is always present, sooner or later after infection, in the brain, spinal cord, nerve trunks, and saliva of infected animals. It is present in these situations even before any symptoms have developed, during the incubation period, while the animal is apparently well. It is usually not present at any time in the milk, lachrymal secretion, pancreas, testicle or semen, aqueous humor of the eye, cerebrospinal fluid, or in the fœtus, though it has been found occasionally in one or other of these situations.

Accidental infection usually results from the bite of a mad dog, and therefore is due to the introduction of the saliva of the rabid animal into the wounds made by the teeth. Sometimes infection results from the licking of an abrasion by a pet dog that is going through the incubation period and before any symptoms of the disease have manifested themselves in the animal. For this reason mad dogs are specially dangerous while they are going through this stage. They are not suspected of being mad, and are not avoided as they are after the symptoms appear. Novi states that midges and flies are also capable of carrying the contagium. Artificially, as already stated, the disease may be produced by inoculating animals with tissues from an infected animal. Injection under the dura mater of suspensions of the spinal cord from an animal dead of rabies in neutral beef broth, is the method very commonly resorted to, and this produces the disease very uniformly. The point of the hypodermic needle is inserted beneath the dura mater through a small trephined opening at the summit of the cranium a little to one side of the median line. With aseptic precautions and with ordinary care in manipulation, there is no immediate danger to the animal from the operation itself, either as regards the effect of the trauma or from infection with pyogenic organisms. Occasional failures to produce the disease by the method just described have been reported, it is true, but the failure was probably due, at least in most of these cases, to the use of too small an amount of material for the injection. To insure success, the amount used must not be less than one-thirtieth of a gram by weight of the cord, according to Kruse, although even smaller amounts are usually effectual. Johne, Dawson, Oshida, and others recommend injecting suspensions of the cord through the optic foramen. If this method is resorted to it is recommended to anæsthetize the animal, or to keep it perfectly still by any method, otherwise there may result a fatal trauma of the brain. Oshida has successfully inoculated rabbits by using a long needle and passing this through the optic foramen, through the brain, up to the dura mater. Similar injections into the sciatic nerve or other large nerve trunks, or into the anterior chamber of the eye, are also usually successful. Intravenous injections are also usually successful in small animals, but not in large. The same is true of intraperitoneal injections. Subcutaneous injection is very uncertain. The reason that has been suggested for the frequent failure of subcutaneous injection is that by this method the virus is not brought in contact with an injured nerve, an essential condition for successful inoculation, according to this view. Those offering this explanation cite in support of their position the facts that the disease is more apt to follow from the bite of a mad dog if the injury is situated on the hands or face where the nerve supply is specially abundant; also that injections into nerve trunks, the brain, or the spinal cord, are uniformly successful, and less so in other situations, as has been said; and, finally, that deep lacerated wounds are particularly dangerous.

Whether the abundant nerve supply renders a part specially liable to infection or no, the danger of infection from bites on the hands and face is at least enhanced independently of this by the fact that these are usually bare, whereas the clothing over the rest of the body may prevent the infectious saliva from coming in contact with the wounds. On the other hand, it has been shown that application of the infectious material to the uninjured

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conjunctiva, the uninjured genital mucous membrane, or to the uninjured alimentary mucous membrane may be followed by the disease; so it does not seem necessary for the nerves of a part to be injured, in all cases at least, unless we assume that where infection follows applications of the virus to the mucous membrane there are minute abrasions too small to be detected with the naked eye. But whatever the portal of entry, the disease develops only where the poison invades the central nervous system, and all observation goes to show that the course of the poison from the seat of infection to the brain and spinal cord is not through the blood or lymph channels, which are the distributors of the micro-organisms and toxins usually in other infectious diseases, but that the virus travels for the most part, if not exclusively, by way of the nerves themselves.

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In rabies, as in other infectious diseases, there is always a period of incubation between infection and the appearance of the symptoms of the disease. This period of incubation varies in rabies not only in different species of animal, but also in different individuals of the same species. In dogs it lasts for from three to five weeks, seldom more, and seldom less. Bollinger states that in one case in a dog it lasted for eight months, and that is the maximum. In human beings the period of incubation varies greatly in length in different cases; from six weeks to two months is common, though cases have been reported in which the period of incubation is said to have lasted for one or even two years; but these long periods of incubation are certainly rare, if they occur at all. The disease usually shows itself in the course of the second month after the person has been bitten, rarely in less than fifteen days, more rarely still after three months or longer. In the rabbit the period of incubation is twelve to fourteen days when the animal is inoculated with cord from a mad dog, but it becomes shorter and shorter by successive inoculations of suspensions of the cord from one rabbit to another through a series—in other words, the virus becomes more and more virulent by successive passages through rabbits. This increase of virulence, however, cannot be carried on indefinitely, for there comes a time when further inoculations do not increase the virulence, and the virulence is then said to be fixed. Pasteur's "virus fixe" is obtained in this way, and consists of a portion of cord from a rabbit dead in nine or ten days of rabies. This explanation of what is meant by "virus fixe" should be carefully borne in mind in order to understand much of that which follows, for it will be necessary to use the term frequently. It may also be noted in passing that this "virus fixe" is made use of in the production of the "vaccines" for treating persons who have been bitten by a mad dog, as explained below. By the use of large rabbits the potency of the virus may be so increased by successive passages that the period of incubation finally will be six or seven days; and by the use of small Russian rabbits the period of incubation may be still further reduced to five or six days. Successive passages of the virus through apes, on the other hand, decreases the virulence, the period of incubation becomes longer. In ducks and geese the period of incubation is fourteen days. In chickens the disease has a period of incubation of forty days. Chickens, like pigeons, are partly refractory to rabies, as shown by Dr. Paul Gibier in 1884 (Thèse de Doctorat, Paris, 1884).

But the symptoms do not appear as soon as the rabies poison invades the brain and spinal cord, for these are infectious for other animals before any signs of the disease have shown themselves in an infected animal. Roux and his pupils, and others, have found that not only the medulla, but also the saliva of infected animals is infectious for other animals for from twenty-four to forty-eight hours—sometimes for three days—before any symptoms have developed. The different parts of the spinal cord become infectious for other animals at different times; the part nearest the seat of inoculation becomes infectious first, as a rule. Högyes found that the brains of rabbits inoculated under the dura mater are fully virulent in six days, as soon as the first characteristic symptoms appear, but that the medulla is fully virulent before this time, on the last part of the fourth or on the first part of the fifth day, at the beginning of the febrile symptoms. Vestea and Zigari and others found that after subdural inoculation the medulla becomes infectious for other animals several days before the lumbar cord. By inoculation into the sciatic nerve, on the other hand, the lumbar cord usually becomes infectious for other animals before the medulla. Nevertheless, this is not always the case, for Kraus, Clairmont, and Keller have shown that the medulla is sometimes infectious after inoculation into the sciatic nerve at a time when the lumbar cord is not infectious at all. This is not the rule, however, for usually the lumbar cord is infectious for other animals in six or seven days after inoculation of the "virus fixe" into the sciatic nerve, whereas the medulla does not usually become infectious by this time by similar inoculation. On the other hand, the medulla becomes infectious for other animals in one day after intracerebral inoculation with "virus fixe," and in three days, or even in a shorter time, after subdural inoculation with "virus fixe," less than half the time required by inoculation into the sciatic nerve for the poison to accumulate in the lumbar cord in sufficient amount to be infectious for other animals. Enough of the poison, however, gets into the lumbar cord in twenty-four hours after inoculation into the sciatic nerve finally to cause the disease in the infected animal, as explained more fully below.

Kraus, Keller, and Clairmont have furthermore shown that intracerebral injection of the "virus fixe" causes the development of the poison more quickly than the subdural injection. In intracerebral inoculation with "virus fixe" the poison is present in the medulla in twenty-four hours in sufficient amount to cause the disease on inoculation into other animals. In subdural inoculation, on the other hand, it is not certain that the medulla is ever infectious in as short a time as twenty-four hours after inoculation. It is true that rabbits inoculated with the medulla of rabbits taken out twenty-four hours after subdural inoculation usually die of gradual emaciation, a sort of marasmus, but they show no symptoms typical of rabies, and the medulla of these rabbits is not infectious.

Subdural inoculation, intra-orbital inoculation, and inoculation into a large nerve trunk, as into the sciatic nerve, all have about the same effect as regards the appearance of the poison in the spinal cord. In no case does the poison invade the entire nervous system all at once; on the contrary, there is always a more or less gradual extension along the course of the nerves or the spinal cord.

Kraus and his colleagues report one experiment in which the inoculation was made with "virus fixe" into the lumbar cord in a rabbit. The cord in this case was cut out twenty-four hours after inoculation, and different portions of it were inoculated under the dura of different rabbits. The results of these inoculations showed that the lumbar portion was typically virulent; the rabbit inoculated with this died of unmistakable rabies. The dorsal portion produced no symptoms. The medulla caused the death of the rabbit in fourteen days without any symptoms of rabies, it is true, but the medulla of this animal caused death in another rabbit in sixteen days with all the symptoms of rabies. The reason why the virus in its passage through the dorsal cord to the medulla from the seat of inoculation in the lumbar cord should not have found conditions for lodgment and development in the dorsal cord is not apparent. It would seem as if this observation shows that the medulla and lumbar cord have special affinity and attraction for the rabies virus. Some of the other observations mentioned above also seem to indicate that the most favorable situations for the development of the virus are, first, the medulla, and next to this the lumbar cord; and that the rest of the central nervous system becomes invaded only after these two locations have been fully impregnated.

The source of the rabies virus also affects the length of time of the development of the disease as well as the ac-

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cumulation of the poison in the central nervous system. Tests upon animals show that the virus present in the cord of a dog suffering from an ordinary case of rabies, the "street rabies," takes longer to invade the nervous system and produce the disease than the "virus fixe," the virus obtained by successive passages through rabbits. This is shown not only in the difference between the period of incubation in the disease produced by inoculation with "virus fixe" on the one hand, and that produced by inoculation with the "street virus" on the other, but also by the fact that the cord of an animal inoculated with the "virus fixe" is infectious for other animals in a much shorter time after inoculation than is the cord of an animal inoculated with "street virus." It has been stated that the medulla of an animal inoculated under the dura with the "virus fixe" becomes virulent in two or three days after inoculation. The medulla of an animal inoculated under the dura with the "street virus," on the contrary, does not become virulent for other animals before the sixth day, and usually is not virulent before nine or ten days, and the lumbar cord is frequently not virulent at any time after inoculation with the "street virus." The reason for this difference between the "virus fixe" on the one hand, and the "street virus" on the other, is not apparent. The disease without proper treatment is just as surely fatal in the one case as in the other, and the symptoms in both seem to be of equal severity. The only difference seems to be that in the one case the poison is generated more quickly than in the other.

But, although, as has been stated, the lumbar cord does not contain enough of the rabies virus to be infectious for other animals for several days after inoculation into the sciatic nerve, enough of the poison gets to the cord in twenty-four hours by this method of inoculation to cause the disease in the animal itself; for Kraus and his co-workers inoculated a rabbit in the sciatic nerve with "virus fixe," and the animal died of typical rabies in spite of the fact that a portion of the sciatic nerve was excised at a point situated between the seat of inoculation and the cord. On the other hand, Bombicci prevented the disease from developing after intra-ocular inoculation by enucleation of the eye twenty-four hours after infection, and Babes and Talasescu also prevented the disease by cauterization of the seat of infection twenty-four hours after inoculation. But Babes has shown that even comparatively late cauterization or excision of the seat of infection delays the appearance of the symptoms, even if it does not prevent the disease, an important factor in the proper treatment of the disease, as will appear in the proper place.

The virulence of the virus may be destroyed, decreased, or increased in various ways. Light, temperatures of 50° to 60° C., drying, various antiseptics, and artificial digestion all weaken or destroy the virulence. Caterina found that formalin destroys the virus in fifteen minutes, but not in five or ten minutes. Putrefaction has but little or no effect on the virulence. The virulence is retained by preserving the infectious material in neutral glycerin and in the cold. Reference has already been made to the fact that successive inoculation through certain animals weakens the virulence for other animals, it even destroys the virulence in some cases, while similar inoculations through other animals increases the virulence. In other words, the rabies virus assumes a certain definite degree of virulence, which is different and characteristic for each species of animal; and the degree of virulence peculiar to a species of animal is attained by a sufficient number of successive passages through individuals of the species. If the virus used for the first inoculation in the series has a shorter period of incubation and kills more quickly than is normal for the species of animal under experiment, the subsequent inoculations of the series will take longer and longer to produce the symptoms and death till the normal degree of virulence for the species is reached. It does not appear from the literature at hand just how many passages are necessary to reduce the virulence in a given case, probably very few. On the other hand, if the virus used for the first inoculation has a period of incubation longer than is normal for the species under observation, it will have a shorter and shorter period of incubation after each passage till the norm is reached. The acquisition of a high degree of virulence is slow; starting with the virus from a mad dog, it takes a year or more to obtain virus of the highest degree of potency in the rabbit. The virulence of the virus is in inverse proportion to the length of the period of incubation. Thus, as has been already mentioned, the virus of rabbits is more virulent than that from dogs, because the period of incubation between the inoculation and the outbreak of the symptoms of the disease is shorter in the rabbit, after a series of inoculations in these animals, than it is in the dog under similar circumstances. The virus from the dog is more virulent than that from apes for the same reason, and while it is true that, starting with the virus from a dog, this becomes more and more virulent for rabbits by successive passages through these animals, a degree of virulence is finally reached beyond which it is impossible to increase the virulence. When the period of incubation is reduced to five or six days it is impossible to reduce this any further, the virulence becomes fixed. So that for each species of animal there appears to be a normal fixed period of incubation. And although increased virulence for the animal through which the virus is passed is usually accompanied by an increased virulence for other animals, it is not always so; for recent observations tend to show that the "virus fixe," the most virulent virus for rabbits, is decidedly less virulent for man. At least human beings inoculated with this virus do not develop rabies, in spite of the fact that they are not previously prepared by inoculations with attenuated virus. It is true that in the cases of this kind so far reported, the persons had been bitten by mad wolves, but it is not clear how this could diminish the action of the "virus fixe"; on the contrary, it would seem more probable that it would increase the action of the latter. After all, it would seem hardly correct to measure the virulence of rabies virus by its relation to the period of incubation on inoculation, for the virus from an ordinary case of spontaneous rabies in a dog causes the disease apparently with just the same certainty and with equal severity as the "virus fixe," only the period of incubation is longer with the former than with the latter. The disease, if not treated, is as surely fatal with the one kind of virus as with the other. Pigeons are not susceptible to rabies, but they become so by starvation, as already stated. In chickens the disease has a period of incubation of forty days, and it can be propagated by inoculation through a series of chickens. For these birds the period of incubation is just the same with the "virus of the street," from a case of spontaneous rabies in a dog, as it is with the "virus fixe." With either virus the disease progresses slowly after the appearance of the symptoms; the fowls usually live fourteen days after symptoms appear, and finally die of progressive paralysis. In ducks and geese the period of incubation is fourteen days. Inoculation of rabbits with the brain of birds dead of rabies is rarely followed by the disease; so while the virulence of the virus by successive passage through birds is preserved for these, it becomes weakened for rabbits.

Kraus and Maresch have studied the effect upon the rabies virus of blood serum of normal animals, and of blood serum of animals possessing artificial immunity. Their results show that the blood serum of ordinary non-immune dogs and rabbits has no effect upon the rabies virus; but the blood serum of dogs and rabbits that have been given artificial immunity destroys the virulence of the virus. Of this serum 0.01 c.c. destroys 0.5 c.c. of the "virus fixe" diluted in the proportion of one part of the virus to fifty of indifferent fluid. Pigeons' blood has no effect, neither the blood from normal pigeons, nor that from pigeons that have been previously inoculated with the virus. Chicken's blood serum, on the other hand, has the property of destroying the virulence of the virus. This property is possessed by the blood serum of ordinary, untreated chickens, and it does not seem to be in-

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creased by previously producing immunity in the chickens. The serum from a normal chicken destroys the virulence of the virus in the proportion of 0.5 c.c. of the serum to 1 c.c. of "virus fixe" diluted in the proportion of 1 part of "virus fixe" to 100 of indifferent fluid. A smaller amount of the serum, 0.25 c.c., does not destroy the virulence of 1 c.c. of the virus.

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Högyes found by using dilutions of various concentration that all strengths above 1 to 200 of the usual thick suspension of the cord constituting "virus fixe" kill rabbits as promptly as the undiluted virus. Even 1 to 250 kills, but less promptly than the undiluted virus. A strength of only 1 to 5,000 occasionally produces death with prolonged incubation of the disease. Very feeble preparations, 1 to 10,000, fail to produce the disease.

During the period of incubation the individual suffers no special inconvenience, not more than would be caused by a wound of equal severity resulting from the bite of an animal that is not rabid. Indeed, it is stated by Tillmann that a wound inflicted by a rabid animal heals usually with exceptional rapidity in human beings; nor are there any other symptoms during the period of incubation to indicate whether the person has been bitten by a rabid animal or no. This lack of anything to characterize the period of incubation applies to rabies in beasts as well as in man.

In dogs the first symptoms of the disease consist of melancholia and moroseness, with restlessness and irritability, loss of appetite, dysphagia, and nausea. The dysphagia is specially noticeable in the case of liquids, and the name hydrophobia is given to the disease on this account. Abnormal appetite is also present; the animal endeavors to eat straw or dirt or anything lying around, no matter how unsuitable it may be as food. These symptoms may be insignificant at first, and for this reason the animal is more dangerous at this time than at a later period when the symptoms are more manifest. This stage lasts from a half day to two or three days, and is usually followed by the stage of raging madness. This, however, is not always the case, for sometimes the morose stage is followed by paralysis affecting the muscles of the jaws and later of the hindquarters. The lower jaw drops, the mouth remains wide open, the bark is peculiar and hoarse, there are also rapid emaciation, tottering, and final complete paralysis of the hindquarters, and the animal dies in two or three days. This form of the disease is spoken of as "dumb rabies," or as "quiet or melancholy rabies," and runs a more rapid course than the "raging madness." In the latter form of the disease the animal is sullen and morose as in the dumb form; there are also the same restlessness, loss of appetite, and emaciation, but in addition to this the animal has paroxysms of maniacal rage characterized by a desire to snap and bite at everything around. Bollinger states that the great aversion to water seen in the earlier stage of the disease is lacking in the maniacal stage, and in this stage there is only exceptionally spasm of the muscles of deglutition. The maniacal stage lasts for three or four days and then passes into the paralytic stage, which is the final stage as in dumb rabies, and lasts for from three to six days. In the paralytic stage the animal has a bristling coat, the voice is hoarse, dyspnœa increases, and there are local or general convulsions. The termination is always fatal.

In rabbits inoculated with unattenuated rabies virus, either "virus fixe" or virus from "street rabies," the disease always takes the form of "dumb rabies." But Genaro has described a peculiar form of the disease in rabbits inoculated with attenuated virus. In this form of the disease the animals die with progressive emaciation, without any of the ordinary symptoms of rabies, but the brain and spinal cord of these animals produce typical rabies when inoculated into other animals. An example of this form of the disease has been noted above in the citation from Kraus, Keller, and Clairmont's result with inoculation of a rabbit with the medulla of a rabbit taken out twenty-four hours after injection of "virus fixe" into the lumbar cord. It will be remembered also that these observers noticed that some of their rabbits died of a sort of marasmus after infection with attenuated cord, but that the cord in these cases was not infectious for other rabbits.

In the human subject the first symptoms to appear after the stage of incubation are psychical. The individual is depressed in spirits, excitable, irritable, and restless. He also suffers from sleeplessness and loss of appetite, and in some cases even at this stage there is antipathy toward liquids. He is also oppressed with a feeling of impending danger. The reflexes and sensibility are often greatly increased. A noise, even loud talking, and a bright light are distressing. The injection of the larynx and consequent difficulty of swallowing, which is the most distressing as well as the most characteristic symptom of the disease in man, is included in this stage by Osler. Tillmann regards this symptom as marking the onset of the second stage. Some authors note a rise of temperature and acceleration of pulse during this period, others not. Huskiness of the voice is also present, but this symptom depends upon the injection of the larynx, and is not always included in the prodromal stage. Although the wound is usually healed by this time, there is sometimes a return of inflammation in the cicatrix accompanied by pain, burning, and itching at this point. Pain in the bitten part is often the first manifestation of the disease and may be present several days before the onset of the other symptoms.

If the injection of the larynx with its accompanying manifestations is regarded as the beginning of the second stage, the prodromal stage seldom lasts more than twenty-four hours; for the injection of the larynx, with spasm of the muscles of deglutition and inability to swallow, appears rarely later than at this time. Along with these symptoms there appear severe spasms of the muscles of respiration. These occur in paroxysms along with the cramps of the pharynx, and are brought on by the slightest excitation of the nerves; even the sight of liquids is enough to cause them. The spasms are not confined to the larynx and respiration, but soon become general, and are usually clonic, sometimes tetanic. The nerves of special sense are also affected, not only the sight and hearing, as already noted, but also the sense of smell. The salivary secretion is also increased. The mind is for the most part clear, but there are apt to be maniacal seizures from time to time. The pulse becomes gradually weaker. After a paroxysm it is greatly accelerated. The temperature is somewhat elevated; it usually runs to 38° or 38.5° C. (100.4° to 101.3° F.). Dating from the laryngeal symptoms, the second stage lasts for from one to three days.

The third stage is marked by weakness, paralysis, and exhaustion. There is abatement of the spasms and of the difficulty in swallowing and breathing. This stage lasts for from six to eighteen hours, when death takes place, sometimes with recurrence of convulsions, but oftener quietly. By some authors consciousness is said to be preserved to the last, by others it is stated that unconsciousness supervenes.

The total duration of the disease in man, from the first appearance of the prodromal symptoms to death, is rarely less than two days or more than four days. The termination is always fatal if the symptoms once develop.

The macroscopic changes shown at autopsy are not characteristic either in man or in beasts. The blood shows insufficient aëration, is dark and thick. The mucous membranes show a catarrhal condition with hyperæmia and ecchymoses, specially pronounced in the mucous membranes of the respiratory and digestive tracts. There are general parenchymatous hyperæmia and cyanosis. In dogs the stomach usually contains various indigestible substances which the animal has swallowed to satisfy the abnormal appetite. Emaciation is also pronounced. But the most marked lesions are met with in the central nervous system. Besides extensive œdema of the brain, there are very considerable microscopic changes. These consist of diffuse myelitis of both white and gray matter, accompanied by degeneration of the nerve fibres and ganglia. The axis cylinders of the nerve fibres of the central ner-

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vous system are hypertrophied. The nerve cells are atrophied and contain pigment. These changes are most marked in the motor centres. The most characteristic lesions, however, are seen in the cerebro-spinal ganglia, in which there is a proliferation of the endothelial capsule of the ganglion cells and a corresponding destruction of the latter cells (Van Gehuchten and Nelis).

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The diagnosis of rabies presents no difficulty. It is true that the disease is simulated by tetanus arising from an infected wound in the regions supplied by the cranial nerves; then, besides, pharyngeal spasms are also a marked symptom of this affection. But the history of the injury would suffice in most cases for a diagnosis; this would be misleading only in case the tetanus bacilli are introduced into a wound caused by a dog bite, a contingency which is not at all probable. The different lengths of the periods of incubation of the two diseases also afford a point of differentiation. But the surest method of diagnosis is the inoculation of a rabbit under the dura mater with a bit of the cord or brain (rubbed up in bouillon or glycerin) of the animal that has inflicted the bite. If this animal was really affected with rabies, this inoculation would produce the disease in the rabbit in from twelve to twenty-one days. Consequently, if this step be taken promptly after the bite has been inflicted, there will still be time enough to prevent the development of the disease by a resort to the Pasteur method, to be described later. However, in cases of bites on the head or face, the treatment must be begun as soon as possible after the accident, and it would be very unwise to wait for the result of such an experiment. A diagnosis may be reached in twenty-four hours, if the dog died of rabies or was at least in the paralytic stage, by the method of Van Gehuchten and Nelis, *i.e.*, by the microscopical examination of some of the cerebro-spinal ganglia, especially the vagus ganglia which are easily found.

If facilities for inoculating a rabbit are not at hand, material from the animal should be sent for diagnosis to some convenient laboratory. It suffices fully for all purposes to send the medulla in a small vessel containing glycerin, as recommended by Kempner. This method not only possesses the advantage of great convenience, but the material arrives at the laboratory in good condition for inoculation, which is not always the case with the other methods of shipment that are recommended.

The disease can be cured, or, rather, prevented from developing, only during the incubation period, before any symptoms have developed; after this, the treatment is only palliative, and consists in keeping the patient as quiet and undisturbed as possible in a darkened room, and in the administration of quieting drugs. Curare is strongly advised by some, while by others it is not even mentioned in the list of suitable drugs. Chloral hydrate, potassium bromide, and similar drugs are also advised by some. Osler advises resorting to morphine hypodermatically and to the use of chloroform at the start. Dr. Rambaud reports that he has obtained the best results (experience of about thirty cases) from the employment of hyoscine hydrobromate in doses of gr. $\frac{1}{100}$ injected hypodermatically. Cocaine applied locally may be used to diminish the sensibility of the pharynx so as to enable the patient to take liquid nourishment where swallowing is otherwise impossible. Nutrient enemata are also recommended.

The disease may be prevented from developing by speedy excision, or by thorough cauterization with the actual cautery or the strong mineral acids, not with nitrate of silver. These are usually of no avail when not resorted to within a short time after the bite. But cauterization or excision would seem advisable, nevertheless, even several hours after the bite, for, as stated above, the absorption of the virus into the nervous system from the seat of inoculation is sometimes delayed as long as twenty-four hours. Moreover, as already stated, Babes has shown that even when the disease is not prevented in this way, the period of incubation is lengthened by excision or cauterization, a most desirable result when the Pasteur treatment is resorted to, as it should be, and indeed now universally is.

Although the disease is altogether beyond treatment after symptoms develop, and although cauterization and excision are uncertain, the Pasteur method of inoculation affords a means of prevention that very rarely fails. The principle of this treatment, or, rather the object aimed at, is the rapid production of immunity in the patient during the period of incubation of the disease. If immunity can be established before the termination of the period of incubation, before any symptoms have developed, the progress of infection is arrested. The method consists in inoculation once a day, for from fifteen to twenty-one days, with virus of graded potency. The virus employed consists of bits of the spinal cord of rabbits possessing such potency, by repeated passages through the central nervous system of these animals, that it produces death from rabies in nine or ten days in rabbits by subdural inoculation. As indicated on more than one occasion above, this constitutes the "virus fixe" of Pasteur. The graded potency which is required if the virus is to be used upon human beings, is obtained in the following manner: The spinal cord of a rabbit that has died of rabies on the ninth or tenth day after inoculation is carefully removed and hung up in a flask, at the bottom of which are placed a few pieces of caustic potash. Protection against dust, etc., is secured by stuffing sterilized cotton into the neck of the flask which is kept in a dark room, at a constant temperature. In this way the cord is subjected to a slowly advancing process of desiccation, as a result of which the rabies virus is rendered progressively less virulent. On the day following that on which the cord was introduced into the flask, it is spoken of as cord of the second day, or No. 2. On the third day it becomes cord No. 3; and so on up to the fourteenth day. After the fourteenth day what remains of it, if not entirely used, is discarded. It is customary, at the Pasteur Institute in Paris, to use for the first injection an emulsion made from portions of the cord of both the fourteenth and the thirteenth days. In the New York Pasteur Institute, however, the first injection contains portions of the cord of the twelfth and eleventh days. An emulsion is made by rubbing up a segment of cord measuring 0.5 cm. in length in 6 c.c. of normal salt solution (sterilized) for one patient. Two separate injections are made simultaneously, one in the right and the other in the left hypochondriac region. Each succeeding couple of injections is made with a stronger emulsion, that is, with an emulsion made from a segment of the cord that has been subjected to one day less of drying than the preceding one. The most virulent cord used in Paris is that of the third day; in New York, that of the second day. The time for using this is reached somewhere between the seventh and the tenth days, and then a return is made to the cord of the sixth or fifth day, after which a gradual increase is again made until cord of the third or second day is reached. But if the treatment has been deferred, for any reason, so long that there is danger of the disease developing before the entire series of injections can be administered one day apart, the interval between the injections is shortened, and two or more injections of increasing strength are given daily instead of one each day for the first three or four days. Finally, when the case comes for treatment very late, and the necessity for such treatment is therefore urgent, it is maintained by some that all the twelve or thirteen injections should be administered in twenty-four hours, or that the preliminary injections should even be dispensed with entirely, and virus of full potency administered at the start. The procedure mentioned last, the use of unattenuated "virus fixe" without any preliminary inoculation with attenuated virus, has been practised with good results in cases of persons bitten by wolves, the most dangerous of all forms of infection. This procedure, however, is condemned by the Pasteur Institute in Paris as well as by the New York Institute, as it has caused several deaths.

Babes has advanced the theory that the reason why the

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"virus fixe" does not itself produce the disease in man is that the injections are always made under the skin of the abdomen where it is not likely, owing to the presence of abundant adipose tissue, that any nerves are injured. But Marx is quoted by Babes as authority for the view that the virus becomes attenuated for human beings and for monkeys by being passed through rabbits, although enhanced in virulence for rabbits themselves.

The writer desires to acknowledge his indebtedness to Dr. George G. Rambaud, of the New York Pasteur Institute, for assistance kindly rendered in revising that portion of the text which relates to preventive treatment.

B. Meade Bolton.

RACHISCHISIS. See *Spina Bifida.*

RACHITIS.—See *Rickets.*

RAG-WEED.—AMBROSIA. *Ambrosia* is a genus of the Compositæ, containing about a dozen species, mostly North American. The best-known species is *A. artemisiifolia* L., the common annual rag-weed, and one of the most abundant and troublesome of weeds. It is best known to medicine because the presence of the pollen in the nares is believed to be the principal cause or occasion of the disease hay fever. This and other species contain small amounts of amaroid and volatile oil, and have been employed, especially in domestic practice, as aromatic bitters. The idea that a preparation of rag-weed can act as a specific in hay fever is in the highest degree fanciful.

Henry H. Rusby.

RAILWAY MEDICINE AND SURGERY.—While, as a matter of course, passengers and employees have been killed and injured ever since the inception of railways, and railway surgeons have been known over fifty years (Dr. W. W. Apply was appointed surgeon for the Erie R. R. in 1849), the recognition of railway surgery as a special branch of the healing art is a matter of the last twenty years, and has reached its highest degree of development in the Western United States. It seems as fully entitled to recognition as military surgery, with which it has many features in common.

Prior to the War of the Rebellion, the mileage was mostly east of the Mississippi; skilled assistance being as a rule easily obtainable, there was little demand for systematic surgical service such as is now met with. Even at the present day in the Eastern States, where railways traverse thickly populated communities, the stations are almost in sight of each other, and cities and towns with well-appointed hospitals occur at frequent intervals. In the extreme Western States, however, perhaps several hundred miles of unsettled or sparsely inhabited territory may intervene between the locations of properly equipped hospitals. Hence during the building of the great transcontinental lines, provision had to be made for the care of employees injured during the construction of the road, all of them away from their homes and in uninhabited districts. In many instances this hospital department became a permanent feature after the roads commenced operation.

Except for the fact that it will have a larger proportion of emergency cases, the practice of the railway surgeon will not differ materially from that of his surgical brethren in general. The injuries with which he has to deal are very similar to the severe crushing injuries from machinery or heavy vulnerating bodies in ordinary surgical practice. They, however, present some special features. Thus, for example, owing to the fact that the extremities often become engaged between two unyielding surfaces—the rail and the flange of the car-wheel,—these railroad injuries are often extremely severe in character, with great destruction and laceration of the soft parts, and comminution of bones. Again, they are attended by a high degree of mortality, and their effect on the nervous system is overwhelming, shock being especially noticeable in this class of injuries. In addition to the crushing force, there should be taken into account the weight and velocity of the moving train. The weight varies from ten tons for empty flat cars to twelve or fifteen for box cars; from twenty to sixty for coaches; and it amounts to one hundred tons or more for locomotives. The railway surgeon often has to exert his skill under the most unfavorable circumstances and the most depressing surroundings, laboring at night with no light but the trainmen's lanterns, far from skilled assistance or even habitations, and amid rain, sleet, and snow.

The present mileage of steam roads in the United States is over 200,000, on which over 600,000,000 passengers were carried last year (1901–02). To operate this system required in 1895 an army of 785,000 men; in 1901 this number had grown to 1,071,000. In the Middle Atlantic States the number of employees per one hundred miles is 1,140; next come the New England States with 827; and so on, the lowest being the Middle Northwestern States with 303. For the year ending June 30th, 1902, the total number of casualties to passengers and employees reported was 42,619 (2,819 killed; 39,800 injured). Passengers killed, 303; injured, 6,089; employees killed, 2,516; injured, 33,711. (Report of Interstate Commerce Commission.)

As regards the different classes of employees, brakemen are injured most frequently, then come switchmen, firemen, and engineers in the order named. In former years the largest number of injuries resulted from coupling and uncoupling cars. In 1893 the "Safety Appliance" law was enacted, requiring the use of automatic couplers. This law went into full effect in August, 1900, and the results from this humane legislation are both surprising and gratifying. The number of employees killed in 1902 as compared with 1893 is sixty-eight per cent. less, and the diminution in the number of those injured is no less than eighty-one per cent., notwithstanding the much larger number of employees. Other frequent sources of accidents to trainmen are getting on or off trains in motion, falling from the cars, collisions, and derailment. The principal causes of accidents to passengers are collisions, derailment, and falls from the cars. According to Herrick, about fifty per cent. of injuries to employees involve the upper extremity, thirty-three per cent. the lower extremity, twelve per cent. the head and face, and eight per cent. the trunk.

To furnish relief for sick and injured employees there are four principal methods in operation at present: (1) the relief system; (2) the surgical service without a chief surgeon; (3) the surgical service with a chief surgeon; (4) the hospital system.

1. The relief system is in operation on a number of roads, among them the Baltimore & Ohio, Pennsylvania, Reading, Burlington, and Plant System. Membership may be either voluntary or compulsory. Under this plan the employee is assessed monthly according to the amount of his wages—usually from twenty-five cents to two dollars. When injured, he receives a certain sum monthly during this period of disability. Provision is also made for death, and for benefits in case of permanent disability. In some associations membership lapses if the employee quits the service of the company, in others the death benefits may be retained. In others again, additional features are found in the shape of savings, building and loan departments, and old-age pensions. The scope of such a system on a large trunk line may be gleaned from the last annual report of the one in operation on the Pennsylvania west of Pittsburg. The membership was 23,179, an increase of 2,122. The average number of members disabled per day was 778, or 35 for each 1,000. The death rate was 13 for each 1,000. Applications for membership were 11,010, while the cessations of membership were 8,868, of this number 8,090 having left the service. The total receipts for the year were $415,643, the disbursements $349,104.

2. The local surgeons are appointed by the superintendent or general manager. Local surgeons are generally located at divisional or terminal points, and along the remainder of the route,—as a rule, about fifty miles apart.

3. A chief surgeon is appointed who selects his own

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assistants. It is asserted for this plan that it reduces the number of damage claims. There being more miles of railroad in the rural districts than in cities and towns, accidents frequently occur at remote points. Consequently it is often the practice to locate, at convenient points, division surgeons who are subordinate to the chief surgeon and who in their turn have charge of a division or branch of the line, and of the local surgeons in their territory.

4. The hospital plan is in operation among other roads—on the Missouri Pacific, Chesapeake & Ohio, Wabash, Southern Pacific, Santa Fé, St. Louis, and San Francisco. It embraces the care of the employee whether sick or injured, and whether his illness occurs on duty or not. The chief surgeon is in charge, and the executive board or board of governors is composed of representatives both from the employees and from the railroad company. As in the relief system there is a monthly assessment, and in addition the company either makes an annual donation or meets a deficiency should one arise. Minor ailments and injuries are attended to by the local surgeons, but if the illness proves to be serious or lasting, patients are sent to the main hospital, or on the longer systems to a branch hospital which is located at some accessible point. The Northern Pacific Beneficial Association, which was founded in 1882, may be selected as a type of this plan. This body maintains two hospitals—one at Brainerd, Minn., for the eastern division, and another at Missoula, Mont., for the western. For the year ending June 30th, 1902, the receipts were $165,865.77, and the expenses $161,063.40. The cases treated at the Brainerd hospital were 3,150 in number, and by the line surgeons of the eastern division, 13,323. The Missoula hospital cared for 1,994 cases, and the surgeons on the western division, for 12,966 cases. A training school for nurses is maintained at Brainerd.

For transporting the injured, several roads have equipped hospital cars which are kept constantly ready for use, and are despatched wherever they may be needed. The first one to be placed in commission seems to have been that which was installed on the Baltimore & Ohio Southwestern in 1894. A general idea of their fittings may be derived from Fig. 3925 (from Herrick's "Railway Surgery").

Nussbaum's dictum that the fate of the wounded depends on the individual who makes the first dressing is now firmly established, and railway employees often infect wounds received by them by applying to them tobacco ends, soiled waste, or dirty handkerchiefs. To guard against this, "first aid" instruction, so successful in Great Britain, has been introduced into this country and is slowly finding its way into favor. Classes of the employees are formed at convenient points and a course of lectures couched in simple language and illustrated by a manikin, etc., is delivered to them by the surgeons. A course may consist of five lectures. The first one is devoted to elementary anatomy and physiology, the second, to arrest of hemorrhage; the third, to sprains, dislocations, and fractures; the fourth, to asphyxiation, artificial respiration, poisons, etc.; and the last to transportation of the injured. Instruction is also given in stretcher drill, and those employees who are found to be proficient are, after examination, formed into ambulance corps. To keep up interest in the work annual competitions in stretcher drill are held, and the winning team retains the trophy for the year ensuing. A small manual on first aid has been compiled by C. R. Dickson especially for railroad men.

In line with this work some roads equip their trains with "emergency boxes," containing a supply of gauze, bandages, etc., which are replaced when used. These are placed in depots, freight houses, or car shops. The contents vary somewhat; the following is an average assortment:

1 Heavy rubber bandage.
12 Assorted muslin bandages.
5 Yards sublimate gauze.
1 Ounce absorbent lint.
1 Ounce styptic cotton.
4 Ounces absorbent cotton.
25 Corrosive sublimate tablets.
2 Ounces bicarbonate soda.
4 Surgical needles.
1 Pair scissors.
1 Pair forceps.
1 Case carbolized silk.
1 Roll rubber adhesive plaster.
1 Dozen safety pins.
1 Pyramid of pins.
1 Esmarch tourniquet.
1 Ounce iodoform.
1 Case for scissors, forceps, needles, etc.
Splints.

The idea is to have wounds protected by clean gauze held in place by a clean bandage, in order that they may reach the surgeon in an aseptic condition, or as nearly so as possible. Directions for using the various articles are pasted on the lid of the box. The following are those used on the Southern Pacific:

"These supplies are for temporary relief, until a surgeon can be obtained.

"In case of a broken bone straighten out the limb by stretching it, and fit a splint on it by padding with sheet cotton. Apply a bandage over the splint to hold it on.

"In case the skin is broken, making an open wound, apply moist gauze, and cover with cotton or lint and a bandage.

"If there is severe bleeding, apply the strip of duck-webbing above or toward the body from the wound, put a stick under it, and turn until the bleeding ceases. Do not stop the circulation altogether. If bleeding does not cease apply bandage on other side of wound.

"For burns or scalds, apply the oxide of zinc ointment, and cover with moist gauze, cotton or lint, and a bandage.

"In case of a cut, where the wound gaps, apply a strip of adhesive plaster so as to hold the wound together, and apply gauze and a bandage over it.

"To relieve pain, give one or two opium pills every three hours, until it is bearable.

"For pain in the eyes due to cinder: Dissolve a cocaine tablet in a few drops of water and apply to the eyeball or lids by dropping, or by means of a bit of cotton wrapped

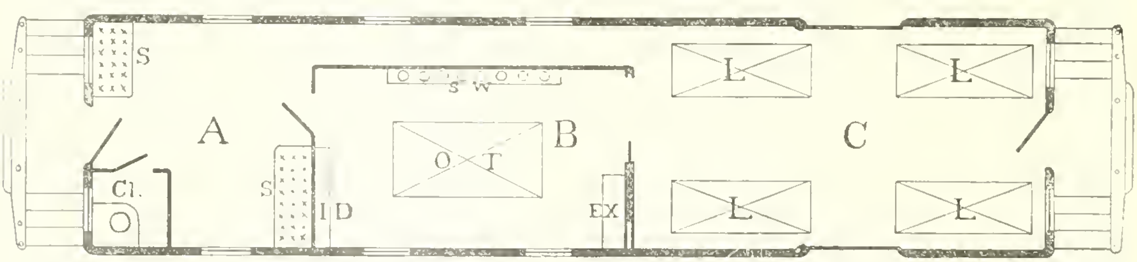

FIG. 3925.—Floor Plan of a Hospital Car. *A*, Sitting-room; *B*, operating-room; *C*, transportation-room; *Cl*, closet; *SS*, seats; *ID*, instrument and dressing case; *OT*, operating table; *SW*, sterilized water and solutions, in racks; *EX*, extra sheets, blankets, and other materials; *L*, *L*, beds. (Herrick: "Railway Surgery.")

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around a piece of wood the size of a toothpick or match. The cinder will often come away with the cotton."

The physical examination of employees is becoming more and more important of late. It is claimed on one road, where the examination is rigid and great care is taken in the selection of new men, that the number of accidents and suits for damages has been lessened over one-half. Claims for damages are sometimes brought to recover for hernia or other conditions stated to have been received while at work, and proved to have been present before the litigant entered the employ of the company. Defective vision and color blindness are frequent causes of rejection, both for admission to the service and for promotion. Thus, on the Chicago & Northwestern, fifteen per cent. of the firemen, and ten per cent. of the brakemen examined were rejected for these reasons. Out of 21,473 examinations on this road since this plan was first adopted in 1895, some 2,785 applicants were found physically disqualified. Of these, 1,469 had defective vision, 664 were color-blind, and 652 were rejected for other physical defects. On some roads applicants are rejected for varicose veins, hernia, epilepsy, heart disease, and hemorrhoids; others exclude applicants with hydrocele, suppurative otitis, rheumatism, etc. The mental qualifications are generally taken into account also, and the examinations, as a rule, are repeated at stated intervals, or whenever occasion arises for promotion. In this connection the age at which applicants enter the company's employ is becoming important since the adoption of old-age pensions on a gradually increasing number of railroads. At present the extreme limit at which applications are received on most roads seems to be thirty-five years; on one road (Erie) it is forty-five. In the first two years' operation of the pension plan on the Pennsylvania road 1,574 employees were retired.

A constantly increasing field of usefulness for the railway surgeon is that of hygiene. The freedom of the ice and of the drinking-water from contamination; the disinfection of coaches after cases of contagious disease have been unwittingly transported, or where, as frequently happens on some roads, tuberculous passengers are carried to health resorts; the cleanliness of cars and depots —all these are subjects which come properly within his sphere.

In common with the members of other branches of medicine and surgery, the railway surgeons early felt the need of societies for the interchange of views and opinions, and as a result several national, state, and local societies have been organized. The first, composed of surgeons on the Wabash Railroad, was organized on January 25th, 1882, at Decatur, Ill.; in the same year the Pennsylvania system's surgeons met and organized. The National Association was formed mainly through the efforts of the late Dr. A. W. Ridenour, of Massillon, Ohio, and its first meeting was held June 28th, 1888. In 1897 it increased its scope to include surgeons from Canada and Mexico, changing the name to International, and at present it has a membership of nearly one thousand. The American Academy of Railway Surgeons, organized in 1894, limits its members, and is made up principally of chief surgeons. Flourishing state associations are those of Iowa and New York. There are numerous bodies composed of surgeons connected with the larger systems of roads; among them may be mentioned the Milwaukee & St. Paul, Wabash, Santa Fé, Pennsylvania, Erie, and Southern.

A few colleges in the West have chairs, either of railway surgery or of accident surgery in general.

The literature comprises two treatises, annual transactions of the national bodies, and a monthly journal, besides many contributions to current medical journals.

Louis J. Mitchell.

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RAILWAY SPINE. See *Nervous System, Traumatic Affections of.*

RÂLES.—This term is applied to certain abnormal sounds heard in the chest. It is customary with many authors to speak of *dry* and *moist* râles. Sibilant and sonorous breath sounds are called dry râles, although there is no more reason for calling these sounds râles than there is for applying the same term to cavernous breathing. Certain authors also call these forms of breathing rhonchi, and use the word râle to designate only the moist sounds. Rhonchus, again, by others, is used as exactly synonymous with râle.

The causes of these abnormal sounds vary considerably. We may have a considerable accumulation of exudation in the trachea and larger bronchi, producing large bubbles, or the smaller bronchi may be more or less filled, giving rise to small bubbles, or perhaps the sounds may be produced in the alveoli themselves. Râles may also be produced by the rubbing of roughened pleural surfaces, by the presence of fibrinous exudate on the pleura, and by the stretching of pleuritic adhesions.

COARSE MUCOUS RÂLES are coarse bubbling sounds produced in the trachea and larger bronchi. They are heard with both inspiration and expiration. They may sometimes be made to disappear for a time by causing the patient to cough. Sometimes, especially in children, they may produce a fremitus easily felt through the chest wall. They are heard most commonly with acute bronchitis in its exudative stage, and with bronchopneumonia, also with chronic bronchitis and phthisis, some cases of œdema of the lungs, lobar pneumonia, compression of bronchi or trachea due to neoplasm or aneurism, some cases of pleurisy with effusion, and empyema, especially with perforation of the lung.

FINE MUCOUS RÂLES are sounds of the same quality as the former, but finer. They are heard under the same conditions.

SUBCREPITANT RÂLES.—These are fine, high-pitched, bubbling sounds, heard during both inspiration and expiration. They may be produced by the bursting of small bubbles in the finest bronchioles or air passages, or they may be caused by fibrin on the pleura, and by pleuritic adhesions. The cause of this râle has been a matter of considerable dispute. On the one hand, it is held that the sound is invariably produced in the finer air passages; on the other, that pleural changes alone can give rise to it. The advocates of the former view hold that sounds resembling the subcrepitant râle may be produced in the pleura, but that a good ear can distinguish these from the true subcrepitant, by a slight difference in quality. Believers in the second dictum say that there is not enough motion in the air in the finer air passages to give rise to the râle. Both of these views are extreme. There are cases in which the subcrepitant râle is heard which show, post mortem, nothing but pleurisy as a possible cause, and there are cases of œdema of the lungs, with no pleuritic changes, in which this râle has been clearly heard, and in which the serum in the lungs is the only demonstrable factor in its production. It cannot be denied that the sound may be due to either of these causes. This râle may be heard in pleurisy, in bronchitis of the smaller tubes, in bronchopneumonia, in lobar pneumonia during the stage of resolution, and occasionally, during other stages, in phthisis, and in œdema of the lungs.

CREPITANT RÂLES.—These are very fine sounds heard only at the end of inspiration, and sounding very near the ear. They occur in abrupt explosions. They are much finer than the subcrepitant râles, and are usually compared to the sound produced by rubbing a lock of hair between the fingers. The causes of this râle are the rubbing together of inflamed pleural surfaces, the entrance of air into ultimate bronchioles or alveoli, the walls of which are partly stuck together by exudate, or perhaps the breaking of very fine bubbles. Of these

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three possible causes the first seems most common, and it is not unlikely that this is really the only cause. It is conceivable that if the pleura be coated with a thin layer of sticky exudation, its surfaces will tend to stick together until the motion of respiration strengthen, in slipping over one another, give rise to the sound. This râle is often said to be pathognomonic of acute lobar pneumonia. This is not so. The râle is frequently heard in the first stage of this disease, but it is also heard in pleurisy, bronchopneumonia, and phthisis. Taken in connection with a rational history of acute lobar pneumonia, the râle is of great value as a sign, especially if with it other signs be found, but it is not to be called pathognomonic.

Pleuritic Friction Sounds are râles produced in the pleura when it is diseased. They may be of a rather moist, grazing character, or may be creaking and dry. They may be heard in all diseases in which the pleura is involved. As has been mentioned, the pleural surfaces, when diseased, may give rise to crepitant and subcrepitant râles.

Pleuritic Adhesion Sounds.—In some cases of old pleurisy, with adhesions, peculiar sounds are heard, which may be accurately imitated by applying one end or a rubber band to the ear and stretching it. The adhesion sounds are probably produced by stretching of old adhesions.

The Metallic Tinkle is a sound resembling that produced by pouring water in drops into a bottle. It is produced either by drops of fluid falling from the roof of a large cavity in the lung, or from the walls of the cavity of a hydropneumothorax, or by bubbles breaking in fluid under similar circumstances. In different cases one or the other of these causes may produce the sound. It is heard over some large cavities, and, in some cases of pneumothorax, it may occur either when the patient speaks or while he is breathing.

Gurgles are coarse râles which are more liquid than mucous râles. They are sometimes heard in bronchitis, in some cases of solidified or compressed lung, and in some cavities.

The Mucous Click is a peculiar dry sound, occasionally heard at the end of inspiration. Its cause and significance are not clear.

Dry and Moist Crackles are sometimes mentioned. They are difficult to distinguish from subcrepitant râles.

Sibilant Breathing, sometimes called sibilant *rhonchus* or râle, is a whistling or hissing sound heard in cases in which a bronchus is narrowed by inflammatory thickening of its mucous membrane or by other causes.

Sonorous Breathing is produced in the same manner as the former. It is of lower pitch and softer quality.

J. West Roosevelt.

RAMSGATE AND MARGATE, ENGLAND.—These two popular though not the most fashionable English coast resorts are situated on the Isle of Thanet, about seventy-five miles east of London. Margate lies to the north, with an eastern sea exposure, while Ramsgate, about five miles to the south of it, has a southern as well as an eastern sea front. Similar but quieter resorts in the near vicinity are Broadstairs, Westgate-on-Sea, and Birchington.

The general climatic characteristics represented by these resorts are those of a cool marine climate, with moderate or quite considerable humidity. Owing to the influence of the Gulf Stream here, as throughout all England, the mean temperature is much higher than is due to latitude. The winters are mild, the summers cool; there are no great extremes of temperature; and there is great seasonal and diurnal equability. There is only a moderate amount of sunshine, and there is always wind. Such a climatic combination is stimulating and bracing, and has been found valuable for anæmia, malaria, convalescence from various diseases, dyspepsia resulting from debility, certain nervous affections, and particularly scrofula and tuberculous conditions other than pulmonary.

These resorts are available all the year, although they are naturally most frequented in the summer.

The soil is of chalk covered with a foot or two of earth, and, consequently, is dry and quickly absorbs moisture.

Ramsgate, like its neighbor Margate, presents to the sea high chalk cliffs, with an abrupt descent to the "sands," which, being thus sheltered from the winds, affords an attractive resort for the invalid and visitor, and good bathing. In general, however, here as at Margate, the winds are frequent and trying, particularly at certain seasons of the year. By the construction of terraces and crescents a certain amount of artificial shelter is obtained. Nevertheless, "even in its stillest corners the keen Thanet air is constantly moving." The southern exposure affords more sun, though the general percentage of cloudiness is 6.7. On account of its situation it is a little warmer here than at Margate.

The town contains about 25,000 inhabitants, and appears to be very healthy, as the death rate in 1891 was only 14 6, and more than one-third of the deaths occurred at over sixty years of age; the infant mortality was 118 per 1,000 births. The drainage is thorough and good, and the water supply is constant and pure. If one desired to live long this would appear to be a desirable resort, as in 1890 one-twelfth of the total number of deaths was of individuals at or upward of eighty years.

Besides the cliffs and sands there are piers for promenading; and the marine view, and the almost daily arrival of foreign fishing smacks afford a constant source of interest. There are also attractive drives in the vicinity. The temperature of the sea water is 61° F. in the summer, thus affording opportunities for bathing. Ewart ("Climates and Baths of Great Britain," 1895) says that Ramsgate has an "admirable winter climate for most invalids," and "many," he continues, "are so fortified by a winter residence as to be able to meet the spring winds without risk."

A climatic table of Ramsgate is appended; it also substantially represents that of Margate, which is only about five miles distant:

Climate of Ramsgate, Lat. 51° 19′ (from "Climates and Baths of Great Britain").

	Jan.	Mar.	May.	July.	Aug.	Oct.	Nov.	Year.
Temperature—								
Average or normal ...	38.8°	40.3°	52.2°	61.2°	61.4°	49.8°	45.9°	49.3°
Mean daily range.....	8.9	11.1	14.2	15.2	15.4	11.8	9.7	12 0
Mean of warmest	43.3	45.8	59.3	68.8	69.1	55.7	49.8	55.3
Mean of coldest.......	34.4	34.7	45.1	53.6	53.7	43.9	40.1	43.3
Highest or maximum .	55.2	63.6	77.3	83.6	83.2	72.9	61.3	83.6
Lowest or minimum ..	20.3	20.1	32.9	42.3	44.2	27.8	22.2	19.0
Humidity—								
Mean relative at 9 A.M.	89%	83%	76%	74%	74%	86%	88%	82%
Precipitation—								
Average in inches.....	1.76	1.44	1.73	2.32	1.35	2.86	2.84	24.23
Days in which rain fell	15	14	12	13	9	15	16	163
Wind—								
Prevailing............	The prevailing wind is from the southwest except in April and June.							S.W.
Weather—								
Cloud at 9 A.M	7.3	6.9	6.1	6.3	6.0	6.6	7.5	6.7

Margate (about 19,000 inhabitants) has been noted for a century for the treatment of scrofula and tuberculous diseases, especially in children, and here is situated one of the oldest and most famous seaside sanatoria for those suffering from these diseases—"The Royal Sea-Bathing Infirmary." There are also many other similar institutions. The town stands on two hills separated by a valley, and facing the north are high chalk cliffs at the base of which is a shallow beach that is quite covered at high tide. It is upon these cliffs that the new portion of the town is situated. The town also stretches some distance back from the sea over undulating ground, affording opportunities to gain a certain amount of protection from the winds. The water supply is good, and the

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drainage is efficiently accomplished both by natural and by artificial means.

The table shows the various meteorological data in detail. Fogs are not frequent. It is rarely uncomfortably hot or cold in summer. January is the coldest month in the year, the average temperature being 38.9° F.

Large numbers of children are sent to this resort for the effect of the sea air and sea bathing, the majority suffering from scrofula and tuberculous diseases other than pulmonary tuberculosis. The benefits obtained in these maladies in some cases are said to be extraordinary. At the Royal Sea-Bathing Infirmary the following percentages of cures are given: 1886, 23.5 per cent.; 1887, 27.84 per cent.; 1888, 38 per cent.; 1889, 46.1 per cent.; 1890, 52.35 per cent. As it requires a certain vigor of constitution to endure this climate, weakly children would probably do better in the milder climate of the Mediterranean shores.

The accommodations at Ramsgate and Margate are good and of varying price, and there are excellent facilities for all sorts of sea-baths.

For a more extended description of this region and its climate the reader is referred to the article of Ewart in "Climates and Baths of Great Britain," to whom the writer acknowledges his indebtedness.

Edward O. Otis.

RANULA.—A cystic tumor in the floor of the mouth, formed by the dilatation of one or more of the acini of the anterior lingual glands (Ward [1]), which are known also as the "Blandin-Nuhn" glands (von Recklinghausen [2]), and are situated at the under side of the tongue on either side of the frænum linguæ, near the apex.

This definition, the correctness of which has been confirmed by later investigations,[3, 4] is founded on the result of a characteristically thorough investigation, by the accomplished Strassburg pathologist, of a typical ranula accidentally found at a necropsy made in his pathological institute. The cyst, about the size of a pigeon's egg, was found on the under side of the left half of the tongue; it extended to a little beyond the median line upon the right side, and penetrated into the intermuscular spaces in different directions. The wall of the cyst was of a nearly uniform thickness of from 1 to 3 mm.; the internal surface was nearly smooth, except in the upper part, where, anteriorly, toward the apex, there was a prominence of some 5 mm. in height, upon which were two furrows; one of these, situated near the top of the prominence, allowed the passage of a bristle to the depth of 2.5 mm., while the other, situated near the base and away from the apex, was impervious. The cyst was everywhere colorless and translucent, except at the inferior part, where there was an opaque spot of about 20 mm. in diameter, of a brownish color, having at its edges two more cysts, each about the size of a pin's head. The ducts of the various salivary glands, Wharton's and Rivinus', as well as Bartolini's, were all to be traced outside of the cyst, having no other relation with it than that of proximity. The microscopic examination showed that the epithelial lining of the cyst wall was in two layers, the inner one of ciliated cylindrical epithelium, and beneath this a layer of small polygonal cells with large nuclei. The cyst contained a clear, somewhat thick, glairy, and viscid mucus, faintly yellow in color. The morphological elements were cells of an epithelial character in various stages of "colloid" degeneration, large brownish granular bodies, and numerous hyaline corpuscles, among which were some quite large, of a diffused, faint greenish-yellow shade, permeated with countless "vacuoles." The chemical examination showed a considerable amount of mucus, but no evidence either of sulphocyanide of potassium or of any fermentative material for the saccharine conversion of starch; therefore the fluid was not saliva. This confirmed the investigation of Besanez [5] made in 1845. Föderl [6] describes a ranula which he dissected as consisting of the dilated duct of the Blandin-Nuhn gland.

Ranulæ, in general, present themselves as translucent pink or bluish tumors, generally globular in shape and fluctuating, lying either wholly in the mouth or between the mouth and chin, according to their size. They project into the floor of the mouth from beneath the tongue, at first quite to one side of the frænum linguæ; but as they increase in size toward the mouth they elevate the tongue, push it over to the opposite side, and in time present themselves against the teeth in front, and may even prevent their closure. They push the frænum toward the opposite side, but may project beyond it, giving the appearance of two tumors, or of one tumor divided into a larger and a smaller portion. As the tumor increases in size the interference with speech and deglutition becomes steadily more noticeable. The elder Cline [7] relates the case of a person who was in great danger of immediate suffocation by a large ranula which thrust the tongue back into the fauces. When not interfered with the tumor will project in the neck below the angle of the chin, and fluctuation may be felt in this situation. When the tumor is large the alteration of the patient's expression is marked; the region of his mouth looks like that of a frog, the pale bluish, translucent hue increasing the resemblance. Hence the name, from *rana*, frog (Ger., *Froschgeschwülste*; Fr., *grenouillette*).

Cysts of other organs than the Blandin-Nuhn glands are also found in this situation. Wharton's duct may be dilated by the damming back of the secretion of the submaxillary gland from the formation of a salivary concretion in the duct, either at its orifice or in its course; and dermoid cysts, often of considerable size, are also found. The latter are especially interesting pathologically, as they undoubtedly represent here the remains of a fœtal organ which normally entirely disappears. The branchial fissures of the fœtus are normally obliterated early in fœtal life, but occasionally a fold of the tegumentary or epiblastic layer becomes included in the deeper tissues in the process of closing in from the sides to form the face, and finally it becomes entirely separated from its attachment to the external skin. It may remain quiescent, giving no evidence of its presence, or the cells of the epithelial lining may be excited to growth and the interior become filled with the products, consisting of broken-down epithelium, fat, cholesterin crystals, and débris, *i.e.*, the usual contents of cysts developed from the dermoid layer. Indeed, hairs, bone, and teeth have been found in them.[8] These dermoid cysts, however, do not spring from the same point as do true ranulæ. They are situated either in the median line, between the two geniohyoglossi muscles, or between one of these and the mylohyoid; but as they grow they extend upward into the floor of the mouth, or downward in the neck, as far, perhaps, as the larynx.[9]

Diagnosis.—These various tumors present points of differentiation sufficiently marked, usually, to allow them to be recognized, and as the treatment of each is different, it is important to have them well in mind. The positions of true ranula and of the dilated Whartonian duct are, by the time they have aroused sufficient attention to be brought to the notice of the surgeon, very nearly the same; they both lie just under the tongue, to one side of the frænum, and fill up the floor of the mouth, elevating the tongue above it, and appearing as a thin-walled, fluctuating, and translucent tumor. In the case of the ranula, this tumor has upon its surface Wharton's duct, the orifice of which can usually be detected near the median line, and into which a fine probe or bristle may be passed, and be seen to glide along the surface to the submaxillary gland, external to and beyond the cyst. Careful search will often also reveal the orifices of the sublingual gland, the ducts of Rivinus. Blood-vessels are frequently seen coursing in waving lines over the cyst. When Wharton's duct is the seat of the tumor, the entrance of the probe into it will be prevented by the obstacle which is blocking it, be it salivary concretion or inflammatory product, and removal of the obstacle will usually allow the escape of the fluid. In these cases there are usually considerable pain and circumjacent swelling, with other evidences of inflammatory action in all the

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parts implicated; the floor of the mouth is hot and tender, the tongue is painful on motion, and under the jaw the submaxillary gland is swollen and tender.

The clinical features of the dermoid cyst are different; indeed, there should be no confusion between them, but inasmuch as, from its situation and gross appearances, it is sometimes mistaken for ranula, it is well to point out the differences. The wall is usually thick and firm, the contents may be quite thick, even mortar-like, sometimes purulent, or the contained fluid may be thin or viscid. There may be fluctuation, but it is less distinct than in ranula, and the surface often pits on pressure. The tumor is situated more deeply under the muscles of the mouth, and, when presenting under the jaw, is embedded among those of the neck, and may penetrate even as far down as the larynx. In the mouth it arises nearer the median line, although as it grows its origin becomes obscured, and may not be readily determined at the time when the case comes under the observation of the surgeon.

TREATMENT.—No other than operative interference is of any avail in the treatment of these cysts, and it is usually necessary to do more than simply to evacuate their contents. If it be a *dilated Whartonian duct*, the removal of the concretion blocking up the orifice is usually sufficient; but this requires some care, as it is often very brittle, and if any fragments remain they set up a good deal of irritation in the duct itself, and serve as nuclei for further collections. Therefore an opening should be made in the duct sufficiently large to "shell out" the stone entire. As these are occasionally quite long, it may require a considerable incision in the length of the duct, but this is preferable to making a small opening and endeavoring to drag the stone out; for if this is attempted it is liable to break, to the subsequent annoyance of both patient and surgeon.

It is better, when practicable, to remove the *dermoid cyst* entirely, though, when it extends deeply and has very firm attachments, this will be difficult, and may be impossible with safety to the patient. When the cyst is not large it is usually easiest to make a free incision through its wall—whether in the mouth or under the chin, depends upon its accessibility—and evacuate the contents. When these are thick and tenacious this may be a matter of some difficulty. After this, the cyst wall being tolerably firm, it will bear considerable dragging upon, and may be enucleated with the handle of the scalpel, aided by occasional snips with the blade or with scissors. Cases are occasionally met, however, in which the operation of entire removal is both difficult and dangerous. In Mr. Mayo's[9] case the tumor extended down nearly to the clavicle, passing between the sterno-mastoid muscle and the trachea. After scooping out the contents and removing a part of the wall, he left the rest to suppurate, first filling the cavity with lint soaked in turpentine, in order both to arrest the hemorrhage and to hasten the suppuration. The patient recovered after a considerable time.

Sir William Fergusson's[10] case filled the mouth so as to threaten suffocation, keeping the teeth forcibly apart and projecting prominently under the chin. He feared to leave "a sac so large and thick to the certainty of a violent inflammation," . . . and "resolved instead to attempt the extraction of the whole cyst." Incisions were made both in the mouth and in the neck, but "the sac was so amalgamated with the surrounding tissues that a free use of the knife was required." No large vessel was cut, but there was much loss of blood both at the operation and subsequently; the ultimate result, however, was entirely satisfactory.

The true thin-walled ranula requires a different treatment. Simple incision is not sufficient, for the edges of the wound usually reunite and the cyst forms again. The wall is also too thin to allow its enucleation *in toto*. A seton introduced through its walls, and allowed to remain for a couple of weeks, more or less, will sometimes, but not always, cure it, and is to be tried first. This failing, some surgeons recommend the removal of a large part of the thin wall, in the expectation that the remainder of the cyst will collapse and the walls unite, thus obliterating its cavity; but, like the seton, this often fails. A sort of plastic operation has, therefore, been tried, and it has usually proved successful. This consists in forming a triangular flap by a couple of converging incisions in the anterior wall, and fastening the apex by two or three sutures to the opposite wall; adhesions are thus formed, and the cyst is kept open until the wall shrivels up. Sonnenberg recommends that the remainder of the gland be dissected out of its bed in the apex of the tongue, thus preventing the development of any other cysts afterward. This is occasionally done, with very satisfactory results, when milder measures have failed. Hippel[11] advises the removal of both cyst and gland through an incision under the chin, as being more accessible and more sure against recurrence. Felizet[12] thinks that he simplifies the procedure of extirpating the sac by first injecting a solution of boric acid into the tissues around it; after which he opens and empties the cyst, stuffs it full with a sponge, and shells it out as a solid tumor (!)

William H. Carmalt.

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[2] von Recklinghausen: Virchow's Archiv, Bd. 84, p. 425.
[3] Sultan: Deutsch. Zeitschrift für Chirurgie, Bd. xlviii., 1898.
[4] Mintz: Deutsch. Zeitschrift für Chirurgie, Bd. li., 1899.
[5] Besanez, Dr. Gorup: Heller's Archiv für Phys. und patholog. Chemie u. Microscopie, vol. ii., quoted by Dr. Owen Reis in the article Saliva, in Todd and Bowman's Encycl. of Anat. and Phys., vol. iv., pt. 1, p. 420.
[6] Föderl: Langenbeck's Archiv, Bd. 49, 1895.
[7] Chelius's System of Surgery, vol. iii., p. 121. Edited by J. F. South, Philadelphia, 1847.
[8] Butlin, Henry S.: Diseases of the Tongue, p. 239. Lea Brothers & Co., Philadelphia, 1885.
[9] Mr. Mayo, of Winchester, England: Lancet, 1847, i., p. 667, quoted in Druitt's Surgery, p. 423, Philadelphia, 1860.
[10] Fergusson's Practical Surgery, p. 445, Philadelphia, 1853.
[11] Hippel: Langenbeck's Archiv, Bd. 55, 1897.
[12] Felizet: Bull. de Chirurgie, 1891, October 21st, p. 603.

RAPE, MEDICO-LEGAL ASPECTS OF.—Rape may be defined as the carnal knowledge of a woman through force and without her consent; or, as it is generally expressed, "forcibly and against her will."

The physician is concerned but little with the legal aspects of the subject. Only the more important facts will therefore be stated, greater space being given to the duties of the medical examiner.

General Considerations.—Rape has always been regarded by civilized nations as one of the most heinous crimes. It is a felony in all the United States, and its punishment varies from fine and imprisonment for a term of years to life imprisonment or death. The severest penalty is imposed in several of the Southern States.

Assault with intent to rape is recognized as a distinct offense in some of the States, but not in others. Where so recognized, it is punished with fine and imprisonment. Handling, touching, or attempting to touch the genital organs of a female, or her breasts, forcibly and without consent, is regarded in some States as a felony or criminal assault; in others, as a misdemeanor.

If it can be shown that the woman gave her consent, the guilt of the man is removed, providing the woman is capable of legally giving consent. Under the old "common law" the age limit, under which a female was not capable of giving consent, was thirteen years. In most of the States this limit has been raised to fourteen or sixteen years; in Wyoming, to eighteen years. Carnal knowledge of a girl under this limit, even at her solicitation, is a felony. An idiotic or insane woman cannot give consent, and an assault or rape committed upon one in a state of anæsthesia or in a hypnotic sleep is generally regarded as being committed against her will. Consent obtained by fraud, as when a man represents himself, in the dark, to be the husband, or when the woman unwittingly assumes that he is her husband, does not mitigate the offense, although a decision was once given in England in which such deception was permitted to pass without punishment. Previous repeated cohabitation between the man and woman does not remove the guilt

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of rape, if force has been used, for the common law holds that even a prostitute may reform or withhold her consent. A woman cannot charge her husband with rape, for the marriage contract involves her consent. Finally, all persons aiding in the commission of a rape or assault are regarded as principals in the second degree.

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The testimony of the prosecuting witness is accepted as competent through recognition of the fact that the crime is generally committed in secret when no other persons are near. But the character of the prosecuting witness is important and may be impeached. The witness is required to answer all questions put by the defence without privilege.

Duties of the Examiner.—The testimony of the medical examiner is generally employed to corroborate that of the prosecuting witness, and there are few positions in which greater care and discrimination must be used. It is the duty of the physician to make an impartial examination and to submit the facts just as he finds them. The statements of the victim and those of her friends are matters for the consideration of the court and should not in the least influence the examiner. In a large majority of all cases of alleged assault the allegation is accidentally or maliciously false. Amos was doubtless correct in his estimate that there are twelve false charges to every true one. The estimate is true also of cases in which a child is the principal witness. Even young children are taught by designing women to tell the story of an assault; but they are often taught to use language most unnatural to their age, and the absolute precision of their statements is often a ground for suspicion. It is rarely indeed that an adult can reiterate a false story without introducing discrepancies. The motives for such deception need not be discussed. The chief of them is revenge, and this is often for the most trivial offense, an unpaid debt, a fancied slight or insult, or a cessation of improper relations with the mother. In such cases the report of the examiner should prevent the case from coming to trial. In cities where these examinations are entrusted to a medical officer of the court or Police Department, his decision is usually accepted and the case is disposed of accordingly, but a physician is generally found by the friends of the prosecution whose sympathy masters his judgment, or one who may innocently err through lack of experience. The inexperienced physician should be exceedingly careful in all cases.

The examiner, on the other hand, would often err if he confined his opinion too rigidly to the physical condition of the victim. He can often further the ends of justice by carefully interrogating her apart from her friends and the officers in charge of the case. For his own protection, however, he should never examine her alone in a closed room. A child when privately questioned may admit that she has been instructed and perhaps injured by her mother; but the testimony of a young child is so unreliable that even this admission may be false. The slightest discrepancy should arouse suspicion, especially in the case of a girl approaching the age of consent, and in all cases a careful inquiry should be made into the possibility of a motive for false accusation. In a case examined by the writer, a girl of fifteen years charged her father with incest on two occasions. Her condition suggested more frequent intercourse, and she finally admitted that the charge had been brought through revenge for being forbidden the attentions of the young man who had been guilty of her downfall.

The examination should be made at the earliest possible moment after the assault, but in the case of an adult woman only with her consent. Refusal to submit to examination may be taken as an indication of false accusation, but no more extensive injuries were ever found by the writer than in a young woman who, after reciting a most incredible account of imprisonment and rape by five young men, was with the greatest difficulty persuaded to undergo an examination.

A complete record should be kept of the examination, including the name, residence, age, and apparent age of the subject, the exact time and place at which the assault is alleged to have been committed, and the place and exact time at which the examination is made. The injuries, if any, should be described with minuteness. The most trivial circumstances often prove of value in the hearing of the case, but particularly the time at which the crime is said to have been committed and the time which was permitted to elapse before complaint was made. An excellent form for this record is given in the "Medical Jurisprudence" of Witthaus and Becker, vol. ii., p. 419.

The principal facts to be established by the physician's examination are: (1) Marks of violence on the woman's genitals; (2) marks of violence on her person or on that of the accused; (3) stains of blood or semen on the person or clothing of either; and (4) the presence of venereal disease, gonorrhœa, syphilis, or chancroid in one or both. It is better to make the examination of the defendant with his consent and under full knowledge of its purpose, for it may otherwise be excluded as being in the nature of an involuntary confession. For the same reason the consent must be obtained without threat or promise. In a recent case the victim, a child of four years, was found to be infected with gonorrhœa, and the accused in a late stage of the disease. The latter, distinctly degenerate, willingly submitted to the examination, and admitted, in the presence of the examiner and an officer, that he had had the disease and had committed the assault. The case was closely contested, but the evidence was finally admitted entire as a voluntary confession, for it was shown that he had been informed beforehand of the purpose of the examination and of the official position of both witnesses.

The examiner is generally expected to testify that he has found, or that he has not found, evidence of the penetration of some blunt instrument. It is sufficient that the penetration has been only slight, as a separation of the labia. A recent rent of the hymen is one of the most positive signs that force has been employed and that penetration has been effected, but it is not essential. The fact that the hymen is intact is of little value as negative evidence, for its firmness must be taken into account. Repeated intercourse is sometimes possible without its rupture. And, on the other hand, the membrane may be torn in many ways other than by sexual intercourse. It is probably congenitally absent in rare instances. The vaginal wall may also be torn. Comparatively few examinations are made early enough to discover a recent bleeding rent of the hymen, and after the third day it is extremely difficult to determine the recentness of an injury. More than one examination should generally be made, and the statements made at each should be carefully compared. In many cases the injury is limited to one or more abrasions just within the labia minora. The examiner should see that this corresponds to a possible injury by sexual contact, and that it is not an excoriation such as might be made with the finger-nail. He cannot, of course, testify as to the manner in which the injury was inflicted, but he may state that the injury corresponds exactly to an injury inflicted in a forcible effort at sexual intercourse.

Complete penetration of the vagina of a young child by an adult male penis is impossible without the most extensive laceration, and this is generally prevented by the outcry. In more than one hundred examinations of young girls the writer has seen but one case in which such injury had been inflicted. When there has been recent complete defloration, complete penetration of a virgin, there are generally well-marked signs of violence. The hymen is lacerated and the external genitalia are inflamed to a variable degree. There may be only slight redness, heat, and sensitiveness, or the swelling and tenderness may be so great as to render a thorough examination almost impossible. The woman walks with difficulty, and separation of the thighs causes intense pain. In the course of from forty-eight to seventy-two hours these conditions may subside or they may become more marked as suppuration develops in the lacerations. Other evidences of a struggle are generally revealed in cases of

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extreme injury, especially contusions, abrasions, and lacerations of the thighs.

Evidence of seminal emission was formerly required as a proof of guilt, but it has been abandoned. Such evidence, if present, however, is of great value as corroborative of the other facts. If stains are found upon the clothing a small piece should be cut out and submitted to careful microscopic examination. Spermatozoa may be found also in the vaginal mucus, on the skin, or on the pubic hair. (See article on *Seminal Stains.*)

Marks of violence on either person are of value chiefly in determining that consent was not given and that force was employed. They are of greater importance, therefore, in the case of a woman above the age of consent. In the case of the prosecuting witness it is necessary to exclude the possibility that the wounds were self-inflicted. This is to be suspected especially in the case of a neurotic or evidently erotic girl, and when the marks consist of parallel lines corresponding in size and position to possible positions of her own fingers.

The much-discussed question of the possibility of rape upon an able-bodied woman by a man unaided resolves itself into a question of the comparative strength and endurance of the two individuals, allowance being always made for the influence of fright and excitement upon the woman.

The presence of venereal disease in both persons is highly corroborative of the charge, providing the disease has appeared in one at a time corresponding to probable inoculation at the time of the alleged assault. Great care must be exercised, however, in the diagnostication of a muco-purulent discharge. Microscopic examination is generally necessary. It is especially important when the defendant is accused with having inoculated the victim with gonorrhea. Such inoculation is possible after the discharge from the male urethra has become extremely scant and has even lost its purulent appearance. The discovery of gonococci in it is sufficient evidence of the inoculability of the disease and goes far toward establishing the guilt of the defendant.

James M. French.

RASPBERRY. See *Rosacea.*

RAVENDEN SPRINGS.—Randolph County, Arkansas. Post-Office.—Ravenden Springs. Hotel Southern, and numerous smaller hotels and inns.

Access.—Viâ Kansas City, Fort Scott & Memphis Railroad to Ravenden Station, thence five miles by coach or hack to springs.

This resort is located in the northern part of Arkansas near the White River Mountains, the range in which the Eureka Springs have their origin. The elevation is twelve hundred feet. The geological formation is the same as that at Eureka, but the mountains are not so high or so rugged. The surrounding scenery is, however, exceedingly fine, and many features of interest are pointed out to visitors. The place takes its name from the "Raven's Den," a small cave with a circular opening a few feet from the top of the highest mountain. In this cave it is said that many of the feathered denizens of the forest, particularly the raven, or black crow, made their homes and hatched their young for a long period of time. Fish and game are abundant, and it is stated that many deer are killed in the vicinity during the winter months. The following analysis of the water was made by Messrs. Wright & Merritt, analytical chemists of St. Louis, in 1885: One United States gallon contains (solids): Lithium carbonate, gr. 1.26; calcium carbonate, gr. 4.61; magnesium carbonate, gr. 4.48; calcium chloride, gr. 1.24; magnesium chloride, gr. 2.99; sodium chloride, gr. 2.19; alumina, gr. 2.36; silica, gr. 0.83; iodine, iron, and calcium sulphate, of each a trace; organic matter, gr. 1.86. Total, 21.82 grains. Gases: Carbonic acid, 21.5 cubic inches; atmospheric air, 13.3 cubic inches. Temperature of water, 59° F.

James K. Crook.

RAWLEY SPRINGS.—Rockingham County, Virginia. Post-Office.—Rawley Springs. Hotel.

Access.—Viâ Baltimore & Ohio Railroad to Harrisonburg, thence a two-hours drive over a macadamized turnpike to springs.

This is one of the famous old Virginia mountain resorts, and it unites many of the best features of a summer resting-place. The elevation is two thousand feet above the sea-level, and the climate peculiarly dry and equable. The surrounding scenery is wild and rugged, but at the same time picturesquely attractive. The hotel at the springs is a comfortable and handsomely furnished building containing seventy-seven rooms, with a dining-room capacity of one hundred and fifty guests. It is well supplied with modern comforts and conveniences and facilities for amusement. The springs here are three in number. The water of each fountain seems to possess the same general characteristics. It is without odor, and possesses a strongly marked chalybeate taste. It exhibits a faintly acid odor from the presence of carbonic-acid gas. This disappears as the paper saturated with it dries. The water is perfectly clear and transparent as it flows from the earth, but on exposure to the air it soon begins to deposit a rust-colored precipitate of the oxide of iron. The temperature of the main spring is about 51° F. According to the analysis made by Prof. J. W. Mallet, one United States gallon contains: Iron protoxide, gr. 1.09; organic matter, gr. 0.03; and very small amounts of manganese protoxide, alumina, magnesia, lime, lithia, soda, potash, ammonia, sulphuric acid, chlorine, and silicic acid. The qualities of the water are improved by the presence of carbonic acid. It is a very useful, lightly carbonated, chalybeate water, and has an extensive sale even at distant points.

James K. Crook.

RAWLINS SULPHUR SPRINGS.—Carbon County, Wyoming. Post-Office.—Rawlins. Hotels.

These springs are pleasantly located about two miles from the enterprising town of Rawlins. The situation is on an elevated plateau, at an altitude of sixty-four hundred feet above the sea-level. The surrounding country is rugged and mountainous. The following analysis was made in 1894 by E. E. Slosson, of the School of Mines of the University of Wyoming, at Laramie: One United States gallon contains (solids): Potassium chloride, gr. 1.40; sodium chloride, gr. 12.18; sodium sulphate, gr. 854; magnesium sulphate, gr. 18.23; calcium sulphate, gr. 19.28; calcium carbonate, gr. 7.41; silica, gr. 8.23; carbonic acid, gr. 0.82. Total, 76.09 grains. Temperature of water at spring, 48° F.

The water is said to be highly sulphureted as it flows. The above analysis having been made at a distance from the springs, this gas was lost by volatilization. Therapeutically, the water has been fully tested in only one disease, viz., rheumatism. In this affection it is stated to be very efficacious, both when taken internally and when used in the form of hot baths. The water, as shown by the analysis, should possess very good diuretic and laxative properties. A first-class hotel and bath-house are much needed to put the resort on a good footing. The natural advantages of the place appear to offer excellent inducements for the establishment of a sanatorium.

James K. Crook.

RAY FUNGUS. See *Actinomycosis.*

RAYNAUD'S DISEASE.—Laveran was the first to apply to this disease the name of its discoverer. To the literature of the condition Raynaud made three contributions, his thesis in 1862, his article on "Gangrene," 1872, and his "New Researches," 1874. His attention was first attracted to the subject by a case of spontaneous symmetrical gangrene which came under his observation in 1861. As the result of personal observation and a searching of medical literature he brought together twenty-five cases (Monro) upon which he based his thesis. After a study of the varied phenomena of these cases, he elaborated his theory of spasm of the arterioles and venules in the

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affected parts, and suggested that, therapeutically, electricity might be of value. He believed symmetry of the lesions and absence of demonstrable changes in the vessels to be two essential features in the disease. He also thought that the larger arteries might be affected by the spasm to such an extent that the radial pulse might be temporarily lost.

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In the "New Researches" he describes a contraction of the arteries of the fundus oculi observed in two cases. He also elucidates more fully the theory of abnormal irritability of the vaso-motor centres with consequent vascular spasm of a reflex nature.

It has long been known that under the influence of cold the fingers may undergo a change of color, becoming white and even blue. The former condition has been designated the "dead finger" (*digitus mortuus*); Raynaud called it "local syncope," and other names, such as "local anæmia" (Hardy), or "regional ischæmia" (Weiss) have been used to describe it. Raynaud applied the term "local asphyxia" to the affected part when it manifested a blue appearance; Weiss suggested the term "regional cyanosis" and Barlow that of "local cyanosis" as more appropriate than Raynaud's appellation. The same condition was called by Boiseau "uterine cyanosis" because of its relation to the suppression of the menses. Monro thinks that, one tymological grounds, Sir George Johnson's criticism of Raynaud's use of these terms was correct, viz., that "local syncope" should be called "local asphyxia" and "local asphyxia" should be termed "local apnœa," but that the attempt to put this into practice would cause much confusion. Symmetrical gangrene is the culmination, and one of the most distinctive features, of Raynaud's disease. Raynaud's clinical tripod, then, is local syncope, local asphyxia, and symmetrical gangrene. Writers have multiplied terms in their endeavor to describe the various phases of this syndrome, but the clarity of our conception of the subject will be greatly enhanced by utterly disregarding the same.

Symmetrical gangrene is a rare condition, but "Raynaud's phenomena" (Hutchinson), local syncope and local asphyxia or either, may occur for years, finally disappearing without any gangrenous manifestation. An illustration of this is Mrs. M., now under my observation. When nine years of age, were she to write, knit, sew, or do any work requiring the dexterous use of the fingers, the first phalanx of the fingers of the right hand would become white, cold, and numb, eventually assuming a purple of bluish aspect; she could not again use them until the attack had passed and feeling had returned. This condition continued until her fifteenth year when it ceased and did not again show itself until a few months ago.

Raynaud's disease usually develops before the thirtieth year. Children, even infants, may be subject to it, but I have known it to occur after the seventieth year as well. Females are more susceptible to it than males. According to Monro the ratio, as found in the medical wards of the Glasgow Royal Infirmary, has been about one in three thousand cases, but this proportion he regards as an underestimate,—*i.e.*, if the disease be considered purely as a neurosis, and not in its relation to other diseases of which it was an incident only. In my own experience "Raynaud's phenomena" constitute a not very infrequent condition.

Raynaud's disease may occur as a pure neurosis or it may be associated with a great variety of morbid conditions such as hysteria, insanity, epilepsy, tabes dorsalis, syringomyelia, myelitis, neurasthenia, spinal tumors, chorea, Graves' disease, lead poisoning, syphilis, phthisis, infectious fevers, Bright's disease, chlorosis, anæmia, diabetes insipidus, and a congenitally small aorta; it sometimes appears also in connection with certain dermatoneuroses, as urticaria, scleroderma, and erythromelalgia. Heredity is present in about eight per cent. of the cases (Monro). The most important causative agent is cold. Emotional influences, malaria, diseases of the female generative organs, and the breaking off of the morphine and chloral habits are all important etiological factors.

Local syncope comes first in the trinity of symptoms which characterize Raynaud's disease. It may exist alone or it may be associated with local asphyxia, a very frequent combination; or, as is more usual, all three symptoms—local syncope, local asphyxia, and gangrene—are present. Numbness and stiffness in the digit affected may usher in an attack, or there may have been in the extremity or parts involved, for days or even weeks previous, severe pain which is intensified as the attack develops.

The seizures are paroxysmal. The parts involved become pale or even corpse-like; they do not bleed when pricked, are cold, and movement is difficult. This latter, Raynaud suggests, is due to a defect of afferent impulses and not to muscular weakness. The nose, cheeks, chin, and ears are but seldom invaded. The case of Mr. G., who consulted me a short time ago, well illustrates this phase. In September, 1902, he noticed that the first phalanx of the thumb, first and second phalanges of the index, and first phalanx of the ring finger became cold and white when exposed to the air or on touching something cold. The local syncope was at first attended by pain in the thumb and index finger, and there were also isolated white spots distributed over the unaffected surface of the ring finger. Occasionally, should the hand become very cold, local asphyxia would occur on its dorsal surface. Sometimes, as the local syncope disappeared, local asphyxia would take its place. The involvement of the thumb here observed is very exceptional; it is usually unaffected.

Local syncope may be unilateral or bilateral. The upper extremities are more frequently involved than the lower. The syncope may attack one finger or all, or it may attack the different phalanges in an irregular manner. There is no regularity in the frequency of the seizures; they may occur once or many times daily, or there may be intervals of uncertain length. They may occur for weeks, months, or years and then cease, either absolutely or for an indefinite period. In my case of Mrs. M., already referred to, there was an interval of twenty-seven years.

The part affected is cold to the touch, tactile sense is impaired, and the various forms of sensibility are irregularly and unequally involved. Temperature sense and pain sense may be lost, or that of temperature may be present and those of touch and pain lost. Local syncope may disappear without leaving any trace or causing any pain. Frequently there occurs a decided reaction accompanied by pain and by annoying paræsthesias.

Local asphyxia constitutes the second stage of this symptom complex. Usually it is preceded by local syncope, but not invariably so. As already stated, local syncope may disappear, leaving no trace and causing but slight discomfort, or it may be followed by a blue, bluish-black, bluish-white, purple, violet or reddish discoloration of the skin affecting, sometimes symmetrically, sometimes unilaterally, the hand, fingers, feet, and toes. A livid marbling of the adjacent parts may be associated with this characteristic discoloration.

Local cyanosis differs from local syncope in not being confined chiefly to the limbs, but in attacking as well the ears, face, lips, chin, tongue, and trunk. Raynaud describes a lividity of the breasts, a painful neurosis which merits the appellation of local asphyxia of the mammæ. The extreme sluggishness of the circulation in the cyanotic area is shown by the slow disappearance of the white spot made by pressure.

The manner in which the parts are involved is most irregular, there being no definite order of sequence. The lower extremities are less frequently attacked than the upper. Sometimes an œdematous condition develops in the asphyxiated parts and instead of a blue or black discoloration of the skin, with a lowered temperature, the affected area assumes a bright red hue, is hot, and becomes covered with perspiration. The œdema pits upon pressure and may precede or even take the place of the cyanosis. One part may be cyanotic and swollen, while at the same time another may be only swollen. The œde-

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ma is not confined to the extremities, as the ears, the face, and the tongue may also be affected (Monro).

Local asphyxia may or may not be attended by pain; often this is absent unless the cyanotic part is handled. The pain at times becomes neuralgic in character, or it may be continuous, www.libtool.com.cn discomfort to an intense agony. A patient of my own complained of irregular attacks of numbness for two years before the onset of the disease. In this case the pain was most agonizing from the very inception of the local syncope, which was in a few hours followed by local asphyxia, the appearance of the latter in no way mitigating the suffering.

There may be loss of motion, temperature sense, and tactile sense. Electrical sensibility may also be affected. Monro has collated some interesting cases showing that vaso-motor instability is certainly a marked feature of this condition. Calmette could readily induce an attack in the susceptible parts by putting cold water on any portion of the body. Raynaud, by using electricity on one hand, caused the disappearance of cyanosis from both, while Israel Sohn, by applying friction to the upper limbs, caused the disappearance of local asphyxia from all four extremities.

The character of the onset in local asphyxia is most erratic. Discoloration may precede or follow the pain, or the two may be associated. The development of the cyanosis may be very sudden; it may take the place of, precede, or follow the local syncope, its duration may be a few minutes, hours, or days; there is no regularity in the occurrence of the attacks. The pulse may be normal or absent. There is no fever, but occasionally there are depression, headache, insomnia, aphasia, convulsions, and even unconsciousness.

Patients who have long been subject to local asphyxia may suffer from changes in the skin called "tachetic" patches; these purple areas are very persistent, are unaffected by pressure, and are probably due to extravasated blood pigment in the deep layers of the skin (Monro). Local asphyxia, once having been developed, is very likely to recur; this liability is not, however, so great as in syncope. The Scotch verdict, "not proven" should be applied to those cases which are reported as cured.

The idea that a disturbed innervation might bear a causative relation to gangrene was entertained long before Raynaud wrote his now celebrated thesis. His contributions gave to the medical profession a new clinical concept, a disease with certain definite characteristics, viz., local syncope, local asphyxia, and symmetrical gangrene, a distinct morbid entity. For more than twenty years medical men regarded this disease as an idiopathic affection dependent upon a vaso-motor disturbance. Although the clinical entity described by Raynaud is generally accepted, it is now believed to be, in the majority of cases, merely a symptom (symptom complex) occurring in a great variety of diseases.

Symmetrical gangrene is the last and most important of this trinity of symptoms. Gangrene is usually associated with local asphyxia; in a very few instances local syncope and gangrene are combined; often the three classical symptoms are all present, while in about two per cent. of the cases gangrene occurs alone.

Raynaud emphasized its symmetrical nature, but it may occur unilaterally as well.

The parts most likely to be affected are the extremities and ears; the thumbs suffer less frequently than the fingers. The tip of the nose, the cheeks, lips, and chin may be affected. Desquamation of the epithelium may be the only evidence of the necrosis. Unfortunately this is but infrequent. The nails may fall off, but usually reappear. Raynaud describes a peculiar type of blister, a large bulla, of a deep brown color when dry, due to gangrene of the papillary layer of the derma. Necrosis may attack one or more of the phalanges of the digits, or a portion of the foot, or even the entire foot. In one of my cases both legs were gangrenous.

The attack may be so severe that spontaneous amputation of the extremities may occur. Recovery is slow, usually extending over months. If the gangrenous process is limited to small necrotic areas, the only evidence of its existence, discoverable after recovery, will be the presence of a slight scar or scars, and the number of these is an index of the number of previous attacks. The gangrene is dry and the parts become mummified. It is usually accompanied by pain which, in grave cases, is most agonizing. The general health may suffer seriously through insomnia, pain, and suppurative processes. Fortunately, "Raynaud's phenomena" often occur for years without the presence of gangrene; indeed it may never supervene, but its appearance is always a matter of grave importance.

The prognosis of Raynaud's disease, considered as a pure neurosis, is, if children are excluded, always good. When associated with other morbid conditions it is that of the underlying disease. For example, a patient of my own died during a very severe attack of Raynaud's disease, gangrene and mummification being very pronounced, but death was evidently the result of a chronic Bright's disease, from which she had suffered for years.

Diagnosis is easy when the three typical stages are present. The occurrence of local syncope and local asphyxia, either separate or associated, constitutes what is known as "Raynaud's phenomena," but the additional element of gangrene is necessary to justify a diagnosis of Raynaud's disease. The age, the sensory, motor, and trophic symptoms, together with the symmetry of evolution, will usually enable one to form a correct conclusion. Gangrene due to old age, ergot, and trauma is wanting absolutely in etiological and clinical characteristics.

There is a consensus of opinion among authors that local syncope and local asphyxia are of vaso-motor origin. Local syncope is undoubtedly due to spasm of the arterioles; authorities are at variance as to whether the venules do or do not participate in this spasm. Local asphyxia is due to an isolated spasm of the smallest venules which impedes the outflow of the venous blood from the capillaries, thus producing stasis (Weiss). The seat of these disturbances is situated in the vaso-motor centre of the medulla oblongata, which regulates blood pressure through the innervation of the muscle fibres of the blood-vessels; and this centre, like any other, may be irritated reflexly or directly, and in each case, varying with the intensity of the irritation, will there be an increased tonus of the vaso-motor constrictors and a spasm of the vessels will result (Burdach).

The explanation of the occurrence of the gangrene is more plausible on the supposition of the existence of trophic nerves and a consequent perversion of trophic influence, than it is under Raynaud's theory of insufficient nutrition due to the occurrence of local syncope and local asphyxia.

We now come to the important question: Is Raynaud's disease to be regarded in all cases as merely a symptom complex of other morbid conditions, or may it occur at times as an uncomplicated neurosis? There can be no doubt that the proper conception would be to class it under both heads, with which the present tendency is in accord. In a majority of instances it is to be regarded purely as a symptom, while in rare and exceptional cases it is, without doubt, a genuine neurosis.

Raynaud's disease offers an excellent example of pernicious habit on the part of the vaso-motor system. The therapeutic problem is how to overcome its morbid paroxysmal manifestations, and, above all, to prevent by proper hygiene and appropriate treatment the tendency to recurrence. If the attack is severe and occurs in winter, and especially if the patient is debilitated and advanced in years, a change to a warm climate is advisable. The effort should always be made, during the interval between the attacks, to build up the general and nervous strength, for by this alone can the paroxysmal tendencies be retarded and possibly overcome. Everything that favors a seizure, especially undue exposure to cold, must be carefully avoided. Appropriate clothing, suitable to the season, should be worn, constriction of the circulation guarded against, and the water used in washing ought to be at blood heat.

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If the attack is at all pronounced, it would be best for the patient to remain indoors in a uniform temperature. A mixed diet is the most suitable. Great caution should be employed in the use of stimulants, as the liability on the part of the neurotic to acquire a taste for alcoholics must never be lost sight of. If the patient has been at all subject to malarial influences quinine is the remedy *par excellence;* in any event it is a drug of unquestioned value. Opium has been greatly lauded; its chief efficacy, however, lies in its power to alleviate pain, to promote sleep, and thus to conserve the strength of the patient. Should the severity of the symptoms demand morphine, it ought never to be given hypodermically at the seat of pain, as the resulting irritation may cause gangrene. Nitrite of amyl and nitroglycerin should be given a trial. The use of thyroid extract is spoken highly of by Short. Iron, arsenic, nux vomica, strychnine, cod-liver oil, and malt are all useful drugs and potential aids in the process of upbuilding.

Spinal galvanization is perhaps one of the most efficient remedies. The negative pole should remain stationary over the sacrum, while the positive is slowly moved up and down the entire length of the spine, care being taken not to interrupt the current. The current strength should not exceed fifteen milliampères; séances should be daily, lasting not over five minutes; if the room is suitably warm, it would be advantageous to vary the spinal treatment by applying the positive electrode directly over the affected area. Galvanization of the cervical sympathetic is recommended. Static electricity is an agent of no mean value, general franklinization being the method employed, together with a local application of the static spray. This form of the current is much more easily applied than faradism, and is in every way as effective.

Massage, general and local, has in certain cases proved very efficacious, but great care must be exercised in its application, as the devitalized skin is liable to ulcerate if roughly handled. Should the immediate area affected be too sensitive to allow of its use, the adjacent parts may be treated. Warm fomentations have been found useful. A fifty-per-cent. alcoholic solution of menthol applied to the members involved, which should then be wrapped in cotton and covered with oiled silk, is to be recommended. It is of first importance that the extremities affected be kept carefully wrapped in flannel. I have known this simple precaution to be of more value than all medication.

The treatment of the gangrene is a purely surgical matter. Sufficient time, however, should be allowed for the demarcation line clearly to show itself, as the actual gangrene may include but a small part of the affected extremities.

Much will depend upon the tact and resourcefulness of the physician, and with all his remedies he must not forget the therapeutic value of hope. *C. Eugene Riggs.*

REACTION OF DEGENERATION (De R) is the term applied to certain changes in electrical excitability, produced by a lesion of the spino-peripheral neuron in any part of its course (the anterior horns of the spinal cord, or the cerebral motor nuclei, the motor roots of the nerves, or the peripheral nerves). When the anatomical lesion is profound complete De R is the result. Partial De R is found in less severe lesions. The nerves and muscles exhibit different reactions to the current. In complete De R, within a few days after the onset of the primary disease, the nerve exhibits a gradual diminution of reaction to the faradic and galvanic currents, and within from one to two weeks its irritability is entirely lost. The muscles supplied by the nerve react differently to the two currents. Their faradic excitability gradually diminishes with the corresponding loss of nerve excitability. The galvanic excitability, on the other hand, presents very peculiar changes. These are best seen when an electrode (preferably a large one) is placed upon an indifferent spot, and the other small electrode is placed directly over the muscle to be tested. Normally, it is found that the muscle responds most promptly to the closure of the cathode (CaCl), then to the opening or closing of the anode (AnO or AnCl), and finally to the opening of the cathode (CaO). The contraction of the healthy muscle is quick, lightning-like. In complete De R the response of the muscle is slow and, on passing the electrode over the belly of the muscle, one set of fibres contracts after the other. This slowness is the most constant feature of the De R and in itself suffices for the diagnosis. In addition, the diseased muscle reacts to an unusually mild current. This is seen very well, for example, in Bell's palsy by placing one electrode upon the chin, when it will be found that the paralyzed chin muscles react to a current which is utterly inadequate to produce a response in the unparalyzed muscles. Complete De R is also attended by the so-called reversal of the formula. It is found that contraction (C) is obtained most readily on AnCl. CaCO also increases relatively and may be greater than AnCO. As the disease progresses and the electrical excitability is gradually lost, AnClC with very strong currents may furnish the last evidence of the all but extinct muscular vitality. This is sometimes found even after the muscle has been completely paralyzed for a year or more.

In partial De R the excitability of the nerves may be merely lessened, the muscles may still react to the faradic current, but the contraction to the galvanic current is slow and perhaps shows some changes from the normal formula. If recovery takes place there is a gradual inverse return to the normal conditions.

Leopold Putzel.

RECRUITS, EXAMINATION OF.—The army of the United States is ordinarily recruited by voluntary enlistment; in time of war enlistment may be compulsory, under Enrollment Acts.

The Recruiting Service is under the direction of the adjutant-general of the army, and is organized into two branches: the general, for infantry and artillery, and the mounted, for cavalry.

THE LEGAL REQUIREMENTS FOR ENLISTMENT.—Any male person above the age of sixteen and under the age of thirty years, effective, able-bodied, and free from disease, of good character, who does not appear to be of intemperate habits, and who has a competent knowledge of the English language, may be enlisted, due attention being given to the restrictions in this article concerning minors. This regulation, in so far as it relates to age, does not apply to soldiers who may re-enlist, nor to those who have served honestly and faithfully a previous enlistment in the army. Applicants for enlistment are required to furnish such evidence of good character as they can obtain. With a view to determine their fitness and aptitude for the service, and to give them an opportunity to secure testimonials, as well as for the inquiry and deliberation contemplated by the Second Article of War, they may be retained and provided for at rendezvous, for a period not to exceed six days, after having signed the declaration of intention to enlist and passed the medical examination. Men so retained are known as *recruits on probation.* The enlistment papers of any such recruit who may be unfit or undesirable for the service, or who may not desire to remain in the service, will not be completed. The enlistment papers of recruits who are accepted and duly sworn will bear the date on which the enlistment is *completed* by administering the oath (A. R., Art. lxxi., 908). . . . The major-general commanding the army is of opinion that if satisfactory evidence of good character, habits, and condition cannot be furnished by the recruit, or be otherwise obtained, the presumption should be against him and he should *not* be accepted; and, further, that these views are concurred in by the Secretary of War and should govern in all cases (G. O., No. 1, Headquarters Recruiting Service, 1890).

These rules and articles shall be read to every enlisted man at the time of, or within six days after, his enlistment, and he shall thereupon take an oath or affirmation in the following form: "I, A. B., do solemnly swear (or

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affirm) that I will bear true faith and allegiance to the United States of America; that I will serve them honestly and faithfully against all their enemies whomsoever, and that I will obey the orders of the President of the United States and the orders of the officers appointed over me, according to the Rules and Articles of War." This oath may be taken before any commissioned officer of the army (Article of War).

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Every officer who knowingly enlists or musters into the military service any minor over the age of sixteen years without the written consent of his parents or guardians, or any minor under the age of sixteen, or any insane or intoxicated persons, or any deserter from the military or naval service of the United States, or any person who has been convicted of any infamous criminal offence, shall, upon conviction, be dismissed from the service, or suffer such other punishment as a court martial may direct (Article of War).

Under a recent act of Congress fraudulent enlistment is declared a military offence, and is punishable by court-martial under the Sixty-second Article of War; the provisions of this law are fully explained to every applicant presenting himself for enlistment with the information that any person procuring his enlistment on or after the 25th day of September, 1892, by false representations or other fraudulent means, will render himself liable to trial and punishment by court-martial. "Fraudulent enlistment" is defined by the law officers of the department as "an enlistment procured by means of a wilful misrepresentation in regard to a qualification or disqualification for enlistment, or by an intentional concealment of a disqualification which had the effect of causing the enlistment of a man not qualified to be a soldier, and who but for such false representation or concealment would have been rejected."

The regulations above quoted sketch in outline the requirements for admission to the enlisted branch of the military service and the duties of officers in connection therewith. For the recruiting officer an essential to success is a knowledge of men and their character, and for the medical officer a painstaking application of professional skill. The duty is a most important one, and in its faithful and thorough performance these officers share a grave responsibility. The influence of their judgment and discretion is felt throughout the entire military establishment, the efficiency of which depends in great measure upon the sound mental and physical condition and the intelligence of its enlisted force. From the varied classes and conditions of men presenting themselves for enlistment they are to eliminate not only those who are defective physically and mentally, but those who are defective morally, and if this duty be performed carelessly or indifferently, men will be admitted to the service with defects which will soon render them unfit for duty, or with moral obliquities that will induce malingering and desertion.

Re-enlistments.—Soldiers who are unable to pass the required examination *in all respects* will not be re-enlisted without special authority from the adjutant-general's office, and then only for their former commands; application for such authority should be recommended only when it is shown that any existing defects will not prevent the full discharge of duty as a soldier and that a continuance in service will be a positive benefit to the army.

Soldiers discharged as privates upon expiration of term of service and failing to re-enlist within one month, will not be again enlisted after they have passed the age of thirty-five years, unless for some good reason in the interest of the public service, and then only for their former commands upon special authority from the adjutant-general's office.

This limitation as to age will not apply to a soldier discharged as *a non-commissioned officer with excellent character*, and desiring again to enlist for assignment to a former command (not already full), either at the station thereof, or at a recruiting depot, provided he passes the required examination and furnishes satisfactory evidence in regard to character and habits since discharge.

Soldiers who have been discharged with good character under the provisions of law may be again enlisted without special authority after a period of two months from date of discharge, upon passing the required examination and furnishing satisfactory evidence in regard to character and habits since discharge, provided such enlistment is not barred by any of the above provisions.

Soldiers discharged before expiration of term of service for any other cause will not be again enlisted without special authority from the adjutant-general's office.

These restrictions, which are intended more particularly to govern re-enlistments for the line of the army, need not necessarily be applied to the hospital corps; the approval of the surgeon-general will be sufficient warrant for the re-enlistment of soldiers into that corps.

The position of a medical officer at a recruiting rendezvous is an advisory one (as a medico-military expert) to the recruiting officer; unlike the medical examiner in life insurance, he, in addition to his strictly professional inspection of an applicant for enlistment, must express an opinion upon his *aptitude*, both mentally and physically, for the military service. In times past, this latter duty was restricted entirely to the recruiting officer, who was also the sole judge of height, weight, and chest measurements; but experience has demonstrated the importance of professional skill in the formation of an opinion as to the general efficiency of a man for the military service, and it is now quite as much the province of the medical officer to decide upon the military aptitude of a recruit, as upon his freedom from grosser physical defects. Of course, his decisions are conveyed as opinions to the recruiting officer, who alone is legally authorized to make an enlistment.

In entering upon these duties, the medical officer should bear in mind the important fact that upon "the faithfulness and thoroughness" with which they are performed depends in a great measure the health of the army, its mental and physical efficiency, and especially its mobility; carelessness or inattention on his part may permit the admission to its ranks of men who soon find their way into the hospital, whose undiscovered diseases may be transmitted to innocent comrades, or whose defects may furnish groundwork for the demoralizing practice of malingering; examinations made in a perfunctory manner will surely result in the unwitting acceptance of men whose mental and physical defects are only too clearly displayed in the company organization, and whose enforced discharge from the service will bring discredit upon the professional skill of the examiner, and undeserved censure upon the recruiting officer with whom he has been associated; he should reflect that, in the sudden emergencies which our troops are so frequently required to meet on the frontier, *able-bodied* soldiers are indispensable to success, or to the saving of life and property from destruction; and that with an army so small as ours, in time of peace, every man enlisted must be relied upon to endure all the hardship of which a physically perfect human being is capable. Nor is this less a necessity in time of war with troops of the line, when celerity of movement and ability to endure great privations, as lack of food and inclemency of weather, are imperatively demanded in the manipulation of armies under the modern science of war.

"The experience of all nations has demonstrated the uselessness of attempting to conduct military operations to advantage unless the rigid scrutiny of the surgeon has been exerted to exclude such men as were subjects of, or predisposed to, disease, or were unfitted to sustain the continued fatigue and exposure of the march."[2]

There are, however, conditions of the service in time of war which warrant a departure from this standard in some respects, and the acceptance of recruits with defects which, in time of peace, would be positive disqualifications; farther on, reference will be made, under the appropriate headings, to these deviations from the peace standard.

In time of peace every enlisted man is presumed to be wholly efficient, and fit for duty at all times; he who to-

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day is nursing the sick in hospital may to-morrow be in his place in a company, or a member of the garrison guard; in time of war men *may* be enlisted who cannot be strictly classed as "fighting men," but who may be equally effective as soldiers in other departments; a man with a hernia, which is kept in place by a truss that is well-fitting, is in every way able to cook for a company, although not fitted to wear a cartridge belt and do active duty in the field; so, also, the loss of certain members—fingers or toes—would not necessarily disqualify a man from guarding a hospital, or driving a team, and thus taking the place of an able-bodied soldier whose services are more urgently needed at the front. For this reason it has been the custom in all armies to relax in certain particulars their peace regulations, and diminish their list of disabilities in time of war, holding to service many men who in time of peace would have been rejected.

Properly to conduct his examinations the medical officer should have plenty of light, air, and time, and good floors.

The room in which the examinations are made should be well lighted and ventilated, not less than forty feet long and twenty feet wide, with a well-laid, solid floor; its furniture should consist of a fixed measuring rod and slide, good platform scales, steel tape measure, vision test cards, and a set of test wools for determining color blindness; in one corner there should be a bed arranged after the fashion of an operating table, upon which applicants can be placed for the examination of suspected strictures, and heights verified, if necessary, by horizontal measurement, etc.; the instruments required are a set of steel sounds, a Cammann's stethoscope, an ophthalmoscope, a set of Snellen's test types, an astigmatic chart, the necessary apparatus for a rough analysis of the urine in cases of suspected lesions of the kidney, and the appliances for immediate vaccination after acceptance of the recruit.

There should also be adjoining the examination room, one fitted with bath-tubs, and liberally supplied with soap and towels, where every applicant for enlistment (who must be carefully and thoroughly washed before examination) can perform his ablutions under the supervision of the recruiting sergeant.

The recruiting officer should always be present at the examinations,[3] and, for obvious reasons, all other persons excepting the recruiting sergeant should be excluded from the room.

A very considerable and important part of the examination can be made before the applicant is stripped, during which defects may be discovered that will render further procedure unnecessary; he should be closely questioned as to his personal and family history, his previous service in military or naval life, his habits, his health in the past, and the receipt of injuries or wounds, or any surgical operations which may have been performed upon him. The examiner, during this questioning, can form an opinion as to the knowledge of the English language possessed by the applicant, his age, intelligence, and general fitness, both as to physique and morale, for the duties of a soldier.

A thorough and satisfactory examination can be made only by pursuing a systematic course, without the adoption of which the most expert examiner will omit important points, and, probably, lose sight even of glaring defects. To accomplish this the War Department, upon the recommendation of the writer, adopted a "form" for the examination of recruits, which contains a series of questions, to be answered by the applicant, and recorded by the inspecting or examining officer. These forms are furnished by the adjutant-general of the army to all recruiting rendezvous.

When the applicant is ready for the inspection of the surgeon, let him take the position of a soldier in the best lighted part of the room; then examine him in the following order after the methods elsewhere set forth.

1. Inspect his general physique, skin, scalp, and cranium, ears, eyes, nose, mouth, face, neck, and chest.

2. The arms should be extended above the head, the backs of the hands being together, and the applicant be required to cough vigorously; any form of hernia may now be discovered by the eye and finger.

3. The man should be required to take a long step forward with the right foot, and bend the knee, the hands remaining extended above the head; this exposes the genital organs, and varicocele or other defects in the scrotum may be recognized by the hand.

4. The arms should now be brought to the sides, and the man required to separate his buttocks with his hands, bending forward at the same time; this exposes the anus.

5. Examine the heart.

6. The elbows should be brought firmly to the sides of the body, and the forearms extended to the front, palms of the hands uppermost. Extend and flex each finger separately; bring the points of the thumbs to the base of the little fingers; extend and flex the hands upon the wrists; rotate the hands so that the finger-nails will first be up and then down; move the hands from side to side; flex the forearms on the arms *sharply*, striking the shoulders with the fists; extend the arms outward, at right angles with the body, and flex the forearm upon the arm until the thumbs rest on the points of the shoulders, while in this position raise and lower the arms, bringing them sharply to the sides at each motion; let the arms hang loosely by the side; swing the right arm in a circle rapidly from the shoulder, first to the front and then to the rear; swing the left arm in the same manner, extend the arms fully to the front, keeping the palms of the hands together; observe carefully the elbows; carry the arms quickly back as far as possible, keeping the thumbs up, and at the same time raise the body on the toes.

7. Extend the legs alternately, resting the heel upon the floor; move all the toes; raise the heel from the floor, moving the foot up and down, then from side to side; present the sole of the foot for inspection; bend the knee and strike the shoulder with it, bending the body slightly forward at the same time; throw the leg out to the side as high as possible, keeping the body squarely to the front; take the military position "to kneel firing," first on one knee, then on the other; get down on both knees; squat sharply several times in succession; hop the length of the room on the toes, first of one foot and then of the other; take a standing jump as far as possible; jump up and strike the buttocks with the heels.

8. Auscultate the lungs.

9. Test the hearing.

10. Test the vision, and for color blindness.

11. Vaccinate the applicant, if accepted.

Mr. Marshall, in his excellent treatise on the examination of recruits, arranges the causes on account of which recruits are rejected under three headings:

First. "Diseases or deformities which a medical officer from his professional knowledge and acquaintance with the duties of soldiers considers are infirmities which disqualify men for service in the army."

Second. "Slight blemishes which do not disqualify a man for the army, but which an unwilling soldier may exaggerate, and allege that he is thereby rendered unfit for military duty."

Third. "Unimportant deviations from symmetry, or slight variations from the usual form or condition of the body; technical or nominal blemishes which do not incapacitate a man for the army, or in the slightest degree impair his efficiency."

Experienced surgeons will reject all recruits whose defects fall under the first two headings, from a conviction that they render the men unfit or ineligible for the army; but those under the third heading are frequently rejected from fear of responsibility—a dread of official correspondence if objected to, and an ultimate damage to professional reputation.

In time of war cases coming under the first heading should be rigidly excluded, while those coming under the second and third headings should be as rigidly held to service.

THE GENERAL EXAMINATION.—*Competent knowledge of the English language* is defined by the War Department as the ability of the applicant to "speak fluently, converse

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intelligently, and fully understand the orders and instructions given in that language."

It would seem almost superfluous to refer to this matter, the importance of which is self-evident, were it not for the fact that so large a number of foreigners have been enlisted, who were ignorant of our language, whose blunders and mistakes have caused annoyances and impediments to the public service, and whose efficiency as soldiers has been thereby seriously impaired. It is of paramount importance that the soldier should be able clearly to understand the orders which are given to him, and to ascertain this fact beyond a doubt is one of the first duties required of the medical officer. Exception to this rule is made in the cases of skilled artisans and tailors, and more particular band musicians.

In time of war familiarity with the language is not so necessary, as foreigners are more likely to be assigned to regiments made up of their own countrymen, with officers who speak their language; they can also be made useful in the administrative departments of the army, taking the places of men better fitted for field service.

Age.—As has been already stated, the limits of age for enlistment in time of peace are, "not less than sixteen years, nor more than thirty-five years"; "minors under eighteen years will not be enlisted except for musicians, . . . and then only under authority from the superintendent."[4]

The regulations of the army require that when minors present themselves for enlistment, they shall be treated with great candor; the names and residences of their parents and guardians, if they have any, shall be ascertained, and notice sent to them of the minor's wish to enlist, that they may have an opportunity to make their objections or give their consent. When consent is given it must be in writing. All recruiting officers are enjoined to be very particular in ascertaining the true age of the recruit. If any doubt upon the point exists in the mind of the recruiting officer, he must not be satisfied with the oath of the applicant as the sole evidence of legal age, but if he cannot, in addition, furnish undoubted proof of the fact, he must be rejected.[5]

The maximum limit of age does not apply to soldiers who may re-enlist, or who have served honestly and faithfully a previous enlistment in the army.[6]

In time of war the limitations of age in compulsory enlistment, under the Enrolment Acts, are twenty and forty-five years; the question of minority between the twentieth and twenty-first years is not considered, except in voluntary enlistments, which are under the same restrictions as in time of peace.

The medical examiner must form his opinion of the age of an applicant from his personal observation of men and upon physiological grounds. It is a point about which the greatest amount of deceit is practised; concealment being attempted in voluntary enlistments with a view of getting into the service, and in compulsory enlistments with a view of exemption therefrom. He must, therefore, be always upon guard against imposition. Young men who would scorn to tell an untruth in other matters will lie about their age with the utmost effrontery, and old men will resort to every artifice to conceal theirs.

While the divisions of life into periods, by years of existence, are in a measure arbitrary, some men maturing at an earlier age than others, it is important to consider certain common evidences of maturity as fixing the period of legal majority, and furnishing a standard, indefinite though it may be, of eligibility for the military service. Among the most prominent of these evidences are the presence of the wisdom teeth, a plentiful supply of hair in the axillæ, and over the pubes, well-formed testicles, and complete corrugation of the scrotal skin. While these conditions are liable to variation in individuals, they may be regarded as common to most youth at maturity, although no one condition can be regarded as more frequently present than another. It has, however, been the experience of the writer to find a peculiarly smooth condition of the skin of the scrotum in every case of minority examined by him. This may be due to lack of development of the dartos. Men of mature age do not display it, but it is very noticeable in minors. The general appearance and bearing of a young man will, in conjunction with physical peculiarities, give the surgeon a very fair idea of his age, and there are few possessed with sufficient hardihood to deny a firm and decidedly expressed opinion by an observant surgeon upon the subject. In those whose age exceeds the maximum there will probably be found presbyopia, the arcus senilis in one or both eyes, a wrinkled skin, especially about the outer angles of the eyes and on the forehead, gray hair, and a peculiar hardness of the nails of the fingers and toes.

HEIGHT, WEIGHT, AND CHEST MEASUREMENTS.—"The *minimum height* of a recruit is at present fixed at five feet four inches for all branches of the service, although recruiting officers are allowed to exercise their discretion as to the enlistment of desirable recruits (such as band musicians, school teachers, tailors, etc.) who may fall not more than one-fourth of an inch below the minimum standard of height; the *maximum* height for the cavalry service is five feet ten inches; that for infantry and artillery is governed by the maximum of weight, to which should be applied the rule for proportion in height."

"The *minimum weight* for all recruits is 128 pounds, except for the cavalry, in which enlistments may be made without regard to a minimum of weight, provided the chest measurement and chest mobility are satisfactory. The *maximum* for infantry and artillery is 190 pounds; for cavalry and light artillery, 165 pounds."

The standards of height and weight are, however, subject to change, instructions to that effect being issued from the adjutant-general's office "from time to time as the requirements of the service may dictate."

These standards are based upon results obtained by skilled observers who, after careful study and the examination of large numbers of men in civil and military life, have established the fact that there is an *average proportion* in healthy, fully developed men between the height, weight, chest measurement, and chest mobility which will admit of slight variations without indicating a departure from health. The rules of this proportion may be formulated as follows:

For each inch of height from 5 feet 4 inches to 5 feet 7 inches, inclusive, there should be calculated 2 pounds of weight. When the height *exceeds* 5 feet 7 inches, calculate 2 pounds of weight for the *whole number* of inches of height; add to this product 5 pounds of weight for each inch of difference between 5 feet 7 inches and the actual height; the sum will be the normal weight in pounds.

The *chest measurement at expiration* in men from 5 feet 4 inches to 5 feet 7 inches in height should exceed the half height about half an inch; in those from 5 feet 8 inches to 5 feet 10 inches it should *equal* the half height, while in those from 5 feet 11 inches upward it should be slightly *less* than the half height.

The *chest mobility*—*i.e.*, the difference between the measurement at inspiration and expiration—should be *at least* 2 inches in men below 5 feet 7 inches in height, and 2½ inches in those above that height.

The following table shows this concisely:

Height.	Weight. Allow for each inch of height.	Chest measurement.	Chest mobility.
5 feet 4 to 5 feet 7 inches.	2 pounds.........	Half height plus half inch.	2 inches.
5 feet 8 to 5 feet 10 inches.	2 pounds and 5 pounds additional for each inch over 5 feet 7 inches.	Half height......	2½ inches
5 feet 11 to.........		Slightly less than half height.	2½ inches

For example, a man who measures 5 feet 4 inches should weigh 128 pounds—*i.e.*, 5 feet 4 inches = 64 inches; 64 × 2 = 128, the normal weight. He should have a chest measurement of 32½ inches at expiration, being half

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height; 32 inches plus ½ inch = 32½; the chest mobility should be about 2 inches.

A man who measures 5 feet 9 inches should weigh 148 pounds—*i.e.*, 5 feet 9 inches = 69 inches; 69 × 2 = 138; difference between 5 feet 9 inches and 5 feet 7 inches is 2; 2 × 5 = 10; 138 + 10 = 148, the normal weight in pounds. He should have a chest measurement of 34½ inches (his half height), and a chest mobility of at least 2½ inches.

It is not necessary that the applicant should conform *exactly* to the figures indicated in the rules, a variation of a few pounds from either side of the standard in the minimum, medium, and maximum weights, and of a fraction of an inch in chest measures being permissible if the applicant is otherwise in good health and desirable as a recruit. The rules are given to show what is regarded as a fair proportion, *but the weight must be at least 125 pounds* except when less is especially authorized by the superintendent or the adjutant-general.

In such cases the recruiting officer's reasons and the superintendent's order should be noted in full on the enlistment papers. Any *considerable* disproportion, however, of *height* over *weight* is cause for rejection; but a marked disproportion of *weight* over *height* does *not* reject unless the applicant is positively obese.

In order that an intelligent application of these rules and their variations may be made, the attention of recruiting officers is called to the manner in which a man's height is made up.

The chest, containing the heart and lungs, is the most important division of the body. It contains the vital machinery and represents the *staying power* of the man. It must, therefore, be ample. The function of the legs is to transport the body; they should be well formed and sufficient, but not unduly long, for length of limb at the expense of the chest is a disadvantage. A long-legged, long-necked man with a short chest is objectionable as a recruit.

The average height of a youth of eighteen years of age, a "growing lad," is a little over 5 feet 4 inches, and increases gradually until he reaches the age of twenty-five years—the stage of physical maturity or manhood—when his average height is between 5 feet 7 inches and 5 feet 8 inches.

During the growing period the framework and vital organs receive their proper development, and considerable departures from the given average of proportionate height to weight indicate an impairment of these organs which may, and probably will, develop into positive disease after exposure to the hardships incident to the life of a soldier; hence they are of greater significance in men of these heights than in taller men, who are presumably of greater age and more mature growth.

After twenty-five years of age, the body being fully developed, the excess of nutritive material over and above that required for its maintenance in health is deposited in the tissues as fat, and it will be found that a disproportion of weight over height occurs usually in adults or men in middle life. It is rare to meet in the recruiting rendezvous with *very* fleshy *young* men.

The following table is given for convenience of reference:

TABLE OF PHYSICAL PROPORTIONS FOR HEIGHT, WEIGHT, AND CHEST MEASUREMENT.

Height.		Weight.	Chest Measurement.	
Feet.	Inches.	Pounds.	At expiration; inches.	Mobility; inches.
$5\frac{4}{12}$	64	128	32½	2
$5\frac{5}{12}$	65	130	33	2
$5\frac{6}{12}$	66	132	33½	2
$5\frac{7}{12}$	67	134	34	2
$5\frac{8}{12}$	68	141	34	2½
$5\frac{9}{12}$	69	148	34½	2½
$5\frac{10}{12}$	70	155	35	2½
$5\frac{11}{12}$	71	162	35¼	2½
6	72	169	35¾	2½
$6\frac{1}{12}$	73	176	36¼	2½

A deviation from the rules of physical proportions may be made in the examination of candidates for admission to the United States Military Academy at West Point, and for members of the graduating class, whenever this is deemed desirable by the Medical Examining Board.

Habits.—Drunkenness, or habits of intemperance, is the cause of a very large number of the rejections made at rendezvous. It is the vice of the army, as well as of most walks in civil life, and the medical examiner cannot be too careful in scrutinizing every applicant for evidences of this demoralizing habit. The regulations of the army are very emphatic on the point, declaring that every man shall be sober when enlisted, and that men *having the appearance* of being hard drinkers will be rejected, "though they may not at the time be intoxicated."[7]

Some recruiting officers go so far as to reject men on whom the smell of liquor can be detected at the time, and they are without doubt correct in their opinions and practice. It is a great mistake to "suspend a final decision . . . for a sufficient length of time to enable a man to recover from the effects of a mere temporary debauch," as is recommended by Tripler,[8] as the man who will indulge in such debauchery *before* enlistment will be pretty sure to repeat it afterward; and such men are not wanted in the army. If a man has to resort to the stimulation of alcohol to "brace himself up" for the ordeal of the examination, it is a fair presumption that his habits as to the general use of stimulants will not bear much criticism. The evil wrought to the service by men having these habits is so great that it is far better to err, and run the risk of occasionally rejecting temperate men, than, by relaxing any vigilance, to enlist those who may eventually prove themselves sots.

While it is sometimes difficult to detect the habitual drunkard, and the medical examiner is forced to rely, to some extent, upon the man himself for such information as he may be willing to give, yet the long indulgence in habits of intemperance will almost surely be indicated by persistent redness of the eyes, tremulousness of the hands, attenuation of the muscles—particularly of the lower extremities,—sluggishness of the intellect, an eczematous eruption upon the face, and purple blotches upon the legs.[9] Close and skilful questioning will often develop the facts connected with the antecedents of the applicant, and materially assist the examiner in forming his opinion of the case.

Masturbators and Sodomites are also to be looked for and rigidly excluded. In addition to the well-known general signs of physical prostration due to indulgence in masturbation, Howe, in his little work on "Excessive Venery,"[10] says, "the local signs are sufficient for a diagnosis. . . . The penis is thinner and smaller than usual. It is often elongated, and cold to the touch at different points. The glans is much larger than the rest of the organ. . . . The veins of the integumental covering are dilated and varicose. In many patients the penis is bent laterally, and the inclination is generally toward the left side. . . . The scrotum is also relaxed and elongated, the testicles are small and soft; . . . sometimes they are extremely sensitive." The air of embarrassment which so often overtakes subjects of this vice, when closely questioned, will also lead to their detection.

Sodomy may be suspected if the anus is much dilated, or is infundibuliform in shape: "The absence of the radiating folds is considered one of the best medico-legal proofs of the vice."[11] Tidy says,[12] "a peculiar, funnel-like depression or hollow of the nates toward the anus, the anus gaping and the sphincter relaxed," are signs of the practice of this vice, to which greater or less importance may be attached as the circumstances of the case demand.

Mental Disorders.—Insanity, idiocy, imbecility, and *dementia* are disorders which will call for the closest scrutiny and observation by the medical examiner; their nature is such that a careful diagnosis in the limited time allotted to the examination of a recruit is rarely possible. The necessity, therefore, of an acquaintance with their

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physiognomy is apparent. To one skilled in this means of diagnosis the detection of the less obscure grades is not a matter of great difficulty. The idiot, the imbecile, or the demented patient presents such well marked characteristics that an error can hardly be made. It is in those unfortunates who are upon the borderland of mental deficiency, and the insane, that the greatest difficulties of diagnosis may be expected. Unless an insane person betrays by action or speech some evidence of this disease, a correct diagnosis would be a matter of great difficulty, and no surgeon would be held responsible for accepting one who afterward manifested insanity. Should the examiner have reason to suppose that the applicant is deficient in mental capacity, or has not the aptitude to acquire readily a knowledge of his duties as a soldier, he should be rejected. It is much safer to take even an extreme view of such cases, and run the risk of an erroneous rejection, than to accept one about whom a suspicion of mental alienation can rest.

Physique.—While a decision of cases under this heading does not always fall within the province of the medical examiner, his opinion is entitled to great weight with the recruiting officer. His knowledge of anatomy and the proper proportions of the human frame, as well as his familiarity with physiognomy, eminently qualify him to form a correct opinion as to the general appearance, both physical and moral, of the applicant, and his fitness for the duties of a soldier, in cases in which no technical disability exists or can be discovered by a non-professional man. His experience with the *effects* of disease, bad habits, food, and living upon the constitution will enable him to judge as to future efficiency, although there may be no direct evidence in the case before him that the applicant has ever been subjected to such hardships.

There is probably no one class of men which furnishes such large numbers to the hospitals, the guard-house, and the list of deserters as this, designated indifferently by military men as "poor physique," "feeble constitution," or "general unfitness."

The leading characteristics of a good physique may be briefly enumerated: "A tolerably just proportion between the different parts of the trunk and members; a well shaped head, thick hair, a countenance expressive of health, with a lively eye, skin not too white, lips red, teeth white and in good condition, voice strong, skin firm, chest well formed, belly lank, parts of generation well developed, limbs muscular, feet arched and of a moderate length, hands large."[13] The gait should be sprightly and springy, speech prompt and clear, and manner cheerful. The medical examiner should endeavor to judge from the eyes, from the whole expression of the countenance, from the conformation of the limbs, which of the candidates are capable of making the best soldiers; there are as certain and as well understood indications for judging of the soldierly qualities of men as there are for ascertaining the value of a horse or a hunting-dog.[14] All lank, slight, puny men, with contracted figures, whose development is, as it were, arrested, should be set aside. The reverse of the characteristics of a good constitution, already enumerated, will indicate infirm health or a weakly habit of body; loose, flabby, white skin; long cylindrical neck; long, flat feet; very fair complexion, fine hair; wan, sallow countenance, etc.

Under our present system of recruiting in large cities a very objectionable description of men present themselves for enlistment, whose health has suffered from debauchery of various kinds. They are tramps: men who wander about over the face of the country, too lazy to work and too vicious to live in a well-regulated community—a set of Ishmaelites who seek service in the army as the easiest method of getting food, clothing, and shelter, but without the slightest design of performing any more duty than they are compelled to. They generally appear as winter approaches, driven by inclement weather to seek an asylum until the opening of spring. No more undesirable or unfit class of men come before a recruiting officer. They are seldom, after enlistment, out of the guard-house or hospital, and the company to which they belong is fortunate if, when they take their flight in the spring, they do not carry away with them all the available cash, or articles of value, upon which they can lay their hands. Another class of men, having neither apparent disease nor well-characterized physical or moral defect, are equally objectionable; there is a "something" about them which satisfies an expert that they will make either indifferent or bad soldiers, for which reason they should be rejected. The power of recognizing these two classes of men is a talent which is greatly improved by practice, and which the medical examiner should cultivate to the highest degree, persistently rejecting all about whose ultimate efficiency he has the slightest doubt.

Even in *time of war*, when the urgency for men may be ever so great, there should be no deviation from the general rule as to men of this stamp and character, who, if once admitted will serve only to encumber the army either by their shiftlessness or by their viciousness. An army, in whatever strait it may be, is vastly better without than with them.

GENERAL INTELLIGENCE.—A higher degree of intelligence is now expected from the soldier than was the case in the earlier days of the republic. Promotion is open to him, and he is encouraged in every way to improve himself; libraries are established to which he has ready access; reading-rooms, with liberal supplies of newspapers, are prepared for him, and schools are organized in which he has opportunities for study. "It is worthy of notice that much of the advantage to be derived from modern improvements in the mode of educating, training, dieting, and clothing the soldier depends upon his capability of appreciating the objects with which they have been introduced,"[14] and while it is impossible to formulate any specific standard of intelligence by which his eligibility is to be judged, such a direction can be given to the questions necessarily asked during the physical examination as will enable the medical officer to form a very good opinion of his general intelligence, and afford an opportunity to exclude men who, while they may not be exactly idiotic, are "a sort of demi-simpleton."

The remarkable strides which have been made during the past quarter of a century in the science and art of war; the superior mechanism of the rifle now in use; the attention that is paid to target practice, and the efforts that are made to instruct the soldier in the management and care of his weapon and ammunition, tend to make his profession both instructive and interesting, and justify the expectation that men of better tastes and habits than those obtained in the past will, in the future, be attracted to the profession of arms.

It is well stated by Dr. Crawford, in the article from which quotation has been made, that the criminal and invaliding statistics of the army leave no doubt as to the frequent enlistment of the fatuous and imbecile, as well as the criminally vicious, and that if the development of the head, and the symmetry of its proportions were as carefully examined and as dogmatically insisted upon as is customary in determining the form, development, and symmetry of other organs and regions, a proportion, at least, of such men might be excluded from the service.

SPECIAL EXAMINATIONS.—*The Cerebro-spinal System.*—*Epilepsy, chorea, stuttering or stammering, all forms of paralysis, tabes dorsalis, neuralgia*, disqualify.

It is not to be expected that the medical examiner will make a diagnosis of all the different forms and phases of this class of diseases. It is sufficient for practical purposes that he should recognize such general symptoms as are indicative of grave lesions of the system, and should satisfy himself of the incapacity of the applicant for military duty; in their later stages the manifestations are so well pronounced that it is hardly possible for errors of diagnosis to occur; but the earlier symptoms are in many instances obscure, requiring close observation for their detection. The personal appearance, facial expression, and gait will often betray the existence of many forms of nervous disorder, for which reason the medical examiner should require each applicant, after being stripped, to approach him from a distance, and if necessary, walk

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about the room, during which time he can thoroughly scan his person, observing particularly any deviations from the normal conditions. By this means the halting gait of paralysis of the lower extremities, or the shuffling unsteady step of tabes may be detected. A careful examination of the spine should be made by pressure upon the spinous processes from the cervical to the lumbar vertebræ, and any tenderness or pain manifested by flinching made mental note of. Unsteadiness of the hands and arms should suggest a suspicion of tabes dorsalis, and the simple tests of standing or walking while blindfolded, the tendon reflex, and the tactile sense, should be made with care.

Stammering may be congenital, due to habits contracted in childhood, to malformations of the vocal apparatus, or to organic lesions in the nervous system; by whatever cause it may have been produced, if it is sufficient in degree to interfere materially with ordinary conversation, the applicant should be rejected. Some care will be necessary in arriving at the degree of this affection, because the nervous excitement incident to the examination will of itself react upon the patient, whose embarrassment will increase his difficulty of speech. A little patience and kindliness of manner will, however, soon reassure him, and the true extent of the difficulty be appreciated. *In time of war* attempts will often be made to simulate disorders of this class for the purpose of securing exemption from military duty. The different forms of paralysis and tabes can, by the exercise of some patience and care, be detected; indeed, it would require a man to be possessed of great self-control, shrewdness, and a considerable knowledge of the symptomatology of disease to simulate, with any reasonable prospect of success, any form of paralysis. Ocular evidence of a convulsion should always be obtained by the examiner before he is justified in exempting a man from military service on the ground of *epilepsy*. No statements, however well substantiated, should lead him to deviate from this rule. He should satisfy himself by the absolute loss of sensibility of the conjunctivæ, the dilatation and immobility of the pupil, and the character of the convulsions, that the attack is one of true epilepsy before recommending the case for exemption. The pain of *neuralgia* may be simulated; but true neuralgia of sufficient intensity to disqualify can hardly exist without producing such decided constitutional effects as will be visible to the eye of the examiner.

Constitutional syphilis disqualifies.

The late forms of this disease, as gummata, rupia, periostitis, ostitis, caries, etc., are rarely brought to the notice of the examining surgeon, or if such cases should be presented, the cachexia will be so well marked that there can be but little difficulty in making a diagnosis. It is the early manifestations of the disease which he is to watch for with great care, particularly as men are often the subjects of syphilitic infection without being aware of its existence, and therefore truthfully disclaim any knowledge of a disability for the service on that account.

Careful examination should be made of the cervical, epitrochlear, and inguinal glands, as one of the earliest and most important manifestations of constitutional syphilis consists in their enlargement and induration. Otis, in his work on "Syphilis," states that this abnormal change extends, to a greater or less degree, throughout the entire lymphatic system. He describes the enlarged glands as varying in size from a small shot to a pigeon egg; as being hard, movable, and painless; those in the epitrochlear region being the most valuable in a diagnostic point of view, and rarely present before, or absent after, the tenth or twelfth week succeeding inoculation of syphilis, whether any roseola can be detected or not. Sometimes only one gland is enlarged, which may be above the trochlea, along the inner border of the biceps, and therefore difficult to find. There is variation, also, as to locality in the different cervical and inguinal glands that are enlarged, a patient search for which will generally be successful. The next evidence in order is the classical roseola, with its bright hue in the early stages, and its faucial inflammatory engorgement; the papular eruption with its crop of papules along the upper border of the forehead, hard to the touch, and painless (the corona veneris of Ricord); the circle of white scales arranged about the base of the papules on the body (the collarette of Biett); the coppery-colored stain left after the disappearance of this papular eruption; alopecia and mucous patches. These, either alone or taken together, should be sufficient evidence of the existence of the disease in its earlier stages to warrant the examiner in rejecting the applicant. As the cicatrices of buboes are not evidences of the existence of syphilis, they should not be made a cause for rejection, although their presence should lead to careful examination for signs of the disease, as heretofore mentioned.

In time of war this disease (syphilis) is cause for rejection.

Cancer, in whatever form or stage of development, is a cause for rejection. The "pipe-smoker's cancer," epithelioma of the lip or tongue, and cancerous affections of the testicles, are the forms most likely to be seen among men desiring enlistment. As, however, the disease is one of middle or advanced age, it is very rarely met with at recruiting rendezvous, and is only mentioned in this place as one of a class of diseases which the surgeon may be called upon to reject.

The Skin.—All chronic, contagious, and parasitic diseases of the skin; nævi; extensive, deep, and adherent cicatrices; chronic ulcers; vermin, and *indecent tattooing*, disqualify.

Although vermin may be considered to be only temporary annoyances, it will be found, as a rule, that the men upon whom they take up a residence are undesirable by reason of filthy habits. The fecundity of vermin is so great, so many opportunities are afforded for their migration where numbers of men are associated together, and their presence is so disgusting, that, in time of peace, men infested with them should either be summarily rejected, or acceptance deferred until their persons are rid of the parasites. The most common form met with at recruiting stations is the crab louse (*pediculus pubis*). Of parasitic diseases *scabies, favus, tinea tonsurans*, and *sycosis* are most frequently met with, and should be causes for rejection, or action should be deferred until a cure has been effected. The *tattooing of indecent devices* upon the skin, on any part of the body, is cause for rejection, upon the ground that a man who will voluntarily submit to such defacement is morally unfit to be a soldier. The *presence of cicatrices from cupping* should lead to a close examination of the internal organs in their vicinity, which may have been seriously damaged by disease, or are liable to become again affected after exposure to the hardships of a winter campaign. When *extensive adherent cicatrices* impede the free motions of the limbs, they are absolute causes for rejection; but when seated on other parts, as, for example, the head or trunk, they are not in themselves objections in a recruit; as indications, however, of constitutional cachexia they are important.[16] *Cicatrices, non-adherent*, white and smooth, resulting from an incised or lacerated wound, or a burn, and not involving much loss of substance or lesion of subjacent organs, are not causes for rejection. *Chronic ulcers* are not likely to be found, except in persons of broken-down constitution. Those resulting from abrasions or slight wounds, in persons who do not present any evidence of constitutional disorder, have probably been kept active from some local cause, upon the removal of which they will heal; but those involving much loss of substance, with atrophy of a limb, with a general constitutional disorder, or with varicose veins, especially when located on the lower extremities, should disqualify; even when healed they are apt to open again, so soon as the soldier is exposed to any cause of irritation, such as long marching or inclement weather. The skin of the negro seems especially prone to ichthyosis, and to keloid growths at the seat of even trivial injuries; unless the affections are extensive, or the keloid growths so situated as to interfere with the motion of limbs, or otherwise impair the efficiency of an applicant, they should not be considered causes for rejection. *In time of war* exemption should be given only on account of

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long-standing or incurable diseases of the skin; the milder forms, as acne, herpes, urticaria, etc., as also some of the parasitic diseases, including scabies, may be treated with reasonable prospect of recovery in a short time, and the men accordingly should be held to service. Ulcers may be produced and purposely kept open with the view of evading service under conscription. Suspicion will naturally be aroused when an otherwise healthy man claims exemption from service on account of an ulcer of long standing, as this lesion is seldom seen except in persons of broken-down constitution, and generally in middle or advanced age. The appearance of the ulcer, and the tissues surrounding it, will furnish some evidence as to its age, active inflammation pointing to voluntary irritation and a recent lesion, while an old ulcer presents characteristics the reverse of this. Such cases should be placed under close observation in hospital, and every means taken to prevent the patient from keeping up any irritation of the parts, the fact being borne in mind that an almost endless variety of foreign substances are used for this purpose, and that the finger-nails are especially convenient for such use; it may even become necessary to put the patient into a straitjacket before a correct diagnosis can be made.

The Head.—Abnormally large head; considerable deformities, the consequence of fractures; serious lesions of the skull, the consequence of complicated wounds or the operation of trephining; caries and exfoliation of the bone; injuries of cranial nerves; tinea capitis; alopecia, disqualify.

Any injury of the skull affords ground for suspicion of consequent injury to the brain, and the existence of epilepsy or some disorder, greater or less, of the mental faculties; hence all such injuries should be carefully examined as to their extent and seat. It is well known that the skull may receive extensive injury without any subsequent impairment of the faculties, and also that very slight injuries may be followed by serious consequences, more especially by epilepsy; hence, although no positive disease may be detected, it is safe to reject any applicant who has evidence of considerable injury to the skull, if for no other reason than that its presence affords the man an opportunity for evasion of duty, and, if he choose to make it, a claim for discharge from the service on account of some alleged nervous affection, should military duty become distasteful to him after joining his command. With the evidence of an injury to the head before him, it would be difficult for a medical officer to disprove any assertion by a malingerer of the existence of disease.

Wounds of the scalp, especially if non-adherent, should not reject; *injuries of the cranial nerves*, producing paralysis or impairment of function in the parts to which they are distributed, are causes for rejection; *tinea capitis* is laid down in many works on recruiting as a disqualification. It is a disease almost exclusively confined to childhood, and is very rarely met with at a recruiting station. In the examination of several thousand men at the depot at Columbus Barracks, Ohio, the writer did not see a case, nor has he ever seen one among the soldiers with whom he has served. The discovery of any disease of this genus in the hairy scalp would be cause for rejection, not only on account of its contagiousness, but because it is both unsightly and offensive. The *papular eruption of syphilis* is frequently situated in the hairy scalp, and may be easily felt by an examination of that part with the fingers. *Alopecia* is occasionally met with in recruits, and has given rise to much difference of opinion among army surgeons as to its being a disqualifying cause; if it is the result of a pre-existing disease, which will be manifest by the appearance of the scalp, if the loss of hair is total, or if but a few tufts remain about the back of the head and in the neighborhood of the ears, the man is unfitted for service; the head coverings issued to the soldier not being sufficient, in the absence of the natural covering, to protect him from accidents resulting from exposure to the heat of the sun or to the inclemency of the weather; partial loss of the hair, either over the crown or above the forehead, is not cause for rejection; *in time of war* baldness is not cause for exemption.

The Spine.—Caries; spina bifida; lateral curvature of the cervical, dorsal, or lumbar regions; lumbar abscess; rickets; fracture and dislocation of the vertebra; angular curvatures, including gibbosity of the anterior and posterior parts of the thorax, disqualify.

Lateral curvatures of the spine are often the result of some particular trade or occupation; if the curvature is slight, and unaccompanied by signs of constitutional weakness, it should not disqualify. An appearance of lateral curvature frequently results from undue development of the muscles of one shoulder. This will be readily detected by making the recruit stoop forward from the attitude of attention, stretching out his hands over his head, and curving the back until his fingers reach the ground. A glance at the recruit's spine, when so bent, from before backward, will enable the surgeon to estimate the extent of lateral curvature, if it really exists.[17] The following good rule for the determination of the degree of curvature which demands rejection has been suggested by Major Daingerfield Parker, U. S. A. The recruit standing erect, draw an imaginary line from the base of the skull to the end of the spine; if the spinal prominences are curved one inch either side of the line, reject. Any *pronounced* angularity of the spine (gibbosity) sufficient to impair the symmetry of a man's figure, or distortion of the chest interfering with respiration, should reject. The fact that knapsacks and other heavy weights are no longer carried by soldiers upon their backs in modern campaigning removes the objection formerly made to men having this defect in a moderate degree. In young men posterior curvature may be overcome by attention to drills and gymnastics, but in men beyond twenty-five years of age it is useless to attempt an improvement.

In time of war slight curvatures, lateral or angular, should not exempt.

The Ear.—Deafness of one or both ears; all catarrhal and purulent forms of acute and chronic otitis media; polypi, and other growths or diseases of the tympanum, labyrinth, or mastoid cells; perforation of the membrana tympani; closure of the auditory canal, partial or complete, except from acute abscess or furuncle; malformation or loss of the external ear, and all diseases thereof, except those which are slight and non-progressive, disqualify.

Diseases of the ear inducing deafness are not often symmetrical, and affections of one ear are much more likely to be met with than those of both; hence the fact should be borne in mind that while an applicant for enlistment may apparently hear perfectly, a careful examination of both ears will show that he may be deaf in one.

To properly make a preliminary examination of hearing power for the voice, the examiner should stand at the side and in rear of the applicant, at least forty feet distant, while the recruiting sergeant closes the external meatus of one ear by pressing the tragus gently backward and inward. A few words are then to be addressed to the applicant, distinctly, in a middle tone, and not too rapidly. If there is any defect in the hearing of the uncovered ear, it will at once be discovered by the failure to repeat what is said; the same manœuvre should be practised with the opposite side. The voice may be heard at least fifty feet distant in a closed room when both ears are normal; should there be deafness of either ear, the applicant must be rejected.

It will be found that deafness is occasionally caused by the accumulation of cerumen in the ear; in which case, should the recruit be otherwise desirable, it would be proper to defer final action, and an opportunity given him to have the obstruction removed, when, if hearing is restored, he could be accepted.

In time of war deafness is frequently simulated. Real deafness cannot be concealed, but the detection of simulated deafness is at times a somewhat difficult matter. Here every artifice which ingenuity may suggest will be employed to deceive the examiner, whose opinion of the case must be made up of negative evidence entirely, the

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only positive evidence available being the motive of the conscript, if this can be styled evidence.

Besides that by means of the voice there are three methods to be employed in testing the power of hearing, viz., the watch, the tuning-fork, and the double stethoscope of Cammann. An opinion should not be formed from any single test, but from the results obtained by all.

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In using the first test, the applicant should be blindfolded while one ear is closed; the watch is to be held in the air at various distances from his head—above, below, in front of, and behind the unclosed ear. The distance at which its ticking can be heard by the normal ear may be determined by the operator's sense of hearing. This being used as a standard, the degree of hearing by the applicant can be approximately determined. Each ear should be carefully tested by this method, and the result noted.

To use the second test, uniform sound can be obtained by striking the tuning-fork on the knee while the leg is flexed upon the thigh, or even by extending the palm of the hand and striking the tines of the fork upon its fleshy part. In the normal ear the tuning-fork, when placed on the central incisors, is heard equally well in both ears; the same is true if the fork is placed on the vertex or on the centre of the forehead; if placed on the mastoid process, it is heard better in the ear of the same side: it is heard longer when placed in the air near the meatus, than on the teeth, etc.

When there is some defect in the hearing dependent on disease located in the middle or external ear, the tuning-fork placed by its base upon the teeth, or on any of the central portions of the skull, will be heard better in the *diseased* ear. If placed in the air near the ear, it may not be heard as well as in the previous position. In doubtful cases, if the fork is laid a little to one side of the median line, it assists to confirm the diagnosis. For instance, the patient thinks he hears the fork best in the right ear, and it is then moved to the left side a little. If he still hears it as well in the right ear, or even hears it equally well in both ears, there is no question of his hearing it better in the right.[18]

In diseases of the labyrinth having a nervous origin these conditions are reversed, and the tuning-fork will be heard *better* in the good ear—both ears being stopped. Hence the examiner must be on his guard, when investigating a case of suspected simulation, that he does not have a case of labyrinth disease before him. In such instances ocular inspection of the middle ear will be of value in completing a diagnosis.

The third test, by the use of Cammann's binaural stethoscope, is a very ingenious one, and is best described in the language of its originator, Dr. David Coggin.[19] It is, however, serviceable only in simulated absolute deafness of one ear: "The patient affirmed that he was deaf of the left ear. I therefore inserted a tightly fitting wooden plug into the right caoutchouc tube, and then put the two caoutchouc tubes into the metal ones. When I tried the instrument on myself, I found that words spoken could not be understood by the right ear. After the patient had adjusted the stethoscope, he repeated without hesitation the words which I had whispered into the bell of the instrument, which served as a mouthpiece. The tube containing the plug was then taken out of the right ear, which was firmly closed by pressure on the tragus. When I again spoke into the stethoscope, which was still in connection with the left ear, the patient positively assured me that he could no longer distinguish the words. He was, of course, aware that the tube through which he had before heard was no longer in connection with the right ear."

It is more than probable, before the examiner has completed these tests, that the simulator will have become so confused as to betray himself, when, of course, the examination would cease. He must, however, be prepared to find men very obstinate, who have made up their minds to deceive, and he may, therefore, be obliged to employ all the methods at his command in making a diagnosis.

The preference of the writer is for the tuning-fork, about the use of which men are ordinarily ignorant, although the tests by the watch and stethoscope give excellent results. Careful inspection of the meatus should be made for evidence of inflammatory affections or for morbid growths.

In time of war cases of otitis may be placed in hospital for observation, to be exempted from service if subsequent treatment develops the fact that organic changes have taken place, or that permanent deafness has resulted; deafness of one ear is not an objection, but when both ears are thus affected the man should be exempted.

The Eyes.—Class 1. *Loss of an eye; total losss of sight of either eye; conjunctival affections, including trachoma, entropion; opacities of the cornea, if covering part of a moderately dilated pupil; pterygium, if extensive; strabismus; hydrophthalmia; exophthalmia; conical cornea; cataract; loss of crystalline lens; diseases of the lachrymal apparatus; ectropion; ptosis; incessant spasmodic motion of the lids; adhesion of the lids; large encysted tumors; abscess of the orbits; muscular asthenopia; nystagmus.*

Class 2. *Any affection of the globe of the eye or its contents; defective vision, including anomalies of accommodation and refraction; myopia; hypermetropia, if accompanied by asthenopia; presbyopia; astigmatism; amblyopia; glaucoma; diplopia; color-blindness (for the Signal Service only)*, disqualify.

For convenience of examination the foregoing list of disqualifications has been separated into two classes: the first including those defects which may be discovered by the unaided eye; the second requiring for their detection the use of special instruments. Loss of sight of the *right* eye, or loss of the entire globe, as well as other defects interfering with the vision, has been held by the War Department as cause for rejection. The writer is of the opinion that these disqualifications should apply to *either* eye, exceptions thereto being confined entirely to men desiring to re-enlist. Aside from the disfigurement, there are certain manœuvres in the drill and other exercises in military life which cannot be properly performed by recruits unless they have the perfect use of both eyes. Old soldiers are so well instructed in their duties and familiar with drills that nearly all military movements may be exercised by them without the use of both eyes, dependence being placed upon the word of command.

The acceptance of one-eyed men has been advised, provided the sight of the remaining eye is perfect, and it is asserted as a fact that some of our best rifle shots among frontiersmen are thus mutilated. This may be true, and there could be no objection to such enlistments if the terms of the proviso could be made continuous; but it is a well-known fact that when one eye has been permanently injured or diseased, the remaining organ is more or less liable to attacks of sympathetic ophthalmia, to avert which enucleation of the defective eye is often the sole resort. The slighter forms of injury or disease which may affect vision, if uncomplicated by an affection of the iris or ciliary body, are not followed by this result; but it is after the more severe injuries and diseases, particularly when these bodies are involved, that sympathetic inflammation is to be anticipated. It is not always possible for the surgeon to form an opinion as to the cause of blindness in these severe forms of injury without careful ophthalmoscopic investigation, to make which it is neither desirable nor proper for him to spend time. The fact that a disease affecting the integrity of the sound eye is likely to occur at any time would seem sufficient reason for objecting to the admission of such cases to the army. The writer is, therefore, of the opinion that loss of sight of either eye should in time of peace disqualify. Catarrhal affections of the conjunctiva, whether acute or chronic, are causes for rejection, as it is impossible to predict what their terminations may be; a very mild conjunctivitis may develop into a most violent disorder, attended with total loss of the eye; or a chronic affection may linger for years, producing trachoma, affections of the lids, etc. Pterygium, if large and encroaching upon the cornea to an extent that interferes

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in the slightest degree with vision, and strabismus, either convergent or divergent, if decided, reject. Any affections of the globe of the eye, as keratitis, sclerotitis, retinitis, iritis, etc., whether acute or chronic, should reject. Careful examination should be made for the divergence of one or both eyes, when the applicant is required to look steadily at an object (asthenopia), or their oscillation (nystagmus); both of which conditions are likely to become more pronounced from the nervous excitement incident to the examination.

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Examination of the *sight* should be made with the utmost care, as perfectly clear vision is demanded for rifle practice as conducted at the present day. The medical examiner should have a reliable sergeant to assist him. The applicant should stand facing the surgeon, and twenty feet from him, with his face to the light, as in this position the iris is moderately contracted, and opacities of the cornea, which may cover any part of the pupil, will be more readily discovered; the sergeant should cover one eye with a card, instead of the hand, as is directed in most instances; if the hand is used, undue pressure is, unconsciously, liable to be made on the globe, the circulation is interfered with, and more or less discomfort and dimness of vision experienced when the eye is uncovered; or a careless sergeant may, when covering the eye, so spread his fingers that the applicant can see the objects placed before him with the so-called covered eye, should the one uncovered be defective.

The instructions given by the War Department for conducting this examination are contained in a general order, from which the following extract is made: "1. *Range of vision necessary in recruits.* Hereafter no recruit shall be enlisted who cannot see well, at six hundred yards, a black centre three feet in diameter on a white ground. This test will be made by means of cards prepared under the direction of the surgeon-general of the army. The black spots on the cards will be circular, four-tenths of an inch in diameter, and the recruit must be able to count them with facility at twenty feet distance."[20] In compliance with that order the surgeon-general issued instructions from which the following extract is made: "These test cards are ten in number, with black spots arranged like those on playing-cards, and ranging from one to ten on each card: . . . the surgeon . . . exposes successively the faces of two or three of the cards to the applicant, who must be able to state promptly the number of dots on each. This examination must be made with each eye separately, and may be varied by showing to the applicant one of the higher numbers, such as the nine or ten card, and covering up a part of its face with another card so as to expose one or more spots at a time. This test does not represent absolutely perfect vision, but admits recruits with minor degrees of refractive anomalies. It has been thought best, however, that recruits with these minor anomalies should not be excluded on account of them, provided their eyes are healthy in other respects."

If there should be any doubt upon the subject with this simple test, the test types of Snellen should be used.

To determine the degree of errors of refraction, either the simple optometer or the test glasses should be used.

The writer is free to confess that he has failed to obtain any satisfactory results with the optometer, and has been compelled in all cases to resort to the trial glasses for the desired information. Astigmatism may be determined by the optometer, or by the use of the astigmatic charts furnished with the cases of trial glasses. To detect color blindness a set of test wools is required, which should be used in accordance with the directions published by Holmgren, reprinted in Jeffries' work on "Color Blindness," p. 210 *et seq.*

In time of war the following defects, which disqualify in time of peace, should *not* exempt drafted men from service: *Loss of either eye; loss of sight of either eye; opacities of the cornea; strabismus, unless extreme; diseases of the lachrymal apparatus; ptosis, unless complete and indicative of serious brain lesion; asthenopia and nystagmus, unless excessive; anomalies of refraction, unless extreme.* The most common defect of vision among persons in this country is myopia, the degree of which to disqualify in time of peace, or exempt in time of war, has not been determined for the United States Army. Dr. Baxter, in his "Report of the Medical Statistics of the Provost Marshal General's Office," states that "near-sightedness does not exempt"; Dr. Bartholow states, "Myopia . . . is not a ground for exemption under the Enrolment Act, unless decided."[21] Tripler says, "Myopia is an objection to a recruit."[22]

As has been stated, the range of vision for recruits, determined by the test dot cards, admits them "with minor degrees of refractive anomalies"; so far as myopia is concerned, these degrees are such as to admit men from whom efficiency as riflemen cannot possibly be expected. A man whose degree of myopia is as high as $\frac{1}{24}$ can, with each eye separately, count the dots at twenty feet, although he does it with difficulty; but it is not possible for him to read the test types of Snellen, that should be normally seen at that distance, nor to see the bull's eye on a target at any of the ordinary firing ranges, and if accepted as a soldier, he is therefore useless as a rifleman. Even with so low a degree of myopia as $\frac{1}{36}$, the target is seen very indistinctly, and it is a question admitting of considerable doubt whether in such a case the soldier would ever become efficient as a marksman without the aid of spectacles; his vision would, however, be sufficiently acute for all ordinary purposes, and hence, if otherwise a desirable man, he might be accepted. The order promulgating the vision test is so worded that but few recruiting officers would feel themselves compelled to exact a literal compliance with its requirement for the recruit to "count with facility," and considering that he could "see well," if able to count the dots even with the difficulty encountered by a myope of $\frac{1}{24}$ degree, they would accept him.

In time of war, however, higher degrees of myopia may be admitted without serious detriment to the service, especially if a system were adopted by which men so defective could be utilized in branches of the service other than the line, as is the case in foreign armies, where, for example, as in France, myopes of $\frac{1}{4}$ and higher, and those of $\frac{1}{12}$ and higher in Italy, Austria, Switzerland, and Holland, are accepted; to do this, the use of spectacles would, of course, be necessary. In the English army recruits are admitted to the general service, and without being graded, with $\frac{1}{24}$ myopia; although Professor Longmore states it "to be very questionable whether any man with myopia = $\frac{1}{24}$ ought to be accepted as a recruit."[23]

When the facts are considered that the character of our service necessitates acuteness of vision in the use of the rifle, and that we have a vast population from which to recruit a small army, it seems proper that the highest standard of vision should be insisted upon, and that recruits should not be accepted in time of peace unless they have normal vision, as determined by test types, or are myopic to a degree not exceeding $\frac{1}{36}$, when otherwise very desirable men. In time of war all degrees of myopia above $\frac{1}{24}$ should exempt, unless the use of spectacles is permitted, in which event, of course, most higher degrees could be accepted. A very simple method for roughly determining the higher degrees of myopia in cases which are free from astigmatism and other defects of vision is to ascertain the distance at which ordinary newspaper type can be read by the myope. With the normal eye this type is distinct at forty or forty-eight inches, and the distance less than this at which vision is distinct in the myope will express the denominator of a fraction indicative of the degree of his myopia; for instance, if the type can be read at fifteen or twenty inches, the person examined is about $\frac{1}{15}$ or $\frac{1}{20}$ myopic, etc.

As in the case of deafness, the surgeon must be prepared, in the examination of a conscript's vision, for the most artfully laid schemes of deception; but if he has patience, and works systematically, he will, in a large majority of instances, be able to ascertain the true state of the case, and expose deceit if it be attempted.

Several excellent tests for the exposure of simulated

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defects of vision have been published, of which, doubtless, the most convenient for use at a recruiting rendezvous is that suggested by Dr. Howard Culbertson, U. S. A., and styled by him "the prismometer." He describes it as follows: "The prismometer detects errors of refraction by means of the displacement of the false image seen through a prism. Its essentials are: a perforated disc carrying a prism which covers one-half of the perforation, its truncated, thin edge dividing the perforation into two equal parts, and a sharply outlined, dead-white disc, about 22 mm. in diameter, on a black, lustreless ground placed at a distance from the prism of 15 to 20. This distance and the strength of the prism must be in such proportion that when an emmetropic eye is placed back of the perforation and directed to the white disc, a true and a false image will be formed, whose peripheries will be exactly tangent.

"In case the examined eye is hypermetropic the images will stand apart to a degree varying with the degree of hypermetropia; in the case of myopia, on the other hand, they will overlap. The degree of ametropia in either case is measured by the lens, which, when held before the perforation, will render these discs tangent. By revolving the disc bearing the prism through an angle of 180° the false image appears to revolve about the true, and in case of astigmatism the separation or overlapping is greatest in the meridian in which the astigmatism is greatest. Its axis may be determined by an index pointing to a graduated arc in contact with the disc; its degree by the spherical or cylindrical glass which renders the discs tangent in the meridian in which they varied most from tangency."

Professor Longmore[24] describes the prism test of von Graefe and the test by the stereoscope suggested by Mr. Lawrence.

All of these tests depend for their success on the confused statements of the simulator, when compelled to look with his normal eyes through a prism, or to describe objects especially prepared for view through a stereoscope. The stereoscopic objects require special preparation, and while a most excellent test upon men of more than ordinary intelligence, who may understand the effect of prism on vision, it is not always practicable; any test by a prism is a good one, but that proposed by Dr. Culbertson is not only simple but effective, both against simulation and in the detection of refractive errors; besides these are the Snellen test with colored glasses and test types; the use of various trial glasses, the ruler test, etc., the description of which may be found in most works on diseases of the eye. Valuable information may be gained by a careful examination of the pupil in simulated blindness of one eye; in an eye suffering from complete amaurosis the pupil is moderately dilated, and but feebly responds, or not at all, to the stimulus of light falling into it; but does respond to the stimulus of light thrown into the other eye. In the simulator, of course, the pupil is normal. Other defects of the eye mentioned in the foregoing list should not exempt a conscript from duty, unless the vision is very materially interfered with, or, as in the case of disease of the lachrymal apparatus, the irritation produced by them keeps up a chronic inflammation.

The Nose.—Loss of the whole or part of the nose; deformities of the nose disfiguring the face, sensibly altering the voice, and impeding respiration; stenosis and atresia of the nasal cavity; chronic rhinitis (ozæna); polypus; purulent and fœtid discharge from the nose, whether due to old and incurable ulcerations, or to any other lesion of the nasal mucous membrane, disqualify.

Loss of the nose or parts thereof may be congenital, accidental, or the result of syphilitic or scrofulous ulcerations; in the two former instances, unless the mutilation is of sufficient degree to make a noticeable disfigurement, or interfere with respiration, it is not cause for rejection; in the latter instances it would, of course, disqualify. Deformities of the nose are generally produced by accident or by disease, congenital deformities being rare; the nasal bones may be so flattened, distorted, or destroyed by caries as to interfere with respiration and speech. Syphilis creates great havoc in this location, hence these deformities should lead to suspicion of that disease, and careful investigation of the case. Stenosis and atresia are either congenital or due to alterations in the natural position of the septum, or to hypertrophies of the erectile tissue lining the cavity; in which latter condition the overgrown tissue covering the turbinated bones is forced against the septum, or projected in comb-like growths into the naso-pharyngeal space; the breathing of persons laboring under this defect is entirely by the mouth, and their facial expression is often vacant and silly; the irritation produced by the hypertrophied tissue keeps up an excessive mucous secretion, to relieve which there is an incessant hawking and spitting, and unless the cavities are cleared, decomposition takes place and is attended by its peculiar and nauseous odor. Deflection of the nasal septum is probably the most common cause of stenosis and atresia, the bone, in some instances, being forced against the side of the nostril, to which its mucous tissue may become adherent. Chronic rhinitis (ozæna) is readily detected by the horrible stench which patients carry about with them; it is generally an evidence of a low grade of constitution, and aside from its disgusting local symptom would require rejection. Polypi, purulent discharges, etc., are all causes for rejection. *In time of war,* losses and deformities of the nose and ozæna, are the only defects which should exempt from military duty.

The Face.—Nævi; unsightly hairy spots; extensive cicatrices on the face, disqualify: "their presence would subject the man to the impertinent jests of his comrades, to his personal annoyance, and to the prejudice of good order in his corps."

The Mouth and Fauces.—Harelip, simple, double, or complicated; loss of the whole or a considerable part of either lip; unsightly mutilation of the lips from wounds, burns, or disease; loss of the whole or part of either maxilla; ununited fractures; ankylosis; deformities of either jaw, interfering with mastication or speech; loss of certain teeth; cancerous or erectile tumors; hypertrophy or atrophy of the tongue; mutilation of the tongue; adhesion of the tongue to any parts, preventing its free motion; malignant disease of the tongue; chronic ulcerations; fissures or perforations of the hard palate; salivary or bucco-nasal fistula; hypertrophy of the tonsils sufficient to interfere with respiration or phonation, disqualify.

At the present day the army surgeon has to consider only the number and condition of teeth required for the proper mastication of food; the question of bygone days as to their utility or necessity in biting cartridges having been settled by the introduction of breech-loading rifles, and the substitution of metallic for paper cartridges. It is probable that for many years to come the majority of our army will be stationed in the sparsely settled Territories, and be compelled to make annual campaigns, as has been done in the past, for the protection of settlers from the lawless people and disaffected or vicious Indians among whom they have cast their lot. These campaigns, from a food standpoint, are as trying to the digestion of the men engaged in them as can be any campaigns in civilized countries in times of war; for, as the men are moving constantly from one camp to another, there is but little opportunity for the preparation of soft bread, and the hard biscuit must be used instead thereof; if cattle are driven with the command, they soon become poor from constant travel, scanty food, etc., and their meat is so tough and stringy that the best of teeth can make but little impression upon it, and the strongest stomachs have difficulty in digesting it. Since the abolition of the paper cartridge, the tendency among military writers on this subject has been to underestimate the necessity for sound teeth, apparently forgetting the fact that the soldier is often placed in circumstances in which they are an absolute necessity for his health, and certainly indispensable for his comfort. The statement made by Dr. Baxter[25] that, "as a matter of fact, there are not many days in which the soldier is not supplied with soft bread," is a grave

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mistake; if he had plenty of soft bread the mastication of commissary beef in the field would still require the assistance of a goodly number of sound teeth; hard biscuit can be softened by a variety of processes, but no amount of cooking will ever succeed in doing this for the beef referred to. It has been within the experience of the writer that men have been disabled through sheer debility, while on a protracted "scout," because of their inability to masticate the food on which the command was obliged to subsist. The molars and bicuspids, as the principal agents in mastication, should therefore be in good condition; it is not necessary that they should all be present, but the smallest number should be six, viz., two upper and lower molars, and one upper and lower bicuspid on the same side, all sound, and opposed to each other; if the incisors and canines are perfect, but the molars and bicuspids gone, or extensively carious, rejection is demanded. Caries of a large number of the teeth, particularly if advanced, with destruction of considerable portions of the crowns, should reject, because it is probable that, before the expiration of an enlistment, they will be so far destroyed as seriously to interfere with mastication. The irritation of the gums caused by carious teeth is also frequently followed by abscess and troublesome swellings of the face and jaws. If artificial teeth are worn, the fact should be noted on the enlistment papers, but the artificial substitutes cannot be regarded as taking the places of the natural teeth, nor as removing the disability for the military service arising from their loss. Lesions of the hard and soft palate must be carefully looked for, and the tonsils thoroughly examined; ulcerations and consequent perforations of the hard palate are often situated in the anterior part of the roof of the mouth, and unless the head is thrown well back, and the jaws are widely separated, they may be overlooked. Ulcerations of the cheeks and gums, and especially on the sides and back of the tongue, must also be carefully searched for; in the latter situations they are often difficult to see, unless attention is called to them by the patient, as their location, either between the papillæ or following the course of the muscular fibres, conceals them from ordinary observation, especially if the tongue lies quiescent in the floor of the mouth, with its sides protected by the teeth. The subjects of excessive hypertrophy of the tonsils are undesirable as recruits, because of the likelihood that, at most inopportune times, they may be seized with an acute attack of inflammation of the parts, it being a well-established fact that previous attacks, of which the hypertrophy is the sequel, predispose to subsequent and more severe ones at any time; phonation, too, is materially interfered with, unfitting the man for certain important duties, especially while detailed as a sentinel.

In time of war, simple harelip, loss of teeth, cicatrices, hypertrophy of tonsils, should not exempt.

Exemption on account of loss of teeth is frequently claimed by conscripts, and has been regarded as good cause; men with such defects can, however, be made useful in the various administrative departments of the army, where the necessity for having sound teeth does not exist; therefore exemptions should not be granted for this cause; the wearing of artificial teeth may, under these circumstances, be favorably considered.

The Neck.—Goitre; ulcerations of the cervical glands; cicatrices of scrofulous ulcerations; tracheal openings; wry-neck, chronic laryngitis, or any other disease of the larynx which would produce aphonia; stricture of the œsophagus, disqualify.

Goitre is not often met with among the class of men who are applicants for enlistment; should it be recent and growing, or of sufficient size to interfere with respiration, or with the hooking of the coat collar, or buttoning of the coat, it is cause for rejection. The cicatrices which are found in scrofulous subjects, who in childhood have had suppuration of the cervical glands, are both unsightly and liable to become irritated in hot weather by the coat collar; of course, as being indications of the presence of scrofula either in the past or present, they render it necessary that a careful inspection should be made of the person for other signs of that disease; if none exist, and the cicatrices are healthy, the applicant, if otherwise desirable, may be accepted; but if they are numerous, purplish colored, or adherent, rejection is demanded. Any ulceration about the neck, either of the lymphatics or in the tissues, is cause for rejection; wry-neck, if permanent from any cause, should reject. Any chronic inflammation of the larynx, producing a huskiness of voice sufficient to render speech indistinct, or to induce actual aphonia, should reject. Of course the simple hoarseness of ordinary colds is not to be considered, but any well-marked alteration of the voice should lead to an examination of the larynx in which the existence of organic changes would be cause for rejection.

In time of war, only very extensive cicatrices, active ulcerations, or tracheal openings, should exempt; the presence of goitre, unless very large and unsightly, and wry-neck, if caused by rheumatism or any curable disease, should not exempt.

The Chest.—Malformation of the chest, or badly united fractures of ribs or sternum sufficient to interfere with respiration; caries or necrosis of ribs, deficient expansive mobility; evident predisposition to phthisis; phthisis pulmonalis; chronic pneumonia; emphysema, chronic pleurisy; pleural effusions; chronic bronchitis; asthma; organic diseases of the heart or large arteries; serious and protracted functional derangement of the heart; dropsy dependent upon a disease of the heart, disqualify.

In obtaining measurements of the chest the movements of inspiration and expiration should be confined entirely to the muscles of respiration; the applicant should be required to inflate the lungs to their fullest extent by an easy, though complete, inspiration; expiration should be made in the same quiet manner, and is most completely accomplished by requiring the applicant to count aloud until the necessity for a fresh supply of air compels him to inspire again. No contortions of the body should be permitted—such as throwing the chest forward and shoulders backward during inspiration, nor forcing the shoulders forward during expiration,—as these movements can do nothing more than produce erroneous results. The measurements are to be taken when the man is stripped; the arms are extended above the head, the tape is brought around the chest in such a manner as to fall just below the points of the scapulæ behind, and the nipples in front; the arms are then to be brought down by the sides of the body, and while the tape is held tight enough to lie snugly against the skin, the man is directed to respire after the manner before related.

Attention must be paid to the proper proportion of the chest; the fact, however, being borne in mind, that certain occupations have a tendency to change its shape without producing any lesion of the lung tissue; the lateral flattening of the chest walls so often found in tall, slender men, or those of slight frame, with projection of the sternum—the "pigeon breast"—is more likely to be associated with organic changes in the lungs than is the flat or hollow chest—the antero-posterior flattening. Malformations of the sternum and cartilages of the ribs are less likely to be present in the puny or phthisical subject, and have little or no significance in pulmonary disorders. It should be the object of the medical examiner to accept only men who have well-formed chests, or, as it is expressed in the Army Regulations, "whose chests are ample"; any deviation from the typical healthy thorax being considered good ground for suspicion of changes in the normal character of its contents.

It is entirely beyond the scope of this article to go into the details of a physical examination of the lungs; hence it will be sufficient to say that both auscultation and percussion should be performed before the examiner is satisfied to pronounce upon the availability of his patient for the military service; with the exception of the examination of the heart, there is none other which demands the exercise of so much care. Close questioning should be made into the family history of every applicant, as well as into his own life and habits, for any evidence of a pre-

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disposition to phthisis or the occurrence of attacks of pneumonia or pleurisy; for a general susceptibility to changes of climate, weather, etc.; for the occurrence of asthmatic attacks, spitting of blood, etc.; in fine, for anything which would bring out a clew to the previous existence of any affection connected with the pulmonary apparatus. Particular stress is laid upon this subject, because it is no uncommon thing to find men seeking army life with a hope that its supposed freedom, regularity of habit, and their own location in particularly salubrious climates, might benefit an already existing lung trouble. Parents consent to the enlistment of their boys under the impression that the life of a soldier will "harden their lungs," and recruiting officers will often urge the acceptance of applicants whose skin is suspiciously clear, upon the ground that the service will "bring them out"; "make new men of them," etc.; the medical examiner must, therefore, be especially on his guard against the admission of such men into the service, and recollect that he is not required to diagnosticate any particular lesion of a lung in order to reject an applicant, but, if he has reason to *suspect* a predisposition thereto—unhesitatingly to reject.

Dr. Tripler quotes very aptly from Bézin, as follows: "It is true we run the risk of rejecting men who may afterward become very robust, and who, by a long and successful life, may contradict the prognosis we may have pronounced in their cases, but . . . you will be astonished at the number of young men who, received because no determined lesion of the thorax was recognized when they were inspected, succumb afterward with phthisis, or whom it was necessary to send back to their friends and families with broken health, after their strength had been exhausted." (Aide-Mémoire.)

Of organic diseases of the heart, those affecting the valves are easily detected, and require no detailed notice here; there is occasionally heard, however, a cardiac murmur which is not indicative of any disease of either heart or lungs, and about which the text-books on the general subject are silent. It has been described by Dr. Hamilton Osgood, in a paper read in March, 1883, before the Boston Society for Medical Improvement, and published in vol. cviii., No. 13, of the *Boston Medical and Surgical Journal*. Dr. Osgood gives to it the very appropriate name of a "misleading cardiac murmur"; it is heard during the respiratory act, with a portion of which it is synchronous (especially inspiration), and is located at the base of the heart. When respiration is temporarily suspended it may be heard, although not so distinctly as during the normal act; its true nature is to be discovered by auscultation *during forced collapse of the lungs*; mere ordinary expiration will not uncover the heart, and the patient must be instructed to force out all the air possible, continuing his efforts until air can no longer be expelled from the lungs; after which the lungs must be kept immovable. By this procedure the heart is brought more closely in contact with the ear, and is freed from the presence of lung tissue, which, in the inflated lung, partially covers it; the "misleading murmur" will now be found to have disappeared. Aside from its value in determining this point of doubt, forced expiration of the lungs is a valuable adjunct in the examination of the heart under any circumstances; when that organ is uncovered, the natural as well as morbid sounds are more sharply accentuated, and deviations from the normal will be more easily discovered. If the patient is required to put the anterior chest wall on the stretch by standing with his back against a door or post, and his hands carried forcibly behind his back, the results will be much more satisfactory.

In the diagnosis of cardiac hypertrophy, associated or not with dilatation, the inexperienced medical examiner may be easily misled. The movements of the heart are so largely under the influence of the sympathetic nervous system that any cause acting directly through that system may produce such alterations of its rhythmical action as will lead to the opinion that they are the result of organic change. When the hand is placed upon the chest of an applicant who has just passed through the preliminary questioning, and has been stripped for examination, the heart will probably be found in tumultuous action; in some instances so violent as to produce a feeling of faintness. The excessive use of tobacco and coffee, or either, will also produce so much functional disturbance, irregularity of action, and palpitation, that organic changes may be suspected. The powerful, rhythmical action of the enlarged organ in true hypertrophy, taken in connection with the permanent change in the location of its apex beat, will supply the evidence mostly to be relied upon in forming a correct opinion of the case presented. It is not, however, always possible, in the short time allotted to the preliminary examination, to decide whether the abnormal action is functional or organic, and in all cases of doubt the applicant, if otherwise desirable, should be kept under observation for two or three days, in order that he may become accustomed to his surroundings, and recover somewhat control of his nervous system. Should it become apparent that even a functional disorder of the heart is persistent, or so serious as to interfere with the usefulness of the applicant, he should be rejected. The sequelæ of cardiac lesions, dropsies, pulmonary engorgements, etc., will require close consideration, particularly in their earlier stages; but it is a rare occurrence for men in a state of disease so far advanced as these symptoms would indicate, to come to a rendezvous. In all cases of suspected cardiac lesions, the urine should be carefully examined.

The directions stated in the "mode of examination," on a previous page,—viz., to auscultate the heart before requiring the applicant to go through the violent exercise of running, jumping, etc.,—were given for the reason that the sounds of the heart are best heard when the patient is at rest. The lungs are best examined while rapid breathing is induced; hence the directions for their examination *after* the exercise mentioned. Should any lesion of the heart have been suspected, its rapid action after exercise will tend to bring out more prominently the abnormal sound. Advantage should be taken of this excessive action to examine the course of the bloodvessels in the neck and other parts of the body, with a view to the detection of aneurisms.

In time of war all diseases of the heart and lungs should be cause for exemption, without exception.

The Abdomen.—All chronic inflammations of the gastro-intestinal tract, including diarrhœa and dysentery; diseases of the liver or spleen, including those caused by malarial poisoning; ascites; obesity; dyspepsia, if confirmed; hemorrhoids; prolapsus ani; fistula in ano; considerable fissures of the anus; hernia in all situations, disqualify.

Among the list of disqualifications mentioned by Tripler and Baxter are engorgement of the mesenteric glands, chronic peritonitis, stricture of the rectum, and tæniæ. The first three of these diseases are exceedingly rare, and their diagnosis is a matter of considerable difficulty at best. It is not very likely that the subjects of them will present themselves for enlistment, and they are accordingly omitted from the disqualifying list, because they fall within the list of general affections impairing the efficiency of men for military duty, the mere mention of which would extend an article into the limits of an elaborate treatise, and the discovery of which would naturally be cause for rejection. The existence of any species of tapeworm is not considered a disqualification, their expulsion from the intestine being so easily accomplished, and their presence producing so little constitutional disturbance in the adult. To ascertain whether chronic inflammation of the gastro-intestinal tract, or dyspepsia of an aggravated form, is present, the medical examiner will be compelled to rely largely upon the statements of the man himself. Accuracy of diagnosis cannot be expected except after observations conducted for a greater or less period of time; many instances terminating only in negative results. The grosser signs of these disorders may lead to suspicion of their existence, but in men anxious for enlistment, all evidence tending to establish the fact will be concealed, although the emaciation attendant

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upon long-standing and serious cases should put the examiner on his guard. Fortunately, but very few of them are presented, and the mere mention of their names is enough to draw attention to the probabilities of their presence. Affections of the liver and spleen are of more practical moment, www.libtool.com.cn the fact that a large proportion of our recruits is drawn from sections of the country in which malaria is rife, and where men whose systems are broken down by the influence of this poison are forced to quit their ordinary employments and seek a livelihood in some other and more healthful region; the army offering the easiest means for accomplishing the object. In these instances enlargements of the liver and spleen will be found, and associated with them the anæmia and generally debilitated condition characteristic of malarial poisoning. From some of the rendezvous subsidiary to the depôt at Columbus, O., which were located in malarious regions, the men enlisted were feeble and anæmic, with enlarged spleens, dropsical legs, and a mental depression which was an apparent bar to improvement under their changed condition of life; in many instances this change of climate, etc., brought about a recurrence of the periodic fever, necessitating admission to, and protracted treatment in, hospital, and leaving the men utterly useless for future service. The evil became so great that orders were finally issued to discontinue the objectionable rendezvous, and abandon the infected districts; attention, then, must be given to the condition of these organs, in all cases in which the general appearance indicates malarial poisoning. Obesity, or pendulous abdomen, impairs the efficiency of men for military duty; they cannot take active exercise without loss of breath, or in warm weather without suffering from excoriations, prickly heat, etc.; and moreover, in all such cases the presence of fatty degeneration of the heart and arteries is to be suspected. Hemorrhoids are so very common, and of so many degrees of severity, that it is impossible to lay down any fixed rule by which all cases are to be decided; each must be judged upon its own merits, and rather by the effects of the disease upon the individual, than by the size of the tumors or their age. Internal hemorrhoids, except when protruding, cannot be discovered unless they are bleeding at, or just before, the time of examination, the evidences of which will appear upon the person or clothing of the applicant; they may possibly be ulcerated, in which event there will be a purulent discharge from the anus, which, however, may occur from other causes; but its appearance should be the occasion for a careful inspection of the rectum, if the man denies being the subject of piles. Their existence is an absolute cause for rejection. External hemorrhoids, if multiple and large, ulcerated or inflamed, should reject. The small, accidental pile commonly met with in men of constipated habits; the pedunculations found in men of lax fibre, or old piles in which the former mucous lining has become transformed into a hard and insensitive covering similar to true skin, are not causes for rejection, if the man states that they have not given him trouble. These statements should, however, be taken with many doubts, as the desire to enlist will lead men to prevaricate about that point, and the medical examiner will be obliged to form his own opinion from the appearances presented by the tumors, and from their effects upon the surrounding parts.

Although fistula in ano may be discovered by means of the discharge from its track in most cases, a careful inspection of the parts near the anus, for the external opening of the fistula, is necessary; in very hairy men, the hair must be pushed aside and every point suggestive of the appearance of a fistula explored with a probe.

There should be but little difficulty in discovering any well developed forms of hernia; it is those cases which are incomplete or partially developed about which the surgeon may be perplexed. The examination should always be made while the man is standing, and with his hands extended above his head; the surgeon should examine the umbilicus, and afterward each inguinal canal, carrying his finger well up to the internal ring, and requiring the man to cough vigorously; if the bowel protrudes to any degree from the abdominal cavity into the canal, it can easily be felt. There can be no doubt as to the unfitness for service, in time of peace, of an applicant who has a hernia, all varieties of which, whether complete or incomplete, are absolute causes for rejection; cases, however, in which the inguinal rings are relaxed, in which there is supposed to exist a "tendency to hernia," are not so easily disposed of; the question as to the acceptance of men having this tendency being still an open one. In some foreign armies it is considered a sufficient cause for rejection, but in our service the judgment of most medical officers is adverse to such an opinion. While it is true that the exertion incident to certain phases of military life may produce a hernia in men having relaxed inguinal rings, it is equally true that the accident may happen quite as often (relatively) to men who do not have this defect; indeed, there is no especial evidence to show that this is more frequently a predisposing cause than is any other. The experience of the writer fully confirms the statement made by Tripler,[26] that "by far the greater number of herniæ that have fallen under our observation have occurred in comparatively robust, thick set men; just the men who rarely have relaxed external rings." The exclusion of this class of cases would, it is believed, result in the loss to the service of many excellent men, and until it is shown that they are more liable to the defect than others, rejection is not demanded. The examination for a hernia should, however, be very carefully made, and the applicant required previously thereto to run, jump, or take other violent exercise; care must be used in the examination of a scrotal hernia, that a mistake be not made in confounding it with other tumors connected with the cord or testicle—an error one might very easily fall into when examining any large number of men. The tissues covering an umbilical hernia are so very thin that there can be but little room for error in diagnosis; indeed, the fact is that any thinning of the abdominal walls in that vicinity amounts practically to a hernia; but one must not confound with a hernia a not uncommon malformation of the umbilicus, in which, through some morbid process during the separation of the cord, a nipple-like tumor has been left that bears no small resemblance to an umbilical hernia.

In time of war it would not be proper to reject men who had hemorrhoids, unless, if internal, they were very large, and the constitutional effects produced by the bleeding, or the irritation set up by their presence, was plainly visible; in case of external hemorrhoids they should be very large, painful, and of long standing, to be cause for rejection. Herniæ which are easily reducible and retained in position by a well-fitting truss, or those which are incomplete, should not be cause for exemption. All other defects which disqualify in time of peace do so equally in time of war.

The Genito-Urinary Organs.—Any acute affection of the genital organs, including gonorrhœa and venereal sores; loss of the penis; phimosis; stricture of the urethra; loss of both testicles; permanent retraction of one or both testicles within the external ring; any chronic disease of the testicle; hydrocele of the tunic and cord; atrophy of the testicle; varicocele; malformations of the genitalia; incontinence of urine; urinary fistulæ; enlargement of the prostate; stone in the bladder; chronic cystitis; all diseases of the kidney, disqualify.

The existence of gonorrhœa, or a venereal sore upon the penis, should be cause for rejection; aside from the fact that the subject of either of these affections is liable at any time to communicate it to his comrades, it is not possible for any one to foresee the complications which may arise during the course of either form, nor the sequelæ it may leave behind. Venereal diseases are so very common, and held in such light estimation by the laity, and indeed by many of the profession, that their existence is looked upon rather as an incident in the ordinary life of a soldier, than as a serious matter which may disable the victim for life. Men who have been inadver

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tently enlisted with some form of venereal disease should be placed in hospital at once, both as a measure of cure and for the purpose of isolation. It is to the interest of the service that such cases should receive prompt attention as, even if their progress toward a cure is not delayed by complications, their terminations are liable to be marked by permanent disabilities, demanding final discharge. Cases of gonorrhœa are frequently followed by stricture of the urethra, and venereal sores are almost as likely to prove syphilitic as innocent. The instructions laid down in text-books for the differential diagnosis between chancroids and chancres will prove but a poor defence should a recruit who at the time of enlistment is the subject of a chancroid be afterward discharged on account of constitutional syphilis. The principle that the Government is justified in caring for such cases in its hospitals, for the purpose of securing the services of good men temporarily unfortunate, is entirely wrong, and the desired result is seldom attained. The experience of the writer is to the effect that the large majority of such cases terminate by discharge, before the subject has been able to render any considerable portion of the service for which he was enlisted.

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The existence of any stricture of the urethra is cause for rejection; its presence can be definitely determined only by the use of the sound, a procedure demanded in all cases giving ground for a suspicion of disease; the condition of the stream passed in urinating must be carefully inquired into, and all information relative to a history of the case elicited by closely questioning the patient, before resorting to the use of an instrument. Simple narrowing of the meatus, which is congenital in many persons, should not be considered a cause for rejection.

Phimosis, if complete, is liable to give a great deal of trouble to a soldier by repeated attacks of balanitis; if there is adhesion between the prepuce and the glans, partial or complete, graver symptoms may present themselves, and his efficiency may be impaired by reflex paralyses, epilepsy, or other nervous affections, for the relief of which surgery is required; for these reasons it is made a cause for rejection. When both testicles are absent from the scrotum, the inguinal canals must be carefully examined for evidence of their retention therein; loss by injury may be known by the scar remaining on the scrotum; should one or both testicles be found permanently resting in the inguinal canal, or absent from the scrotum from any cause, the applicant should be rejected. In affections of the testicle, discrimination must be made between true diseases of this organ and morbid changes in the epididymis, the result of inflammatory action. The most common defect among the class of men who present themselves for enlistment is the enlargement from interstitial deposits following orchitis—sarcocele—which, when inconsiderable in size, is not a cause for rejection; a diagnosis must, however, be made between it and other enlargements of the testicle, either syphilitic or malignant; and should there be reason to believe that the enlargement is due to either of the latter causes, or should its size be such as to give annoyance to the patient, rejection is demanded. A hydrocele may mislead one in cases of this nature, and the test by transmission of light should therefore not be omitted in any examination of the organs.

It is exceedingly rare to find a varicocele of such size as to become a real disability to a willing soldier in any branch of the service, excepting perhaps that requiring him to be mounted—under which circumstances he may injure it or the testicle—which in these cases hangs very low—against the saddle; but as it is a defect which may be made to appear a disability, the soldier has an ever-present excuse for the evasion of duty, or a ground upon which to base an application for discharge. So long as he can demonstrate the existence of a disease or defect in any organ, so long will it be impracticable to insist upon a performance of his duty, and it is this circumstance rather than any well-grounded belief in the disqualifying nature of a varicocele, as well as the more general principle that no men should be enlisted who are the subjects of any recognizable physical defects, which leads to its being placed upon the list of causes for rejection. The rule laid down by Tripler is an excellent one for the determination of the degree of varicocele which should reject: "If the testicle on that side is atrophied, whatever may be the volume of the circocele (varicocele), or if the volume of the latter exceed that of the former, the recruit should be rejected." [21]

Among malformations may be mentioned epi- and hypospadia, where the urethra terminates at a distance nearer the body than one-fourth the length of the penis. Incontinence of urine may be suspected by a urinous odor about the person of the applicant, or by the appearance of his clothing, which may be stained; of course there can be no evidence of the fact except after certain observation, and, therefore, the statement of the man must be taken as to its absence before he can be accepted.

If any disease of the kidney is suspected, a careful examination of the urine should be made by chemical reagents, extended if necessary to an examination by the microscope. It is, of course, presumed that the applicant will be closely questioned as to the existence of any symptom which would point to renal trouble; the presence of albumin, sugar, blood, or pus in the urine, although due to temporary ailments, is ground for absolute rejection, as would also be dropsical effusions into any of the tissues in the body.

In time of war acute affections of the generative organs should not exempt; the subjects thereof can be placed in hospital until cured of the primary difficulty, and those who are free from constitutional taint, or who have very slight strictures, should be sent to active duty. Phimosis, loss of testicles, hydrocele of the tunics and cord, unless interfering with locomotion, and spermatorrhœa, are not causes for exemption, as men suffering from these defects can be made useful in the administrative department, and in some cases in the line of the army.

Affections Common to both Upper and Lower Extremities.—Chronic rheumatism; chronic diseases of joints; old or irreducible dislocations or false joints; severe sprains; relaxation of the ligaments or capsules of joints; dislocations; fistulæ connected with joints or any part of bones; dropsy of joints; badly united fractures; defective or excessive curvature of long bones; rickets; caries; necrosis; exostosis; atrophy or paralysis of a limb; extensive, deep, or adherent cicatrices; contraction or permanent retraction of a limb or portion thereof; loss of a limb or portion thereof, disqualify.

Nearly all defects in the extremities are apparent by some impairment of the natural shape or motion of the limb, and can hardly escape the notice of one who examines attentively his cases; indeed, in the inspection of large numbers of men one becomes so expert as to discover departures from normal shape and motion as if by intuition. Diseases which affect the continuity of limbs but which do not necessarily interfere with motion or alter shape, may occasionally require careful search for their detection.

It is more frequently the case that the surgeon is called upon to exercise his judgment in deciding how far an existing blemish may impair the efficiency of an applicant, than he is to exercise his skill in searching for hidden or obscure disqualifications; this is particularly the case in severe sprains, dislocations, large cicatrices, and chronic rheumatism. It should be remembered, in the preliminary examination of the shoulder-joints, that it occasionally happens that men cannot touch the point of the shoulder with their fingers, and a careful search fails to reveal any imperfection of the joints of the extremity. It is important, in such a case, that the elbow and wrist should receive special inspection, as a defect is most likely located at one or both of these points; but rejection is not demanded unless a defect is clearly made out, as an extreme muscular development may be the cause, or a congenital shortening of some of the bones exists without an interference with any other than this particular movement. Men desiring to enlist will seldom, if ever, admit the presence of chronic rheumatism, and it is

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only when, as a result of this disease, one or more joints are swollen or otherwise disabled, that the surgeon can be aware of its existence. The absence of any of these evidences will occasionally enable a man to enlist who has been previously discharged from the service on account of alleged chronic rheumatism, in which event the medical examiner would be blameless of the charge of carelessness, as in all probability the discharge was procured through fraud and malingering. Chronic rheumatism of sufficient severity to warrant a discharge from service should be followed by tangible evidence, in the shape of swollen or distorted limbs, deposits in the joints, or enlargements in the surrounding tissues, and these are not likely to disappear; close inspection must be made of all joints to discover any swelling or other evidence of sprain; lameness of an inferior extremity, or stiffness of a superior one, should be an indication for careful questioning as to the receipt of injury.

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It is not always wise to place too much confidence in the statements of men as to their freedom from pain or ability to move joints which have been injured. It is well known that the remote effects of sprains and other joint injuries, particularly of the ankle and wrist, are liable to manifest themselves, even at a late period, in swellings or pain after severe exertion; and however honest one may be in the belief of his perfect cure from such an injury, and ability to perform all duty required of him, there may be an actual defect of which he is ignorant. The medical examiner, therefore, must exercise his own judgment from the appearance of the parts, their sensitiveness, etc., as to whether this is the case or not, and he should reject in all instances which give room for doubt. Fractures which have been properly treated, and have united without deformity, are not of themselves causes for rejection, but when they are followed by neuralgic pains, or if there has been much displacement of fragments, so that the symmetry of the limb is destroyed, or if from excessive bony deposits there is impairment of motion, they *are* causes for rejection. Fractures of the bones of the forearm are very likely to give trouble by interference with the motions of pronation and supination, both of which are necessary in handling the rifle during the exercises in the manual of arms. Malformations of the limbs, as excessive curvature—bow-legs—are objections rather because of the awkward gait they induce than from any interference with the ability of the man to march; when the curvature is caused by a constitutional taint, as rickets, etc., there can be no question as to the propriety of a rejection. Abnormal cartilaginous or bony formations in the muscles, or loose cartilages in the knee-joint, are objections when they impair the use of the joint.

In time of war especial care is necessary, particularly in those affections which present but little external evidence of injury, to detect deception; chronic rheumatism, sprains, alleged dislocations and fractures, must not be made causes for exemption unless the evidences of impaired strength and motion of the parts in which they are located are indisputable. Allegations of pain, loss of motion, involuntary contractions, etc., will constantly be made, and if the surgeon has no other means of completing his diagnosis in a case of suspicion, he should resort to the use of anæsthetics, under which simulation ceases, and the true state of an alleged disability will be made apparent. One must, however, bear in mind the fact that in central lesions of the brain contractions disappear during chloroform narcosis. It should be stated that authority for the use of anæsthetics is limited "to cases of professed rheumatic contraction of joints when unattended with perceptible alteration of form or structure,"[2] although it is recommended in a wider range of cases by Tripler and Bartholow, both authorities recognized by the War Department. An ingenious test for simulated contractions of limbs—flexures—has been suggested by a Russian military surgeon, and is published by Zuber.[23] It consists in applying tightly to the affected limb an Esmarch bandage, as if for amputation; when the bandage is removed, the rubber cord remaining, the limb straightens itself involuntarily. The test has been tried in but few cases, and may not invariably succeed, but it is worthy of further trial.

All officers of experience in the examination of malingering soldiers agree upon the fact that their most vulnerable point is in an exaggeration of the symptoms which they endeavor to simulate. When a man comes limping before a surgeon with every expression of pain upon his countenance, or assumes the most unnatural and constrained positions of body or limb, he may, in nine instances out of ten, be set down as a malingerer, if he presents no external physical signs of disease; there is something about a real sufferer or cripple which is very hard to describe, but which every surgeon will recognize; and in a large number of instances the problem will be, not so much in recognizing the deception, as in compelling the subject to admit it.

The Superior Extremities.—Fracture of the clavicle; fracture of the radius and ulna; webbed fingers; permanent flexion or extension of one or more fingers, as well as irremediable loss of motion of these parts; total loss of either thumb; mutilation of right thumb; total loss of the index finger of the right hand; loss of the first and second phalanges of all the fingers of either hand; total loss of any two fingers of the same hand, disqualify.

Fractures of the clavicle, which are almost invariably followed by more or less deformity, are causes for rejection in consequence of the painful pressure made at the seat of injury by the rifle, during certain movements in the manual of arms, and by the "sling straps" when carrying the knapsack or haversack. The mere fact that the clavicle has been fractured is not of itself cause for rejection, and even the presence of a slight deformity should not be objectionable, provided there is neither pain on pressure nor interference with the free motion of the arm. The improved means of transporting the baggage of the soldier have in a great measure done away with the necessity for his knapsack; the few articles of clothing which he requires in the field are rolled in his blanket, which is slung over the shoulder and across the chest, and thus carried without inconvenience or pain to any part of the clavicle which may have sustained an injury. The haversack strap may, however, on long marches, or when the sack is well filled, produce painful pressure, or even excoriate the skin, and the gun is very liable to injure a prominent deformity on this bone. Therefore a tumor at the seat of fracture, from whatever cause, if considerable, would be a valid objection to enlistment. Any fracture of the radius and ulna, particularly Colles', is liable to be followed by impairment of the motions of pronation and supination of the forearm—movements indispensably necessary in the drill of the manual of arms, the "set up" drill, and other military exercises. Should this be the case, rejection is demanded; otherwise, union and motion being perfect, the injury is not a cause for rejection. The degree of mutilation of the hand which should disqualify can be determined only by the facility with which a man so injured can handle a rifle. In loading the Springfield (army) rifle, the breech block is thrown open and the cartridge thrust home by pressure of the right thumb, the rifle is also cocked by the same member; hence it is very important that it should be intact; and any injury which materially interferes with its flexion or strength is a cause for rejection. The common distortion of the extremity due to contusion or felon need not disqualify; the loss of the entire member would, of course, reject; loss or mutilation of the last phalanx of the left thumb need not disqualify. The first and second phalanges of the right index finger may be lost or mutilated without necessarily disqualifying an otherwise very desirable recruit, or a soldier who desired to re-enlist; it is ordinarily the finger used in pulling the trigger, but this can be done with facility by a stump, or by the middle finger, as is the case with many marksmen whose fingers are perfect; it should, however, be the rule for recruits to have a perfect right forefinger, departures from which rule should be made only in rare instances and for very good reasons. Permanent flexion or extension, or loss of motion of any fingers, so materially interferes

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with a military use of the hand as to demand rejection. The congenital malformation of the little finger of one or both hands, which is so common, is not considered a disqualification.

In time of war, the loss of the right thumb; loss of any two fingers of the same hand; loss of the first and second phalanges of the fingers on the right hand; permanent flexion or extension of two fingers of the right hand, or all the fingers united (webbed), are causes for exemption.

The Lower Extremities.—Varicose veins; knock-knees; club-feet; splay or flat feet; webbed toes; the toes double or branching; the great toe crossing the other toes; bunions; corns; overriding or superposition of any of the toes to an extreme degree; loss of a great toe; loss of any two toes of the same foot; permanent retraction of the last phalanx of any of the toes, or flexion at a right angle of the first phalanx of a toe upon the second, with ankylosis of the articulation; ingrowing of the nail of the great toe; bad-smelling feet, disqualify.

Dr. Baxter, in his "Report of the Provost Marshal General's Bureau," says that to be cause for rejection varicose veins must be "voluminous and multiplied." There is no doubt of the fact that the judgment of many surgeons is in error as to the degree of varicosity of the veins of the leg which should disqualify, and men have been discarded with veins so slightly enlarged that they could hardly be called varicose. The network of small veins so often seen in the popliteal space, and inside of the thigh, upon men of spare habit, or in those whose occupations have required them to stand a great deal, are not sufficient in degree to cause rejection; nor, indeed, is such the case when a single vein may be more or less enlarged without the function of its valves being impaired. It is only when several veins are very large and tortuous, with failure of their valves, or when there is œdema, thickening of the integument, or much ulceration, that they become disqualifications. An exception to this rule should be made in cases in which hemorrhoids are present, when even slightly varicose veins are causes for rejection. One may see occasionally an instance in a very muscular man, where there has been a rupture of the sheath of some muscles in the leg, which closely resembles a varix; if the finger is placed over such a tumor during the contraction of the muscle, its true nature will be apparent. Knock-knees, if existing to such a degree as to interfere with the free use of the limbs, should disqualify; as a general rule, if the inner borders of the feet, from the heel to the ball of the great toe, cannot be brought within one inch of each other without passing the inner condyles of the femur, respectively, in front of and behind each other, the applicant should be rejected. Flatness of the feet to a degree requiring rejection is very seldom met with among applicants for enlistment, notwithstanding the fact that it is supposed to be very common among the laboring population; as a cause for rejection it has been very much exaggerated; the ordinary flatness of foot so often seen, especially among negroes, is not more likely to become a cause of disability in marching than is the more shapely foot, unless an ill-fitting shoe is worn; the anatomical peculiarity which disqualifies has been described by Goreke, of the Prussian service, substantially as follows: The inner ankle is very prominent, and is placed lower than usual; a hollow exists below the outer ankle of a greater or less extent; the dorsum of the foot is not sufficiently arched; the foot is broader at the ankle than near the toes; the inner side is flat and sometimes convex, and when the foot is placed on the ground the sole projects so much on the inside that the finger cannot be introduced below it; the body rests on the inner side of the sole, and the usual motion of the ankle-joint is impeded.

Bunions, if large and presenting evidences of old or recent inflammation, should always reject; they are a fruitful source of disability on long marches and in hot weather, the pain produced by the pressure of the shoe setting up an irritation which extends to the entire foot. The same may be said of corns when located on the sole of the foot; those under the head of the metatarsal bone of the great toe are the most painful, and produce lameness sooner than any others; they are, moreover, very intractable. Of the malpositions of the toes, that in which the first phalanx is flexed at right angles upon the second to such an extent that the man walks upon the end of the nail (hammer toe) is the most painful, and will disable more speedily than the others; there is no shoe which can be made that will remedy the defect, and it is in consequence an absolute cause for rejection. Ingrowing of the nail of the great toe, if deep and accompanied with signs of irritation, inflammation, or suppuration, renders a man unfit for service; if, however, he is very desirable otherwise, the simple operation of shaving away the redundant tissue on the border of the toe, in a majority of instances effectually cures the disease, after which he may be accepted.

The fetid odor exhaled from the feet of some men is such as to make their presence in a squad-room unbearable to their comrades. The excessive perspiration causing this odor keeps the toes and under surface of the feet soft and the skin macerated, for which reason very slight exercise produces painful excoriations and unfits the man for duty. When the feet show evidence of this condition the applicant should be rejected.

In time of war very large varicose veins, club-feet, an excessive knock-knee, loss of great toe, and flexion of the phalanges of the other toes to an extreme degree should exempt; men having other defects of the feet, if unfit to join the active line, can be made useful in the administrative departments and should be held to service.

Charles R. Greenleaf.

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RECTO-VAGINAL FISTULÆ. See *Vagina, Diseases of.*

RECTUM, MANUAL EXPLORATION OF THE.—In 1872 Professor Simon, of Heidelberg, published, in the *Archiv für klin. Chirurgie*, an article "On the Artificial Dilatation of the Anus and Rectum for Exploration and Operation," in which he first described a method of exploring the lower bowel by the introduction of the entire hand. By this method of examination he asserted that not only was he able to explore all of the pelvic organs and to distinguish any pathological changes they might have undergone, but that the greater part of the abdominal cavity could also be reached. He further asserted that this method was so entirely free from danger that he had not hesitated to practise it on patients anæsthetized for other purposes.

Manual exploration of the rectum is now only of historical interest. It is no longer employed, and has been superseded by the no more dangerous and much more wide-reaching and satisfactory method of exploration, viz., by abdominal section. *N. P. Dandridge.*

RECTUM, SURGERY OF THE. See *Anus and Rectum. (Surgical.)*

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RED BOILING SPRINGS.—Macon County, Tennessee.

POST-OFFICE.—Red Boiling Springs. Hotel.

ACCESS.—Viâ Louisville and Nashville Railroad to Gallatin; thence by private conveyance to the springs.

This resort is located in the foothills of the Cumberland Mountains, sixty-five miles northeast of Nashville www.libtool.com.cn and seven miles from the Kentucky line. It has an elevation of about twelve hundred feet above the sea-level. The visitor will at this resort find a cool and pleasant retreat for the summer months. The hotel is said to be well kept and comfortable, and the cuisine of an excellent character. There are three springs in the group—two red sulphur springs and one black sulphur spring. Those most generally used are the "Little Red" and the "Black Sulphur" Springs. The former was analyzed by Lucius Pitkin, analytical and consulting chemist, of New York City, in 1890, with the following results:

Little Red Spring.—One United States gallon contains (solids): Sodium chloride, gr. 5.57; sodium sulphate, gr. 0.94; calcium sulphate, gr. 8.18; potassium sulphate, gr. 0.41; calcium bicarbonate, gr. 3.20; magnesium bicarbonate, gr. 4.55; iron bicarbonate, gr. 0.15; silica, gr. 0.80. Total, 23.80 grains.

Sulphureted hydrogen gas is present in large quantities.

The following analysis was made by James T. Anderson, of the Alabama State Agricultural and Mechanical College at Auburn:

Red Spring No. 2.—One United States gallon contains (solids): Sodium chloride, gr. 10.73; sodium carbonate, gr. 1.03; calcium carbonate, gr. 9.64; calcium sulphate, gr. 15.36; magnesium sulphate, gr. 7.97; alumina, gr. 0.12; iron oxide, gr. 0.08; silica, gr. 0.58; organic and volatile matter, gr. 2.31. Total, 47.82 grains. Sulphureted hydrogen gas is present in only small quantity. The temperatures of the waters are 54° and 52° F., respectively, and they do not vary during the year.

These waters are said to be actively diuretic, and to exert a general tonic and alterative effect upon the system. Hot and cold sulphur baths may also be had at all hours. A competent physician is always at hand to explain the proper use of the waters. *James K. Crook.*

REDLANDS AND RIVERSIDE, SOUTHERN CALIFORNIA.—These two places may be taken as representing the climate of the eastern foothills of Southern California, where are to be found many resorts favorable for a winter or an all-the-year round residence.

Redlands (1,350 feet), in San Bernardino County, lies in the East San Bernardino valley, and is surrounded by mountains from 5,000 to 12,000 feet high on the north, east, and south, and lies open to the sea on the west, from which it is distant about eighty miles. The city is beautifully situated and substantially built, and contains about six thousand inhabitants. It is a favorite place of winter residence for Eastern people, and in attractiveness of situation and the character of its inhabitants and residences is comparable to Pasadena. Parks, many churches, a fine public library, excellent schools, clubs, golf links, good hotels, are all to be found here. The soil is porous and rich, and especially favorable for the cultivation of the orange, which is the principal fruit grown here. The water-supply is a fine one, and affords irrigation for the orange groves. There is a sewer and storm-water system, and the sanitary condition appears to be of the best.

Redlands has good railroad connections and electric roads, and from it one can easily reach the various attractive mountain resorts on the one side and those of the coast on the other.

One rarely meets with a more attractive town, even in Southern California, than Redlands, exhibiting as it does so many of the natural attractions peculiar to all this region. Wherever there is irrigation, flowers of endless variety abound, and the most luxuriant vegetation flourishes. The dust of the streets is laid by the crude petroleum, so abundant in Southern California. By this process an almost perfectly dustless road is obtained, and remains so for many weeks from a single application of the oil.

The characteristics of the climate of Redlands, as, indeed, of all this eastern foothill region, are equability, comparative dryness, abundant sunshine, and a small rainfall occurring mostly in the winter and spring. Early morning fogs, so-called "high fogs," may also be considered a climatic characteristic, for they are not of infrequent occurrence here, as elsewhere in Southern California.

The average rainfall is 15.59 inches, of which 7.45 inches falls in the spring and 6.55 in the winter. The mean annual relative humidity as given by Bridge ("The Climate of Southern California," Transactions of the American Climatological Association, 1901) is 64.4 per cent. The average mean winter temperature as given by the same authority is 54.7°; for summer, 75.3°; spring, 63°; autumn, 66° F. (Solly). Sanborn ("The Climate of the Eastern Foothills," by Dr. C. A. Sanborn, Redlands, Cal., Transactions of the American Climatological Association, 1902) gives for Redlands the following extremes of temperature from an average of three years for the three months exhibiting the greatest extremes of heat and cold:

January	Mean maximum temperature	62 degrees.
	Mean minimum "	40 "
February	Mean maximum "	about 69 "
	Mean minimum "	42 "
July	Mean maximum "	about 95 "
	Mean minimum "	59 "
August	Mean maximum "	about 91 "
	Mean minimum "	58 "

The average mean relative humidity of Redlands for these months is given by the same authority as 55.7 per cent.

In the summer the temperature occasionally goes above 100° F. in the middle of the day, but with the dry atmosphere this is not so uncomfortable as might be supposed. The difference between the day and night temperatures is great, something like 20° to 30°. Similarly, there is a great difference between the night humidity and the day humidity. "This means to an invalid," as Solly remarks ("Medical Climatology"), "a climate possessing, in the course of the day, perhaps six hours of moderate dryness, and eighteen hours of positive dampness."

These two characteristics of the fall in temperature and increase in dampness at night probably account for the apparent chariness with which the residents open and keep open their windows, and the fear they have of sitting out of doors at night. As paradoxical as it may seem, one can evidently sit out of doors more evenings in the year in New England than in Southern California; or else the New Englander is more venturesome and hardened in enduring the evening air than is the Californian of the South.

Freezing weather is very rare.

The mountains to the north of this valley shut off the winds from the desert, but the sea breeze blows daily, beginning usually about ten o'clock in the forenoon, and lasts until sunset. There are said to be over three hundred sunshiny days in the year at Redlands. At San Bernardino, about eight miles to the northwest, the total number of clear days, as given by Dr. A. K. Johnson, a volunteer observer (period not given), is 235; fair days, 95; cloudy, 35; rainy, 33½. According to Sanborn (*loc. cit.*) "patients with pulmonary lesions, not far advanced, do well in this climate (Redlands and vicinity), especially in that part of the valley where orange growing and the consequent dampness from irrigation do not prevail." Sanborn also refers to the irritation of the respiratory tract brought about by the extensive use of commercial fertilizers. He has noticed a prevalence of tonsillitis and pharyngitis occurring at the time of using this material. "Nervousness" is said to be increasing here as well as in other portions of Southern California, and it is attributed by Sanborn to various causes, climatic and others, such as eye strain from a succession of bright days, and nostalgia.

Five miles from Redlands, on the line of the Southern

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Pacific Railroad, is the *Loma Linda Sanatorium* (about twelve hundred feet), beautifully situated on the hillside about two hundred feet above the surrounding country. It is approached through a stately avenue of pepper trees, and is surrounded by orange groves and beautiful gardens. The view from the sanatorium is extensive and grand, the lofty "Arrowhead" and its hot springs lying directly in front. The buildings of this institution are well equipped, containing operating-rooms, etc., and excellent accommodations are offered to the nervous and other invalids, as well as to those who only desire to rest under such favorable conditions of situation and climate. The tuberculous are not received here.

Riverside (elevation eight hundred and fifty feet) is a city of ten thousand inhabitants, about sixteen miles by rail southwest from Redlands. It is the most famous orange-growing district in Southern California, and is well supplied with water for irrigation and domestic purposes, from a number of artesian wells near the mountains. The drainage is good, and the city affords every opportunity for comfortable living, either for the transient or for the permanent resident. There are attractive parks, in one of which is the curious "cacti garden." There are also beautiful estates, many churches, fine school buildings, a Carnegie library, miles of pleasant roads through the orange groves, and avenues shaded by the eucalyptus, the pepper, and the palm, among them the famous Magnolia Avenue.

The vegetation, as at Redlands, is most luxuriant, and besides the orange, the pomegranate, olive, persimmon, fig, and other fruits are found here. Flowers abound in a wild profusion, and this whole area seems like one vast park or garden.

The accommodations are good. Besides the lovely drives and walks, there are opportunities for golf, polo, and tennis.

The climate is similar to that of Redlands. The average yearly rainfall for fourteen years was ten inches, February and March being the rainiest months (Solly, "Medical Climatology"). The relative humidity for the year 1888 was 65.5 per cent. The mean monthly temperature for the seasons, covering a period of twelve years is as follows: Spring, 60 ; summer, 74 ; autumn, 71 ; winter, 51° F.* The mean for July is 76° ; maximum, 106 ; mean for August, 76° ; maximum, 104° ; mean for January, 50° ; minimum, 29°. The average variation between the day and night temperatures, as given by Sawyer ("A Study of Riverside Climate," etc., Southern California *Practitioner*, 1887), for January is 20°, and for July, 34°. "The ordinary wet season at Riverside," says the same author, "is much drier, has less rain, and a larger proportion of dry, clear sunshiny days than the average summer in New York, Boston, or Chicago." The amount of sunshine is great, and, according to Sawyer, there were two hundred and eighty absolutely clear days from July, 1885, to July, 1886.

Thirty-five miles southeast of Colton, which is eight miles north of Riverside, is the little town of Hemet, the starting-point for the carriage ride to the health resort of *Idyllwild*. This is a journey of twenty miles, the last ten of which are up a steep mountain road. Idyllwild has an elevation of 5,250 feet, and is situated in the Strawberry Valley, in a large forest tract of fifteen hundred acres, which is again bounded by extensive government forest reservations. The valley is well timbered, the pine, cedar, and live oak predominating. The climate possesses the characteristics of the high altitudes in a comparatively warm latitude, the atmosphere being dry and pure ; and the temperature warm but not hot in summer, and in winter cool, but not generally going below the freezing point. As is generally true of this whole region the majority of the days are sunny.

The Idyllwild Sanatorium occupies a well-protected situation, and besides a large, well-appointed central building containing fifty-one rooms, there are several cottages of three and six rooms, tents, etc. There are appliances for furnishing steam heat and electricity, an ice plant, and a steam laundry. Families who come with their invalids can also find accommodations here, and means of recreation in riding, golf, tennis, etc. There is also a school for the younger children. The sanitary conditions are well looked after. The water comes from a pure mountain spring, and there is a well-constructed sewer system. The plumbing is modern and good.

Pulmonary tuberculosis in the curable stages is the principal disease treated here, and there are a resident physician and nurses.

From a personal visit the writer can testify to the wild beauty of the scenery, the delicious purity of the air, and the energy and devotion of the managers in building on this mountain plateau a well-equipped and extensive sanatorium, with all modern improvements. For one who desires to take the open-air treatment in the high altitudes, and at the same time avoid the severity of the winter climate found in the altitudes farther north, such as at Colorado and in the Alpine resorts of Europe, Idyllwild would seem to afford ideal conditions, not only of climate, but of accommodations. The only drawback is the long, tiresome carriage ride, but this in time will probably be obviated by a mountain railway.

Edward O. Otis.

RED SULPHUR SPRINGS.—Monroe County, West Virginia. Post-Office.—Red Sulphur Springs. Hotel.

Access.—Viâ Chesapeake and Ohio Railroad to Alderson's, thence by stage to springs.

These springs are beautifully situated on Indian Creek, and are surrounded by pine-clad mountains. They are two in number, and flow two hundred and ten gallons per hour. The water has a temperature of 51° F. It was analyzed in 1842, but the results were not very satisfactory. The total solids found to be present in one United States gallon amounted to about twenty-four grains, and approximately one-third of this consisted of sulphur.

A new analysis of this water is very much to be desired. Its virtues are presumed to rest to a great extent upon the sulphur which it contains. Aside from this substance it contains ingredients which justify us in classing it as a light saline calcic water. From abundant corroborative medical testimony there seems to be no doubt that the water causes a decided slowing of the heart's action in an excited state of the circulation. The water further seems to exert a soothing influence upon the mucous membrane of the lungs and bronchi, allaying irritation and diminishing expectoration. In virtue of these properties it has often proved decidedly beneficial in hæmoptysis, early phthisis, chronic bronchitis, chronic pharyngitis, and chronic laryngitis. In small quantities the water is said to be cathartic, while in larger doses it is diuretic.

James K. Crook.

REDUCTION-DIVISION.—When in the course of cell division the chromatin is distributed to the daughter nuclei in such a way that the material forming one daughter nucleus has a different ancestral history from the material forming the other, the division is called a reduction, or, better, *reducing division* ; and is thus distinguished from the ordinary *equal division*, in which every particle of the chromatin is divided equally between the two daughter nuclei (see article *Cell*).

Theoretical.—If we suppose that the physical basis of heredity consists of distinct units in the chromatin material of the nuclei of the germ cells, then at each union of two germ cells in sexual reproduction the number of ancestral units, or ancestral germ-plasms, will be doubled. And, unless prevented in some way, this doubling will continue with each successive sexual union, until either the germ cells will be increased to an enormous size, or else the units will be reduced in size so much that they are smaller than the proteid molecule.

Roux in 1884 published an elaborate review of the whole subject of mitotic cell division, so far as it had

* Quoted by Solly from a meteorological record issued by the Riverside Board of Trade.

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been developed at that time, and his conclusion was that the *longitudinal splitting* of the chromosomes and the whole mechanism by which the two halves of an originally single chromosome are always carried to opposite poles of the spindle, has for its object the distribution of the chromatin, both as to quantity and as to quality, in exactly equal proportions to the two daughter cells (see *Chromosome*).

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A study of the phenomena of heredity led Weismann to suppose the chromatin to be made up of elements as indicated in the previous paragraph (see also article *Heredity*) and that these ancestral germ-plasms maintain their individuality through successive generations. And this led to the further supposition that sexual reproduction can be continued only in case there is a reduction in the number of ancestral germ plasms, a reduction that must be repeated in every generation. But Roux's conclusions would seem to make such a reduction improbable so long as the division takes place by the ordinary method accompanied by a longitudinal splitting of the chromosomes.

Writing in 1887, Weismann says: "This is the only kind of karyokinesis which has been observed until recently; but if the supposed nuclear division leading to a reduction in the number of ancestral germ-plasms has any real existence, there must be yet another kind of karyokinesis in which the primary equatorial loops are not split longitudinally, but are separated without division into two groups, each of which forms one of the two daughter nuclei. In such a case the required reduction in the number of ancestral germ-plasms would take place, for each daughter nucleus would receive only half the number which was contained in the mother nucleus." After discussing the work of van Beneden (1883) and Carnoy (1886), then recently published, Weismann defines the terms "reducing division" and "equal division," and then adds the following explanation of his prediction: "The 'reducing division' must be always accompanied by a reduction of the loops to half their original number, or by a transverse division of the loops (if such division ever occurs); although reduction can only occur when the loops are not made up of identical pairs. And it will not always be easy to decide whether this is the case. On the other hand, the form of karyokinesis to which a longitudinal splitting of the loops takes place *before* they

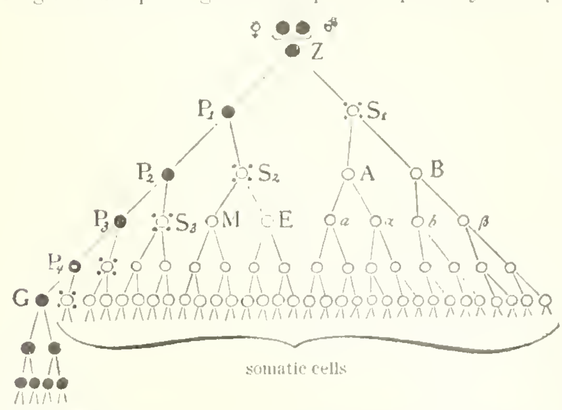

FIG. 3926. —Diagram showing the Pedigree of the Germ Cells of Ascaris. *Z*, Fertilized egg; P_1, P_2, etc., protogonocytes; *G*, primordial germ cell (P_5, Fig. 2611, article *Heredity*); S_1, S_2, etc., primary somatic cells; *A* and *B*, primary ectodermal cells; *E*, primary endodermal cell; *M*, cell which produces mesoderm and part of ectoderm. (Modified from Boveri.)

separate to form the daughter nuclei must always, as far as I can see, be considered as an 'equal division.'"

This prophecy is one of the most famous in the annals of science, because it has been one of those most fertile of results, having furnished the stimulus for a large number of very careful investigations. It is the purpose of the present article to describe some of these results, and to consider whether they show a fulfilment of this prediction.

The Germinal Cycle.—The complete history of the germ cells has not yet been followed through all its stages in any animal or plant. But enough is known to make it

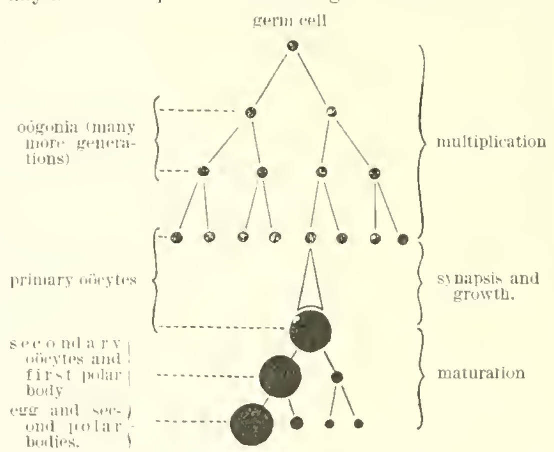

FIG. 3927. Diagram showing the Genesis of the Egg. (Modified from Boveri.)

clear that there is a complete continuity of generations of cells in this history, which consists of a series of cycles, and we may consider each cycle as having its beginning and its end in the act of fertilization. These cycles follow one another in unending sequence so long as the race remains extant.

The *germ cells* are those which have for their purpose the provision of the material out of which future generations are to be produced, and they form but a small portion of the body of any multicellular organism. The greater part of the body is made up of *somatic cells*, which serve to shelter and nourish the germ cells. The history of the somatic cells is likewise a series of cycles having their beginnings in the act of fertilization. But there is no continuity between the cycles. For the somatic cells, having fulfilled the purpose of their being, die, and have no genetic relation to the cells forming the body of the next generation, except community of origin in the ancestral germ cells.

In the history of the germ cells each cycle may be divided into several periods, and the cells in each period have been given distinctive names. We shall follow in the main the terminology recently adopted by Waldeyer (1902).

By the union of an ovum and a spermatozoon there is formed a single cell with a nucleus of double origin (see *Impregnation*). This cell is the fertilized egg, or *oöspermium*. Immediately after fertilization there follows a series of cell divisions resulting in what is known as the segmentation of the ovum (see article *Segmentation of the Ovum*). The result of the first division is the formation of two cells—the first primary somatic cell and the first stem cell, or *protogonocyte* (S_1 and P_1, Fig. 3926). The latter divides again to form a second primary somatic cell and the second protogonocyte (S_2 and P_2). This series of divisions continues through a series of generations of cells, the number of which varies with the species (see *Heredity*), until finally the last protogonocyte gives rise to a primary somatic cell and the primary germ cell or *archigonocyte* (S_5 and *G*, Fig. 3926). In the mean time, of course, the somatic cells have been dividing to form the tissues of the embryo.

The second period begins with the division of the archigonocyte to form two *gonocytes*. These continue to multiply by division until, according to Beard, they reach a certain number, which may be approximately constant for the species. Finally, whether by migration or otherwise, the gonocytes come to lie in the germinal epithelium upon the genital ridge. (For the sake of clearness we

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Reduction-Division.

will confine our attention to the higher animals for the present.)

The beginning of the third period coincides with the differentiation of the genital ridge into ovary or testis, and in this period the history of the germ cells begins to diverge in the two sexes. In the female the last generation of the gonocytes may produce two kinds of cells. Some produce follicle cells or other cells serving to nourish the eggs, while others give rise to the first generation of *oögonia*, or primordial eggs. The oögonia continue to multiply for an undetermined number of generations. Finally this period of multiplication is followed by a period of growth during which division ceases. The oögonia have now become *primary* oöcytes (see Fig. 3927).

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The period of growth is followed by the period of maturation, during which two cell divisions occur, usually in rapid succession. The primary oöcyte, having attained its full size, divides very unequally to form the *secondary* oöcyte and the first polar body. Then the oöcyte divides again unequally, forming the second polar body and the ripe ovum, or *ovium* (Greek ὠίον, egg), as Waldeyer prefers to call it. The first polar body may divide also at the same time, so the maturation divisions result in the formation of four cells—the relatively large ripe egg and three very small polar bodies. The view now universally held, that the polar bodies are abortive eggs, was first stated by Mark in 1881.

These periods in the history of the egg are exactly parallel in the history of the spermatozoon. In the male the last generation of gonocytes may likewise give rise to nutritive cells and to *spermatogonia*. The latter multiply by division for an indefinite number of generations of cells and the last generation gives rise to primary *spermatocytes*, which then enter upon a period of growth (Fig. 3928). This is followed, as in the egg, by two maturation divisions. In the first the primary spermatocyte separates into two secondary spermatocytes, and by the second division each secondary spermatocyte produces two *spermatids*. Thus the maturation divisions result in the production of four cells, but in the male these are all of the same size and all are capable of becoming functional.

But in order to become functional the cell must pass through another period, not represented in the history of the egg. This is the period of histogenesis, during which

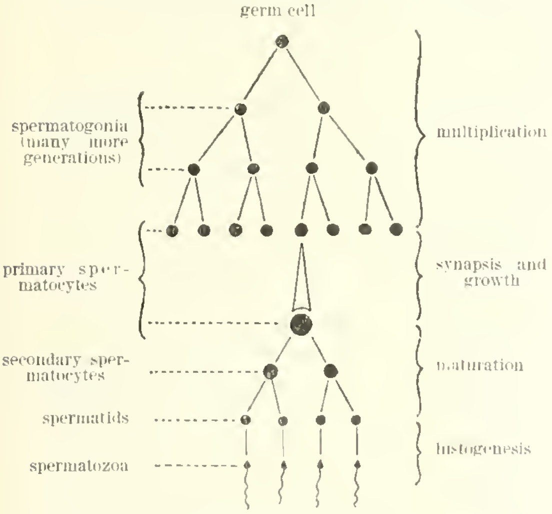

FIG. 3928.—Diagram showing the Genesis of the Spermatozoa. (Modified from Boveri.)

the spermatid undergoes a remarkable metamorphosis by which it becomes transformed into a *spermatozoon* with the characteristics peculiar to its species (see article *Spermatozoa*). With the entrance of the spermatozoon into the egg and the union of the sperm nucleus with the egg nucleus the old cycle ends and a new one begins.

During the periods from the first cleavage of the ovum to the last division of the oögonia or spermatogonia the number of chromosomes present during the prophases of division is always the same in individuals of the same species and is, with rare exceptions, the same as the number found in the somatic cells (Figs. 3936, 3937, and 3929, *B*). But at the beginning of the growth period the nuclei of the germ cells undergo a remarkable series of transformations, which result in the reduction of the number of chromosomes to one-half the number present in the earlier periods; and the reduced number is found in the oöcytes, spermatocytes, and spermatids, and in the egg and sperm nuclei previous to their union. (Compare the figures cited above with Figs. 3938, 3940, and 3929 *L*.)

Therefore, if a reducing division, as defined by Weismann, really occurs, it is to be sought for in one of the two divisions immediately following the growth period. These are the maturation divisions.

In considering the results of investigations upon this subject, the reader should bear in mind that before the material can be studied it must be killed, hardened, embedded in paraffin, cut into sections, stained, and mounted in balsam; and that each one of these operations is a possible source of error. Moreover, the objects are so minute that they can be studied only with the aid of a microscope of high magnifying power, and, further, it is impossible to view any one of these objects from more than one side. It is doubtless due to these difficulties of observation that the published descriptions of what takes place during this most interesting and important period in the history of the germ cells are so diverse and so often contradict one another. Although much has been written on the subject, the diversity of results is so confusing that it is impossible to formulate any general description that will apply to all species. Nevertheless there is sufficient agreement to encourage the hope that the progress in the improvement of methods will eventually lead to such a uniformity of results as to make it possible to formulate a general law applicable alike to all species of animals and plants.

At present the most complete and consistent account is to be found in a series of papers by Montgomery, who has studied the spermatogenesis in forty-two species of bugs, hemiptera heteroptera, and in Peripatus, a form of special interest on account of its supposed relation to the ancestral type of the insects and their allies. The following general description will be based, therefore, chiefly upon Montgomery's results, supplemented by the work of Paulmier upon spermatogenesis in the squash bug, *Anasa tristis* (Fig. 3929). The general account will be followed by sections, treating briefly of the parallel phenomena in oögenesis, and by others referring to variations to be found in other animals and in plants.

The Last Spermatogonic Division.—In the resting spermatogonia the chromatin appears to be scattered irregularly throughout the nucleus, but the granules are connected by the threads of linin. The nucleus is like a lacework ball made of strings of beads, in which the thread is the linin and beads the chromatin. In the early prophase of division the chromatin becomes arranged in a single long winding thread covering; according to Montgomery, a single strand of linin. This is the dense spireme stage. The spireme continues to shorten, and at the same time the chromatin becomes segmented into the number of chromosomes characteristic of the species. This number varies from eleven to twenty-eight in the bugs. But the linin remains intact and connects the chromosomes by their ends. The achromatic spindle is formed, the chromosomes are arranged in the equatorial plane, split longitudinally, and the halves are drawn to opposite poles in the typical manner.

In Peripatus the chromosomes are rod-shaped at this stage, and in the late anaphase they lie parallel to the spindle fibres. The ends pointing toward the centrosome are called the *central ends* and the opposite ones are

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the *distal ends*. The distal ends of sister chromosomes are joined by "connecting fibres" of linin, and although unable to prove it, Montgomery thinks that probably the linin in each daughter group of chromosomes still forms a continuous spireme, so that each chromosome is connected by it at the central end with its neighbor on one side, and at the distal end to the neighbor on the other side. Finally the chromosomes become massed in a dense group, but not fused, near each centrosome, and the cell body becomes constricted in the middle. The two daughter cells are primary spermatocytes.

Synapsis.—The young primary spermatocytes are easily distinguished from young spermatogonia by the peculiar condition of the nucleus. The changes which take place at this stage were first described by J. E. S. Moore in 1895, under the title *synapsis* (συνάπτω, to fuse together). And it now seems probable that the synapsis is a stage of universal occurrence in the history of the germ cells of both animals and plants. An especially characteristic feature of the synapsis is the grouping of the chromatin in a dense mass on one side of the nucleus, leaving a large clear space on the other side, between the chromatin and the nuclear membrane. (Compare Figs. 3929 *D* and *E*, 3933 *B*, 3934, and 3938.) The interest attached to this phase is due to the fact that when the chromatin emerges from this tangle it is found to be divided into segments of just *half* the number present in the previous anaphase, and these segments are either split longitudinally or soon after become split. It is at this time, then, that the *reduction* in the number of chromosomes takes place; and it would seem that this reduction without division, as has been held by Moore, Farmer, and others, destroys all ground for Weismann's theory of a reducing division.

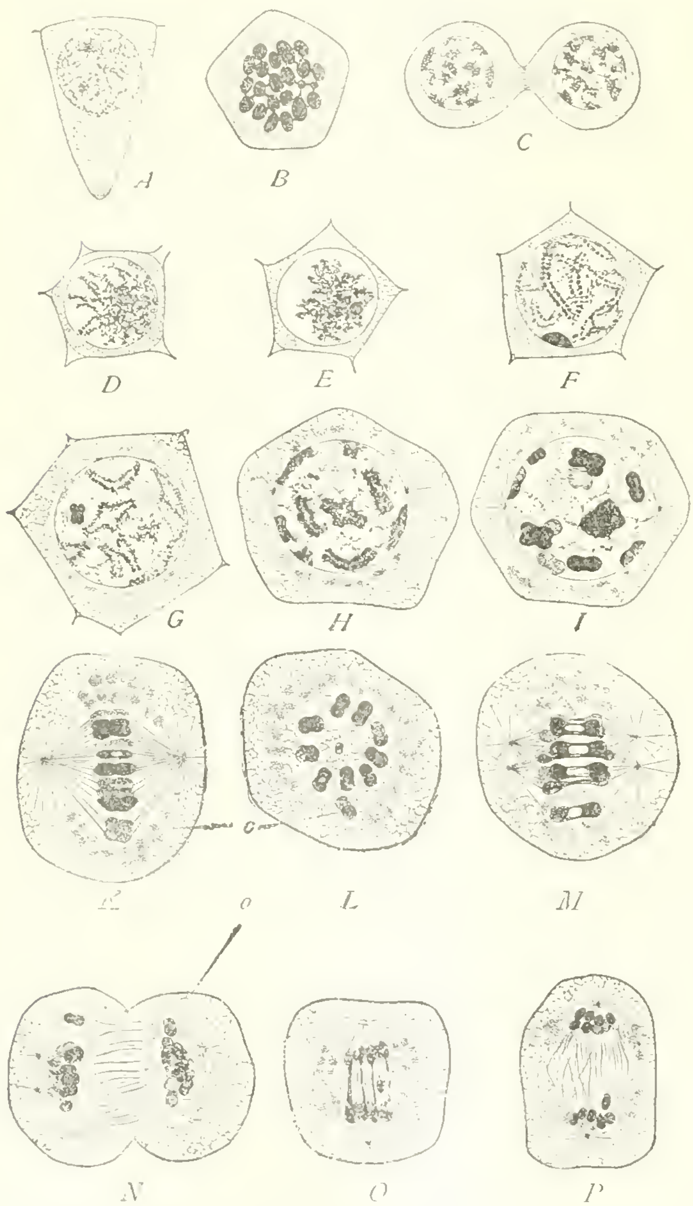

FIG. 3929.—Various Stages in Spermatogenesis from Sections of the Testes of the Squash Bug. *A*, Spermatogonium; *B*, spermatogonium preparing for division, cross section of equatorial plate showing twenty-two chromosomes; *C*, division of spermatogonium nearly completed; *D* and *E*, primary spermatocyte in synapsis; *F*, *G*, *H*, and *I*, stages in the formation of tetrads; *K*, *L*, *M*, and *N*, first division of spermatocyte; *O* and *P*, second division of spermatocyte; *c*, accessory chromosome. (From Wilson, after Paulmier.)

In most forms the mass of chromatin during the synapsis is so dense that it is impossible to see what takes place within it. But in Peripatus Montgomery was so fortunate as to find a form in which it is possible to distinguish the individual chromosomes, and he was able to determine that they become *fused in pairs by their central ends*, and a similar result has been obtained by Sutton in the grasshopper (Fig. 3938). Thus if the twenty-eight chromosomes that enter the synapsis stage in Peripatus are univalent, the fourteen that emerge from it are bivalent, and no true reduction has taken place after all, for there has been no discharge of chromatin from the nucleus. The bivalent chromosomes have the form of the letter V or U, and the angle of the V or U marks the position of the central ends, which in some cases can be seen to be connected by a short band of linin.

On emerging from the synapsis stage the chromosomes gradually elongate, and finally fill the nuclear space again. During this process the chromatin becomes separated into granules, all connected by an axial band of linin. Then the granules become flattened and finally divide in the plane of the longitudinal axis of the chromosome, forming a row of granules on each of the opposite edges of the now flattened axial band (Figs. 3929 *F* and 3939).

Finally the axial band splits and the rows of chromatin granules become more widely separated. At the same time very fine filaments of linin appear to connect each pair of granules, and to connect these in turn with pairs of granules in neighboring chromosomes. Thus the nucleus passes gradually into the resting condition of the growth period, in which it is rarely possible to distinguish the boundaries of individual chromosomes. In exceptional cases the resting condition of the nucleus appears to be entirely omitted at this stage, as in two families of bugs, the Coreidæ and Reduviidæ, and also in plants (Figs. 3929 and 3938).

The First Maturation Division.—The prophase of the first maturation division in Peripatus begins with the coming together of the chromatin granules to form an irregular reticulum. There is no spireme, but the reticulum appears to give rise to the chromosomes directly, and

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Montgomery gives reasons for believing that the reticulum is only apparent, and is really formed of overlapping and interlacing chromosomes that have never lost


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FIG. 3930.—Chromosomes from Primary Spermatocytes of the Squash Bug, showing changes of shape leading to the formation of tetrad. *a*, Distal end; *b*, central end; 6, completed tetrad with long axis corresponding to the longitudinal split. (After Paulmier.)

their identity. The chromosomes shorten and assume a great variety of form, most of them being more or less U- or V-shaped. Sometimes the two limbs of the U are twisted together, sometimes they are united at the ends to form a ring. These chromosomes are seen to be bivalent, that is, composed of two univalent chromosomes united by a band of linin at the bend of the U, and each univalent component is split longitudinally. The chromosomes which take part in the first maturation division are therefore similar in form as well as equal in number to those at the end of synapsis.

By the time that the chromosomes reach the equators of the spindle they have become very much condensed, so that the central linin band is covered with chromatin and the longitudinal split is represented by a mere notch at the distal end. In Peripatus the chromosomes at this stage most frequently have the form of a bent dumbbell,

FIG. 3931.—Primary Spermatocyte of Batrachoseps in a Stage Immediately Preceding the Metaphase. Eight of the twelve chromosomes are seen approaching the equator of the spindle. × about 1,500. (After Eisen.)

sometimes it is a straight dumbbell, sometimes two thick parallel rods, and more rarely a ring-shaped chromosome is found. In many insects and crustacea the chromosomes at this stage have the form of *tetrads* (Fig. 3929 *K*); that is, each bivalent chromosome is seen to be composed of four minute balls of chromatin more or less closely pressed together. In vertebrates and in the higher plants the chromosomes are more or less ring-shaped at this stage (Fig. 3931).

The chromosomes now divide in a plane at right angles to the axis of the spindle, and the halves are drawn toward the opposite centrosomes. In the case of Peripatus the dumbbells are divided transversely. Where the tetrads are present, the daughter chromosomes are *dyads*, each composed of two balls of chromatin (*M* and *N*, Fig. 3929). The ringshaped chromosomes are broken so as to form two horseshoe-shaped bodies (Fig. 3932).

If this division of the bivalent chromosomes takes place in such a way that their original univalent components are separated, we have here a *reducing division*, as de-

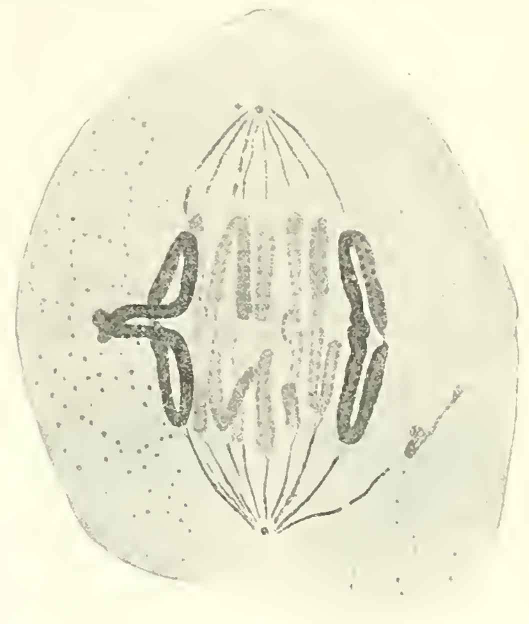

FIG. 3932.—Primary Spermatocyte of Batrachoseps in the Metaphase, Chromosomes Dividing. × about 1,500. (After Eisen.)

scribed by Weismann. But if the daughter chromosomes consist of parts of two originally separate chromosomes, then we shall have to seek farther for the reducing division.

The question can be decided only by very careful study of the changes in form and structure exhibited by the chromosomes from the beginning of the synapsis to the completion of this division. This has been done by Paulmier in the case of the squash bug, and by Montgomery in forty-two Hemiptera and in Peripatus. They find that in all of these species the first maturation division is transverse, and is a *true reducing division*, separating each bivalent chromosome into its original components.

Both Montgomery and Paulmier figure each daughter chromosome as being drawn toward its respective centrosome by two spindle fibres (*K*, Fig. 3929). Soon each centrosome divides into two preparatory to the next cell division, and it is found in Euchistus and in the squash bug that of each pair of spindle fibres one is connected with one daughter centrosome, and the other fibre is attached to the other one (*M*, Fig. 3929). With the division of the cell bodies the first maturation division is completed, forming two *secondary spermatocytes*.

The Second Maturation Division.—Usually there is no resting condition of the nucleus between the first and second maturation divisions. The longitudinal split which appeared in the chromosomes during the prophase

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of the first division has reappeared during the anaphase. At the beginning of the second division the daughter centrosomes move through an angle of ninety degrees, and a spindle is formed with the chromosomes arranged in an equatorial plate. They are arranged now so that the split is at right angles to the spindle. During the anaphase the halves of the chromosomes are drawn to opposite poles (*O* and *P*, Fig. 3929).

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The secondary spermatocyte then divides, forming two *spermatids*. The change from a group of chromosomes to a resting nucleus, which ensues at this stage, is peculiar in that it is effected by the swelling of the chromosomes. A vacuole appears in each chromosome, so that each one becomes a small vesicle. These vesicles uniting form the resting nucleus, around which there is finally developed a nuclear membrane.

The history of the spermatid in the final period of histogenesis, during which it becomes transformed into a functional spermatozoon, will be treated elsewhere (see article *Spermatozoa*).

The Maturation of the Egg.—The parallel between the course of development of the egg and that of the spermatozoon in their external features has been pointed out in a preceding paragraph. The parallel extends also to the nuclear changes, as was first clearly suggested by Platner in 1889. Comparison of the processes of spermatogenesis and oögenesis in Ascaris led Boveri to make a more positive statement in 1890, and its truth was completely demonstrated, so far as Ascaris is concerned, by O. Hertwig a few months later.

These discoveries relate chiefly to the divisions of the chromosomes. The synapsis stage was first clearly recognized in the development of eggs by Woltereck (1898) through his studies on the Ostracoda. In 1900 von

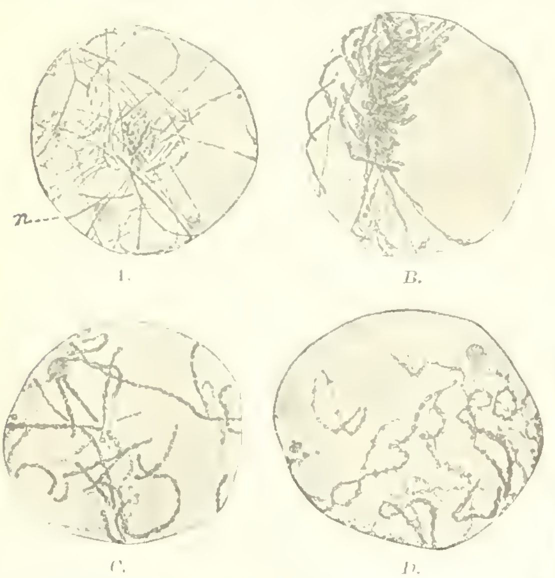

FIG. 3933. Nuclei from the Ovary of a Human Fœtus of about Seven Months, showing consecutive stages in the development of the oöcyte. *B*, synapsis; *n*, nucleolus. × 1700. (After Winiwarter.)

Winiwarter published an elaborate description of this stage in the history of mammalian ova (Fig. 3933). An abstract of his results is given in the article *Ovum*.

As in the corresponding stages in spermatogenesis, shortly after the last division of oögonia, the nuclei of the young oöcytes pass through the synapsis stage, characterized by the massing of chromatin filaments at one side of the nucleus (Fig. 3933 *B*). The chromosomes emerge from the tangle with their number reduced to half the number present during the previous anaphase. These chromosomes are, or soon become, split longitudinally. They continue to elongate, and finally the nucleus enters into the resting condition. It remains in this condition during the growth period, during which the oöcyte increases enormously in size. This period may extend through many years, as in man.

Just before, or very soon after, the egg is discharged from the ovary the first maturation division occurs, which results in the budding off of the very small first polar body from the egg, which then becomes a secondary oöcyte. The nuclear phenomena at this time are exactly like those to be observed during the division of the primary spermatocytes of the same species.

In the same way the process of formation of the second polar body is like the division of the secondary spermatocytes of the same species.

Thus the processes of oögenesis and spermatogenesis are parallel in every essential particular; the main difference being that in the maturation divisions of the spermatocytes, the resulting cells are equal in size, while those that result from the divisions of the oöcytes are very unequal; and the spermatids undergo a further metamorphosis associated with the special function of the spermatozoa, a change which the special function of the egg renders entirely unnecessary.

Variations in the Process of Maturation.—The forms of the chromosomes and the details of their divisions during maturation differ widely in different groups of animals, and this has resulted in various interpretations of the process by different writers.

Many authors have confirmed Weismann's prediction that a reducing division takes place. But they are not all agreed as to the time when the reducing division occurs. Weissmann predicted on theoretical grounds that the reducing division would occur during the formation of the second polar body. Paulmier and Montgomery found, on the contrary, that in Hemiptera the first is a reducing division, the second an equal division. Similar results were obtained previously by Korscheldt in an annelid, Ophryotrocha, by Wilcox in a grasshopper, Caloptenus, and by Henking in a firefly, Pyrrhocoris. On the other hand, Häcker, von Rath, and Rückert are agreed that in the copepoda the reducing division comes after an equal division, as predicted by Weismann. Similar results have been obtained by von Rath in the mole cricket, Gryllotalpa, by Calkins in the earth-worm, Lumbricus, by Griffin in Thalassema, and by Sutton in Brachystola.

In Ascaris and various vertebrates, chiefly selachians and amphibia, it has been found that both maturation divisions are accompanied by longitudinal splitting of the chromosomes, and authors working upon these forms have been led thus to deny the existence of any reducing division. In Ascaris the two chromosomes, which appear in the oöcyte preparing for division, are elongated and split longitudinally in two planes at right angles to one another. By the shortening of these rods each chromosome becomes a typical tetrad, which divides in the usual manner; that is, in the first maturation each tetrad divides, forming two dyads. One dyad of each pair remains in the egg and separates into two single chromosomes, one of each pair going to the second polar body, so that the first polar body receives two dyads, the second polar body and the ripe egg each two single chromosomes.

In the vertebrates the chromosomes in the spermatocytes preparing for the first division are U-shaped. At an early period a longitudinal split appears at the bend of the U, but the two halves remain united at the ends and open out to form a ring (Fig. 3931). In the metaphase the ring shaped chromosomes separate into two U's by breaking across at the points of union (Fig. 3932). This form of mitosis was called *heterotypical* by Flemming, and is highly characteristic of this stage in the vertebrates. In the next division each chromosome again splits longitudinally. Montgomery has rightly contended that it does not necessarily follow that both divisions are equal, even if they are both longitudinal. In the Hemiptera it was shown that the chromosomes of the first spermatocyte are bivalent having been formed by the union

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of two univalent chromosomes end to end, and it is perfectly possible that in the vertebrates the corresponding bivalent chromosomes are formed by the union of two univalent ones side by side. In this case one of the longitudinal splittings would be a true reducing division, separating the original chromosomes or the halves of originally separate ones. This question can be settled only by a very careful study of the fusion of the chromosomes during synapsis.

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FIG. 3934.—Pollen Mother-Cell of the Lily with Nucleus in Synapsis. × 585. (After Sargant.)

Reduction in Plants.—In the vascular cryptogams and the flowering plants the phenomena attending a reduction in the number of chromosomes preparatory to sexual reproduction are closely parallel with those found in animals, but present interesting differences.

In these plants the cell corresponding to the last generation of oögonia or spermatogonia in animals usually lies just beneath the epidermis and divides parallel to the surface into an outer *tapetal cell* and an inner cell, the *archesporium*. The mitosis is typical with the normal number of chromosomes. When the archesporium prepares for division the chromosomes reappear reduced in number to one-half, and the normal number is not restored until the male and female pronuclei unite in fertilization. Usually the archesporium divides twice in rapid succession. The result in the Hepaticæ and ferns is the production of four spores. Each spore may then divide by typical mitosis, but with half the normal number of chromosomes. It thus, by continued cell division, forms a prothallium, which exists for some time as an independent plant, and bears the sexual organs, in which the ova and spermatozoa are produced.

In the male flowering plants, the archesporium gives rise to four pollen grains. It is not, however, the primary nucleus of the pollen grain that forms the male pronucleus, but it is its granddaughter nucleus. In the female flowering plants Schniewind-Thies (1901) has found three types of development. In the first the archesporium divides into two daughter cells, and each of these divides into two, making four cells in a row perpendicular to the surface. One of these cells is the young "embryo sac," the others are cover cells, which subsequently undergo degeneration, and may be compared to the polar bodies of animals. Within the embryo sac three nuclear divisions occur, and one of the resulting nuclei is the female pronucleus. In the second type the archesporium divides into two daughter cells, one of which becomes the embyro sac, in which three divisions occur as before. Finally in the third type the archesporium itself becomes the embryo sac. In each case the reduced number of chromosomes first appears in the archesporium and the divisions of the archesporium and its two daughter cells differ from the typical mitoses, being described as heterotypical and homeotypical respectively. These terms were applied originally to the first and second maturation divisions in vertebrates, and their use here indicates the striking similarity of the phenomena.

FIG. 3935.—Section of a Pollen Mother-Cell in a Later Stage, showing twisted chromosomes with double row of granules. *n*, Nucleolus. × 585. (After Sargant.)

As to whether a reducing division does or does not take place, opinion is much divided. Some good observers, notably Ishikawa and Belajeff, regard the first as an equal division and the second as a reducing division. But the majority of authorities, led by Strasburger, insist that both divisions are equal.

This result may be due in part to the fact that most of these authors have completely ignored the synapsis stage, and in their search for a reducing division, undoubtedly influenced by Weismann and Häcker, have concentrated their attention upon the daughter cells instead of upon the archesporium.

The history of both the pollen grain and the embryo sac of *Lilium martagon* has been studied and described with great care by Miss Sargant. In both series she finds a typical synapsis; but it is at the end, instead of at the beginning, of the growth period (Fig. 3934). The chromatic filaments, which showed signs of splitting before the synapsis, emerge from that stage as long flattened bands of linin bearing a row of chromatin granules upon each edge, as in Peripatus. These bands are bent and twisted together (Fig. 3935). As the chromosomes become more condensed the granules merge into a solid mass of chromatin, apparently covering up the linin; and when it reaches its place at the equator of the spindle, each chromosome is composed of two limbs tightly twisted together, giving the appearance of a minute skein of yarn; or, better, a very much twisted doughnut. In the metaphase the two limbs of the chromosomes are separated, and as they are pulled apart, they often assume a V shape; and apparently the original longitudinal split may reappear at this stage, as is indicated by Strasburger's figures. At any rate Miss Sargant finds, and her results are confirmed by many others, that in the second division the chromosomes are separated into two equal halves by a longitudinal split.

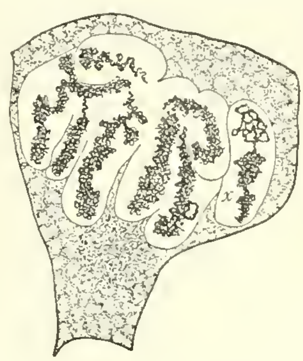

FIG. 3936.—Spermatogonium of Lubber Grasshopper in Early Prophase, showing very fine spiremes arranged in their respective diverticula of the nucleus. From a section. (After Sutton.)

But, aside from their inferences to the contrary, the writer is unable to find anything in the facts, as shown by the descriptions and figures published by Miss Sargant, Strasburger, Farmer, and Schniewind-Thies, that is inconsistent with the inference that the chromosomes previous to the first division are bivalent, formed by the union during synapsis of two univalent chromosomes end to end, and that the two limbs separated during the anaphase are originally independent chromosomes.

That the apparent reduction in the archesporium previous to division may be due to fusion of pairs of chromosomes end to end, was suggested by Strasburger in 1894, and Farmer, who first clearly recognized the synapsis stage in plants, suggested in 1895 that the *first* one might be a true reducing division, separating the univalent constituents of bivalent chromosomes. But he regarded this view as untenable, "for in animals no 'reduction' is claimed at this stage." Now the work of Montgomery, Paulmier, and others has made it clear that reduction may occur in animals at this stage, the first maturation division, and thus the chief ground for deny-

FIG. 3937.—Polar View of Equatorial Plate of Spermatogonium, showing twenty-two chromosomes and accessory, *x*; *i*, *j*, *k*, three pairs of small chromosomes. From a section. (After Sutton.)

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ing the existence of reducing division in plants appears to have been removed. Moreover, the similarity is so close at this stage that many of the figures drawn by Strasburger, Miss Sargant, and Schniewind-Thies to illustrate forms of chromosomes in plants might be substituted for some of Paulmier's or Montgomery's figures, representing corresponding stages, with very little change.

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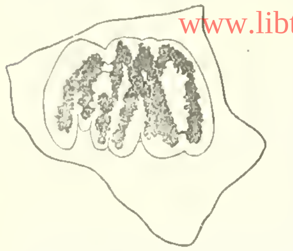

FIG. 3938. Primary Spermatocyte of Lubber Grasshopper in Synapsis (telophase of spermatogonium). Only a few of the chromosomes are shown. (After Sutton.)

Synapsis, Reduction, and Heredity.—As stated in the introduction, the conception "reducing division" had its origin in an attempt to satisfy the requirements of a theory of heredity. The conception has very recently gained new interest and importance through an announcement made by E. B. Wilson (1902) and the publication of preliminary papers by Sutton and Cannon. It was found by Montgomery that in certain species of bugs the spermatogonia contain a pair of chromosomes that

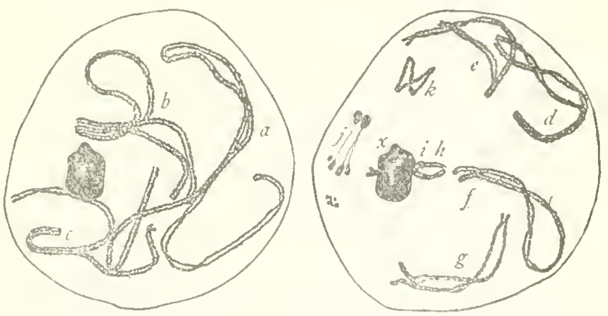

FIG. 3939.—Spiremes, or Chromosomes, from a Primary Spermatocyte in Early Prophase. Drawn in two groups to avoid confusion. From a smear preparation. (After Sutton.)

are unusually large or otherwise peculiar, and that after the synapsis in these cases there is only one large chromosome. Evidently the two peculiar ones have united. As a result of the maturation divisions each spermatid likewise contains one peculiar chromosome. The same is probably true of the egg. So one of these bodies in the spermatogonium is probably of paternal and the other of maternal origin. For this and other reasons Montgomery reaches the important conclusion that during the synapsis each bivalent chromosome formed is half of paternal and half of maternal origin, and the subsequent reducing division results in the separation of homologous paternal and maternal elements and their final isolation in separate germ cells.

FIG. 3940.—Chromosomes from Primary Spermatocyte in Middle Prophase, showing Longitudinal Split. *a*, *b*, *c*, etc., same as in Fig. 3939. (After Sutton.)

Now, as announced by Wilson, W. S. Sutton has found in the study of the spermatogenesis of a grasshopper, Brachystola, nearly complete proof of this inference, and W. A. Cannon has come to the same conclusion from the study of the maturation divisions of hybrid cotton plants. The chief results of Sutton's work are illustrated by Figs. 3936 to 3941. The last generation of spermatogonia have lobed nuclei, and each chromosome is formed in a separate diverticulum (Fig. 3936). In the late prophase of division the chromosomes are seen to be of different sizes, and there is one pair of each size, as *i*, *j*, *k*, Fig. 3937. In the following synapsis stage the chromosomes are seen to unite in pairs by their ends (Fig. 3938) and in the subsequent prophase there are eleven bivalent chromosomes, *a*, *b*, *c* . . . *k*, Figs. 3939 and 3940, corresponding to the pairs in the spermatogonium. The second maturation division is a true reducing division (Fig. 3941). If the oögenesis is the same, and the individuality of the chromosomes is maintained throughout the germinal cycle, then, of the two chromosomes that unite in synapsis, one must be of paternal and the other of maternal origin.

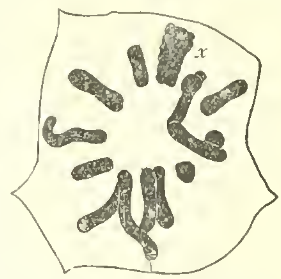

FIG. 3941.—Polar View of Equatorial Plate of Secondary Spermatocyte, showing eleven chromosomes and the accessory, *x*. (After Sutton.)

It was discovered recently by Boveri, that when the chromosomes in the segmenting ovum of a sea urchin have become disarranged as the result of double fertilization, and consequently unequally distributed to the blastomeres, abnormal larvæ result. He inferred from this that the chromosomes differ qualitatively and stand in definite relation to inheritable characters.

Taking all these results together, Wilson points out that they seem to confirm and to show a physical basis for Mendel's principle of heredity, which is being much discussed at present (see *Reversion*). Whether Mendel's theory be true or not, it is certain, as was shown in the article dealing with heredity, that it is in the nucleus of the germ cells, and especially in their chromatin constituents, that we must look to find the physical basis for heredity, and therefore the changes which these constituents undergo in the course of sexual reproduction possess the deepest interest for all students of biology.

Robert Payne Bigelow.

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REEDY CREEK SPRINGS.—Marion County, South Carolina. Post-Office.—Latla. Hotel and cottages.

This resort is located about three-quarters of a mile from the Atlantic Coast Line Railroad. The surrounding country is level and covered by the long-leafed pine. The springs are three in number, and have had a local reputation for more than thirty years. The water has a constant temperature of 45° F., and its flow is very large. Mr. John L. Dew, of the springs, sends us the following list of ingredients resulting from a partial analysis by former State Chemist Chizzell: Iron carbonate, calcium, magnesium, and sulphur. The water is used more particularly for stomach, liver, and kidney disorders and debilitated states of the system. *James K. Crook.*

REFLEX ACTIONS OR REFLEXES. See *Knee-Jerk.*

REFLEXES. (CLINICAL.)—Descartes introduced the conception of reflexes into biological literature. In "Passions de l'âme" he stated that stimulation of a sensory nerve impulse may be transmitted through the brain to motor nerves and thereby give rise to contraction of muscles, and that this contraction takes place without volition, and even contrary to it. The general reflex centre he believed to be the glandula pinealis.

This definition of reflexes was correct in the early days of biology, but, with the advance of knowledge, our conception of the reflexes has been enlarged.

The term is used in medical literature to-day in a twofold sense:

1. *Specifically*, as in pupillary, knee, plantar reflexes, etc.

2. *Generically*, as in reflex neurosis, reflex spasms, reflex cough, etc.

In both the strict sense (pupillary and knee reflexes, etc.) and in the broader sense (reflex cough, reflex neurosis, etc.) reflexes are centrifugal phenomena produced by reflexion and eventual transmutation of centripetal stimulation. In other words, reflexes are physiological or pathological, motor, vaso-motor, visceromotor, secretory or trophic phenomena, the cause of which is to be found in sensory stimulation.

There is still another group of phenomena called "reflex," to which the foregoing definition does not apply. This group is represented by a set of *centripetal* phenomena—reflex pains, reflex neuralgias, etc. Investigation shows that these phenomena are not genuine reflexes. One group of them, for instance pain in the distribution of the fifth nerve due to disease of the teeth or other structures of the head, or arm pain accompanying an anginoid attack, is, according to Head, an irradiation of a sensory stimulus to other parts or branches of the peripheral sensory apparatus of the affected locality.

Another group, for instance headache due to disease of the abdominal viscera, is, according to the same author, due to irradiations of the sensory stimulation to a central sensory station, and from here to allied sensory structures. Thus the difference between the two types becomes quite apparent.

The genuine reflex phenomena consist of neural stimulation that is reflected from one set of neurones (centripetal neurones) to a physiologically different set of neurones (centrifugal neurones).

The other type consists of neural stimulation that is irradiated and propagated from one set of neurones (centripetal) to another physiologically homologous set (centripetal neurones).

Finally, the term reflex is used promiscuously in medical literature to denote a phenomenon, the cause of which operates at some distance from where its effects are manifest.

According to the conception of genuine reflexes outlined above, all organic functions, save perhaps the distinctly voluntary functions, and some automatic visceral functions, may be looked upon as reflexes. Whether this be fully so or not, we will not attempt to decide. The considerable interest bestowed upon these phenomena, since the times of Descartes, testifies to the great importance of reflexes. (For further details in regard to these, consult the article on *Knee-Jerk* in Vol. V.)

In 1875 Erb and Westphal, working independently, demonstrated the clinical value of reflex phenomena, and since then their importance is daily more appreciated.

Prior to the publications of Erb and Westphal reflexes were observed and registered at the bedside in Charcot's Clinic. Charcot apparently divined their importance, but he had not yet appreciated their clinical significance.

Abundant clinical, experimental, and histological facts have been collected for the proper theoretical interpretation of reflex phenomena. However, a unanimity of opinion has not yet been reached. Some accept the original teachings of Erb, who interpreted reflexes, particularly tendon reflexes, as true reflexes; others adhere to Westphal's teaching, who believed that they were not true reflexes, but phenomena dependent upon the muscle tonus. Gowers calls the tendon reflexes myotatic phenomena, and his conception is akin to that of Westphal.

We shall not consider here the evidence which tends to substantiate either of these theoretical views. Here the theoretical basis of the reflex phenomena will be discussed only in so far as is necessary for a proper and intelligent interpretation of these phenomena at the bedside. The best-known and most studied of all reflexes are the tendon reflexes, and their classical representative is the knee-jerk.

The subsequent remarks apply to tendon reflexes in general, and to the knee-jerk in particular.

A reflex is a neural phenomenon which originates in a sensory end organ, travels along a centripetal pathway, passes a ganglionic station, and leaves it changed or unchanged in quality or quantity, and pursues its way outward on a centrifugal pathway to a centrifugal end organ. The anatomical structure subserving this consists of: A sensory end organ, a peripheral sensory fibre, a ganglion cell, a peripheral motor fibre, a motor end-organ—in other words, a sensory and a motor neurone of the peripheral kind.

This anatomical structure is called a reflex arc. The primary reflex arc is under the influence of one or more secondary arcs, which are represented by an analogous arrangement of secondary neurones.

The centrifugal branch of one of the supposed secondary arcs is represented by the fibres of the pyramidal tracts. The centripetal partner and the central connection of the two are not fully known. The former is probably found in the ascending cerebral and cerebellar tracts, and the central station is probably situated in the gray matter of the cerebrum and cerebellum, and in the nuclei and gray matter of the mesencephalon. The tendon phenomena are accompanied by conscious sensation. Whether this sensation is carried up along the centripetal pathways above mentioned or not is not known. Usually, when a reflex arc is spoken of, only the strict neural elements are understood to represent it, while the sensory and motor end-organs are not included. The ganglionic stations are spoken of as reflex centres. In addition a reflex arc is under the modifying influence of individual segments of the spinal cord above it.

In the lowest forms of life the anatomical substratum of most reflexes is represented by one reflex arc only. This is the case also in some of the simpler forms of reflexes.

All that has been said thus far applies particularly to the tendon phenomena. For other reflexes, skin reflexes, visceral reflexes, etc., analogous anatomical structures are supposed to exist. Their exact location and connections are fully known in some instances, not entirely in others, while in still others they are altogether hypothetical.

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Reflex centres are constituted either by the gray matter of the cerebro-spinal axis, or by the gray matter of the sympathetic (visceral) system. The afferent and efferent pathways are either exclusively cerebrospinal, or exclusively sympathetic (visceral) or mixed.

It is believed that a reflex arc is constantly traversed by neural energy which establishes in this arc a sort of functional equilibrium. Under normal conditions this equilibrium is altered in consequence of changes in the secondary reflex arcs, and this results in voluntary action or reflex action. Within physiological limits a variety of general and local causes, acting on all or some parts of the reflex arcs, will greatly modify reflex activity. This will be still more so in the domain of pathology.

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It is thus seen that the semeiological value of reflexes is not exclusively reserved for neuropathology. Diagnostic and particularly prognostic aid is occasionally received from a study of reflex phenomena in general diseases. Attention has lately been drawn to this fact by Pfaundler and Luethye in their investigations on the behavior of reflexes in pneumonia and other acute infectious diseases (*Münch. med. Wochenschrift*, July, August, 1902).

The systematic study of reflexes in neuro-visceral diseases will probably yield valuable information.

The theoretical controversy about the nature of reflexes is exclusively concerned with tendon reflexes and hinges upon the question of the interrelation and interdependence of tendon phenomena and so-called muscle tonus. The nature of all other reflexes (skin and visceral) is apparently undisputed; they are believed to be genuine reflexes.

According to Jendrassik reflexes investigated at the bedside may be divided into three categories, according to the supposed situation of their centres.

1. *Spinal:* Tendon, muscle, periosteum, bone reflexes, jaw-jerk.

2. *Cerebral* (cortical) cutaneous reflexes: Scapular, abdominal, cremasteric, scrotal, gluteal, plantar, palpebral, conjunctival, pharyngeal, anal.

3. *Visceral* (sympathetic): Sneezing, swallowing, vomiting, coughing, erection, ejaculation, etc.

The first group, also called physiological spinal reflexes, is characterized by the following points:

(1) The reflex is elicited from moderately sensitive areas.

(2) The reflex movement is usually not accompanied by specific sensation.

(3) The exciting stimulus is a simple mechanical irritation.

(4) The intensity of the reflex movement is not so variable as in the second group.

(5) It can be elicited on one's self as well as on others.

(6) The period of latency is the shortest.

(7) The reflex movement is a simple twitch and is apparently not adapted to certain ends.

(8) Muscular exertion increases this reflex.

(9) In diseases of the brain (after a certain time) these reflexes are increased.

(10) Delay is not observed

(11) Mental influences are of little effect. Distraction of attention makes the demonstration easier.

Reflexes of the second group are characterized by the following points:

(1) The elicitation of the reflexes takes place from very sensitive localities.

(2) The reflex is accompanied by sensation.

(3) The exciting stimulus must be of sufficient duration to produce a distinct sensation

(4) The intensity of the exciting stimulus is not always proportionate to the result. Individual variations are great.

(5) These reflexes can be elicited on one's self only with great difficulty.

(6) The period of latency is longer than in the first group and not as constant. The period of latency is proportionate to the speed of the sensory conduction.

(7) The resulting movement is more complicated and seems to have the purpose of removing the irritated parts from the source of irritation.

(8) Increased muscular activity frequently diminishes these reflexes.

(9) These reflexes are diminished or absent in cerebral lesions.

(10) They are delayed in appearance when the sensory conduction is delayed.

(11) Mental influences increase or diminish these reflexes. Distraction of attention frequently diminishes them.

Reflexes of the third group are characterized by the following points:

(1) These reflexes are elicited from sensitive points.

(2) They are accompanied by specific sensation. The sensation here is of greater importance than in the reflexes of the second group.

(3) The time for the necessary stimulation is here the longest.

(4) These reflexes have great individual variations.

(5) They are elicitable on one's self, but depend upon specific stimulation.

(6) The time of latency is the longest.

(7) The resulting movement is very complicated—bilateral.

(8) Muscular exertion diminishes these reflexes.

(9) In cerebral lesions they are increased or diminished.

(10) Mental influences are of great importance.

Dejerine divides reflexes, according to the nature of the peripheral parts of the reflex arc, into four groups:

1. Reflexes, the centripetal and centrifugal branches of whose arc are represented by cerebrospinal fibres: tendon reflexes, cutaneous reflexes, reflexes of deglutition.

2. Reflexes, the centripetal branch of whose arc is a cerebrospinal fibre, and the centrifugal branch a sympathetic (visceral) fibre: salivation, blushing, intestinal contraction, pain reaction of the iris.

3. Reflexes, the centripetal branch of whose arc is a sympathetic (visceral) fibre, and the centrifugal branch a cerebrospinal fibre. This group is represented mostly by pathological reflexes: reflex phenomena due to irritation or disease of the abdominal viscera.

4. A group which logically would be presented by reflexes, the centripetal and centrifugal branches of whose arc are built up of sympathetic or visceral fibres. Physiological: secretion of digestive juices. Pathological: Visceral congestion, redness or pallor of the skin in consequence of hepatic colic, etc.

In Dejerine's original article,* however, this last-named group is thus characterized:

4. In the last group can be placed the reflex acts whose paths of conduction do not arise from the sympathetic system. Physiological: The secretion of intestinal juices in the course of digestion. Pathological: The phenomena of visceral congestion, blushing, pallor, coldness of the skin produced by organic affections (colics, etc.).

For the clinical understanding of the tendon phenomena, Sherrington's classification seems helpful. He believes that one ought to distinguish under the name of tendon reflexes two different varieties of phenomena:

1. True spinal and cerebrospinal reflexes, excited by stimuli applied to the tendons.

2. Pseudo-reflexes, commonly called tendon phenomena or tendon concussions.

The true tendon reflexes have no considerable clinical importance. The pseudo-reflexes are not genuine reflexes because: (1) The time occupied for their production is very short. (2) The muscular contraction is a simple twitch and not prolonged or tetanic; therefore the knee phenomenon is not a true spinal reflex, but a direct response of the muscle to a sudden mechanical tension. Only when the muscle is in connection with its neural supply can this response be obtained. For the production of the knee phenomenon the tonus of the muscle is indispensable.

* Ch. Bouchard: "Semeiologie des Reflexes." "Traité de Pathologie générale," tome v., p. 939, 1901.

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The number of reflexes so far described is quite considerable. Additions are constantly being made, and the future will undoubtedly bring more. Only a few of this large number have general clinical importance. The others gain in importance and prove useful and reliable guides in segmental and topical diagnosis, in proportion to their anatomical definition.

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The following reflexes are among the older and better known:

A. *Superficial Reflexes:* Palpebral, corneal, conjunctival, pharyngeal, interscapular, epigastric; upper, lower, middle abdominal; cremasteric, scrotal, anal, gluteal, lumbar, pilomotor or goose-skin reflex.

B. *Deep or Tendon Reflexes:* Patellar, Achilles, triceps or olecranon, biceps, ulnar, radial, masseter or jaw-jerk.

C. *Visceral Reflexes:* Pupillary, bladder, rectal, sexual.

Some of the newest reflexes are: The lumbo-femoral of Bechterew, the infraspinatus of Steiner, the supra-orbital of McCarthy.

The exciting stimulus necessary for the production of a reflex varies in quality and quantity. The pupillary reflexes respond to specific irritation of the optic nerve—photic stimuli. The superficial reflexes are evoked by stimulation of the tactile or algetic senses. The tendon reflexes are the result of mechanical stimulation of the tendon. Under certain conditions mechanical stimulation of the adjacent structures (periosteum, bone, articulatory surface) yields a reflex contraction.

The sensory (tactile or algetic) stimulation of the skin around the knee occasionally gives rise to a contraction of the quadriceps muscle. This is not a genuine tendon phenomenon, but is known under the name of pseudo-knee-jerk, and has been described by Wespthal, with a note of warning to keep this phenomenon distinct from the genuine tendon jerk. The pseudo-knee phenomenon may be observed even when the genuine knee-jerk is absent.

The intensity of the sensory stimulation necessary for the production of a reflex has an upper and lower limit of efficacy. Below a certain limit of irritation the reflex phenomenon dependent upon this irritation naturally does not ensue. Equally disturbed is the reflex response in its clearness, or it is even entirely frustrated when the sensory stimulus is above a certain limit of intensity. Therefore the intensity of the sensory stimulus may be looked upon as an index of the reflex activity of the centres or arcs, which vary considerably within physiological limits. The intensity and extensity of the reflex response are also quite variable. The muscular contraction is sometimes vigorous, quick and lightning-like, at other times sluggish and less active. When the reflex response is considerably exaggerated, the irritation is followed by a succession of contractions, known as clonus (patellar clonus, ankle clonus, wrist clonus). In a still higher degree of increased reflex irritability, this clonic response spreads over wide territories, and is then called "epilepsie spinale."

Under certain conditions the muscular contraction is limited to one muscle only, and at other times it spreads to neighboring muscles, or even to homologous muscles of the opposite side of the body. Furthermore, a cumulative quality of the sensory stimulation is occasionally observed. A reflex occurring at times from one stimulation will need at other times a repeated stimulation for its production. Sometimes the reflex response shows a peculiar exhaustibility. This is seen when the same stimulation is followed at one time by a normal contraction, at another by a much weaker one or by none at all. Another expression of the same tendency is to be seen when a reflex that responds to a stimulus becomes exhausted after frequent stimulation, then reappears again after a short interval of rest. These variations when occurring under the same conditions of stimulation also permit the inference as to the state of the reflex activity of the centres or arcs. At the same time these variations of the reflex response may be profitably kept distinct from the variations of the response depending upon the intensity of the stimulation. The latter may be designated as variations of the reflex irritability, and the former as variations of reflex mobility.

Frequently the attempt has been made to express the described variations of the sensory stimulation and motor response of the reflex phenomena in more exact terms. Apparatuses have been devised for the purpose of measuring the one as well as the other; these investigations have aided the physiological conception of reflexes; but clinically they have not been of much value.

If all of the foregoing be borne in mind, the following propositions will be self-evident:

Reflexes are Increased.—1. When the sensory end apparatus, or the centripetal fibre, or the centrifugal fibre, or the primary reflex centre, is in a more or less marked state of irritation.

2. When the inhibitory influence of the secondary reflex arc is diminished or paralyzed.

Reflexes are Diminished or Absent.—1. When the sensory end-apparatus, or the centripetal fibre, or the centrifugal fibre, or the primary reflex centre, is in a state of more or less marked paresis or paralysis.

2. When the stimulating influence of the secondary reflex arc is diminished or paralyzed.

Lastly, reflexes will be increased or diminished according to the increase or diminution of the exciting stimulus.

There are a maximum and a minimum of conditions favorable to the elicitation and demonstration of reflexes. For the pupillary reflexes it is necessary that the difference between the stimulations (light and dark) be quite marked. The skin and tendon reflexes are considerably impeded by the will and by concentrated attention; the skin reflexes less so than the tendon reflexes. Difficulties encountered clinically in the demonstration of pupillary reflexes are obviated by examining the patient in a dark room, with artificial light, and by taking care that accommodation is excluded.

In the case of skin and tendon reflexes, various means have been devised for distracting the patient's attention during the examination. To obviate these difficulties recourse is had to what is commonly called the method of reinforcement, or the Jendrassik method. This consists of the following: The patient is directed to link his hands into each other and then to attempt to pull the hands forcibly apart. Care must be taken that the tap of the tendon is synchronous with the greatest effort of the patient.

A characteristic and peculiar degree of muscular contraction is indispensable for the demonstration of tendon reflexes. A muscle contracted above a certain limit is incapable of expressing an additional contraction, and a muscle relaxed beyond a certain limit is also irresponsive to reflex stimulation. Finally it is not to be forgotten that recent or previous disease of the structures around the knee- or ankle-joint is carefully to be excluded.

It should not be said that a reflex is absent unless the examination has been made with the above-mentioned precautions.

At the end of this article will be found a list of all reflexes with their respective anatomical locations and constituents, and their clinical significance.

It remains only to discuss in detail the most important reflexes: the pupillary phenomena, the knee-jerk, the Achilles jerk, and the plantar reflex.

Pupillary Phenomena.

The following points are noted in the examination of pupillary phenomena:

1. The size of the pupils.
2. Their shape and outline.
3. The light reactions (direct and consensual).
4. The accommodative and convergence reactions.
5. The pain reaction.

Recent or previous disease of the structures of the eyeball (cornea and iris, anterior chamber, etc.) must be carefully excluded before any conclusions are drawn. Under average physiological conditions both pupils are of medium dilatation and equal when exposed to diffused daylight. Inequality of the pupils (anisocoria) is, as a rule,

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pathological. Exceptions to this rule are few and not fully understood. Very wide pupils (mydriasis) are sometimes within physiological limits, but are most often observed in sensitive neurotic subjects. Very small pupils (myosis) are more often pathological than the preceding. It is not to be forgotten that drugs are occasionally the cause of the mentioned states of the pupils (belladonna, opiates).

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Normally the outline of the pupil is circular, and the free border smooth. Serrations of outline and imperfections of the circle are significant. As a rule this denotes previous syphilitic infection.

The direct reaction consists of dilatation of the pupil when light is shut out, and of contraction of the pupil when light is admitted.

To ascertain this reaction, the patient is directed not to accommodate for any near object, and both pupils are alternately exposed to and protected from the light, and the result is watched. This reaction, "reaction to light," is never absent in health.

When the light reaction does not ensue, and care has been taken to avoid the mentioned possibilities of error, the pupils are said to be "stiff." This constitutes the Argyll-Robertson phenomenon.

The consensual reaction consists of contraction or dilatation of the pupil of the opposite side, following the admission or exclusion of light from the other pupil. This is best examined for as follows: The pupil is watched while the lid of the other eye is raised or lowered. This reaction is rarely disturbed alone. It is seen sometimes in conjunction with other disturbances of the pupillary play.

The accommodation reaction consists of contraction of the pupil on fixation of near objects and of dilatation of the pupil when looking into the distance.

The convergence reaction is a contraction of the pupil on convergence of the eyeballs (simultaneous innervation of both internal recti).

The pain reaction consists of a dilatation of the pupil upon painful stimulation of face or neck, or sometimes upon painful stimulation of any part of the body.

The hemiopic pupillary reaction of Wernicke is a rare pupillary phenomenon. It occurs in cases of hemianopsia, central or peripheral.

Light reaction occurs only on stimulation of the sensitive half of the retina, and does not ensue when the non-sensitive half is irritated. It is best demonstrated when one-half of the pupil is protected by a small shield and the other is alternately stimulated by admission and exclusion of light.

Occasionally one finds in literature the term paradoxical pupillary reaction. The reaction is said to be paradoxical when the pupil dilates on admission and contracts on exclusion of light.

Sluggish and lively pupillary reactions are likewise spoken of. These depend of course upon the speed with which, and extent to which, reactions take place.

Lastly a phenomenon has been described by Strasburger and Saenger (*Neurol. Centralbl.*, 1902) under the name of myotonic pupillary reaction. They mean reactions that occur in such a way that the iris remains for a short time in dilatation or contraction, as the case may be, before changing.

Pupillary reactions have also been observed as a type of associated movements coincident with looking upward or upon forcible closure of the eyes.

It has further been stated, by good authority, that even the mere suggestion of light and dark, for instance to totally blind people, is sometimes followed by the corresponding pupillary reaction.

A state of unrest and constant change of width of pupil has also been noticed at times, and been given the name of hippus.

Knee-Jerk.

The knee-jerk (knee kick, knee reflex, patellar reflex, knee phenomenon, Erb or Westphal phenomenon) is the name given to a contraction of the quadriceps femoris, that follows a blow upon the patellar tendon. The contraction is more marked in the internal division of the muscle (vastus internus). The knee-jerk is rarely absent in health.

In order to demonstrate this phenomenon, it is necessary, as was explained before, to prevent inhibition on the part of the patient.

The knee phenomenon is elicited in the following way:

1. The knee is allowed to swing freely on the examiner's hand, or the foot is put flatly upon the floor, so that the leg and thigh form a slightly obtuse angle, or one leg is crossed upon the other, and the leg is allowed to swing freely.

2. A sharp tap is made upon the patellar tendon with the tips of the fingers, with the ulnar border of the hand, with a percussion hammer, or with any other suitable instrument. Thereupon a contraction of the quadriceps muscle ensues, more or less quick and vigorous. This contraction can frequently be seen and felt, and it gives rise to a more or less marked excursion of the leg. This reflex varies quite considerably within physiological and pathological limits. These variations are designated by the names of normal, lively, increased, diminished, exaggerated, etc. In states of exaggeration, a reflex response is elicited not only upon mechanical stimulation of the tendon, but also upon irritation of a wider area around the knee and the upper part of the tibia. In states of diminution of the reflex response, the reflexogenic zone is considerably narrowed, and the reflex response is more liable to occur upon stimulation of the median than upon stimulation of the lateral half of the patellar tendon.

Evidence of greater exaggeration of the knee reflex is patellar clonus. This is demonstrated in the following way:

The lower extremity is slightly hyperextended and the patella is pushed quickly downward, and percussed or tapped in this position. A sharp clonic contraction is the result. Sometimes the reflex contraction is not limited to the quadriceps muscle alone, but is observed in the adductor group of muscles of the same side, or occasionally of the opposite side of the body. Rarely the contraction occurs even in the quadriceps muscle of the other side. The latter phenomena are called crossed adductor and crossed knee-jerk respectively.

Direct mechanical stimulation of the belly of the muscle is also followed by contraction of the muscle. This is, however, the expression of the so-called mechanical muscular irritability, and reveals itself clinically in two forms:

1. The contraction is fascicular and limited to the site of the irritation.

2. The entire muscle contracts.

This last-named contraction is not to be confounded with the true knee reflex. It is frequently found, for instance, in cases of tabes, in which the reflex is absent.

The occurrence of a pseudo knee phenomenon—a contraction of the quadriceps upon algetic stimulation of the skin around the knee—has been mentioned above.

Achilles Jerk.

The Achilles jerk consists of a contraction of the calf muscles upon tapping of the Achilles tendon. This reflex is examined for in the following way:

1. The foot is slightly dorsiflexed, the knee is slightly flexed, and the Achilles tendon is tapped. A plantar flexion of the foot ensues.

2. The lower extremity is slightly flexed at hip and totally flexed at knee, and in this position the entire leg rests on a chair while the foot is free. In this position the Achilles tendon is tapped, and a plantar flexion of the foot is the result.

When this reflex is exaggerated, a forced dorsiflexion of the foot is followed by a succession of contractions. This is called the ankle clonus. This clonic contraction keeps up as long as the dorsiflexion of the foot is maintained. At other times it soon ceases and may or may not reappear. The ankle clonus which is difficult to de-

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monstrate, and in which the clonic contractions are not vigorous and are easily exhaustible, are sometimes spoken of as pseudo-ankle clonus.

Sometimes difficulties are encountered in the demonstration of ankle clonus, and then it is well to use the following procedure: Bend the lower extremity slightly at hip- and knee-joints; exert sharp dorsiflexion of the foot, and in addition tap repeatedly the Achilles tendon.

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The pseudo-ankle clonus is very rarely evidence of organic disease, although undoubtedly cases of disease of the pyramidal tracts occur in which the ankle clonus is of a pseudo type.

On the other hand, the genuine ankle clonus which is expressed by vigorous clonic contractions, which persist as long as the dorsiflexion of the foot is kept up, is usually, though not always, evidence of organic disease.

The question of the occurrence of genuine ankle clonus in hysteria is not fully decided. There are undoubtedly a few cases of hysteria with marked ankle clonus on record.

Care should be taken not to confound the genuine Achilles reflex with the expression of the mechanical irritation of the muscle. The Achilles reflex is rarely, if ever, absent in health, although it is not believed to be as constant as the knee-jerk.

Plantar Reflex.

The plantar reflex is the most constant representative of the skin reflexes. It consists of a sequence of contractions of a variety of muscles of the lower extremities, following tactile or algetic stimulation of the sole of the foot.

For the production of the reflex, the median half of the sole is more sensitive than the lateral half. Under normal conditions, and under mild stimulation, the muscles most frequently seen to contract are the tensor fasciæ and the plantar flexors of toes and foot.

In states of increased reflex excitability the whole foot is dorsiflexed, and in a still higher degree the entire lower extremity is removed from the source of irritation.

The same takes place when the exciting stimulus is stronger or frequently repeated in succession.

Reflexes.	Neural Mechanism.			Demonstration.	Remarks.
	Afferent.	Efferent.	Centre.		
Corneal and conjunctival.	Fifth nerve......	Seventh nerve...	Nucleus of seventh nerve.	Irritation of conjunctiva or cornea, followed by contraction of orbicularis oculi.	Diminished in Basedow disease. (Stellweg phenomenon.)
Pupillary (light)	Optic nerve......	Oculomotor......	Ciliary ganglion (?).	Alternately illuminating and shading the pupil.	Absent in tabes and general paresis.
Pain reaction of pupil.	Cerebral or spinal sensory nerves.	Cervical sympathetic fibres.	Cilio-spinal centre, fourth to seventh cervical	Painful stimulation of skin anywhere, particularly around neck, followed by dilatation of pupil.	Absent in diseases of cervical sympathetic.
Pharyngeal.....	Ninth nerve	Seventh nerve...	Nucleus of seventh nerve.	Tickling of palate, followed by contraction of velum.	Believed to be absent or diminished in hysteria.
Jaw-jerk (chin phenomenon).	Fifth nerve......	Motor portion of fifth.	Motor nucleus of fifth.	Percussion of lower jaw, with mouth slightly opened, followed by contraction of masseters.	Inconstant in health. Exaggeration observed in disease of upper part of pyramidal tracts.
Mimetic reflex of face.	Nerves of special senses. Psychic stimuli.	Facial nerve.....	Thalamus opticus (?).	Laughing or crying on appropriate mental stimulation.	Absent in disease of thalamus. In exaggerated states, impulsive laughter and impulsive crying. In intracranial disease, particularly of basal ganglia.
Scapular........	Sensory roots, fifth cervical to first dorsal.	Same motor roots	Anterior horns, seventh cervical to first dorsal.	Tactile or algetic stimulation of skin, along inner border of scapula. Adduction of scapula.	Absent in disease at this level. Inconstant.
Palmar.........	Sensory nerves, seventh cervical to first dorsal.	Motor nerves, seventh cervical to first dorsal.	Anterior horns, seventh cervical to first dorsal.	Tickling of palmar surface of hand, followed by closure of hand.	Very inconstant.
Epigastric......	Sensory nerves, fourth to seventh dorsal.	Motor nerves, fourth to seventh dorsal.	Anterior horns, fourth to seventh dorsal.	Tactile or algetic stimulation of upper abdomen. Contraction of abdominal muscles.	Absent in disease of this level of the cord. Diminished or absent on one side in disease of contralateral cerebral hemisphere.
Abdominal.....	Sensory nerves, seventh to eleventh dorsal.	Motor nerves, seventh to eleventh dorsal.	Anterior horns, seventh to eleventh dorsal.	Tactile or algetic stimulation of lower abdomen (below umbilicus). Contraction of abdominal muscles.	Absent in disease of this level of the cord. Diminished or absent on one side in disease of contralateral cerebral hemisphere.
Cremasteric	Sensory nerves, first to third lumbar.	Motor nerves, first to third lumbar.	Anterior horns, first to third lumbar.	Tactile or algetic stimulation of skin around inner and upper part of thigh, followed by pulling up of testicle.	Absent in disease of this level of the cord. Diminished or absent on one side, in disease of contralateral cerebral hemisphere. Not to be confounded with the tunica dartos reflex.
Gluteal.........	Sensory nerves, fourth to fifth lumbar.	Motor nerves, fourth to fifth lumbar.	Anterior horns, fourth to fifth lumbar.	Sensory or algetic stimulation of skin of buttocks. Contraction of glutei.	
Plantar.........	Sensory nerves, first to second sacral.	Motor nerves, first to second sacral.	Anterior horns, first to second sacral.	Tactile or algetic stimulation of sole of foot, followed by contraction of various muscles of lower extremities.	Babinski phenomenon.
Triceps.........	Sensory nerves, sixth cervical.	Motor nerves, sixth cervical.	Anterior horns, sixth cervical.	Relaxed and semiflexed upper extremity. Tapping of tendon of triceps. Contraction of triceps.	Inconstant. Exaggerated in disease of pyramidal tracts.
Biceps..........	Sensory nerves, sixth cervical.	Motor nerves, sixth cervical.	Anterior horns, sixth cervical.	Relaxed and semiflexed upper extremity. Tapping of tendon of biceps. Contraction of biceps.	Inconstant. Exaggerated in disease of pyramidal tracts.
Wrist-jerks.....	Sensory nerves, sixth to eighth cervical.	Motor nerves, sixth to eighth cervical.	Anterior horns, sixth to eighth cervical.	Tapping of ends of ulna or radius, followed by flexion or extension, respectively.	Inconstant. Exaggerated in disease of pyramidal tracts. Occasionally wrist clonus. Forcible dorsiflexion of hand followed by clonic palmar flexion.
Patellar reflex..	Sensory nerves, second to fourth lumbar.	Motor nerves, second to fourth lumbar.	Anterior horns, second to fourth lumbar.	Mechanical irritation of the patellar tendon followed by contraction of the quadriceps femoris.	
Achilles reflex..	Sensory nerves, third to fifth sacral.	Motor nerves, third to fifth sacral.	Anterior horns, third to fifth sacral.	Plantar flexion of foot upon tapping of Achilles tendon.	

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Refuse Disposal.

The plantar reflex has lately been invested with considerable clinical importance through the investigations of Babinski. Under the name of Babinski phenomenon, or big toe phenomenon, the following variations of the plantar reflex have been described:

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Upon stimulation of the sole of the foot, the big toe is dorsiflexed, and the other four toes are plantar-flexed. When this occurs slowly this is the typical Babinski phenomenon. It is believed to denote disease of the pyramidal tracts.

In children below two years of age, in whom the pyramidal tracts are not fully medullated, this variety of plantar reflex is normal.

While the typical *Babinski phenomenon*, as just described, is believed to be undisputed evidence of disease of the pyramidal tracts, with the mentioned exception in children, its absence does not prove that the pyramidal tracts are not diseased.

There are many combinations and changes of the Babinski phenomenon, and the significance of all of them is still under dispute.

At present it is best for clinical purposes to accept the following guide:

The Babinski phenomenon is positive, and the inference therefrom justified:

1. When upon stimulation of the sole of the foot there is dorsiflexion of the big toe and plantar flexion of the other toes.
2. When upon stimulation of the sole of the foot there is dorsiflexion of the big toe only.
3. When upon stimulation of the sole of the foot, there is dorsiflexion of all the toes.

The significance of the third variety is doubtful. All authorities do not agree that the Babinski phenomenon is always an indication of organic disease of the pyramidal tracts.

In examining for the plantar reflex, it is well to observe carefully the result of the first stimulation. After repeated stimulations, the patient's attention and conscious interference can never be fully excluded and a variety of cerebral reflexes occur which obscure considerably the interpretation of the result.

As a result and consequence of disturbed and changed reflex activity, a set of phenomena have received clinical study and attention. These phenomena are comprised under the name of associated movements and contractures. From among them the so-called Strümpell phenomenon is of clinical value, although limited.

The *Strumpell phenomenon* consists of the following:

When the patient is asked to flex the thigh upon the hip, and the leg upon the knee, there is an associated plantar flexion of the foot observed in cases of disease of the pyramidal tracts.

Under physiological conditions, or when there is no disease of the pyramidal tracts, the foot is dorsiflexed under the above-mentioned conditions. The so-called Kernig sign, which is believed to be pathognomonic of cerebrospinal meningitis, also belongs to this group. The Kernig sign is an inability on the part of the patient to extend the leg when the thigh is flexed.

Contractures and muscular rigidity are frequent accompaniments of exaggeration of tendon reflexes; the exceptions to this rule are few.

The state of the reflexes has been of considerable value for diagnosis and correct anatomical interpretation of pathological motor phenomena.

The terms flaccid and spastic paralysis refer particularly to the state of the reflexes of the paralyzed muscles.

A flaccid paralysis is a more or less marked motor paralysis, with loss of reflex activity and diminution of the reflex tone.

A spastic paralysis is a more or less marked motor paralysis with increase of reflex activity, and increase of tonus.

Joseph Fraenkel.

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REFUSE DISPOSAL.—By this term is here meant the disposal of the waste matters of a city, town, village, or family, not including the sewage which is deposited in and escapes through the underground system of sewers. The items usually embraced in the term "refuse," as distinguished from "sewage," are the following:

Garbage or offal, consisting of the organic waste matter from kitchens; ashes; house dust; waste paper and rags; tin cans, crockery, bottles, and broken glass; street sweepings; night soil, or contents of vaults, cesspools, and pail systems.

Broadly speaking, the term refuse includes sewage, but since this form of waste product is usually disposed of by a distinct system of underground pipes managed by a board of sewer commissioners, the term refuse will here be limited to its usual significance, that of the material gathered periodically from houses, hotels, and streets, by a system of collection intended for this purpose. The municipal management necessary for conducting this class of work often constitutes a serious problem, in consequence of the liability of causing nuisance, either in the methods of storage, collection, and transportation, or in the final disposal of the material.

FIG. 3942. Push-Cart Used for Collection of Street Sweepings. (From report of Street Department, Boston, 1900.)

GARBAGE.—Garbage is usually defined as the waste products of food material. In addition to this, Chapin[1] enumerates, under the head of "refuse," such waste materials as glass, crockery, street sweepings, oyster and clam shells, sawdust, corkdust, old boots and shoes, dead

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Refuse Disposal.

animals, lawn clippings, bottles, earthen, tin or iron ware, rubbish, tin cans, poisonous matter, excrement, urine, coal, and dirt. Dead animals and slaughterhouse refuse add value to garbage if it is to be made into fertilizers.

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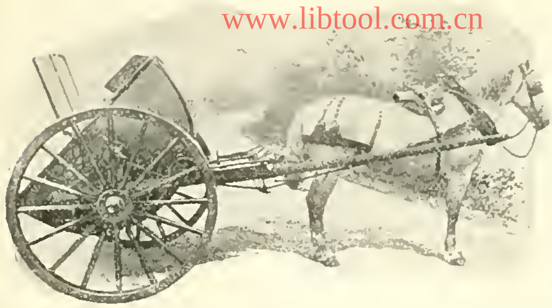

FIG. 3943.—Garbage Cart at an Angle for Washing or Easy Loading.

If the materials are sorted and such articles as tin cans, bones, and paper are selected out for utilization, then there is no objection to the deposit of such articles with garbage. But if the garbage is to be fed to hogs, or ploughed into the ground, tin cans are usually excluded. The rules and regulations in force at Lowell provide that "kitchen refuse, apple and potato parings, corn husks, cabbage leaves, shoes, rubbers, old bedding, soiled linen or cotton, and all refuse that can be burned shall be placed in the garbage vessels."

Household Storage.—In order that nuisance may be prevented, it is desirable that proper receptacles shall be provided by householders, hotel and restaurant keepers, and others for the storage of ashes, garbage, waste paper, etc., and that these be placed in convenient and accessible places for collection. Receptacles for ashes are best

FIG. 3944.—"Columbian" Dumping Cart showing Use of Dumping Lever.

made of metal. Those intended for garbage should be water-tight and provided with a well-fitting cover to exclude rain, prevent leakage, escape of odors, and access of dogs and other animals. In some cities separation of ashes, garbage, and paper is required by regulation; in others such separation is not so required.

Frequency of Removal.—Garbage is usually collected three times a week, but in some cities collection is made oftener, and in others not so often. In some cities definite hours are specified for such removal.

Vehicles of Removal.—The best form of vehicle for removal of garbage is made of metal, and so constructed as to admit of dumping instead of shovelling the contents. In some cities stout wooden barrels or iron casks are used, ten or more making a load.

In some large English cities where the pail system of collection for the removal of excremental waste is employed, the receptacle is removed from each house with the contents, and replaced with an empty or clean pail or tub. These receptacles are usually of metal painted and have a capacity of about a half-bushel. (Fig. 3943.)

The vehicles used for this purpose should always be provided with covers, either fixed or movable, for use when driving through the public streets.

Collection of Garbage.—In some cities garbage is collected by contract, and in others by some city authority. Municipal removal, however, as a general rule secures the most satisfactory service.

The following data present the cost and amount of collection of garbage in some of the largest American cities, the data referring either to 1898, 1899, or 1900. The following table relates to garbage only:

City.	Amount collected—tons.	Cost of collection.
Brooklyn	102,000	$120,000*
Baltimore	49,000	65,404
Boston	60,000	112,641
Buffalo	22,881	33,000*
Cleveland	22,375	69,400*
Milwaukee	28,716	61,883
New York (Borough of Manhattan)	152,000	101,840
Philadelphia	199,357	398,000*
Pittsburg	25,000	92,000*
St. Louis	69,634	99,673
New Orleans	67,500	97,200*

* Cost of collection and disposal.

The Separation of Refuse.—In very many cities it is the custom to separate the refuse into two or three or even more sorts; a very common method requiring the separation of the ashes, garbage, and paper or light combustible rubbish into three classes, the ashes being usually disposed of as a filling for waste lands, the garbage being fed to hogs, and the paper or light rubbish sold or burned. In addition to other classes, it is quite a common practice to separate the tin cans, bones, old iron and glassware, each of which has a certain market value. Such separation is often made a requirement by city regulations, and may be enforced by a penalty.

The English law relating to refuse is as follows (Section 42 of the Public Health Act, 1875): "Every local authority may, and when required by order of the Local Government Board, *shall* themselves undertake or contract for the removal of house refuse from premises; the cleansing of earth closets, privies, ashpits, and cesspools, either for the whole or for any part of their district."

By Section 43 of the same act, the local authority is made liable to a penalty of five shillings per day, payable to the occupant of a house, for failure to remove refuse after notice in writing from such occupant.

The street refuse of London is removed daily by boys with shovels and brush, and placed in iron dust bins, which are stationed at intervals along the edge of the pavement. In dry weather the streets are watered before being swept. The manure and dirt are removed by carts and taken to depots generally close to the river or to a railway station.

Each house has its dust bin or ashpit for the house refuse, from which the contents are collected periodically. The necessary depots for refuse are subject to the following general regulations:

1. The depots must be as distant as possible from inhabited places.
2. The refuse must not be put into pits, but above the ground level. If necessary, a special floor, three inches above the ground, must be made.
3. The ground should be drained and paved with impermeable material.
4. The depots should be sheltered from sun and rain, but the air should enter freely.
5. The ground leading to the depot should be well paved, so as to prevent pollution of the soil.

The custom of sorting refuse is vigorously opposed by some authorities. Mr. Goodrich[2] quotes Dr. Sedgwick Saunders as follows: "When the dust carts arrive at the wharf their contents are tipped into heaps at a place most

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convenient to the people who are engaged as sorters. About seventy persons, chiefly women, were engaged in this degrading and loathsome work, most of whom are paid by piece work, but female sifters received seven shillings and a little coal and wood weekly. The appearance of the women is most deplorable, standing in the midst of the dust piled up to their waists, with faces and upper extremities begrimed with black filth, and surrounded by, and breathing, a foul, moist, hot air, surcharged with the gaseous emanations of disintegrating organic compounds. I shall not forget visiting some of these poor creatures in a hospital, and witnessing the condition of their skins."

In Paris, previous to 1887, the refuse was put into the street in the evening. The ragpickers came and collected the rags, paper, bones, and glass. The refuse thus became scattered about the streets, rendering the collection difficult. The custom was forbidden by a decree of March 7th, 1887. The greater part of the refuse is taken to depots outside the city, where it is allowed to decay for five or six months, at the end of which time it becomes valuable as manure. Part is taken in boats to Corbeil, up the river, and to Pontoise, below the city. The removal of these heaps is done at much expense, the loss to the city averaging 2,000,000 francs ($400,000.)

In Brussels the refuse is collected at 7 A.M. from October 1st to March 1st, at 6:30 A.M. from March to September, and again at 6 P.M. from April 1st to September 1st. All refuse is conveyed in carts daily to the ash yard on the landing step of one of the canals, whence it is conveyed in boats directly to farmers, or to a depot at Evère outside the city.[3]

The Disposal of Garbage.—Briefly enumerated, the methods of final disposal of the garbage of cities are the following: Private or individual disposal, dumping at places designated for the purpose, ploughing into land, depositing in water, feeding to animals, economic reduction, and cremation or burning.

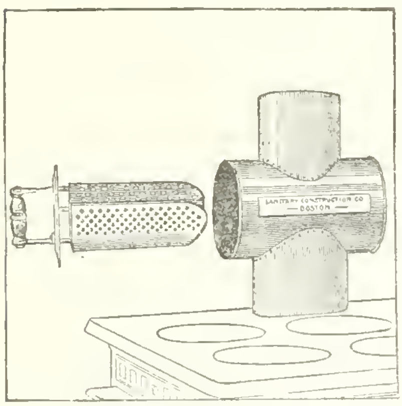

FIG. 3945.—Domestic Garbage Carbonizer as Applied to Kitchen Stove or Range.

The method which is practised in some households, of disposing of the garbage *by burning* it either in the kitchen range or stove, or in some appliance connected with the same, is both neat and cleanly, and avoids the foul odor which invariably attends the storage of such material in receptacles of any sort. Several appliances have been invented for the purpose of facilitating this method of disposal (see Fig. 3945).

The disposal of refuse *by dumping* at places designated for the purpose is the most objectionable, and unsanitary of all methods so far as organic or putrescible refuse is concerned, since it is sure to give rise to foul odors, and thus to become a source of complaint, even to persons living at a considerable distance. The habit of wild and domestic animals, of visiting such places and scattering the deposit, increases the nuisance. Frequent covering with earth in some degree obviates the trouble. Such disposal of ashes unmixed with organic matter, however, is not objectionable, nor is their use for the filling of waste lands to be condemned. This method, usually called "tipping" in England, is acknowledged, however, to be extremely unsatisfactory. Over eight hundred local authorities in England and Wales alone, each with a population exceeding two thousand, still either tip their refuse or dispose of it in some other equally primitive manner.[2]

With reference to the economy of using coal ashes for the purpose of filling waste land, the following quotation is worthy of note: "It is said that from the Manhattan and Bronx Boroughs, New York, there could be recovered one hundred and fifty thousand net tons annually of small coal, thrown away with ashes from domestic and other fires. What wasteful people the Americans must be if these figures are correct. Viewed in the light of modern practice in this country, such use for land development is quite astounding."[2]

Ploughing into the Land.—This method of disposal allows the garbage to be used as a fertilizer for growing crops, and is less objectionable than dumping. Chapin gives a list of eighteen cities where it is practised either as a whole or in part. In several other places it was once disposed of in this way until it became a nuisance, and was then abandoned.

Depositing in Water, either Salt or Fresh.—Several cities situated either upon the sea coast or near great rivers or lakes find it convenient to deposit garbage directly into the water, either directly from a wharf or by towing it to a distance in scows or other vessels designed especially for such work. Coal ashes and other heavy material thus treated sink to the bottom, but light material floats upon the surface, and while this method may be satisfactory to the city which adopts it, other places may find it a source of annoyance when favoring winds, tides, or currents deposit the floating matter upon their shores.

Feeding to Animals.—While this is perhaps the most economical mode of getting rid of the waste food products of a community, it is open to serious objections in consequence of the liability to cause a nuisance wheresoever large numbers of swine are kept for this purpose, and because of its liability to produce disease in such animals. The feeding of city offal to milch cows is forbidden by law in some States, and should not be permitted except in such institutions as require the very careful selection and separation of bread and vegetables from the waste food immediately after it is received from the tables, and the use of the same before decomposition has begun. In the neighborhood of many large cities, piggeries exist having one thousand animals and more in each, to which the foul and offensive offal of cities is conveyed for feeding such animals. This process cannot be conducted without causing a nuisance to neighboring communities. So urgent has this matter become in the metropolitan district of Boston as to induce one large raiser of hogs to purchase a tract of unoccupied land in a neighboring State, where he proposes to feed ten thousand to fifteen thousand hogs, and to transport thither by rail the garbage of a large part of the district.

Pork raised in this manner, however, is much more liable to become infected with trichinæ than that which is produced by feeding good and wholesome food.

Cremation.—When the question of expense is not considered, burning by fire is undoubtedly the most satisfactory mode of refuse disposal. Great Britain is the principal country where this process is employed more than any other. Goodrich enumerates one hundred and twelve cities in which the refuse is treated by destruction by fire (all in England and Scotland). The material, however, which is sent to the crematory, differs essentially from that which is so treated in America, since in England the ashes (mostly of soft coal) are quite generally mixed with other refuse, and burned in the destructors. The product of such destruction is an ash or cinder, which may be used for making roads or walks, and to some extent for building construction. There is also added in some cities the material from the pail closet system, where this plan of disposal still exists. This primitive system is rapidly diminishing in its extent, and giving way to the introduction of water-carried sewage in all large cities. In some places, as at Ealing, the sewage sludge from precipitation works is burned in the destructor. In Manchester, England, the dried excreta from the pail closets

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sell for £3 per ton. At Liverpool the bulk of the refuse is sent to sea in steam barges, each carrying four hundred and fifty tons at a load. The deposit of this material causes complaint along the Welsh coast. It is rare to find in the reports of any of the English cities instances in which the destructors are of sufficient capacity to deal
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second fire pass downward and underneath the grate, and are finally discharged through the chimney. By this second fire the liquids which drop through the grates from the garbage upon the hearth are also evaporated.

The general features of the Dixon furnace do not differ essentially from those of the Engle, but the Smith de-

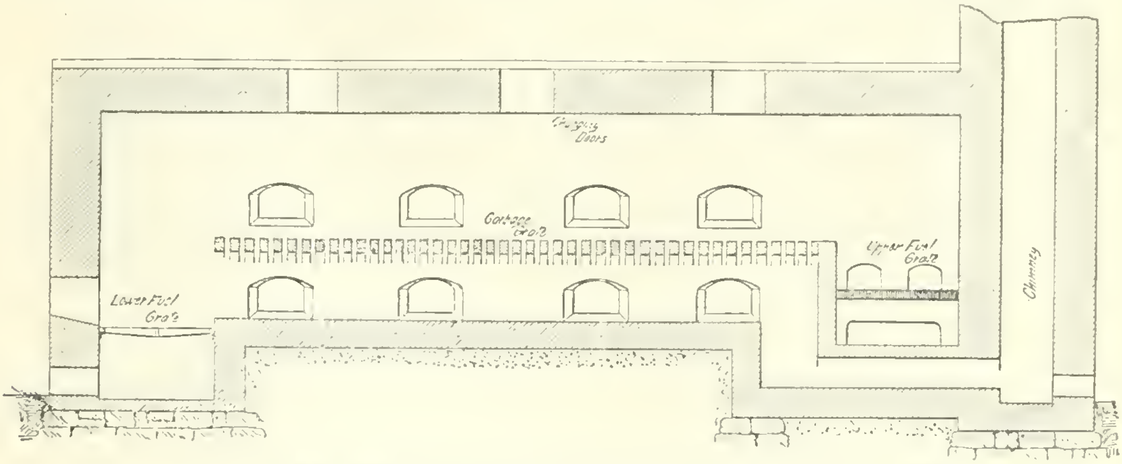

FIG. 3946.—Engle Garbage Incinerator. (From "Report of Brooklyn Health Department," 1896.)

with the entire refuse of the city. The following list shows the disposal of the refuse of Birmingham for 1897:

	Tons.
Refuse sent to the tips, principally barged	34,703
Refuse dealt with by destructor	96,309
Mixed manure, ashpit manure, fish, sweepings sent to tips by boat, to fields by cart, or sent away by rail	74,855
Brickbats sent to tips	416
Material sold:—	
Oyster shells	15
Glass	19
Scrap tin	296
	206,613

In consequence of the location of English destructors in or near the populous parts of large cities much attention has been given to the subject of avoiding the nuisance arising from foul odors. This has been accomplished by the use of tall chimneys, high temperatures for combustion, and by the provision of secondary fires.

At present much attention is being given in England to the secondary use of refuse, that of steam raising for the purpose of generating electricity, sewage and water pumping, and other purposes.

The principal types of destructors employed in England are the Fryer, Horsfall, Warner, and Meldrum, while in America preference is given to the Engle, the Dixon, and the Smith.

The Engle consists of a brick furnace with chimney at one end, seventy-five to one hundred feet high. Several circular openings are made upon the top of the furnace, one being large enough to admit the carcass of a large animal. Driveways lead to the platform upon the top, the whole being enclosed in a covering house of brick or iron. On one side of the furnace there are doors for fuel, and another set of doors below them for removal of ashes. Between these two sets of doors are placed the grate bars upon which the refuse is dumped through the openings in the top. At each end of the furnace a fire box is placed. Below the garbage grates is a long combustion flue connecting with the base of the chimney, and controlled by a damper. A similar damper governs the admission of heat from above. (Fig. 3946.)

When the furnace is charged with a quantity of garbage, the flames from the firebox near the chimney (the upper damper being closed) pass over and through the refuse, driving the smoke and gases into and across the second fire where they are consumed. The flames of this

structor is constructed on an entirely different plan from either. It consists of two sets of furnaces to which gas is supplied as fuel from a generating apparatus. Each furnace is a simple pot or tank lined with fire brick. There are no grates, the garbage resting upon the bottom. The gas is made to pass into the furnace, which is charged with refuse, the gases of combustion then pass on to the empty furnace of the pair, and thence to the flue leading to the chimney. This flue is filled with open brickwork, which being heated to a white heat burns the resulting gases, and deprives them of foul odor. When the charge is consumed, the process is reversed, the empty furnace being filled and the gases passed in the opposite direction, the same chimney being used in each instance.

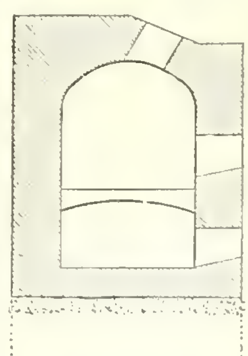

FIG. 3947.—Cross Section showing Location of Charging Door, Stoke and Ash-doors.

Reduction.—The refuse of cities contains a considerable proportion of material which is utilizable. Hence various processes have been devised by which this material may be recovered and sold. The valuable portions are the fat or grease, the nitrogen, phosphate and potash, these latter ingredients being useful for conversion into fertilizers. Colonel Waring, under whose supervision the collection of refuse was efficiently carried on in New York, estimated the average composition of 3,000 tons of summer garbage as follows:

	Pounds.	Per cent.
Rubbish	140	7
Water	1,420	71
Grease	40	2
Tankage	400	20
	2,000	100

The tankage of one ton contained about 13 lbs. ammonia, 13 lbs. phosphoric acid, and 3 lbs. potash; if these

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ingredients could be utilized, garbage would be worth according to Waring $2.47 per ton.

The following estimates are made of the amount, in pounds, of garbage collected per capita annually in large cities:

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Boston	247
Buffalo	137
Milwaukee	205
New York	147
Paterson	80
Philadelphia	321
St. Louis	223

Dr. Chapin makes the following just comment upon the foregoing figures: "If the above average be correct, millions of tons must be collected annually from our large cities, worth double that number of millions of dollars. It is not to be wondered that energetic efforts have been made to save this waste."

From Waring's figures it appears that more than seventy per cent. of the garbage consists of water, which must be removed before salable products are obtained. Hence the practice in some cities of allowing the garbage to drain before it is treated, either by reduction or cremation. In Ealing near London, the garbage, ashes, and sludge from the town sewage works are stacked in pens for some time before treatment, by which means the mass is deprived of much of its water.

The following brief description relates to one of the more common methods employed for the reduction of

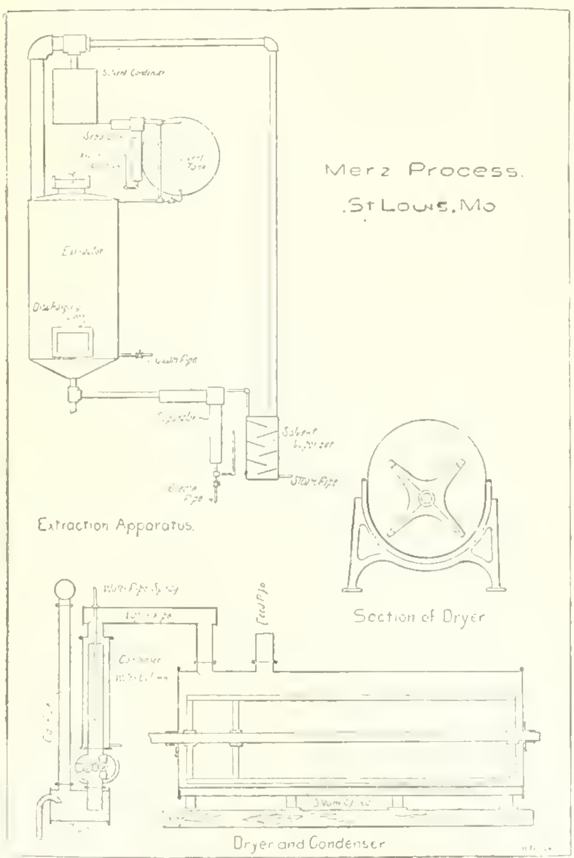

FIG. 3948.—Merz Reduction Apparatus. (From "Report of Brooklyn Health Department," 1896.)

garbage the Merz process: When first received at the works, the garbage is put into a steel hopper and the superfluous water is allowed to drain into the sewer. The rags, bones, tin cans, etc., are then selected out and sold, and the garbage is put into the dryers, which consist of jacketed cylinders with revolving shafts and arms sto stir the garbage while drying. Each dryer holds about three tons. The dark-brown product is then put into the extractors, which consist of closed tanks with false bottoms. Naphtha percolates through the mass to extract the grease. The grease in solution is drawn off, the naphtha separated from it and the grease barrelled for sale. This grease is of a brownish color and of inferior quality. The dry residue after separation of the grease is ground, and sold to fertilizer manufacturers. The Simonin process, like the Merz process, extracts the grease from the garbage by the use of naphtha. It has this advantage over the Merz process, in that the garbage can be at once placed in the extractors without previous drying. It was carried on at Providence and at New Orleans, but was abandoned at both places. This method is now conducted at Cincinnati, but the advance in the price of naphtha has made it unprofitable.

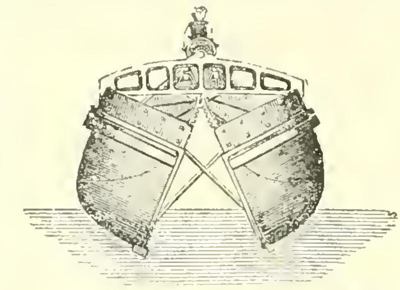

FIG. 3949.—Barney Dumping-Boat, after Discharging at Sea.

Chapin believes that this method can be successfully conducted with a moderate degree of profit, even without the payment of a bonus; but that this can be done only in a city where the garbage is very carefully separated.[1]

Another process, known as the Arnold process, is conducted at Boston, New York, and Philadelphia. It consists in rendering the garbage to recover the grease and drying the residue to be used as a fertilizer. Little attempt is made to prevent odors arising from the process. It is evidently considered by the operators to be cheaper, not to try to prevent nuisance, but to seek a location where the nuisance will affect only a few persons.

The cost of collection and disposal of garbage varies greatly in different cities, from a minimum of about 60 cents per ton to a maximum of $3.40 per ton, and from a minimum of 10 cents per capita to about 30 cents or more per capita.

Dry Refuse.—Dry refuse in many cities includes ashes and all the rubbish which accumulates in private homes and in stores, markets, etc. Manufacturing wastes are not usually removed by municipal collection. At the present day it is quite customary to require that three receptacles be provided, by the householder—one for ashes, one for garbage, and one for paper and other light refuse. The receptacles should be made of galvanized iron or other metal.

Usually dry refuse is disposed of by using it as a filling for lowlands, the owners of which are glad to have it disposed of in this manner.

In a few instances a small revenue of 10 to 15 cents per load has been received from the sale of ashes.

Experiments made in New York showed that the average ash of that city contains twenty per cent. of unburned coal, but probably some of this is finely divided and cannot be recovered with ordinary sifting processes. In some cities situated upon the seacoast and upon large rivers, the dry refuse is dumped into the water. In Boston the Barney dumping-boat is used, the material being dumped in the water at a distance of at least ten miles from the city on the ebb tide. On arriving at the point of disposal the two halves of the boat are separated by means of a hinge motion, very much like that of a clam shell. The towboat is started forward and the dumping boat is rapidly flushed out by the swiftly running water, and the two halves are brought together again. The boat is provided with water-tight compartments (see Fig. 3949).

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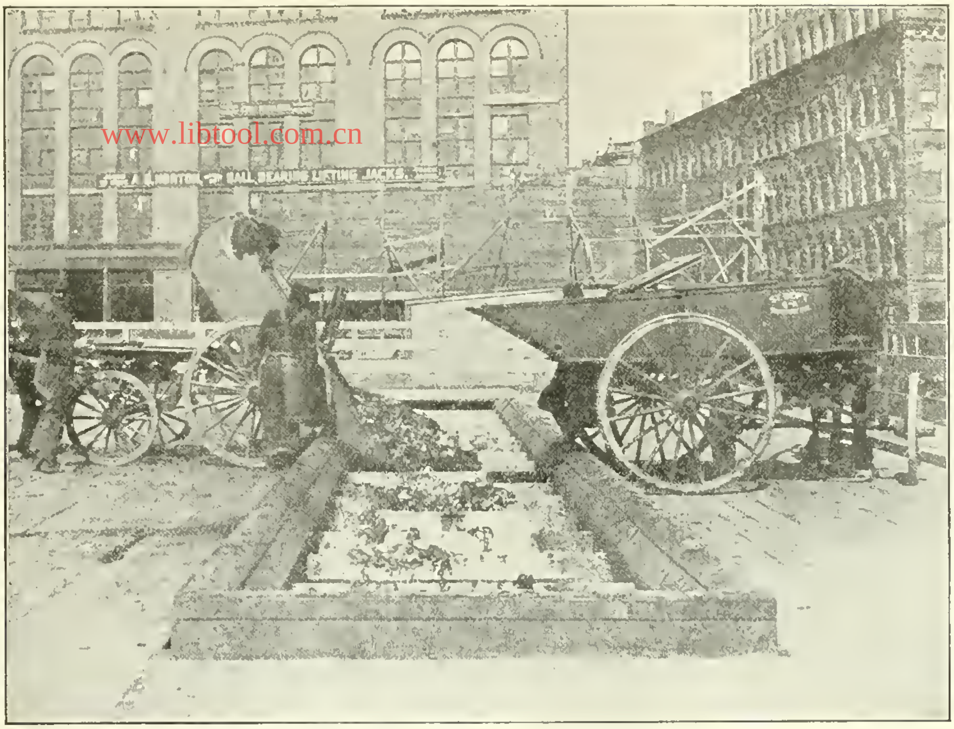

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FIG. 3950.—Unloading Garbage into Scow at Wharf.

In Boston and New York attempts are made to utilize a portion of the material found in dry refuse. The plant for this purpose at Boston consists of a large room in which the wagons deposit their loads.

A long travelling apron, four feet wide, runs from the front of this room, through it into the furnace-room, where it discharges into the furnace. The power for moving the apron, for baling, and for furnishing light is obtained from the furnace. The persons who cull out the paper, rags, metal, glass, rubber, etc., and sort and prepare it for sale, stand at the sides of the moving apron. About eighty per cent. of this refuse is marketable, and the value of the daily collection is about $60.

The following are the prices obtained for the principal marketable portions of this dry refuse:[4]

Manilla paper	$0.50	per 100 pounds.
Newspapers	.35	" 100 "
Mixed paper	.25	" 100 "
Straw board paper	.25	" 100 "
Black rags	.30	" 100 "
White rags	1.50	" 100 "
Mixed rags	.90	" 100 "
Woollen rags	7.00	" 100 "
Soft-back carpets	.90	" 100 "
Hard-back carpets	.30	" 100 "
Linsey carpets	.65	" 100 "
Twine	.11	" 100 "
Old shoes, good	.12	" 100 "
Old shoes, poor	.11	" 100 "
Bagging	.40	" 100 "
Mixed bottles	.45	per barrel.
Old iron	9.00	per ton.
Copper	.11	per pound.
Brass	.10	" "
Lead	.04	" "
Zinc	.10	" "

In New York (Manhattan district) the amount of rubbish collected and disposed of in a similar manner in 1898 was 94,000 tons, and for this the sum of $63,500 was obtained.

Mixed Refuse.—In some cities the garbage and dry refuse are collected and disposed of together. This was for many years the plan adopted in New York, and is still in use in several quite large cities. When thus collected the garbage, ashes, and dry refuse are mixed together in the receptacles, which are usually of metal and are provided with covers, but quite often nothing better than ordinary barrels and boxes are employed. Regulations provide for the location of the full receptacles either on the sidewalk or upon the householder's premises. Provision is also made for regular hours and frequency of collection. Disposal is usually

FIG. 3951.—Night-Soil Barrel, Used in Connection with Odorless Excavation Apparatus. (From Chapin's "Municipal Sanitation.")

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made by dumping either upon lowlands or into water. The former usually creates more or less nuisance, but is tolerated because of its economy. In San Francisco the mixed refuse is cremated. In Troy a portion only (the most offensive part) is cremated, while in a few Southern cities parts of the garbage and dry refuse are burned in the open air at the dump.

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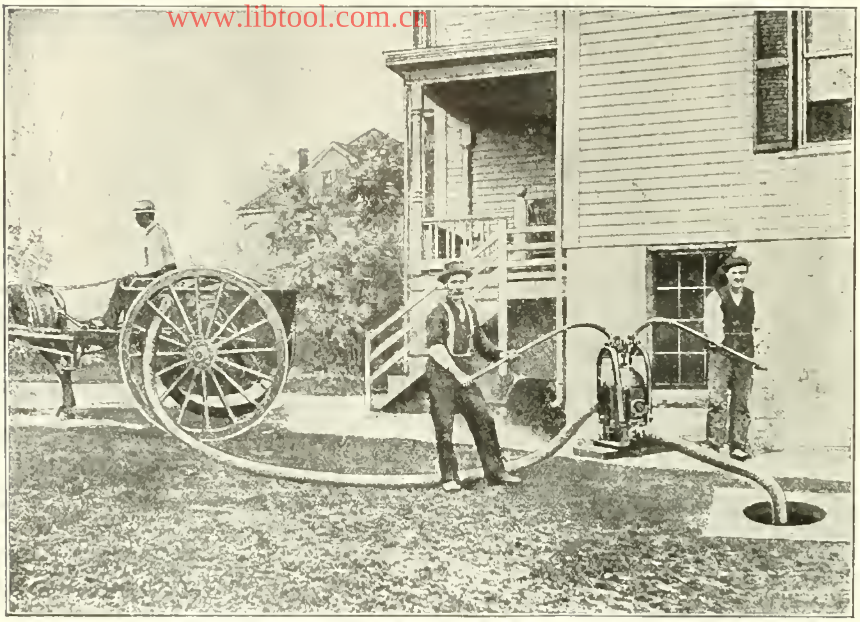

FIG. 3952.—Odorless Excavating Apparatus in Operation.

Night Soil.—By this term is meant the liquid or semi-liquid contents of privy vaults and cesspools, derived from the household wastes of the water-closets, bath-tubs, and other fixtures, including that of the kitchen sink. The latter often proves troublesome in consequence of its greasy character and its liability to clog the traps and pipes through which it flows.

On account of the liability to cause nuisance in the performance of this work it is customary to require that the scavengers, or other persons who conduct it, shall be licensed and placed under careful supervision.

It is customary to require the use of tight receptacles for the removal of night soil, either barrels or tubs provided with handles and tight-fitting covers. (Fig. 3951.) Boxes or movable tanks are also employed. The so-called pneumatic odorless pumps are well adapted for this class of work. (Fig. 3952.) Tubs and barrels are conveniently handled, ten or twelve of such receptacles usually constituting a load.

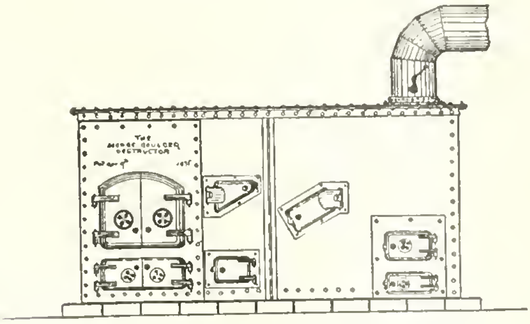

FIG. 3953.—Garbage Destructor for Use in Public Institutions, Factories, etc.

It was formerly customary to remove such material only at night, but this practice is gradually being substituted by removal in the daytime, when with improved apparatus it is practicable to do the work in a more cleanly manner.

Disposal.—In some cities the night soil is taken to suburban districts and there used upon farms as a fertilizer, a practice liable to cause nuisance to the neighborhood, if thus disposed of in the vicinity of dwellings. In some places it is dumped into water, either a large river, lake, or the ocean. In a few English cities where the pail system of excrement removal is still in use, the contents of the pails are taken to the crematory and burned together with other sorts of refuse.

The Refuse-disposal of Public Institutions and Other Establishments.—Special destructors are now made of smaller size than those in use by cities, for the destruction of the waste products of public institutions, hotels, department stores, factories, medical colleges, and other isolated establishments. Such forms of apparatus (Fig. 3953) are specially adapted to the destruction of infected bedding, clothing, rags, and other infected material which is not worth the trouble and expense of saving by any process of disinfection.

Samuel W. Abbott.

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[1] Chapin: Municipal Sanitation in the United States, Providence, R. I., 1901.
[2] W. F. Goodrich, A.I.M.E.: The Economic Disposal of Town's Refuse, London, 1901.
[3] Palmberg: Public Health and its Applications, p. 242.
[4] Boston Post, January 21st, 1900.

REGENERATION.—Regeneration is the process which leads to the replacement of lost tissue. The term is applied equally to the reproduction of cells to take the place of those cast off under normal physiological conditions on the one hand, and to the repair of tissue destroyed by lesion on the other. In both cases the process is essentially the same. The new tissue is formed by the proliferation of cells in the immediate neighborhood of the area from which the cells have been cast off or destroyed. Moreover, the new tissue is derived from remaining tissue of like kind, connective tissue from connective tissue, epithelium from epithelium. Where reproduction of epithelial tissue does not take place, or where the reproduction is incomplete, the defect, it is true, is filled with connective tissue forming a scar; but this scar tissue is derived from the connective tissue around the defect, and not from the epithelium. Physiological regeneration goes on continuously to supply tissue waste; regeneration after lesion occurs in the healing of wounds, in the restoration of the mucosa after catarrh, and in similar processes.

There are two methods of multiplication of cells, direct division or amitosis, and indirect cell division or karyokinesis, mitosis or karyomitosis. In the former of these two methods the mother cell simply increases in size and

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Regeneration.

finally divides into two daughter cells after a division of the nucleus. In karyokinesis the process is more complicated, consisting as it does of a cycle of definite changes in the chromatin of the nucleus preceding the division. Direct division or amitosis is said by some authorities to take place only in cells which are no longer capable of forming new tissue, whereas mitosis occurs in active vigorous cells which form new tissue. Other authorities, on the contrary, regard the two processes as of equal significance.

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The power of reproduction differs in different tissues. Surface epithelium and epithelium lining glands are capable of regeneration to a very large extent, as are also nerve fibres and many of the other tissues of the connective-tissue group generally. Of the latter, the periosteum is capable of the greatest degree of regeneration, whereas cartilage has only a limited power of regeneration. Ganglion cells once destroyed are probably never replaced by ganglion cells in the adult, and glandular epithelium is completely restored only where the defect is slight and where some of the original cells remain uninjured in the area of the lesion.

Regeneration of Epithelium.—In regeneration of epithelium the protoplasm of the cell divides in the later stages of karyokinesis, or after this is complete. In some cases the cell sends out processes of protoplasm, and the new nuclei wander out from the parent cell into these before the protoplasm is constricted off to form the new cell.

In a lesion of an epithelial surface, where the area destroyed is not too great in extent, the epithelial cells proliferating from all sides completely repair the defect; if it is more extensive, the defect is incompletely filled by connective tissue, thus forming a permanent scar. In the latter case, the connective tissue forming the scar results, as in all cases, from the proliferation of pre-existing connective tissue, not from proliferation of epithelium. Epithelium reproduces epithelium, never connective tissue, but it is also true that the character of epithelium reproduced is not always the same as that which is lost; for squamous epithelium may replace cylindrical epithelium, as is seen in atrophy of the mucosa of the bronchi and stomach in chronic inflammation of these surfaces.

Minor defects of epithelial surfaces, where underlying tissues are not destroyed, are quickly and completely restored by the proliferation of the surrounding epithelium. In recovery from acute Bright's disease, or in the healing of an ulcer of the stomach or intestines, the epithelium is often completely restored by the multiplication of the remaining mucous glands as well as by growth downward of the epithelium on the surface. Lesions of the liver are also completely restored by multiplication of the cells of the parenchyma and by the formation of new bile ducts.

Larger defects of epithelial tissue, particularly where the underlying structures are involved, result in a scar, with more or less incomplete reproduction of glands which are for the most part usually atypical.

Regeneration of Structures Consisting of Connective Tissue.—Defects of structures made up of connective tissue in any of its various forms may under favorable circumstances, as where the lesion is not too extensive, or in lesions of certain of the tissues of this group, even though they be extensive, be completely restored by the new formation of tissue identical in character with that originally present. Where the lesion is more extensive, particularly in one that occurs in certain of the connective-tissue structures, the defect is more or less filled up by connective tissue of a different type from that originally present. Connective-tissue structures such as the periosteum, bone marrow, blood and lymphadenoid tissue, are all readily restored completely after lesion. On the other hand, cartilage does not readily reform, and defects in this structure are replaced by ordinary scar tissue or by bone. New bone is formed not from pre-existing bone but from the remaining periosteum and from the bone marrow. Sometimes new bone is formed in other connective tissue, as in the intermuscular connective tissue and from the perichondrium. But muscle tissue is formed only from pre-existing muscle, never from connective tissue of any other kind. Ganglion cells are probably never restored after injury, defects in this tissue being replaced by scar tissue or by glia cells; but nerve trunks are readily restored, provided that the ganglion cells from which they spring are uninjured, for the regeneration is brought about by the growth of the axis-cylinder processes. The peripheral portion of a severed nerve always undergoes degeneration, it is never restored; all parts of it finally break down into granules and are dissolved away. The central portion of a severed nerve, on the contrary, undergoes degeneration for only a short distance from the end, back to the first or second Ranvier constriction from the end. In a few days after the occurrence of the lesion the axis cylinder in the central portion of the severed nerve begins active proliferation. At first the new axis cylinders are naked save for a layer of protoplasm rich in nuclei, but sooner or later the proper sheaths are reformed. If the degeneration of the peripheral segment of the severed nerve has not yet affected the Schwann's sheath, the new axis-cylinder processes may enter these and fill them out again. The regeneration of nerves takes weeks or months for completion.

In regeneration of connective tissue, as in reconstruction of other tissues, the proliferating cells are always much larger than the cells at rest. The proliferating cells, or formative cells as they are also called, not only possess a relatively large amount of protoplasm, but the nuclei are large and vesicular and contain nuclear bodies, many of them showing, by proper methods of hardening and staining, the various stages of karyokinesis. Frequently the formative cells contain more than one nucleus, sometimes even a large number of nuclei, forming giant cells (Fig. 3954, *i*). The tissue made up of these

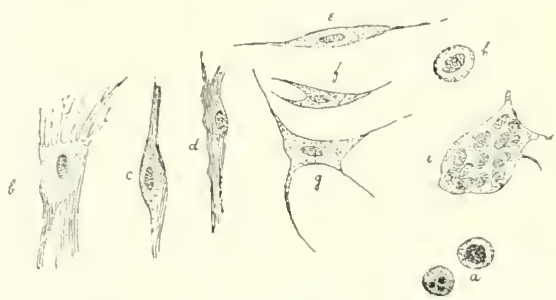

FIG. 3954.—Cells met with in New Formation of Connective Tissue. (After Ziegler.)

formative cells is appropriately called embryonic tissue, and the character of the permanent tissue arising from the development of the embryonic tissue is determined by the nature of the embryonic cells. If the formative cells are destined to form scar tissue they are called fibroblasts; if they are to form cartilage they are called chondroblasts; if bone, osteoblasts.

The formative cells are of many different shapes; some are large, round, or oval masses of protoplasm (Fig. 3954, *h*), others spindle-shaped (Fig. 3954, *e*), others roughly star-shaped (Fig. 3954, *g*), others irregular with long processes (Fig. 3954, *c*, *d*, *f*), or bundles of fibres at the ends as if the protoplasm were frayed out (Fig. 3954, *b*).

If fibrillated connective tissue develops from the embryonic tissue, fibres make their appearance between the formative cells, and by continuous increase they encroach more and more upon the latter till the formative cells finally lie compressed in fissures between the densely packed fibres.

Cartilage develops by the formation of a homogeneous intercellular substance instead of fibres, but the formative cells are encroached upon and compressed just as in the case of ordinary fibrillar connective tissue. The

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formative cells become much reduced in size, and finally lie in the characteristic openings in the homogeneous intercellular substance.

The process of new formation of bone is similar to the new formation of cartilage; the lime salts are finally deposited in the intercellular substance.

Mucous, lymphadenoid, and fatty tissues may all arise from embryonic connective tissue.

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Fibrillated connective tissue may arise from any form of connective tissue that has suffered lesion, and has been converted into embryonic tissue.

From what has been said, it is evident that the stage which is preliminary to the new formation of permanent tissue after lesion is characterized by the appearance of embryonic tissue. The further development of this embryonic tissue is not the same in all cases; in some instances there is perfect reproduction of tissue in all respects like the original, or *restitutio ad integrum*. In many cases the restitution is only partial; in others again there is replacement of the original structure by connective tissue of a different type from the original. The replacement of the original structure by connective tissue of a different type from the original may occur in any kind of connective tissue, and is in truth a very common occurrence, constituting the formation of a scar, where the original structure is replaced by dense fibrous connective tissue, whose only function is to fill a gap. Where the original structure is endowed with any special function, the scar tissue is incapable of taking on this function. If, for example, the scar tissue is formed to fill up a defect caused by a lesion in a muscle, the scar tissue serves only to unite the divided ends of the muscle fibres, but is not itself capable of contraction. Scar tissue formed in the brain, in the liver, in the kidney, in the spleen, or in the lung does not perform the peculiar function of the tissues of these organs. The substitution of connective tissue of lower functional power than that originally present constitutes a form of degeneration, and is met with in cirrhosis of the liver and other organs. But although these processes are spoken of as degeneration, it would perhaps be more correct to regard them as hypertrophies of the connective tissue, for this is what they are in fact.

Regeneration of the formed elements of the blood does not differ essentially from regeneration of the other connective tissues. The leucocytes are reproduced in the lymphadenoid tissue in various parts of the body as well as in the circulating blood, as is shown by the fact that white corpuscles showing karyokinetic figures are met with abundantly in these situations. Direct nuclear division and fragmentation also occur, as is shown in the lobed and disrupted nuclei of the polymorphic nuclear leucocytes.

New Formation of Blood-Vessels.—A very important factor in regeneration is the new formation of blood-vessels.

FIG. 3955.—New Formation of Blood-Vessels. (After Tillman.)

These are formed by sprouts arising from the vessels beneath the injured area. Each sprout is at first a solid arch, in reality a long cone or horn, of protoplasm projecting from the wall of the vessel (Fig. 3955, *a*) terminating in a long-pointed process. The solid arch may even send out several long processes (Fig. 3955, *b*, *c*). Sooner or later the solid arch becomes hollowed out by liquefaction of the interior, forming a cavity which finally opens into the parent vessel, or the arch may be hollow from the start and consist merely of a bulging of the wall of the parent vessel (Fig. 3955, *c*). In either case the arch next becomes a tube by the pressure of blood flowing in from the parent vessel, and this also causes the long processes to split and form hollow, conical tubes. Meanwhile nuclei formed by karyokinesis of the cells of the endothelium of the parent vessel wander into the walls of the hollow tube and convert it in this way into a capillary. The capillaries produced in this way have walls consisting of flat endothelial cells, but these cells are frequently quite thick; and when this is the case, the new-formed capillary resembles a tubular gland on cross section. The long, slender processes from the arches unite freely with the similar processes from other vessels (Fig. 3955, *b*) and even directly with the walls of other vessels, or they may unite with the parent vessel at a different point from the origin (Fig. 3955, *c*). In this way abundant anastomosis between the vessels is formed.

This is not the only origin of the new capillaries, for certain cells which at first have no connection with blood-vessels also take part in the process. These cells are spindle- or club-shaped masses of protoplasm which lie free in the tissue at first, but later become united with the long processes from the arches (Fig. 3955, *b*). After they become united with the processes from the arches they become perforated by a central canal and finally assume the character of capillaries.

Many of these new-formed capillaries subsequently change to arteries and veins by thickening of their wall through proliferation of the cells of the walls. The different coats finally become differentiated.

The account here given of the new formation of blood-vessels is that given by Ziegler, and is the one that has found universal acceptance. But some authorities claim that the blood-vessels are also formed in other ways. They maintain that the cells that wander into the area of the lesion unite to form capillary vessels, and that they also form new red blood corpuscles in a manner similar to the formation of vessels and blood in embryonic tissue. This method of new formation is not recognized by Ziegler in pathological regeneration.

Another process of new formation of blood-vessels claimed by some authorities is that certain spindle-shaped cells form in parallel rows, leaving a canal between them. Vessels apparently formed in this way may be seen in organizing blood clot, but Ziegler regards these as really deceptive offshoots from pre-existing blood-vessels.

B. Meade Bolton.

REGISTRATION OF DISEASES. See *Vital Statistics.*

RELAPSING FEVER.—(Synonyms: Febris recidiva; typhus recurrens; famine fever; bilious typhoid; spirillum fever; epidemic remittent fever; remitting icteric fever; fièvre à rechute; fièvre récurrente; typhus à rechute; Hungerpest; Rückfallsfieber; Wiederkehrendes Fieber; Armentyphus; tifo recidivo, etc.)

DEFINITION.—A specific, contagious fever, which may prevail as an epidemic among the destitute, and especially among those who live in overcrowded tenements, during seasons of unusual scarcity of food; hence the name famine fever. It is characterized by the presence of a mobile spiral filament in the blood—a spirillum or spirochæte (*S. Obermeieri*)—which is found during the relapses as well as during the initial paroxysm, but is absent during the apyretic intervals. The first febrile paroxysm lasts for from five to seven, or even nine days, and is terminated abruptly in profuse perspiration; after an apyretic interval of a week or more a relapse commonly occurs, which is similar to the initial paroxysm, but of shorter duration; in some instances a second, a third, or even a fourth relapse occurs.

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HISTORY.—The attempt has been made (Spittal, 1844) to show that some of the fevers described by Hippocrates correspond with relapsing fever. This view is considered by Hirsch to be quite erroneous. He says: "It is clear that Hippocrates speaks there of bilious remittent malarial fever." The first notice of the occurrence of relapsing fever in Europe is found in the writings of the Scotch and Irish physicians of the early part of the eighteenth century. Hirsch says: "I have searched in vain, in the descriptions which the physicians of the sixteenth and seventeenth centuries have given of the fever epidemics observed by them, for any indications of relapsing fever that would be in some measure precise." The fact that the disease was not recognized, and differentiated from other specific febrile affections, cannot, however, be taken as evidence that it did not exist prior to the date of the first clearly recorded epidemic in Ireland (1739). An account of this epidemic has been given by Rutty, who wrote in 1770. The earliest accounts of the disease in Scotland date from 1741 (Hirsch). But the literature relating to relapsing fever belongs for the most part to the past century. It prevailed in Ireland and in Scotland during the years 1799–1800, 1817–19, 1826–27, 1842–48, and in the latter year (1848) it invaded several of the larger towns of England. In 1868–70 it again prevailed in England and Scotland, and cases are reported to have occurred in London as recently as the year 1873. On the Continent the first accounts we have come from Russia—Odessa, in 1833; Moscow, 1840–41. In the autumn of 1863 the disease reappeared in Odessa; the following year it became epidemic over extensive areas in Russia, and extended to Livonia and Finland (1865), to Siberia (1866), and to Poland (1868). According to Hirsch, the disease continued to prevail in Russia over extensive areas during subsequent years, and was observed among the Russian troops as late as 1878–79. In Germany an extensive epidemic broke out in 1868, as a result of importation from Russia (Hirsch). A second, more restricted, epidemic occurred in 1871–72, and a third in 1878–79. In the west and southwest of Europe—Switzerland, France, Italy, Spain—the disease is as yet unknown. In India relapsing fever has, no doubt, prevailed for many years, but the differential diagnosis between it and remittent fever, or the specific continued fevers which prevail there so largely, was not clearly made out by the earlier observers. During the last forty years, however, numerous outbreaks of this disease in various parts of India have been recorded, and Carter has demonstrated that the disease, as it occurs in that country, is identical, as regards its clinical history, with relapsing fever as described by recent European authorities, and also that it is characterized by the constant presence of the spirillum discovered by Obermeier in blood drawn during a febrile paroxysm. Relapsing fever has several times been imported to the United States, but its prevalence has been limited to restricted areas in our largest seaport cities. In 1844 fifteen cases were received into the Philadelphia Hospital from an emigrant ship sailing from Liverpool; in 1848 a few cases arrived in New York, and in 1850–51 Dr. Austin Flint saw a number of cases, among recently arrived Irish emigrants, received into the Buffalo City Hospital; but no epidemic resulted from these importations, and it was not until some years later (1869–70) that the disease became epidemic in certain sections of the cities of New York and Philadelphia. Parry, who made a careful investigation with reference to the origin of the first cases in Philadelphia, was unable to trace it to importation; but this can scarcely be questioned in view of what is known of the history and etiology of the disease, and in consideration of the fact that Philadelphia is a seaport city which has constant communication with ports on the other side of the Atlantic which at that time were known to be infected. Parry and Pepper have given us admirable accounts of this epidemic in Philadelphia. We quote from a recent article by the last-named author the following statement, relating to its progress and extent: "In Philadelphia, of 1,176 cases in which the date of occurrence is known, there occurred in September (1869), 4 cases; December, 6 cases; January (1870), 5 cases; February, 13 cases; March, 124 cases; April, 209 cases; May, 325 cases; June, 293 cases; July, 115 cases; August, 19 cases; September, 28 cases; October, 15 cases; November, 1 case; December, 2 cases; January (1871), 2 cases; February, 1 case; March, 2 cases; May, 7 cases; June, 2 cases; September, 7 cases; October, 2 cases.

The coincidence of relapsing fever and typhus has been noted in many of the epidemics which have occurred in Europe, but the history of this coincidence does not justify the supposition that there is any etiological relation between these diseases other than that furnished by common predisposing causes, viz., the depressing effects of overcrowding, insufficient food, and filthy surroundings. This view is supported by the fact that either disease may occur alone, and by the circumstance that sometimes one and sometimes the other has the precedence in time in those epidemics in which coincidence has been observed.

FIG. 3956.—Spirilla of Relapsing Fever. (After Soudakewitsch, *Annales de l'Institut Pasteur*, vol. v., 1890.)

ETIOLOGY.—The discovery by Obermeier, in 1873, of a minute vegetable parasite—*Spirochæte Obermeieri*—in the blood of patients suffering from relapsing fever, and the subsequent demonstration, by numerous observers in various parts of the world, that this micro-organism is constantly present in the blood of relapsing-fever patients during the febrile paroxysms, has thrown a flood of light upon the etiology of this disease, and is one of the most significant facts with reference to the etiology of the infectious diseases in general which have been brought to light by modern microscopical researches. Conservatism suggests the possibility that the parasite may be simply an accompaniment of the disease, and not directly concerned in its etiology as the essential and specific cause. This hypothesis seems to us to be hardly tenable in view of what is now known of the pathogenic action of certain other micro-parasites of the same class, and of the following facts: (*a*) The parasite is constantly present in the blood during the febrile paroxysms, and in smaller numbers during the latter part of the period of incubation, and is absent during the apyretic intervals. (*b*) This parasitic organism is peculiar to the disease under consideration, *i.e.*, repeated researches by competent microscopists have failed to demonstrate the presence of a similar organism in any other disease. (*c*) The parasite is present in the blood in such numbers that its pathogenic power can scarcely be questioned. Carter says: "During specific fever several organisms (*e.g.*, five to ten) are visible in the field at one time; not seldom they are too numerous to count, and occasionally they are present in swarms, being apparently nearly half as common as the red discs themselves." (*d*) The disease may be communicated to man (Motschutkoffsky) and to the monkey (experiments of Koch and of Carter) by inoculations with blood containing the spirillum, and the parasite is found in great numbers in the blood of the inoculated individuals during the febrile paroxysm which results—after an incubation period of three or four days (Carter)—from such inoculations. The morphology of the relapsing fever "germ" is shown in Fig. 3956. The spiral filaments are exceedingly slender, their diameter being not more than 1 μ (0.001 mm., Lebert), or, according to Carter, $\frac{1}{50000}$ to $\frac{1}{40000}$ of an inch. The length varies from two to six times the diameter of a red blood disc (Carter). The motion of these spiral filaments, in blood recently drawn, is very lively, "rotary, twisting, and rapidly progressive, but soon ceases under the ordinary condi-

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tions of microscopic examination" (Lebert). According to Carter, the movements may continue for from a few hours to one or two days or longer.

A good objective and a certain amount of skill in the use of the microscope are required for the detection of the spirillum in fresh blood. This is shown by the fact that Obermeier himself failed to recognize the presence of the parasite in the microscopic researches made by him some years prior to the date of his discovery; and by the failure reported by some of those who have since attempted to verify his observations. Carter says: "That, as regards the examination of fresh blood, obstacles do exist, is proved by the fact of the organism being originally found only after long-repeated scrutinies; and at Bombay I have met with observers, not unaccustomed to the use of the microscope, who could never clearly see the filaments." The demonstration is more readily made when a thin film of dried blood attached to a cover-glass is stained, *secundum artem*, with one of the aniline colors—an aqueous solution of methyl violet, or of Bismarck brown, or fuchsin.

It is not yet certain whether the spirillum of relapsing fever is reproduced by spores as well as by "spontaneous fission," but it seems extremely probable that this is the case. Carter supposes that certain short filaments which he has observed in the blood are germinating spores, and remarks that "the practical facts of contagion require the presence of fertile spores, since spiral filaments are absent in the *secreta* and *excreta* of the body, and propagation by blood inoculation is obviously not the rule in common life." The same author gives several instances in which an attack is supposed to have been due to accidental inoculation while making an autopsy. Other cases are ascribed to simple contact with the dead body, independently of any wound. That the disease may be transmitted from individual to individual by direct contagion, or indirectly through fomites, is demonstrated by a multitude of observations; and, indeed, we have no satisfactory evidence that it is transmitted in any other way, or that the specific infective agent—spirillum—is capable of multiplication in an external nidus, and thus of giving rise to an epidemic independently of direct contagion, as is undoubtedly the case in certain other diseases, *e. g.*, typhoid fever, cholera, yellow fever. On the other hand, the evidence on record shows that in well-ventilated apartments and hospital wards the attendants upon the sick and patients suffering from other diseases are not very liable to contract the disease. Where, however, the sick are massed together in insufficiently ventilated hospitals, or when cases occur in the overcrowded tenements of the poor, the transmission of the disease to attendants and others exposed to contagion is far more frequent.

Up to the present time attempts to reproduce the spirillum of relapsing fever in a series of *cultures* have not been successful. Carter has, however, observed a growth of the spirilia in length, and the development of a tangled network of long filaments in a culture cell containing aqueous humor, kept in a warm chamber at a temperature of 40.5° C. (105° F.).

PREDISPOSING CAUSES.—There is no evidence that *climate* or *season* has any marked influence upon the prevalence of relapsing fever; the disease has prevailed in Siberia as well as in India, and its preference for certain localities is quite independent of climatic conditions, relating rather to circumstances connected with the mode of life and hygienic surroundings of the population. No *age* is exempt, and *sex* has no apparent influence; but children are more subject to be attacked than adults, and susceptibility seems to diminish to some extent with advancing age. According to Murchison, only 195 out of 2,111 cases received into the London Fever Hospital, in twenty-three years, were over fifty years of age. To appreciate the value of these figures it would evidently be necessary to know how large a proportion of the exposed population were over fifty years of age.

Insufficient food is generally recognized by medical writers as a potent predisposing cause, and epidemics have so frequently been observed to coincide with periods of unusual scarcity that the name "famine fever" has been applied to the disease. Some authors have even gone so far as to ascribe to starvation and its accompaniments, overcrowding and filthy surroundings, an essential rôle in the development of the disease. But, as in the case of other specific contagious diseases, there seems to be very little foundation for the idea that relapsing fever may be developed *de novo* in times of famine, and its epidemic prevalence at such times is to be ascribed rather to increased vulnerability, on the part of the starving population, to the action of the specific exciting cause of the disease. We know that under favorable hygienic conditions the disease has but little disposition to spread, and that in the severest epidemics it finds its victims almost exclusively among the destitute. On the other hand, in the numerous instances in which shipwrecked mariners, Arctic explorers, etc., have been subjected to absolute starvation, we have no account of the development of any such disease as relapsing fever. *Overcrowding* is considered by Parry to be a more potent predisposing cause than starvation, and his careful study of the circumstances of those who were taken sick during the prevalence of the disease in Philadelphia (1870) seems to justify this conclusion—which is, moreover, supported by the observations of Muirhead, Bennett, Lebert, and others.

One attack of relapsing fever does not protect the individual from subsequent attacks, and second, or even third, attacks during the same epidemic have been noted.

Carter's experiments upon the monkey have led him to the conclusion that "the human virus becomes intensified in its passage through this animal." It is noticeable that, with one or two exceptions, there was but a single febrile paroxysm in the numerous successful inoculation experiments made by the author quoted. This does not invalidate the value of the evidence furnished by his experiments as to the identity of the disease produced in the monkey with the specific infectious disease of man known as relapsing fever, for this single paroxysm was characteristic in its origin, duration, and termination, and in the constant presence of the blood parasite which is peculiar to this disease. Moreover, in man the relapse is not an essential feature of the disease. Thus Carter, out of a total of 411 cases, found that in 98 (23.8 per cent.) there was but a single febrile paroxysm. Pepper has recorded the fact that in 10 out of 181 cases observed in Philadelphia there was no relapse; and Murchison, in a series of 2,425 cases collected from various sources, found that there was but a single paroxysm in 30 per cent.

CLINICAL HISTORY.—As a rule, the primary febrile paroxysm begins abruptly, without noticeable *prodromes*. In certain cases, however, the patient experiences a certain amount of malaise, loss of appetite and headache, for a day or two prior to the sudden access of fever. The *period of incubation* has usually a duration of from five to seven days (five to nine days—Murchison), but instances of a longer or shorter incubation are not infrequent. In several cases of accidental inoculation, at autopsies, which came under the observation of Carter, the period of incubation was from three and a half to seven days; and in the successful inoculations in the monkey, made by the same author, the mean duration of this period was about ninety hours. Speaking of these experiments, the author referred to says: "My experiments showed conclusively that prior to the onset of the fever there always occurs a more or less prolonged period of visible blood contamination; and hence that the interval between infection and fever is divisible into two parts, viz., an earlier and usually longer non-spirillar stage, and a final stage of spirillar manifestation during which the body heat, so far from being augmented, is often rather depressed."

The *initial paroxysm* of fever is commonly inaugurated by a decided chill, or at least by slight chilly sensations, accompanied by headache, pain in the back and limbs, and a feeling of weakness, with indisposition to exertion.

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Relapsing Fever.

The tongue is coated; nausea and vomiting are of common occurrence; and there is usually a certain amount of tenderness on pressure in the epigastric region. Enlargement of the spleen occurs early in the attack, and usually a certain amount of enlargement of the liver may also be detected after the second or third day. Jaundice is of frequent occurrence in certain epidemics, and in others is quite rare. The abrupt seizure usually occurs during the daytime, and is marked by a rapid rise of temperature and a correspondingly rapid pulse. The pyretic movement exhibits a somewhat remittent character, the evening temperature being one or two degrees higher than the morning temperature, and attaining a maximum of 103.5° to 105° F. during the first twenty-four hours—a maximum which may be exceeded by a degree or two during subsequent evening exacerbations. The distinctive character of the pyrexia is its sudden termination by crisis, as a rule on the fifth or seventh day—more rarely as early as the third or as late as the twelfth day. This sudden termination of the febrile paroxysm is commonly attended with profuse perspiration, and occasionally by a critical diarrhœa, or hemorrhage from the nose, rectum, or vagina. The temperature frequently falls, during this termination of the paroxysm by crisis, as much as 10° or 12° F. in a few hours, and, as a rule, a subnormal temperature is quickly reached, and may persist at the morning observation for two or three days. *Defervescence* may occur at any time during the twenty-four hours, but the observations of Carter indicate that in a majority of the cases (66.6 per cent.) it happens between the hours of 4 P.M. and 7 A.M., or in other words, that it is most likely to occur during the night. It is attended by a complete relief of the distressing symptoms which marked the febrile paroxysm, and with the exception of a feeling of lassitude the patient has nothing to complain of, his tongue cleans up, his appetite returns, and within three or four days he might be considered convalescent, were it not for the known tendency of the disease to relapse after an apyretic interval of about a week. In one hundred and ninety cases analyzed by Carter the mean duration of the *apyretic interval* was 7.4 days, the extreme range being from three to twelve days.

The *relapse*, occurring commonly on the fourteenth day from the date of seizure, resembles the initial paroxysm in its sudden onset and abrupt termination, but is usually of shorter duration—three to seven days. The temperature not infrequently attains a higher point than during the initial paroxysm, and there is a correspondingly rapid pulse, but with the exception of increased debility the other symptoms are, for the most part, of a milder character. Defervescence is attended with profuse perspiration, and, as in the first apyretic interval, a subnormal temperature is quickly reached. After a *second apyretic period*, of from six to fourteen days, a *second relapse* of still milder character and briefer duration may occur, and, in exceptional cases, this may be followed by a third or even a fourth relapse.

SPECIAL SYMPTOMS.—The characteristic features of the *pyrexia* are shown by the accompanying chart (Fig. 3957) of a case reported by Murchison, which, however, cannot be taken as entirely typical, inasmuch as the initial paroxysm and the relapse are of about the same duration, whereas the rule is that the relapse is not so protracted, and the date of its occurrence is more commonly the fourteenth rather than the twelfth day, as in this case. Variations from the typical form are, however, the rule rather than the exception, and the most we can say is that there is a tendency to crisis on the seventh day, and to relapse on the fourteenth day. The remittent character of the pyretic movement is often more marked than in this case, and especially so in the relapses. We remark, also, that the subnormal temperature which follows crisis and sudden defervescence is less marked than usual in this case, after the first febrile paroxysm, although shown very well in that part of the chart which represents the second apyretic interval. This is a very noticeable feature of the disease, although not peculiar to it, a subnormal temperature being quite common during the "calm stage" of yellow fever. We have the authority of Murchison for the statement that the temperature may fall as much as 14.4° in the course of twelve hours, reaching as low a point in certain cases as 94°, 93°, or even 92° F.

Pepper has observed a fall from 107.2° to 95°, and states that this is as low a point as is commonly reached. The observations of Carter, also, indicate that a fall below 95°, in non-fatal cases, must be extremely rare. The acme of temperature is commonly reached during the twenty-four hours immediately preceding the crisis, and in certain cases a sudden rise of several degrees has been noted to occur just before the abrupt fall which terminates a paroxysm. In a typical series of cases analyzed by Carter the maximum temperature observed during the initial paroxysm was 108°, on the evening of the sixth day; the maximum temperature noted during the relapse in the same series of cases was 106° F. Pepper has recorded a temperature of 107.5° as having come under his observation, and in a typical case, of which he gives a chart (*op. cit.*, p. 380), a temperature of 107° was reached at the termination of the initial paroxysm, and also during the relapse. In this chart a slight febrile movement is seen to follow the subnormal depression after the relapse. "Reactionary fever" of this kind, of moderate degree and irregular in its course, is commonly seen to follow the febrile paroxysm and subsequent subnormal depression of temperature in yellow fever. In relapsing fever it is not perhaps so common, but is sufficiently so to have attracted the notice of Carter, who speaks of it as the "rebound" or "secondary fever," and states that it was observed in about one out of six of his cases. "Its duration is brief, and the blood spirillum is invariably absent."

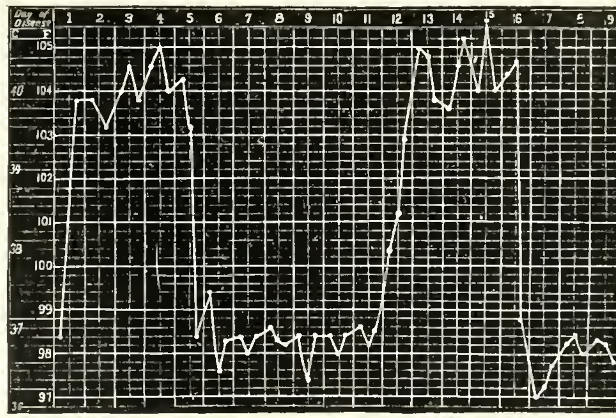

FIG. 3957.—Temperature Curve in a Case of Relapsing Fever.

The *pulse* in relapsing fever presents no distinctive character. During the pyretic movement it is very frequent, and at the outset is commonly full and tense; but with defervescence there is a rapid reduction in its frequency, and during the first portion of the apyretic intervals, when the temperature is subnormal and the patient is in a state of partial collapse, it becomes small and feeble, and occasionally extremely slow—as slow even as in the corresponding stage in cases of yellow fever. Thus, Obermeier has seen it as low as 44, and other observers have seen it even lower than this—Muirhead 34, Stillé 30. While, in general, the rapidity of the pulse corresponds with the pyretic movement, yet this is not an invariable rule, and according to Murchison is less true as regards the relapse than in the initial paroxysm; thus, he has seen a pulse of 90 when the temperature was 106°. On the other hand, Carter has noted that in the

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Bombay epidemic the sudden fall of temperature marking the crisis was not attended with a corresponding decline in the frequency of the pulse. During the height of the fever the number of pulsations per minute, in adults, may be stated as from 110 to 140, while in children it often reaches 160 or even 170. After the crisis, an irregular or dicrotic pulse is not infrequent, and as a rule it is feeble and compressible. At this time there is danger of sudden death from syncope. A soft systolic murmur heard over the base of the heart and along the large vessels is frequently discovered, both during the primary paroxysm and during the relapse.

Pain in the back and limbs is complained of during the first days of the primary attack, and to a less extent during the relapse. Articular pains, unaccompanied by swelling, may also persist during the apyretic interval. But the most distressing pain is felt in the head. *Headache* is usually frontal; it is an early and often very persistent symptom, disappearing only with the crisis, and recurring with less severity with the relapse. Other symptoms referable to the nervous system are: *Vertigo*, induced by assuming an erect position; especially common at the outset of the attack, and often persisting throughout the paroxysm; *delirium*, usually of an hysterical character, and most common among the victims of chronic alcoholism; or the low muttering delirium which accompanies suppression of urine, and which, in the absence of relief, passes into stupor and coma; *convulsions*, the result of uræmic poisoning or of extreme nervous irritation due to severe and protracted pyrexia; *insomnia*, due largely to the distressing pains, and not readily controlled by hypnotics; *paralysis*, limited to single muscles or to groups of muscles—of rare occurrence. Of these symptoms vertigo and insomnia are the only ones which are so common as to constitute a characteristic feature of the disease.

The symptoms referable to the *digestive system* are those common to febrile complaints generally, viz., thirst, loss of appetite, a coated tongue, torpid bowels, and nausea, with vomiting of ingesta and bilious matters. The *tongue* usually remains moist and is coated with a thick white fur which may become yellowish or, in cases having a typhoid tendency, brown and dry. It is usually somewhat swollen and indented at its edges by contact with the teeth. This appearance, together with the frequent absence of coating upon the edges and over a triangular space at the tip, which remains bright and red, has been regarded by some authors as of diagnostic value. Occasionally the tongue is red and glazed, and it may become deeply fissured, or in severe and protracted cases dry and brown. The tongue quickly clears up and appetite returns when the febrile paroxysm has terminated by crisis, and when a relapse occurs it again becomes coated and there is a return of anorexia and gastric disturbance. *Nausea* and *vomiting* are almost constant symptoms at the outset of the attack, and, less frequently, recur during the relapse. Occasionally a considerable quantity of bile is ejected; more commonly the vomited matters consist of ingesta or glairy mucus tinged with bile. "Black vomit," due to the presence of blood in the vomited matters, has been seen by several observers, and in certain epidemics seems to have been not very infrequent. It is a symptom of grave import. Three cases out of four in which it was noted by Pepper terminated fatally. This author observes that, "judging from the frequency with which in fatal cases we find ecchymoses of the gastric mucous membrane, with blood-stained mucus in the cavity of the stomach, we should expect black vomit to be more often observed than is the case." More or less tenderness and pain on pressure in the epigastric region is a common symptom during the early part of the febrile paroxysm; in this particular, as in several others, there is a noticeable resemblance to yellow fever.

The *bowels* are commonly constipated at the outset of the attack, but later diarrhœa is not infrequent, and this may be profuse and of a critical character, occurring at the close of a febrile paroxysm, and to a greater or less extent taking the place of the usual critical sweating.

Enlargement of the liver may usually be demonstrated by careful percussion, and in some instances this organ extends to three inches below the margin of the ribs toward the close of the febrile paroxysm. Pressure in the hepatic region causes pain, and occasionally hepatic tenderness is quite a constant cause of distress. *Jaundice* is a prominent symptom in certain epidemics, occurring in from twenty to twenty-five per cent. of the cases. At other times it is comparatively rare. It appears toward the close of the primary paroxysm, or in one of the succeeding febrile paroxysms, and usually disappears after the crisis. According to the observations of Pepper and of Stillé, it is more frequent in the negro than in the white man.

Enlargement of the spleen is a constant and early symptom, and it is not unusual for this organ to attain from three to four times its normal bulk. It may be detected as early as the second day, projecting below the margin of the ribs, and toward the close of the febrile paroxysm it often forms a visible tumefaction on the left side of the abdomen. During the apyretic interval its volume rapidly diminishes, to increase again during the relapse.

The *skin* is free from any characteristic eruption, but occasionally an eruption of pinkish or rose-colored spots has been observed (Carter), and "true petechiæ have been quite common in some epidemics" (Pepper). Sudamina and herpetic eruptions about the mouth and nostrils are of common occurrence. Desquamation of the cuticle, especially from the hands and face, is not infrequent. Several observers have noted a peculiar odor, exhaled from the body of the patient, which is said to resemble that given off by "burning straw with a musty odor."

The *urine* is somewhat scanty and high-colored during the febrile paroxysms, and, as is usual in such cases, has a higher specific gravity than normal; its reaction is usually acid, and it deposits, on standing, a more or less copious sediment of urates, associated sometimes with crystals of oxalate of lime. The amount of urea present is subject to considerable variations, but the general rule seems to be that it is increased during the paroxysms, and decreased at the time of the crisis, to increase again during the first part of the apyretic interval. In certain cases the critical sweating is replaced by an abundant discharge of light-colored urine of low specific gravity, but under ordinary circumstances the amount of urine is greatly reduced at the time of crisis; subsequently the quantity is increased and the specific gravity is reduced to a minimum, and this may persist for some time after convalescence is established. Thus, Carter reports a case in which the daily amount, for two weeks after the relapse, was one hundred and thirty ounces, while the specific gravity was only 1002.6. Slight *albuminuria* has been noted by several observers as commonly occurring toward the close of the febrile paroxysm, or shortly after its termination. According to Carter, other evidence of acute renal congestion, such as blood discs and tubular casts, is almost never found. Other observers, however, have reported the presence of tube casts in those cases in which the urine is albuminous, and Obermeier has claimed that acute desquamative nephritis is one of the ordinary phenomena of the disease under consideration.

Epistaxis is of rather frequent occurrence in relapsing fever, and hemorrhage from the stomach, from the bowels, and from the kidneys, has been noted in rare cases. Pepper reports fifteen cases in which very profuse epistaxis occurred at the crisis, evidently as a critical discharge, replacing to some extent the usual perspiration.

Convalescence is usually rapid in the absence of any complication, but, after very severe and prolonged attacks, a considerable interval must elapse before the emaciated patient regains his usual strength. The average duration of the period included between the date of seizure and complete convalescence is about six weeks (Wilson).

VARIETIES.—At least one relapse, occurring after an apyretic interval, is necessary to constitute a typical case of relapsing fever. But in a certain proportion of the

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cases occurring during an epidemic, there is but a single febrile paroxysm—*abortive form* (Carter)—which, however, is undoubtedly due to the same specific cause, as is shown by the constant presence of the spirillum of Obermeier in blood drawn during the pyrexia. These cases are often mild in character, and in the absence of a microscopic examination of the blood and demonstration of the presence of the spirillum, the diagnosis would remain uncertain. The form of fever denominated *bilious typhoid* by Griesinger and other German authors is undoubtedly a variety of relapsing fever. It is characterized by intense jaundice, a tendency to suppression of of the urinary secretion, to hemorrhages from mucous surfaces, and to those grave symptoms which constitute the typhoid state, viz., great prostration, muttering delirium passing into stupor and coma, hypostatic congestion of the lungs, a dry and brown tongue, etc. These symptoms may be developed during the primary febrile paroxysm in such a manner as to interfere with the termination of this paroxysm by crisis, and to render obscure the apyretic interval which, in typical cases of relapsing fever, distinctly separates the initial paroxysm from the relapse.

Complications.—One of the most frequent and fatal complications of relapsing fever is *pneumonia*. It commonly occurs after the crisis of the primary paroxysm, but may also follow the relapse, or may occur as a more remote sequel of the disease—three or four weeks after the close of specific pyrexia. In 97 autopsies Carter found evidence of pneumonia in 27 instances. Out of 23 autopsies, Pepper found the lesions of this complication in 8. It is more frequent in adult males than in females and children. *Pleurisy* was found by Carter to coexist with pneumonia 13 times in 21 autopsies in which inflammation of the lungs was verified. Deaths from pneumonia commonly occur within a week or ten days after the first crisis. The onset of this grave complication is marked by the usual symptoms and physical signs, and by pyrexia, which may be confounded with that of the relapse due to specific blood contamination. The pyrexia attending this complication is, however, distinguished from that of the preceding or subsequent specific febrile paroxysm by the absence of spirilla from the blood. The same is true of the "secondary" or "reactionary" fever, which in severe cases sometimes follows the critical defervescence, and which is independent of any recognizable organic complication.

Diarrhœa, in certain epidemics, is rather common as a complication or sequel, and may be the immediate cause of death. It occurred in 33 per cent. of the cases observed by Pepper in Philadelphia, and in 50 per cent. of the cases in the Königsberg epidemic. *Parotitis* occurred in from 2 to 3 per cent. of the cases collected by Carter, and was observed by Pepper in 3 cases out of 185. It may result in resolution, or more commonly in suppuration. As a rule, it is developed during the first apyretic interval. *Hiccough* is a distressing complication which frequently occurs in severe cases, especially in those attended with jaundice. It is most common toward the end of a febrile paroxysm, and usually disappears after the termination of the paroxysm by crisis. *Bronchitis* of a moderate degree of intensity is a frequent complication which is developed, for the most part, during the febrile paroxysms, as a result of congestion of the bronchial mucous membrane, and disappears, or is greatly modified in degree, during the apyretic intervals. *Acute laryngitis*, with œdema, is an occasional complication. *Enlargement of the spleen* is so constant that it may be considered an essential feature of the disease, rather than a complication. In certain cases the enlargement persists for many weeks, and is attended with marked debility and anæmia. *Rupture of the spleen* has been reported by several authors, and *splenic abscess* has been noted in certain rare cases. The former accident is marked by suddenly developed pain and collapse, and is quickly fatal; the latter commonly gives rise to pyæmia, or may induce acute peritonitis or pleurisy, by discharging into the cavity of the abdomen or the left pleural cavity. Other complications which have been noted as events of rare occurrence are: hemorrhage from the stomach; metastatic abscesses of the lung; suppuration of the mesenteric glands; general peritonitis; thrombosis of veins, and cerebral hemorrhage. When pregnant women are attacked with relapsing fever, *abortion* is almost sure to occur; and in those cases in which menstruation occurs during the attack, it is usually profuse, and sometimes dangerously so. Among the sequelæ of the disease, we may mention as most prominent: diarrhœa, dysentery, anæmia, neuralgic pains, local palsies, keratitis, and inflammation of the deeper tissues of the eyeball, mental hebetude, mania, and in rare instances gangrene of the feet, nose, or ears, as a result of arterial thrombosis (Wilson).

Diagnosis.—The early diagnosis of relapsing fever is made easy by the discovery of Obermeier, and by the fact, now verified by numerous observers, that the spirillum peculiar to this disease is found in the blood during the entire period of pyrexia—including the relapses—and usually for a short time in advance of the febrile paroxysms. Without this test the diagnosis must always remain somewhat uncertain for some days, inasmuch as there are no pathognomonic symptoms marking the outset of the attack. The sudden termination of the initial paroxysms by crisis, and the relapse after an apyretic interval of five to twelve days, will, however, be sufficient to establish the diagnosis in typical cases; but, as in other specific febrile diseases, there are many atypical cases in which the diagnosis might remain uncertain if it depended upon the clinical history alone. This is especially true of the so-called "abortive form," in which there is but a single paroxysm, in that form which has been denominated bilious typhoid, and in cases in which the typical character of the pyrexia is masked by complications of one kind or another. In countries where severe forms of malarial fever prevail there can be no doubt that cases of relapsing fever, especially at the outset of an epidemic, before the prevalence of this disease has been generally recognized, are often ascribed to malarial poisoning, and fall under the denomination "remittent fever" —a term which in former years, and in the absence of precise knowledge, has been made to do duty in tabular statements of disease and mortality for more than one specific disease, *e.g.*, typhoid fever, yellow fever, relapsing fever. The investigations of Carter make it appear probable that relapsing fever is by no means a new disease in India, yet it has been only recognized during recent years, and the available records of an epidemic which prevailed in Bombay so recently as 1863–64–65 do not permit the author mentioned to decide positively whether the enormous mortality from "fever termed remittent" was in truth due to relapsing fever or to typhus, as was claimed by some of the local practitioners. The differential diagnosis between relapsing fever and true malarial remittent presents no serious difficulties, although there are many symptoms—such as headache, vomiting, epigastric tenderness, enlargement of the spleen, and jaundice—which are common to both diseases. The character of the pyretic movement, the sudden termination by crisis, the failure of quinine favorably to influence the course of the disease, the protracted apyretic interval, and the relapse, will suffice. But in addition to these facts relating to the clinical history, there are various circumstances relating to the epidemic prevalence of the disease which will aid greatly in its recognition. Thus, relapsing fever is transmitted from individual to individual by contagion, and is a disease of towns, and especially of the overcrowded portions of such towns where the poorer classes of the population are congregated under unfavorable sanitary conditions; whereas remittent fever is especially a disease of the country, the prevalence of which depends upon circumstances relating to locality, climate, and season, and not upon personal intercourse and social condition. As a rule, it may be said that a fatal epidemic disease which prevails among the crowded population of a large city is not remittent fever, whatever else it may be.

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Typhus fever and relapsing fever are often associated as regards their epidemic prevalence, although there is no evidence that they bear any etiological relation other than that due to common predisposing causes. That they are specifically distinct is well established, and the clinical history of each is sufficiently characteristic. The eruption of typhus, the continuous course of the pyretic movement, and the fatal tendency of the disease are all in contrast with relapsing fever. A more detailed account of the clinical points of difference is hardly necessary in view of what has preceded, and of the ready means of establishing the differential diagnosis which is furnished by the microscope. The same may be said as regards enteric fever, which disease is also characterized by a less abrupt onset, and a pyrexia which presents peculiar features essentially different from that of relapsing fever, together with special symptoms, such as a tendency to delirium, abdominal distention, an eruption of rose spots, etc. The differential diagnosis in that form of relapsing fever which is denominated by Griesinger "bilious typhoid" may perhaps present greater difficulties, and, before the discovery of the spirillum of Obermeier, much uncertainty existed as to the etiological relations of this fatal form of disease. In addition to the presence of the spirillum it is distinguished from enteric fever by its mode of onset, by the early appearance of jaundice, and by the character of the pyrexia, together with a tendency to hemorrhage from mucous surfaces, a more decided enlargement of the spleen, and the absence of rose-colored spots.

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Bilious typhoid might very easily be mistaken for yellow fever in countries where this disease prevails, and we have the authority of Murchison for the statement that this mistake has been made by Graves, Stokes, and Cormack. The two diseases have many features in common, but also essential points of difference. Thus, yellow fever prevails only in certain latitudes and during the summer season, while relapsing fever is quite independent of climatic conditions. Yellow fever is extremely fatal, and a single attack protects from subsequent attacks; the reverse is true of relapsing fever. Relapsing fever is propagated by direct transmission from individual to individual; yellow fever is not, and its extension depends upon external conditions. The negro has a partial immunity from the effects of the yellow-fever poison, but is especially susceptible to relapsing fever. There are also essential differences in the clinical history of the two diseases. In one—yellow fever—the acme of temperature is commonly reached during the first twenty-four hours, and defervescence is gradual; in the other defervescence is rapid and accompanied by a critical discharge, and the acme of temperature occurs, as a rule, shortly before the crisis.

The "stage of calm" in yellow fever is a period of the gravest danger, the urine is scanty and highly albuminous, and complete suppression is a common, and almost invariably a fatal, event. the febrile paroxysm is usually not so protracted as in relapsing fever, and is attended with less distress, but the effects of the specific poison upon the blood, the kidneys, and the mucous membrane of the stomach are of such a nature as to place the life of the patient in the greatest jeopardy. The apyretic interval in relapsing fever is, on the other hand, a period of comparative safety and comfort; the urinary secretion is abundant, the appetite returns, and the stomach resumes its functions. This apyretic interval is, however, not so clearly defined in severe cases of bilious typhoid, as death occurs in from thirty to fifty per cent. of these cases, and most frequently during the initial paroxysm, or as a result of complications which interfere with the normal course of the disease; and as there are jaundice, albuminous urine, and a tendency to hemorrhages from mucous membranes, it is easy to see how mistakes may arise, and the diagnostic value of the microscopic test, demonstrating the presence or absence of the spirillum, becomes apparent. It must be remembered, however, that the spirillum is not found during the reactionary fever which sometimes follows the crisis, or during the pyrexia attending a complication.

Prognosis and Mortality.—The mortality from relapsing fever, in the absence of complications, is low. Out of 2,115 cases admitted to the London Fever Hospital in twenty-three years (1847–70), there were 39 deaths (1.84 per cent.). Murchison, to whom we are indebted for these figures, has also analyzed the statistics furnished by Scotch physicians. In a series of 6,300 cases the mortality was 4.12 per cent., and in a second series of 10,444 cases it was 4.42 per cent. According to Pepper, the mortality in the Philadelphia epidemic was 14.4 per cent., the total number of cases being 1,174. These figures scarcely sustain the statement that relapsing fever is a comparatively mild disease, and the mortality in the cases in which jaundice was a prominent symptom—"bilious typhoid"—which is said to have been not less than fifty per cent., places this form of the disease on a level with yellow fever and typhus, so far as its fatality is concerned. In India, out of 616 cases collected by Carter, there were 111 deaths (18.02 per cent.). It is evident from these figures that it is only by excluding cases complicated by jaundice, pneumonia, etc., that the statement is justified that "the death rate in relapsing fever is low." Death may occur during the initial paroxysm, the apyretic interval, the relapse, or subsequently to this. In an analysis of 99 fatal cases Carter ascertained that in 48 death occurred during the primary paroxysm, and of these 37 died at or about the apparent acme of fever, and at the stage of defervescence 11; 24 deaths occurred during the first apyretic interval; 6 during the first relapse; 11 during the second interval, and 1 in a second relapse. The apparent *cause of death* in these cases is said to have been in 63 cases exhaustion, resulting from the immediate effects of the pyrexia and its attendant symptoms; in 17 cases pneumonia as a complication; in 2 copious gastric hemorrhage; in 1 femoral thrombosis; in 7 cerebral hemorrhage was ascertained by autopsy; there was acute dysentery in 8 cases, and hepatic abscess in 1.

The influence of age upon mortality is shown by the following table, which we copy from Wilson (*op. cit.*), who obtained it from the statistics of the London Fever Hospital as given by Murchison.

Of the 2,115 cases admitted there were:

	Cases.	Deaths.	Per cent.
Under 20 years	804	3	0.37
Between 20 and 30 years	562	4	.71
" 40 " 50 "	322	8	2.48
" 50 " 60 "	119	9	7.56
" 60 " 70 "	66	7	10.60
" 70 " 80 "	6	2	33.33

The favorable influence of youth, as shown in this table—0.37 per cent. for all cases below the age of 20—is not in correspondence with the data obtained by Carter in India. He says: "The influence of age was apparent in the greater comparative mortality at both extremes of the scale of years; thus, the general mean death rate being about 18 per cent., the rate was 27 per cent. up to the age of ten years, and then in the two succeeding decennia declining to 11 per cent. (11 to 20 years), and 16 per cent. (21 to 30 years), it rose with advancing age above the mean to 24.5 per cent. (31 to 40 years), 29.4 per cent. (41 to 50 years), and 37.5 per cent. (51 to 60 years).

The mortality is greatest at the outset of an epidemic, and the proportion of cases complicated with jaundice is larger at this time. *Sex* has no apparent influence upon the death rate, when we exclude the decided influence of intemperate habits, and take account of the fact that more males than females are attacked.

Anatomical Lesions.—Most authors assert that there are no constant anatomical lesions in relapsing fever, but Ponfick, of Berlin, who has made the most elaborate researches yet published, based upon sixty-five autopsies made during the epidemic of 1872–73, asserts "that certain changes in the spleen, the marrow of bones, the

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blood (large granule cells); also those of the liver, kidneys, and muscles (especially of the heart), pertain directly to relapsing fever, and taken together are pathognomonic." The splenic changes are said to be absolutely constant, and this assertion at once disposes of the commonly repeated statement that there are no constant local lesions in relapsing fever. Liver changes, too, were invariable; but some difficulty here arose from the likelihood of prior lesion due to alcoholism. It is evident that the epidemic at Berlin was a severe one, there being seen several examples of *typhus biliosus*. The following is a summary of Ponfick's results. *Liver:* The turgescence ensuing during specific pyrexia may be greater than occurs in any other infectious disease; the individual lobules become enlarged, their outlines indistinct, and tint a grayish-red. Microscopically, the increased volume is due to cloudy swelling of the hepatic cells (always present), to their peripheral fatty degeneration, and lastly, to an infiltration of small cells in the portal canals; from an anatomical point of view, no distinction here is possible between the mild and the severe forms of relapsing fever; jaundice was present sixteen times (twenty-four per cent.), and it results from biliary engorgement. *Kidneys:* Changed without exception, and in correspondence with alterations noted in the urine; they may be doubled in size; parenchyma flabby; the cortex broad and clouded; the Malpighian tufts pallid. Or parts alone may be changed, and when dark streaks are visible, then not only is the tubular epithelium more or less fatty, but the lumen of the tubes is occupied by fibrinous or blood-tinged plugs. Such cylinders with red discs have been found in the urine (not at Bombay, H. V. C.). There is also evident, in the extreme degree of swelling, a copious small-cell infiltration of the intertubular tissue; and besides, an amyloid thickening of the vessels, which may be attributed to previous *morbus Brightii*. *Striated muscles:* Lesion of the myocardium is very frequent, its consistence flabby, tint pale gray or brownish, wholly or in streaks, where the fibres have undergone fatty degeneration; such degeneration may be as extreme as in the most virulent kind of infectious disease, or even in poisoning by phosphorus. Dr. Ponfick naturally applies these data in explanation of certain fatal cases of fever, where death occurs by syncope, and no other lesion is found after death. I have above remarked that the like were not witnessed among the temperate natives of West India. *Spleen:* Changes here are localized or diffused; the latter are always present, and induce a swelling of the organ, sometimes greater than occurs in *leukæmia*. The pulp is then dark, livid, and projecting; the Malpighian bodies much enlarged or even effaced, their tint gray or yellowish; at a later stage of fever their outlines become more defined. In cases of unusually rapid turgescence of the spleen, rupture of its capsule may occur, and death, with or without peritonitis; this change is compared with that taking place in enteric fever. Swelling is due to distention of blood-vessels, and to a great increase of the cell elements, including large multinucleated forms in near relationship to the cavernous veins. Dr. Ponfick could not find any spirilla among these cells. Numerous pulp cells were seen containing red blood discs and pigment; and others filled with bright granules which look like spores, but probably are not such; these structures are not peculiar to relapsing fever, though found here in relatively larger numbers than in other fevers; they may be seen in the blood circulating during life, and when very abundant, may be concerned with death of patient. Cases are quoted such as occurred at Bombay. There is also another contamination of the blood which can be demonstrated during life in severe cases, viz., by vascular endothelium cells in a state of fatty degeneration; this, too, is not absolutely peculiar. As to localized splenic changes, the chief pertain to the venous system and comprise the so-called 'infarcts,' which were present in forty per cent. of all autopsies; they resemble closely embolic infarcts, but arise from another cause than arterial obstruction, and hence are peculiar to relapsing fever." (Quoted from Carter, *op. cit.*)

Ponfick also describes certain changes in the marrow of bones which he considers peculiar to relapsing fever. "These changes consist in proliferation and subsequent degeneration of the lymphoid cells of the marrow, with multiplication of the nuclei in the walls of the minute vessels and fatty degeneration of their coats. As a result of these changes spots of puriform softening may form, chiefly in the cancellous tissue of the extremities of long bones, with the production of localized necrosis, and possibly with extension of inflammation to the neighboring articular cavity." (Quoted from Pepper, *op. cit.*)

In addition to these constant changes, a variety of lesions are found which appertain to the complications which occur in this disease with greater or less frequency. Most prominent among these are the lesions due to pneumonia. Pepper found evidence of lobar pneumonia in thirty-three per cent. of his autopsies, Carter in twenty-eight per cent., and Ponfick in twenty per cent.

TREATMENT.—All efforts to cut short an attack of relapsing fever by specific medication have thus far proved unsuccessful, and the knowledge that the disease is due to the presence of a minute vegetable parasite in the blood has not resulted in any decided improvement in our therapeutic resources. The evident indication is to destroy or restrain the development of this blood parasite; but in the list of known therapeutic agents there is not one which can be safely administered in sufficient quantity to accomplish this purpose. Quinine in full doses has been tried again and again, but the testimony of Murchison, of Pepper, and of Carter is in accord as to its failure to exercise any specific therapeutic power. The last-named observer says that "the blood spirillum and the febrile symptoms remain unaffected after quinine given largely to cinchonism, after narcotism by chloral, and after the freest exhibition of spirituous liquors; also after the administration of the carbolates and very large doses of the salicylates." We have no precise data showing the action of germicidal agents upon the spirillum of Obermeier; but Carter states that he once found that weak neutral solutions of quinine seemed to kill the spirillum; and Dr. Litten has ascertained that the movements of the parasite are arrested by a one-per-cent. solution of carbolic acid. The experiments of Ceri show that the development of schizomycetes is prevented by the presence of muriate of quinine in the proportion of 1 to 800 in a culture solution. The development of certain species is prevented by a considerably smaller amount, but so far as our experimental data go the indications are that at least one part in two thousand will be required to prevent the development of organisms of this class in the blood. This would require the *constant* presence of something more than a drachm of muriate of quinine *in solution in the blood* to prevent the multiplication of bacterial parasites present in this fluid. The therapeutic possibilities in the case of carbolic acid are not so favorable as this, and the writer has elsewhere estimated the amount of this agent which would be necessary to restrain the development of pathogenic organisms in the blood to be something more than two drachms. Arsenic was fairly tried by Pepper in the Philadelphia epidemic, and his conclusion is that "there seems to be no reason whatever for any further use of this drug in relapsing fever." Large doses of sodium salicylate have been demonstrated by Unterberger and by Riess to exercise a marked antipyretic effect, but to be impotent for the arrest of the febrile paroxysm or for the destruction of the blood parasite. "Unterberger has seen the temperature brought down 3° C. (5.4° F.), yet the attack was not apparently cut short, or splenic enlargement prevented, or the active blood spirillum visibly affected. Dr. L. Reiss, after essay on twenty-six cases, thinks that it is possible to cut short or mitigate the symptoms (especially the temperature) of specific relapses by very large doses (one hundred grains or more daily), noting, however, that even when the heat is reduced to normal or below it, the spirillum still persists." (Quoted from Carter.) Another remedy, tried by Pepper in a large number of cases, is the hyposulphite of

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soda; his verdict is that "it is certain that it exerted no specific effect upon the disease."

In the absence of any known specific, our therapeutic resources are reduced to those measures which are best adapted to the control of the most distressing symptoms, and to that watchful care and anticipation of complications which enable us to conduct the patient safely through the critical stages of an infectious disease, and to save many lives, notwithstanding our acknowledged inability to cure these diseases. Although the high pyrexia is not so immediately dangerous to life as is the case in certain other continued fevers, it will always be advisable to keep it within bounds, and the tendency to death toward the close of the febrile paroxysm, primary or secondary, should be borne in mind. The evidence on record is in favor of sodium salicylate, rather than quinine, as an antipyretic medicine; it may be given to the extent of one hundred grains, or more, in the twenty-four hours, and is said to be well borne. Its persistent use, however, interferes with the patient's appetite, and it will be best to reserve it for those cases which are marked by a specially high pyrexia, and to administer it, in full doses, only when the temperature approaches 106° F. For a more moderate elevation of temperature, cold sponging of the surface, and the administration of simple febrifuge remedies, such as effervescing draught, or solution of spirit of nitrous ether, will suffice. Aconite, in small and repeated doses, may be given—one drop every two hours—in combination with moderate doses of spirit of nitrous ether, and if any routine treatment for the fever is considered necessary this may be recommended, as less liable to disturb the stomach than certain other drugs which are sometimes used in similar conditions, *e.g.*, veratrum viride, digitalis. There is a tendency to constipation, and a mild aperient will commonly be required at the outset of the attack; a dose of castor oil, or a simple saline purgative, will answer the purpose; later the bowels may be moved, if necessary, by enemata; emetics, as a rule, do more harm than good. *Headache* is to be combated by cold applications to the head. *Insomnia* is a marked and distressing feature of the disease; Carter prefers to administer chloral and bromide of potassium for the relief of this symptom, rather than to give opiates. Pepper, on the contrary, says that "opium and morphine must be regarded as the basis of the rational treatment of relapsing fever. It is called for by the insomnia, the severe headache, and the pains in various parts of the body, the nausea and vomiting, and the pyrexia." One-fourth of a grain of morphine, given at intervals of six to twelve hours, was found by the author last mentioned to relieve pain and vomiting, and often to induce refreshing sleep. It is contraindicated in those cases having a typhoid tendency, as shown by a disposition to stupor and deficient urinary secretion. In the experience of Pepper during the Philadelphia epidemic, bromide of potassium in full doses failed to produce sleep or relieve headache, and chloral, in doses of twenty to forty grains, could not be depended upon, although it sometimes gave relief. In view of the tendency to heart failure in this disease, the author named very properly points out the possible danger which may attend the administration of chloral. For the relief of excessive *tenderness of the liver or spleen*, Carter recommends hot fomentations and poultices in preference to cold applications, "which are seldom grateful to the patient." To control excessive *irritability of the stomach*, Pepper advises the use of small doses of calomel, gr. $\frac{1}{4}$–$\frac{1}{6}$ every two hours, or gr. $\frac{1}{12}$ of nitrate of silver, dissolved in thin mucilage of acacia, administered at intervals of three or four hours. *Hiccough* is a distressing symptom, which often defies all remedial measures. In Pepper's experience, chloroform is the most useful remedy for its relief. As death from *heart failure* may occur at the acme of the pyrexia, or during the depression, often amounting to collapse, which follows crisis, it will be necessary to watch carefully for the slightest indications of such failure, and to guard against it by the administration of digitalis, or strychnia, and the early use of alcoholic stimulants. When the symptoms of *collapse* are developed, it will be necessary to resort to the subcutaneous injection of ether, or of strychnia, and to apply artificial heat to the surface of the body.

In this as in other specific febrile diseases running a protracted course, it is necessary to commence with a *supporting treatment* at an early date. As soon as the stomach will retain it, liquid nourishment should be administered at stated intervals—every two or three hours; meat broths, milk, or gruel may be given if the condition of the stomach admits of their being retained; if not, koumiss, chicken water, or skimmed milk diluted with lime water, may be given in small quantities and at shorter intervals. When the stomach is very irritable, it is probable that iced champagne, or a teaspoonful of good brandy poured upon broken ice in a glass, and taken as cold as ice will make it, will be found the best form of stimulant. Whiskey toddy or milk punch may be given during the apyretic interval, or until convalescence is fairly established, or a good wine may be substituted for these if the patient prefers. In this disease, as in yellow fever, sudden death is liable to occur from cardiac syncope, as a result of very trifling exertion made when the patient is apparently out of danger. It therefore becomes necessary to insist upon absolute quiet and the maintenance of a recumbent position until such time as the strength of the patient is fairly restored. This precaution is especially imperative at the time of crisis, and during the period immediately following it, when there are a subnormal temperature and other evidence of a state of collapse. *George M. Sternberg.*

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REMITTENT MALARIAL FEVER. See *Malarial Diseases*.

RENNIN.—This name for the milk-curdling enzyme of the gastric juice was first proposed in Foster's "Textbook of Physiology," and is now in common use in English-speaking countries. The name of *chymosin* was that given to it by Deschamps; it was later termed *lab* by Hammarsten, and this name is occasionally used by English writers.

The most valuable researches into its mode of action and isolation are due to Hammarsten, who was the first to show that it is distinct from pepsin. This view is now almost universally accepted, although it has recently been stated by Pawlow that rennin and pepsin are identical. Pawlow's experiments, which consist chiefly in a demonstration of a parallelism of intensity of action of gastric juice in digesting proteid and coagulating milk, are not, however, very convincing against the careful experimentation of Hammarsten in the separation of the two enzymes, as described later on in this article.

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Rennin and milk-coagulating ferments allied to it are very widely distributed, for rennin occurs not only in the mucous membrane of the stomachs of all mammalia which have been tested for it, but is also found in the stomachs of birds and fishes where its function is at present unknown. A similar if not identical ferment is found in the cell sap of many plants, such as the butterwort, fig-tree, and artichoke, and in certain of the Schizomycetes.

It is usually prepared commercially as rennet in the form of solution, powder, or tabloids, preserved with boracic acid, from the fourth stomach of the calf; carefully prepared products preserve their power of coagulating milk almost indefinitely, and long after proteid decomposition may have taken place in the other constituents admixed with the rennin.

Rennin is present in man at birth, and in this respect differs from pepsin. In its distribution in the gastric mucous membrane it closely resembles pepsin, being present only in small quantities at the pyloric region. Like pepsin, also, it is present in the gland cells as a zymogen; in fact, it was in the case of rennin that a precursory form or zymogen (Labzymogen) was first demonstrated by Hammarsten in 1872, some years before a similar demonstration was made in the case of pepsin by Langley and Edkins.

The zymogen appears to exist in a more stable form in some animals than in others, for while a neutral extract of the mucous membrane of the sheep or calf contains the enzyme in an active form, similar extracts from birds, fishes, and certain mammalia exert an action upon milk only after these extracts have first been treated with very dilute acid and again neutralized.

Rennin and pepsin and their corresponding zymogens behave very similarly on treatment with dilute alkalies; thus both rennin and pepsin are very rapidly destroyed by traces of caustic alkalies. The active ferments are also destroyed in both cases much more rapidly than their zymogens by the alkaline carbonates in dilute solutions, and this fact has been utilized, especially in the case of pepsin and pepsinogen, for proving the existence of the zymogen.

Rennin differs from pepsin in that it will act in a neutral or even in a faintly alkaline medium, but it acts most quickly when the medium possesses a slightly acid reaction. Excess of acid destroys its activity.

The *optimum* temperature lies at 37° C. to 40° C.; at this temperature the reaction takes place with three times as great rapidity as at 25° C.; activity ceases at 50° C., but the enzyme is not destroyed very rapidly at this temperature, and becomes active again as the temperature is lowered toward the optimum. The enzyme is destroyed, however, in five minutes when heated to 70° C. in neutral solution, or at 65° C. in acid solution. Its activity is also removed by standing under alcohol, but less rapidly than is the case with pepsin.

That the action is a truly enzymic one is shown not only by the above-mentioned destructions of activity, but also by the fact that it can occur in the presence of antiseptics, and by the infinitesimally small amount necessary to evoke the coagulation, one part of "purified" rennin being capable of coagulating, according to Söldner, ten million parts of casein.

The most successful attempt at its isolation was made by Hammarsten, who utilized Brücke's principle of mechanical precipitation by first neutralizing a gastric infusion with magnesium carbonate which precipitates the greater part of the pepsin. The filtrate was then partially precipitated by solution of acetate of lead to remove the remainder of the pepsin, and finally the rennin was thrown out by further addition of lead acetate and ammonia. This last precipitate was dissolved in very dilute sulphuric acid, and the rennin again mechanically thrown out with stearic acid by the addition of a solution of an alkaline stearate. The rennin was then finally obtained in solution in water by suspending the stearic acid in water and shaking up with ether, which dissolved the stearic acid and left the rennin behind in the aqueous layer.

The solution obtained finally did not act at all upon fibrin, but powerfully coagulated milk in neutral solution. This solution behaved in many important respects differently from a proteid solution, viz., it was not coagulated by heat, did not give a xantho-proteic reaction, and was not precipitated by alcohol, tannin, iodine, or neutral acetate of lead.

The chief facts as to the chemistry of the action of rennin upon milk are to be ascribed also to Hammarsten's researches upon the subject. When milk clots the greater part of the proteid separates in an insoluble form as casein (paracasein of Hammarsten), which entangles all the fat in its meshes as it contracts and so expresses a clear fluid called the whey, while the coagulated casein and entangled fat are called the curd. The whey contains the inorganic salts, lactose, and a small amount of albumen and globulin, which are called lactalbumin and lacto-globulin. Hence the casein is that important constituent which is chemically concerned in the process of coagulation.

The proteid from which the casein is formed in the act of clotting is termed *caseinogen* (casein of Hammarsten), and is present, according to some observers, in suspension in fine globules, and, according to others, as a colloidal solution. This proteid body has the properties of a very weak acid which is in fresh milk present as an alkaline salt; when it is set free from its combination it becomes insoluble. It is naturally so set free in the souring of milk, when lactic acid is formed by bacterial action on the milk sugar, and it is for this reason that sour milk curdles. For experimental purposes, such as the study of the properties of caseinogen and its changes during coagulation, it is best precipitated by the addition of a few drops of acetic acid. It can then be redissolved, after washing away the acetic acid, with distilled water, by the addition of water containing traces of alkali or by rubbing up with precipitated chalk.

As in the formation of fibrin from fibrinogen in blood clotting, it is found that calcium salts are necessary for the coagulation to take place, but more exact research has demonstrated that the rôle of the calcium salt is different in the two cases. For while the calcium salt has been shown by Hammarsten to be necessary for the formation of the *thrombosin* which acts as a ferment in blood coagulation, the same observer has also demonstrated that the calcium salt in milk coagulation does not share in forming the ferment, but has its purpose in a second stage of the reaction in actually combining with the caseinogen which has been modified in the first part of the reaction (soluble casein) to form the insoluble casein.

Hammarsten's two stages can easily be demonstrated by taking either a solution of caseinogen, or pure milk to which a few drops of ammonium oxalate have been added to throw down the soluble calcium salts, adding in either case a few drops of rennet, and then warming in a water bath to body temperature for ten to fifteen minutes, when no apparent change will be observed. Still a change has occurred, for if the milk be now boiled so as to throw the ferment out of action in the subsequent operation, and then a few drops of calcium chloride be added so that there is a calcium salt in solution in the fluid, on warming again for a few minutes a clot forms. Here no ferment action can take place in the second process, and as the addition of calcium salt only, and subsequent warming, produce no effect upon milk which has no been treated with rennin as in the first part of the process, it follows that the rennin must in the first portion of the experiment have formed some soluble modification of the caseinogen, which is then thrown out as insoluble casein in the second portion of the experiment.

Working with caseinogen solutions Hammarsten further demonstrated that in the action of rennin upon caseinogen there is detached from the caseinogen a soluble portion, which he termed "whey-proteid," that does not undergo any coagulation, and hence is found afterward in the clear fluid, or admixed in the whey with the lactalbumin when milk is used instead of caseinogen

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solution. This proteid has been referred to as lacto-protein by other workers upon the subject.

The process may hence be summarized as follows: 1. The rennin acts upon the caseinogen of the milk and forms two soluble proteids (calcium salts being absent), "soluble casein" and lacto-protein. 2. The "soluble casein" combines with calcium when calcium salts are present, so forming casein. 3. In the coagulation of whole milk the casein entangles the fat globules forming the curd, and on contracting presses out the water, inorganic salts, lactose, lactalbumin, lacto-protein, and lacto-globulin which form together the whey.

Benjamin Moore.

REPARATIVE SURGERY.—Plastic reparative surgery is that department of the operative art which contemplates the repair of defects and deformities, congenital or acquired. Limited in its early history to the restoration of parts destroyed by trauma, plastic surgery has, in the course of centuries, widened its range of utility until its present achievements have been carried to all parts of the body covered by the general integument and to many of the cavities lined with mucous membrane. When the nose is destroyed by lupus, the eyelid shrivelled out of all semblance by chronic inflammation, the palate cleft, the fingers webbed, or the arm bound down by the scars of a burn; when a gastric or vesico-vaginal fistula, an eversion of the bladder, or a ruptured perineum makes life a burden—a plastic operation is the only measure of relief.

History.—The history of plastic operations presents fluctuations of use and oblivion unknown to the generality of operative measures. For its earliest development we must look to the shores of the Ganges, where from time immemorial mutilations of the face were inflicted in the way of punishment or revenge.

Later, the practice became the portion of the potters and brickmakers, who knew nothing of sutures, but retained the parts in position by the application of clay. There is no evidence that the skill of any of the operators of antiquity went beyond the restoration of mutilated noses, or that they attempted the repair of other parts. It is generally believed that before the Christian era the Brahmins had achieved great proficiency in the restoration of noses, forming them from integument brought down from the forehead or transplanted from another individual, and preferably from the gluteal region. What is truth and what is fiction as regards the rhinoplastic skill of the early priests of India, only appears from the recent translations of relevant parts of the *Süsrutäs Ayurveda*, according to which the nose was formed from the integument covering the cheeks. "The physician takes a leaf the size of the nose to be formed, and, placing it on the cheek for a measure, raises a flap of skin in such a manner as to leave it attached at one part. After vivifying the scarred part the new nose is quickly brought in position, elevated, and retained by placing two tubes in the nostrils."[1] The classical writers of Greece and Rome were for the most part unacquainted with transplantation of skin as a method of relieving defects, which were treated only by freshening the edges by incisions and drawing contiguous portions of skin together.

On the other hand, Celsus certainly entertained a rational idea of the gliding of flaps. He advised that the defect be removed in the form of a square and that two parallel incisions be continued transversely outward and inward, so that the loosened edges might be easily united. If this could not be done, he recommended that two semilunar lateral incisions, which should involve only the skin, be made with the concavity looking toward the defect.[2]

Although Galen and Paul of Ægina repeated the precepts of Celsus, the little that was known of plastic operations lapsed into an oblivion even greater than that which befell general surgery, and from which it was not recovered for over a thousand years. In 1442 Pietro Lonzano, bishop of Lu, published a statement in the *Annales du Monde* that a Sicilian named Branca had found a new method of supplying the loss of a nose. Whence he derived his knowledge does not appear. Among the pupils of Branca was his son Antonio, who had improved and extended his father's method by taking the integument from the arm, and by replacing the loss of lips and of ears in the same way. Plastic surgery doubtless spread rapidly in Italy from the time of the elder Branca, since Vesalius, Fallopius, and others make mention of it. It remained, however, for Gaspardus Taliacotius or Tagliacozzi, professor of anatomy at Bologna, to develop plastic surgery to a degree unknown before him, and to publish the first scientific work on it two years before his death in 1599. In it are described his methods of operating and of retaining the parts in position; and the illustrations accompanying the text have been utilized from century to century by almost all authorities who have written upon the subject. A father of conservative surgery in its best sense, respected by his confrères and beloved by his students, Tagliacozzi well merited the marble statue erected after his death in the amphitheatre of Bologna. In this monument he contemplates a nose which he holds in his hand. The methods of Tagliacozzi failed to obtain a permanent foothold—Paré, Fabricius, Heister, and many others denied the possibility of success. A little over a hundred years after Tagliacozzi's death, the art which he had perfected had again fallen into disuse. Dionys, Desault, Richter, and Chopart only mentioned his practices to condemn them. Such was the state of plastic surgery when, in 1794, a Madras journal brought to England the account of a successful rhinoplasty practised by one of the Koomas, who transplanted skin from the forehead. Although the first rhinoplasty in England was made by Lucas, it was not a success. In 1814 Carpue was more successful in replacing the lower portion of the nose. In 1816 von Graefe introduced plastic operations on the Continent, giving preference to the method of Tagliacozzi. Since the last-mentioned date the utility and feasibility of plastic surgery have not been seriously questioned, and particularly within the last twenty-five years so many additions and improvements have been made that the achievements of the present day doubtless eclipse the best efforts of all former masters in this special art. Associated with the more recent progress of plastic operations are the names of Skey, Liston, and Fergusson in England; Sédillot and Jobert in France; Dieffenbach, B. von Langenbeck, Fritze, and Thiersch in Germany; and the elder Pancoast and Gurdon Buck in this country.

Indications.—Congenital or acquired defects and deformities demand the resources of plastic surgery when, from their exposed position, æsthetic reasons make their removal desirable, or when disturbances of function and impaired utility are plainly due to them in parts that are hidden from view. Hence it is evident that, regarding the imperativeness of plastic operations, cases in which they are indicated may properly be divided into two groups, in which the necessity to interfere varies as much as the end to be obtained. In the first class of cases the operation is designed merely to improve the appearance of the patient by removing a distorting scar, by suturing the fissured lobule of an ear, or by elevating a depressed nose. Here the indications for an operation are far from imperative, and it is not infrequently the importunity of the patient that impels the surgeon to operate. It is well to remember that operations done solely for cosmetic effects are ordinarily the least satisfactory; it is within the experience of almost every surgeon that results obtained by plastic operations in this group of cases, although eminently gratifying to himself and deemed excellent by his colleagues, are sources of deep disappointment to the patients themselves. In the second group of cases the chief indication for operative measures is the repair of defective function or the protection of parts that are exposed. When the absence of the lower lip, destroyed by lupus or noma, permits of the continuous loss of saliva, derangements of the digestion and of the general health necessarily follow. When the lower eyelid is everted or lost, the defect causes characteristic

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Reparative Surgery.

changes in the eye and face which often make vision imperfect, and the overflow of tears adds the suffering from an eczema to the other ills of the patient. A large urethral fistula at the peno-scrotal angle, while neither disfiguring nor detrimental to health, is a bar to the full exercise of the procreative function. In each of these cases the indication for recourse to plastic surgery is apparent, and its imperativeness is commensurate with the impairment of function caused by the deformity. To this group of cases belong extensive destruction of the lips, the nose, or the eyelids; cleft palate, cicatrix from burns, or webbing of the fingers; fistulæ, urethral, vesico-vaginal, or recto-vaginal; lacerated perineum, and exstrophy of the bladder. In this group of cases must also be included those in which the operative production of a defect is to be immediately followed by its closure by plastic means. Thus an ulcer of the leg that has proven refractory to all other means frequently yields to excision and immediate transplantation of skin; or an extensive epithelioma of the lip can be relieved only by extensive ablation of the part, the large defect being at once closed by dermatoplasty.

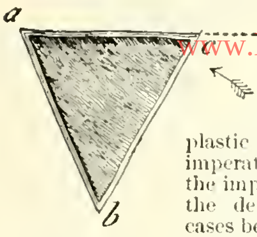

FIG. 3958.

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In considering the urgency of a plastic operation, it is necessary to consider the pathological nature of the defect which it is intended to overcome. A loss of substance may be congenital, traumatic, or the result of destructive neoplasms, like lupus, ulcerative syphilides, or epithelioma. In congenital deformities plastic operations are generally not urgently demanded, unless, as in the case of deficiency of the rectum, the life of the child depends upon their correction. But there are milder cases, congenital in character, in which greater deformity can be avoided by early interference. This is true in cases of harelip associated with cleft palate. In simple fissure of the lip the surgeon may abide his time. In complicated cases, on the other hand, early closure of the labial cleft must be advocated, since it has an undoubted influence in approximating the edges of the bony cleft and greatly increases the probability of success in subsequent attempts to close it. In two complicated cases in which I have thus operated during the first week the result was eminently satisfactory. Due regard should necessarily be paid to the general nutrition of the child before a plastic operation of considerable severity and entailing the loss of no slight amount of blood is performed. Defects that are traumatic in origin almost invariably demand removal by plastic operation while the wound is in condition to promise immediate union. This applies particularly to wounds of the face, the soft parts of which are so mobile that they may be stretched to almost any extent, provided the soft structures be thoroughly lifted from the bone. When suppurative processes have been established it is, as a rule, best to delay operative procedures until complete cicatrization shall have taken place. When the loss of substance is inflicted by the surgeon in the removal of malignant growths, its immediate repair is indicated, since there is every reason for believing that when this is accomplished the danger of recurrence of the primary disease is materially decreased. In such cases the all-important object of the operation is the removal of all diseased tissue, irrespective of the size and form of the wound that remains. In the category of defects that result from destructive inflammations, or from tuberculous or syphilitic ulcerations, operative measures are never indicated until the complete cessation of the original disease has taken place. It is in these cases that patients are most importunate in their demands for relief, and injudicious haste on the part of the surgeon is most frequently followed by disaster. Until a lupous or syphilitic ulceration is entirely under control, until, indeed, the whiteness of the cicatrix and the absence of other evidences of constitutional vice give us reasonable assurance that there is no tendency to recurrence, a plastic operation should not be attempted. An operation too soon performed will often give a new impetus to a disease that has simply been dormant.

NOMENCLATURE.—A number of terms have been suggested as suitable for designating plastic operations. French and German writers generally prefer the word autoplasty (*αὐτός*, self, and *πλάσσειν*, to form). In rare cases, in which the transplanted tissue is taken from a subject other than the patient, this term is evidently inappropriate. To overcome this objection, Velpeau and Guérin have suggested the word anaplasty, signifying to form anew or again. In this country and in England these terms have been generally discarded for the less objectionable one of plastic surgery. When, however, such an operation is performed for the repair or new formation of a particular part, the latter properly gives to the operation a particular name. Thus the formation of a nose is called rhinoplasty; of the lip, cheiloplasty; of the eyelid, blepharoplasty; of the mouth, stomatoplasty; of the urethra, urethroplasty, etc. The scope of this article will not permit the consideration of all the plastic operations. Those of the palate, fingers, urethra, perineum, and vagina are treated of in other parts of the HANDBOOK, while in the following pages will be studied the principles underlying plastic operations in general, and the methods of repairing deformities and defects of the face only.

The underlying basis of plastic surgery is the inherent vitality of the various tissues of the body. This permits them, after partial or total separation, to maintain an independent existence for a greater or less period, and to form new and permanent attachments when brought into contact with freshly wounded surfaces in proximity to, or at a distance from, their original sites. The introduction into defects of strips of epidermis, of the cutis vera, of tendon, of nerve, or of bone, which have been entirely severed from their former connections, constitutes transplantation or grafting. In plastic operations proper, this severance is never complete, a small bridge always being left through which the part to be utilized in the closure of a defect continues to live under the influence of the circulatory, and probably, also, of the nervous, apparatus of the structures whence it was taken, until perfect agglutination in its new position ensues. This occurs in from twenty-four to forty-eight hours, when no untoward complications in the process of wound repair supervene. By the end of a week the union is solidified by the free interchange of blood-vessels between the edges of the defect and the part inserted into it. In wounds of skin more than in those of any other structure is there a manifest tendency to early and firm repair, without which plastic operations would rarely succeed.

METHODS.—The pathology, nature, and extent of a cutaneous defect, and the condition of contiguous parts, will direct the surgeon in the choice of one of a number of methods that are at his disposal. Thus he may utilize the integument from a near or distant part of the body for its closure. Referring, for the present, to the former method only, I will state that the skin in the vicinity may be made serviceable by (1) traction, (2) by gliding, and (3) by transplantation of skin flaps. While typical illustrations of each of these methods differ sufficiently from each other to warrant a separate consideration of each, it is well to bear in mind that in their practical application the simpler often verges into the more complicated procedure.

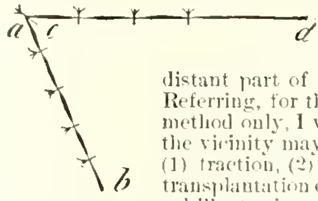

FIG. 3959.

1. The method of closing a cutaneous defect by traction on the vivified edges of the integument surrounding it is based on the extent to which skin can be stretched and yet retain its vitality. This is well illustrated after removal of the breast, in which even the largest wounds can ordinarily be readily closed. In the surgery of the

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face, however, plastic procedures by traction alone are justified only in wedge-shaped or oval defects, the margins of which can be easily approximated and retained

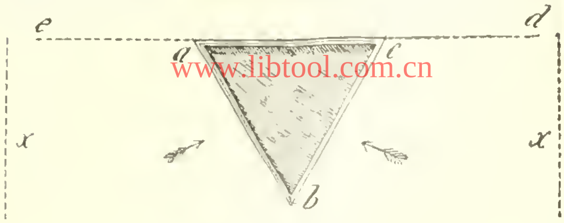

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FIG. 3960.

in position without dangerous traction on the sutures. If there be any strain on them after complete closure of the wound, it may be relieved by an incision through the skin on either side of the wound, parallel with, and at a short distance from it. This method is therefore applicable for the closure of fissures and fistulæ, and for the removal of prominent and ungainly cicatrices.

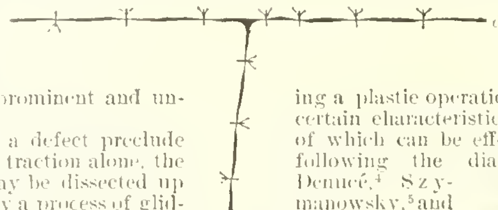

FIG. 3961.

2. When the size and form of a defect preclude the possibility of its closure by traction alone, the skin in the immediate vicinity may be dissected up in a patch of requisite size, and by a process of gliding be brought edgewise into the position of the part to be repaired, where, after proper adjustment, it is retained by sutures. Triangular and rectangular defects, such as result from the partial removal of the lower and upper lip, respectively, can be best remedied in this way. This method of operating by gliding, although mentioned by Celsus, as Linhart suggests, was probably practised before his time, since every operator, even if without previous knowledge, would naturally adopt it.

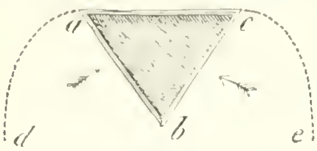

FIG. 3962.

3. The above methods are applicable only when the integument in the *immediate* vicinity of the defect can be utilized. If this is not feasible the borrowed integument, after being given the shape of the defect and being raised from its substructure, is transferred into the defect, but retained in relation with the tissues of its former position by means of a pedicle. Around this latter the flap must then necessarily be turned or twisted. Such a flap, in being transferred to its new site, may be made to describe an arc of

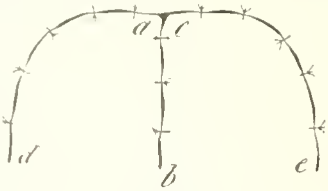

FIG. 3963.

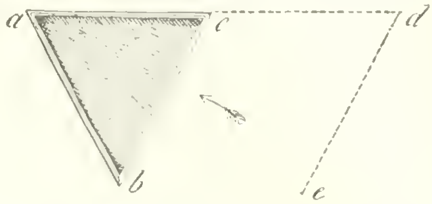

FIG. 3964.

90° or even 180°. In order that the raw under surface of the flap may be everywhere in contact with the subjacent surface, the skin bounding this must in part be displaced. "This displacement, however, should be effected in such a way that the displaced skin, retaining a connecting pedicle for its support, may be made to change

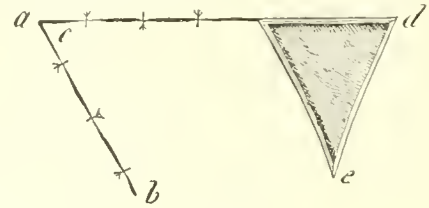

FIG. 3965.

places with the transplanted flap, and thus contribute, as far as it can, a covering for the surface that has been left bare." [3] As illustrations of this method may be cited the formation of a nose from the forehead, and of the upper eyelid from the integument of the temple.

Although every case requiring a plastic operation is a law unto itself, there are certain characteristic forms of defect the effacement of which can be effected in well-defined ways. In following the diagrammatic representations of Dennucé,[4] Szymanowsky,[5] and König,[6] the reader must bear in mind that the shaded parts of each illustration represent the defect, that the dotted lines indicate the incision, and the arrow the direction in which a flap is to be displaced. The supplementary illustration, in each case, indicates the appearance of the parts after union. (König.)

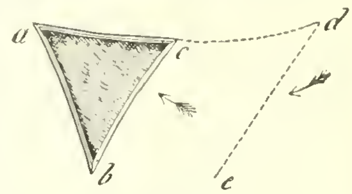

FIG. 3966.

(*a*) Small triangular defects may often be closed by gliding the angles of the wound toward its centre, and suturing the edges, which, when the integument is freely movable, can readily be brought in contact with each other in the form of a small triradiate star. If the defect is too large to be closed in this manner, one or two flaps may be easily prepared by carrying a straight or curvilinear incision from one or two angles of the triangular defect. Figs. 3958, 3959, 3960, 3961, 3962, and 3963 illustrate the manner of sliding the flaps into position. Should the tension of the flaps be too great, liberating incisions may be made (Fig. 3964, *a*), the wounds thus left healing by granulation. If, in addition to the incision *c d*, a second incision (Figs. 3965 and 3966, *d e*) be made, parallel to the side of the triangle, a quadrangular flap will be obtained for the closure of the defect (Dieffenbach, blepharoplasty), and a small triangular wound left to granulate. If the first incision be made at an angle to the margin of the defect, and the second be made in the manner already described, the wound can generally be entirely closed by sutures (Figs. 3967 and 3968). When the triangular defect has a large

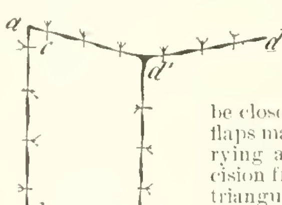

FIG. 3967.

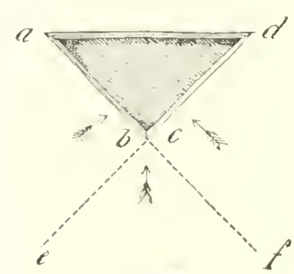

FIG. 3968.

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base, as is often the case after removal of an epithelioma from the lower lip, straight or semilunar incisions carried from the apex in the direction of its sides (Figs. 3969 and 3970) will outline two flaps that, by sliding, can be brought into apposition along a line at right angles to the base of the original defect. Burow, of Königsberg, has devised a method of closing triangular defects which, probably because it sacrifices healthy tissues, has not received the attention which it merits. It is practised as follows: From the base of the defect, and continuous with it, a straight or curvilinear incision is made (*b d*, Fig. 3971), somewhat larger than the base of the defect. From the side opposite to this a triangular piece of integument (*f e d*), equal in dimensions to the defect, is removed. The flaps *c b d* and *a f e*, being then dissected up and glided along the base line *a d*, readily close the wound. The line of suture is shown in Fig. 3972. If the defect is a large one, Burow sacrifices two smaller triangles of healthy integument, as shown in Figs. 3972 and 3973.

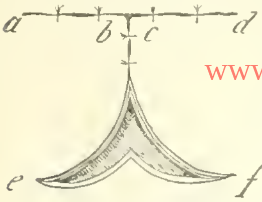

FIG. 3969.

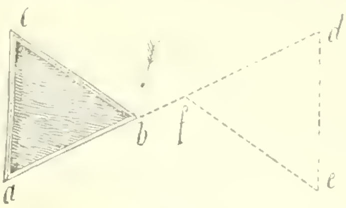

FIG. 3970.

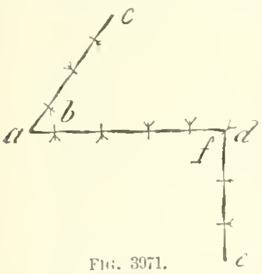

FIG. 3971.

(*b*) Quadrangular defects can, as a rule, not be effaced by suture alone. It is usually necessary to continue the incision in one or two directions, making one or two flaps, after the method of Celsus (Figs. 3974, 3975, 3976, 3977). The tension on these flaps will be materially decreased by making angular or semilunar liberating incisions as indicated in Figs. 3978 and 3979 When the defect is a large one, smaller flaps may be obtained from three directions as illustrated in Figs. 3980, 3981. Quadrangular defects may often be closed by the formation of one or two flaps, which are turned into their new positions around a broad pedicle (Figs. 3982, 3983, 3984, 3985, and 3986).

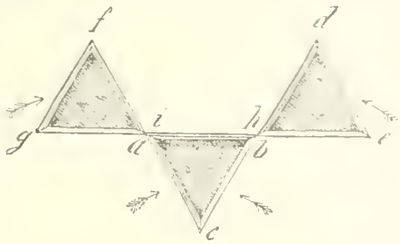

FIG. 3972.

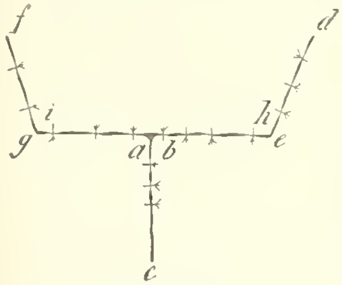

FIG. 3973.

(*c*) Oval and elliptical defects can generally be closed by a little traction along the line of their long axes. If the defect is broader, a liberating incision (Figs. 3987 and 3988) may be made, for the purpose of overcoming dangerous tension in the sutures. Lisfranc closed defects by constructing two flaps from one side of the ellipse by an incision perpendicular to its axis (Figs. 3989 and 3990). If this does not suffice, two curvilinear incisions, *b d*, *b c* (Figs. 3991, 3992), will facilitate the closure of the wound by two flaps that can easily be displaced to cover the wound. The flaps may also be so devised that they can be obtained from both sides, if the integument on one side be insufficient. Thus, by the incisions *a c* and *b d* (Figs. 3993 and 3994), two semilunar flaps will be formed that almost completely cover the defect. Weber's method of obtaining two flaps from one side, the one underneath the other, is shown in Fig. 3995. It is especially serviceable in defects of the lips.

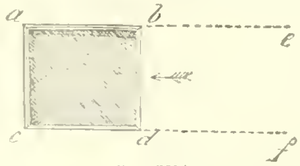

FIG. 3974.

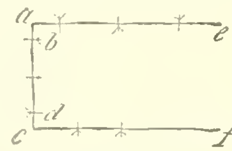

FIG. 3975.

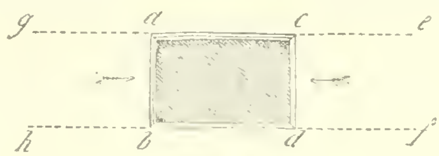

FIG. 3976.

(*d*) Circular defects, if not too large, are most readily overcome by converting them into oval or triangular wounds, preferably oval. If the defect is large, a semicircular flap must be obtained from the vicinity, and turned into the wound in the manner in which the quadrangular defect was closed.

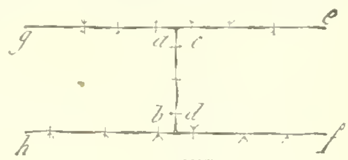

FIG. 3977.

It frequently happens that the integument in the immediate vicinity of the defect is unavailable for plastic purposes. This applies particularly to the extensive ravages made in the face by lupus and noma. After the cure of these diseases, extensive cicatrices often remain in the skin for a considerable distance around the defect. It then becomes necessary to go to a part farther removed from the latter for healthy skin. Thus the surgeon may be forced to fashion an eyelid from the skin of the temple, or a nose from that of the forehead (Indian method). In exceptional cases, it may even be deemed advisable to go still farther from the defect for a flap of healthy skin, as in the Italian method of rhinoplasty, in which the nose is formed from the skin of the arm. In the same manner, the place of a cicatrix from a burn of the wrist may be supplied by skin taken from the abdomen, or, as Maas[?]

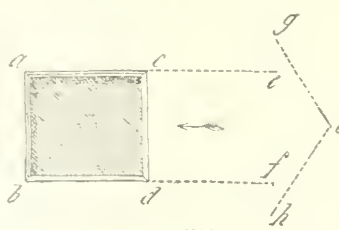

FIG. 3978.

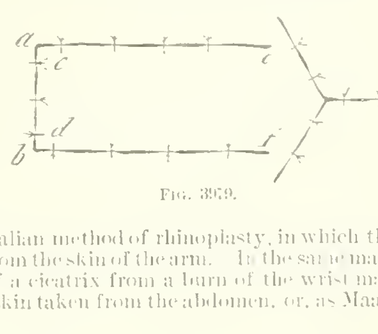

FIG. 3979.

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demonstrated to the congress of German surgeons in 1886, otherwise incurable crural ulcers may readily be closed with a flap of skin obtained from the sound leg. In every case in which flaps are thus brought from a

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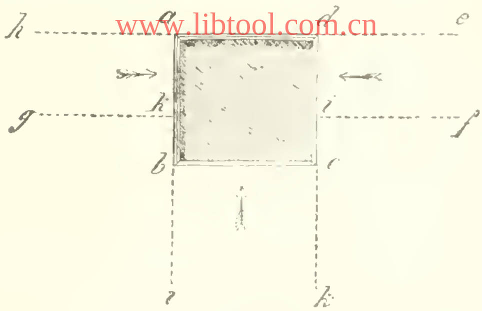

FIG. 3980.

considerable distance, the part whence the integument is to be borrowed must be retained in relation with the defect for a varying length of time. In rhinoplasty after the Italian method, this is accomplished by appropriate bandages. In the case of Maas, the parts were retained in position by a plaster-of-Paris dressing until union was secured.

Nearly all plastic operations may be subdivided into a number of steps which refer, respectively, (1) to the preparation of the defect; (2) the formation and transplantation of a flap and the methods of assuring its vitality; and (3) the permanent and speedy closure of the wound.

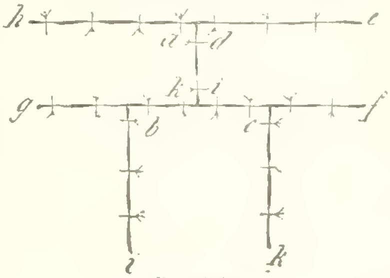

FIG. 3981.

1. The apposition of freshly wounded surfaces being practically an essential of success in plastic surgery, the first step in any operation of this kind is the freshening or vivifying of the defect. In recent traumatic defects, accidentally inflicted or produced intentionally by the surgeon in the removal of a neoplasm, this step of the operation is sufficiently simple. In cases of accident, it is well to bear in mind that the wounds are often irregular in the extreme and their margins bruised, lacerated, and ill suited to primary union. Here it is al-

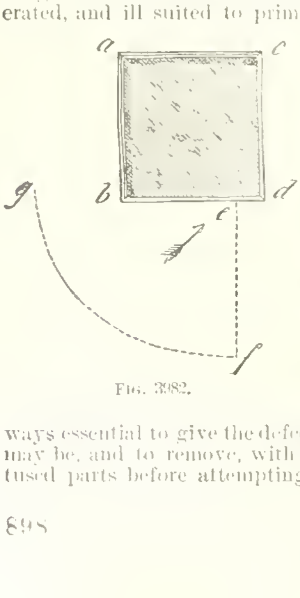

FIG. 3982.

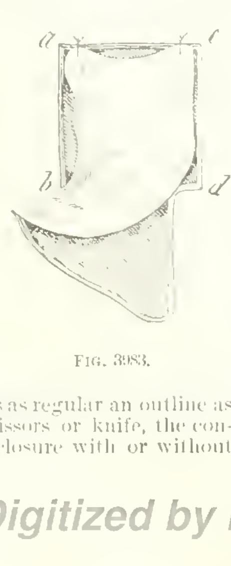

FIG. 3983.

ways essential to give the defects as regular an outline as may be, and to remove, with scissors or knife, the contused parts before attempting closure with or without the aid of a flap. When the defect follows the extirpation of a growth, and is to be closed at once by a plastic operation, every sacrifice must be made to procure radical removal of the neoplasm. The size of the defect is of secondary importance. Nevertheless, the incisions may be so arranged that the closure of the wound may be greatly facilitated. A glance at Fig. 3996 will make this sufficiently evident. In many cicatricial contractions and in congenital deformities, as in polydactylism, the preliminary step is also the formation of the defect for immediate closure. This is easily effected by the linear division of the cicatrix or connecting bands, and the restitution of the parts to their normal positions. When the defect has a free border, on the other hand, as in harelip, fistulæ, oral deformities, etc., the initial step of the operation is the paring or vivification of this margin, whereby the mucous, cutaneous, or cicatricial tissues are removed in such a manner as to procure a surface that is clean, smooth, and well adapted for primary union. Whether the paring be accomplished with scissors or knife, it is an essential of success that the border be removed in its entire thickness, since the presence of any undenuded spot in the line of proposed union destroys the possibility of a perfect result. To insure a broader surface for contact, and thereby greater probability of firm union, it is advisable to vivify the defect obliquely. This is particularly serviceable when, as in defects of a mucous membrane or of old cicatrices about the face, the margins are thin and would, if divided perpendicularly, offer a small surface for adhesion.

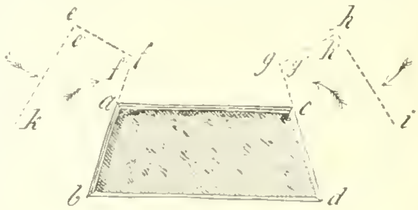

FIG. 3984.

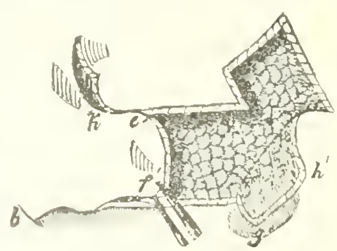

FIG. 3985.

2. The most available material should be selected in forming a flap; its size should be such that tension is nowhere exerted, and every precaution must be taken to insure a sufficient blood supply. The shape and size of the flap vary according to the defect. It is to be remembered, however, that integumentary flaps invariably shrink after, and often before, their transplantation. The amount of retraction varies with the subsequent disposition of the flap. If a raw surface is brought in contact with a plane surface or denuded bone to which it can form adhesions, the danger of primary retraction is less imminent. Thus it is certain that a periosteal flap only slightly larger than a fissure in the palate will easily suffice for its closure, whereas almost twice the integument must be taken from the temple to form an eyelid. In all other cases it is well to make the flap one-fourth or one-third larger than the breach it is intended to cover. Operators of large experience can fashion the flap without a pattern. Dief-

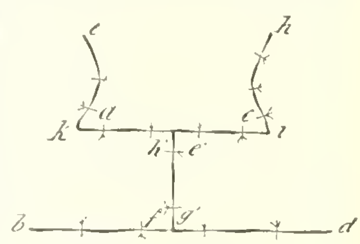

FIG. 3986.

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fenbach always condemned its use, giving to the part to be formed ample dimensions at first, and remodelling it by supplementary incisions. It is certainly safer in all cases to make an accurate model of the part to be replaced, of paper, leather, adhesive plaster, or soft wax, which can be directly applied to the part from which the integument is to be taken, and serve as a guide to the lines of incision. The closest attention is required in the delineation and management of the pedicle. It should never, in a formal plastic operation, measure less than one-third of an inch in width, the probability of the survival of the flap being in direct proportion to the width of its pedicle and its capacity for arterial supply. As far as possible, therefore, the flap should be so outlined that the incisions will not necessitate the division of large arterial twigs. For the same reason, excessive torsion of the pedicle must be scrupulously avoided. Verneuil[8] aptly proposes the name of hilum for this portion of the flap, since this term expresses its important function in the nutrition of the flap.

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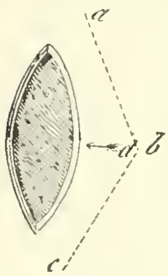

FIG. 3987.

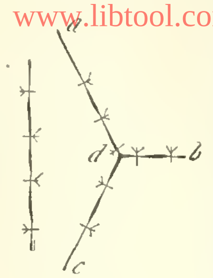

FIG. 3988.

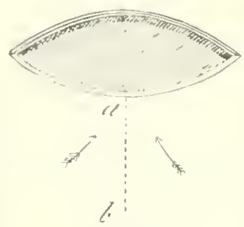

FIG. 3989.

Into the composition of the flap there should enter, as far as possible, tissues histologically analogous to those of the part to be repaired. Skin should therefore, as a rule, be replaced by skin, and mucous membrane by mucous membrane; although the possibility of the convertibility, in the course of time, of the one into the other, should be borne in mind. Thus the integument may, without difficulty, be made to substitute the mucosa of the bladder or of the nares. Mucous membranes, however, do not, as a rule, assume the characteristics of common integument, although that of the vagina forms an exception. The mucous lining of the nares, of the lips, of the nose, and of the bladder may be exposed for years without sensibly approaching the appearance of the skin. When skin enters into the composition of a flap it should, as far as may be, resemble that of the part lost. The delicate integument of the eyelid would not be suitable for repairing defects of the upper lip, nor would the appearance of the nose be improved by a patch of hair on its end. Above all things, the integument to be utilized for the flap should be healthy and freely movable.

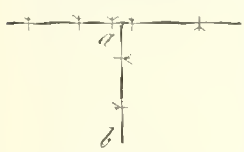

FIG. 3990.

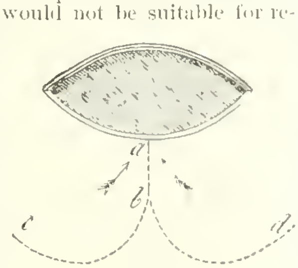

FIG. 3991.

The incisions being made, the integument, together with more or less of the subcutaneous cellular tissue, is to be dissected up from the underlying structures. The thickness of the flap should always be commensurate with its other dimensions. Large and thin flaps often succumb to defective nutrition. The subcutaneous cellular layer is an essential of all large flaps, since it is the medium through which the skin receives its nutrition. An excess of adipose tissue, however, is an element of danger to the vitality of the flap. It has been claimed that muscular tissue should not enter into the composition of a flap when it can be avoided, on the ground that muscle without function is speedily converted into fibrous tissue, and the presence of this cicatricial tissue may become an important factor in marring the final result in many plastic operations.[9] In those upon the face muscular elements cannot be excluded, since they are directly inserted into the skin; nor would their exclusion be advisable, since without them the mobility of a newly formed lip or eyelid would be out of the question. The periosteum may also, in exceptional cases, be included in the flap in plastic operations. B. von Langenbeck[10] and Ollier[11] have thus sought to utilize the osteogenetic function of the periosteum in rhinoplasty and uranoplasty, in the belief that the new bone developed by it would give the normal resistance to the repaired part.

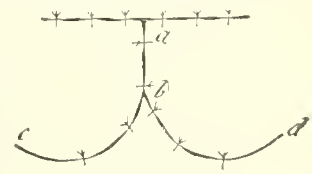

FIG. 3992.

Verneuil, Sédillot, and others question the utility of this procedure, believing, and in some instances with good reason, that the inclusion of the periosteum in a flap is an element of danger to the vitality of the part whence it is taken, and that it increases the probability of sepsis. With modern wound treatment this is excluded. Regarding operations on the palate, the danger of necrosis after periosteal denudations is certainly theoretical. Langenbeck,[12] who has probably operated oftener than any one else for cleft palate, by this method, has never seen the bone exfoliate. He has, however, noticed such an accident after rhinoplasty. Nor can there be any question as to the formation of new bone from periosteal flaps. In every congenital defect of the palate operated upon by this distinguished surgeon which was under observation more than four weeks after uranoplasty the formation of new bone was confirmed. It begins about the third week, and is completed at about the fourth week, although it subsequently gains in solidity. So far as time is concerned, the periosteal regeneration of bone after plastic operations may then be said to be chronologically analogous to that which takes place in the repair of fractures. Nor, any more than after fractures, is there any danger that the newly formed bone will subsequently undergo retrograde changes.

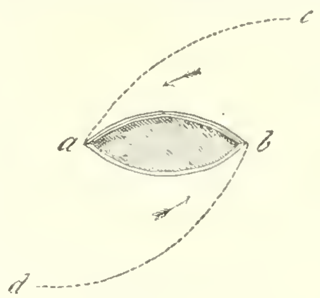

FIG. 3993.

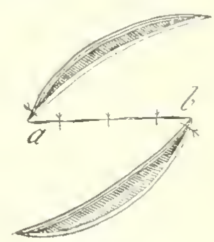

FIG. 3994.

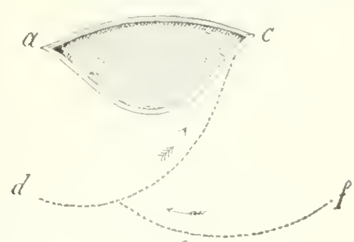

FIG. 3995.

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To increase the thickness and, therefore, the vitality of large flaps, and at the same time approximate the repaired part to the normal structure and function, very thick and even duplex flaps must often be formed. Thus, while a large defect of the lower lip may be covered with a flap from the neck, the new lip will be thin, devoid of muscular fibre, and therefore of movement, and soon becomes firmly attached to the lower jaw. It is preferable, therefore, when possible, to make the flaps of the entire thickness of the cheek, covered with skin and mucous membrane, which, when brought into position, subserve in the best manner possible the purposes of the part destroyed. Or it may be practicable, if it be deemed best to use the flap from the chin, to reflect the mucous covering of the alveolar border for a lining to the cutaneous flap. As will be seen in operations for rhinoplasty and exstrophy of the bladder, this doubling of the flap may be practised with two folds of skin, the lower of which subsequently becomes converted into mucous membrane. For this method Ad. Richard, in 1854, proposed the term "autoplastie par doublure."

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Fig. 3996.—Plastic Operation for Cancer of Lip. Showing (A) the proposed lines of incision, and (B) the completed operation.

3. The transplantation and permanent attachment of the flap constitute the last steps of formal plastic operations. At present all authors are agreed that, save in exceptional cases, the fixation of the flap should at once follow its formation as soon as all oozing has ceased. Tagliacozzi, however, in his rhinoplasties, allowed the under surface of the flap, taken from the arm, to suppurate before fixing it in the new position. Graefe, on the other hand, successfully practised fixation while the surfaces were fresh. In very rare cases the old operation may be followed by good results. Thus the author, in 1876, saw Billroth close a gastric fistula with a flap that had been lifted from its surface one week before fixation, the reason given for this being that the suppurating surface would be less affected by the deleterious influence of the gastric juice than one recently prepared.

In 1889 Mr. Croft described an operation which was based on this principle, and which was particularly useful in relieving the scars following extensive burns. The writer employed it to relieve a dense scar which held the thigh firmly bound to the abdomen. A broad strip of skin, six, eight, or ten inches long, is lifted between parallel incisions from the underlying structures, but left attached above and below. Strips of gauze are inserted underneath for six or seven days until granulations have formed. The flap thereby becomes thickened. At the second operation, after the defect is vivified, the granulations are curetted from the flap, its attachment at one end is severed, and the placing in position follows as in the one-time operation (Med.-Chirurg. Trans., 1889).

In 1854 Roux was compelled by circumstances, in a defect of lip and chin, to resort to a practice which some writers have sought to elevate into a special method, that by successive migrations. "It consists in fixing a flap temporarily in a new position, from which, after the lapse of several weeks, it is removed by a second operation to a part nearer the defect, where, after a number of migrations, it is finally deposited."[14] Buck has resorted to a somewhat similar expedient in extensive deformities of the face. It is only in these that it is ever practicable.

To facilitate the transplantation of a flap and to relieve tension, liberating incisions are often required. Thus, in harelip, success is not generally attainable without freely liberating the segments of the lip which are more or less bound down to the maxilla. Such liberating incisions cannot always be concealed, as in the instance cited. They should then be made as small as is consistent with the effect desired, and in the manner indicated (*g i h*, in Fig. 3978).

To close the wounds resulting from these liberating incisions is permissible only after the defect has been covered and when it is evident that closing the secondary incisions does not cause traction on the more important line of sutures closing the primary wound. Where there is any doubt, it is best to leave the liberating incisions unsutured, and the wounds to heal by granulation. In very many cases these wounds can at once be closed by skin-grafting or by using a Wolff or Krause flap. (See *Skin-grafting*.)

The fixation of the flap by sutures forms the final step of the plastic operation. The care and accuracy in apposition of the raw surfaces observed in other surgical procedures are particularly demanded here. The absence of blood within the wound is an essential to success. Hence Dieffenbach, Lisfranc, and others often postponed fixation for two or three hours until all oozing had ceased. As Verneuil justly says, while admitting the value of this method in former times, "in our day operations are generally made under anaesthesia, from which, when the patients awake, they like to believe that the operation is completed; hence it is a source of great suffering to mind and body to delay the completion of the operation."

In closing the wound the continuous or interrupted suture may be employed. Whenever applicable, the buried subcuticular suture should be used. Suture marks are in themselves often quite disfiguring. As a rule, small needles should be used. The angles of the surfaces are first approximated. While the number of sutures must be sufficient for accurate apposition and the avoidance of wrinkles in the flap, an excessive number is doubtless harmful, since every suture, however fine, interferes in a measure with the circulation in the part, and every suture may become a source of suppuration. When considerable traction must be made to hold the flap in position, one or even two deep sutures of heavy silk may profitably be inserted far from the edges of the wound as after amputation. In this way the tension on the more numerous superficial sutures is effectually removed. The material used for sutures varies according to the length of time they are to remain. In plastic operations about the face an iron-dyed silk probably answers the best purposes. These sutures can be removed, a few at a time, in from forty-eight hours to five or six

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days after the operation, according to the union obtained. When it is desirable to retain the sutures longer, as in operations on the vagina, silver wire is to be preferred, since metals produce vastly less reaction in the tissues than silk.

Regarding the after-treatment, little need be said. The wounds are fre[illegible]re aseptic measures cannot be successfully carried out; as, for example, about the lips or nose. In these cases dry gauze compresses, held in position by properly adjusted bandages or adhesive strips, will go far toward supporting the parts and assuring primary adhesion. The writer has found gauze strips steeped in collodion an excellent dressing in many small plastic operations on the face. Wounds made for plastic purposes should be frequently examined to determine the condition of the parts, and particularly if a flap has been utilized. Immediately after its application a flap is cool, pale, and insensitive. Within from twelve to twenty-four hours, as circulation is established, its temperature rises, and a marked redness distinguishes it from the integument surrounding it. This redness easily yields to a bluish discoloration and excessive swelling, both indications of venous stasis, which, if not checked, often leads to sloughing. Loosening one or two sutures, or scarification of the flap itself, may avert such a result. If suppuration under the flap is suspected, the most dependent sutures must be removed for proper drainage. With proper precaution the presence of suppuration does not necessarily entail failure of the operation, since the flap may be held in position with small strips of adhesive plaster or by a number of sutures inserted at its salient points.

Supplementary treatment and even operations are often necessary after complete closure of the wound. Thus constant attention must be given the nostrils after rhinoplasty, the lower lip after cheiloplasty, lest the former close, or the latter become adherent. Or it may be that the contraction of the flap has not ensued to the degree anticipated, and the newly formed organ presents wrinkles of redundant skin. In the same way, the pedicle of a flap which has subserved its purposes must be excised if at all prominent. Such redundant masses can always be easily removed by oval incisions. In the case of the pedicle, several months must elapse before its excision is even to be thought of. A premature attempt in this direction of improving the result of a plastic operation may easily annul the advantages already obtained.

As has already been observed, every case requiring a plastic operation is a law unto itself. The more complicated the defect, the greater the study and practice required in overcoming it. When the destruction of tissue has been very extensive, as in noma, lupus, or burns, a single operation rarely suffices. Three, four, and even more operations may be necessary before the appearance of the face is in a measure restored. In these complicated cases, too much should not be attempted at one time, and an interval of from one to six months may often be advantageously observed between the different operations. It is in this way that the most successful workers in this field have, by repeated efforts, often extending over a period of two or three years, given a new life to individuals who, from very extensive destructions of prominent parts of the face, have been objects of disgust to themselves and of horror to those with whom it was their misfortune to come in contact.

Blepharoplasty.—Plastic operations in the eyelids as a rule come under the care of the ophthalmic surgeon. A full description of the various methods of blepharoplasty is given in the article by Dr. Van Fleet on *Eyelids, etc.*

Cheiloplasty.—The reconstruction of a lip after its partial or total destruction by injury or disease is termed cheiloplasty. In the preponderance of cases it is performed for epithelioma, and for the most part, therefore, is practised on the lower lip. The upper lip, also, at times is destroyed by noma, lupus, burns, or wounds, and thus becomes the subject of plastic repair. Except in cases of epithelioma these operations are particularly complicated, and tax the ingenuity of the surgeon through the involvement and distortion of the angle of the mouth and of more or less of the integument of the cheek or of the nose. Owing to the great variety displayed by individual defects of the lips, many methods have been devised for their relief. Only those are very serviceable in which a flap covered by integument without and mucous membrane within can be utilized. In all other methods, although at times they must be followed, the flap speedily becomes adherent to the maxilla, immovable, useless for mastication, and incompetent to retain the saliva. Another defect in the immediate result that appertains to almost all methods is the disparity in size between the sound and the reconstructed lip. The latter usually being smaller, the other projects far beyond, while the mouth presents an unnaturally contracted appearance. Still, this abnormal condition is recovered from after the lapse of a few months, the mouth being spontaneously remodelled.

In all cheiloplastics it is essential that the flap be obtained from the immediate vicinity of the defect, since failure is certain to follow any attempt to obtain it from a distance. The mobility of the parts during mastication is such that fixation of the arm cannot be maintained for a sufficiently long time or accurately enough to prevent the loss of the flap.

Cheiloplastic operations may be divided into: (1) Those that affect the lower lip; (2) those that affect the upper lip; and (3) those that affect the angles of the mouth, or the mouth as a whole (stomatoplasty).

1. Since the lower lip is repaired most frequently for epithelioma, the surgeon can often shape the defect in a way to facilitate its closure. If the neoplasm involve only a slight extent of lip, it should be removed by a V-shaped incision, when, ordinarily, no difficulty will obtain in closing the gap with deep sutures, even if the entire thickness of the lip has been removed. When the disease, however, covers a large area but is superficial, removal by a curvilinear incision is preferable, since the defect thereby produced will readily be supplied without plastic procedures. When the entire lip is involved, in thickness as well as in height, rectangular or curvilinear incisions alone are serviceable for the removal of the neoplasm. When, as is often the case, the disease involves the angle of the mouth, the incisions must necessarily be more complicated and altogether regulated by the extent of the disease. Even in extreme cases the gap can often be closed by a combination of V- or W-shaped incisions. Weber mentions a case in which the disease was very extensive. When circumstances compel the surgeon to borrow the material for the flap from the chin or neck, the methods of Chopart, of Lisfranc, or of Berg may be adopted. In Chopart's operation the diseased tissue is included between two parallel perpendicular incisions carried over the chin and on to the neck as far as the hyoid bone, if necessary (Fig. 3997) (Nélaton). When the diseased part is then removed by a horizontal incision, there remains a quadrangular flap which, when dissected up, is brought by a process of gliding to the level of the labial commissures, where it is retained by sutures. Lisfranc preferred to remove the neoplasm by a curved incision, from the centre of which (Fig. 3998) a perpendicular cut of greater or less length, carried downward, outlined two flaps which, when detached, were brought into position. Berg also gave the defect a curvilinear outline, but preferred to use a single flap from the chin and side of the neck. Fig. 3999 shows the manner of delineating the flap, of bringing it into position, and of closing the primary and secondary wounds. If the upper margins of the flap be covered, from each angle of the mouth, by a portion of the ver-

Fig. 3997.

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milion border borrowed from the upper lip, the result will be excellent, although the oral aperture may temporarily be materially decreased in size. To accomplish


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FIG. 3998.

the same end Serre, in an extensive epithelioma of the lower lip, practised Chopart's operation, preserving the mucous membrane of the lip for a covering to the flap.

FIG. 3999.

It is almost needless to say that it is only in exceptional cases of very superficial neoplasmata that this method is at all applicable.

When the defect after removal of an epithelioma is triangular, with base involving the greater part of the lip, the operations of Dieffenbach or Malgaigne may be pro-

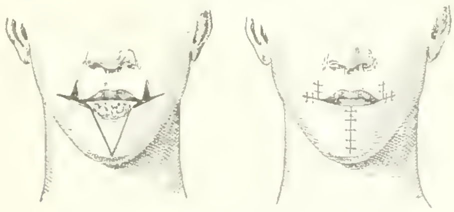

FIG. 4000.

fitably resorted to. That of the German surgeon consists in making an incision on each side from the angle of the mouth toward the masseter and in the line of the labial fissure. The length of the horizontal incision is half that of the base of the defect. The quadrilateral flaps thus raised are brought together in the median line by their

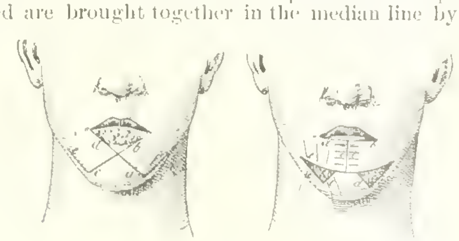

FIG. 4001.

internal borders. The operation of Malgaigne differs from this in that he refrains from the use of the perpendicular incision. To overcome the redundancy of the upper lip, a triangular portion may be excised (Fig. 4000). In either operation the new lip can easily be lined with mucous membrane, if that of the cheek be divided at a higher level than the integument in the horizontal incisions from the angles of the mouth. In cases in which the defect is triangular and shallow its closure by later incisions, after the method of Syme, presents many advantages. By this method the incisions are prolonged downward and outward for an inch, whence they are carried upward and outward for a varying distance. The flaps thus outlined are dissected off the bone and brought together in the median line. The mucous membrane and skin are stitched together along the upper edge, and the triangular interval on each side is left to heal by granulations. To facilitate union of the flaps, the tip of the spur left below the apex of the defect may

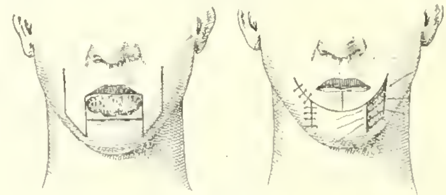

FIG. 4002.

be removed after the flaps have been raised (Fig. 4001) (Nélaton). The very great advantage of this method over those preceding it is that, since the integument covering the chin is not disturbed, the flaps cannot sink or be drawn downward toward the neck, and the new lip will maintain its original height. Quadrangular defects of the lower lip may be successfully overcome by resorting to two rectangular flaps taken from the chin or from the side of the chin. Sédillot (Fig. 4002) made the flaps at right angles to the line of the mouth from the side of the chin, while Bruns preferred to make them obliquely and from the cheek. When the flaps are raised they are turned on their respective pedicles, when their inner borders meet in the median line. When circumstances permit of a choice between the method of Sédillot and that of Bruns (Fig. 3984, diagrammatic), the former should be preferred, since in the latter there is considerable danger of traction on the cheeks with a resulting deformity. The operation of

FIG. 4003.

Sédillot also offers a better opportunity for covering the upper edges of the flaps with part of the vermilion border of the upper lip. When this is severed for half an inch or more on each side from the upper lip, the flaps forming the lower lip can be almost entirely covered. Schuh's practice of tattooing the edge of the lip for cosmetic purposes has probably never been followed by other operators. In 1869 Langenbeck first practised a cheiloplasty which has gained many followers in Germany. In this method the diseased lip is removed by a curvilinear incision (Fig. 4003). A flap is then prepared from the integument of the chin (1) the base of which is on the side of the oral angle. The free extremity of the defect is not directly under the oral defect, but separated from it by a triangular portion of skin (2). Both flaps being raised, the lower is elevated into the defect, while the other is utilized in closing the breach below (Fig. 4004). The presence of the spur prevents the sinking of the lip.

FIG. 4004.

When it is desirable, the upper edge of the flap may be covered with a portion of the mucous border of the upper lip. Gurdon Buck ("Rep. Surg.," p. 22), and Est-

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länder (*Arch. f. Chir.*, xii.), closed defects of the lower lip with flaps taken from the upper. Buck, after removing the growth by a V-shaped incision, or by one horizontal and two perpendicular incisions in more compli-

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FIG. 4005.

cated cases, brought the sides of the gap together directly, or, in the case of the quadrangular defect, by forming two horizontal lateral flaps which were secured to each other in the median line by pin sutures. After closure of the wound had been effected, a secondary operation was performed to transfer the redundant tissue of the upper to the deficient lower lip, and thus to restore the symmetry of the mouth. This operation is performed as follows: A point is selected about a finger's breadth below, and a little without, the oral angle on each side, and marked by the insertion of a pin through the skin. Another pin is inserted on each side at the junction of the vermilion border of the upper lip with the skin, about one-fifth of the distance from the angle of the mouth to

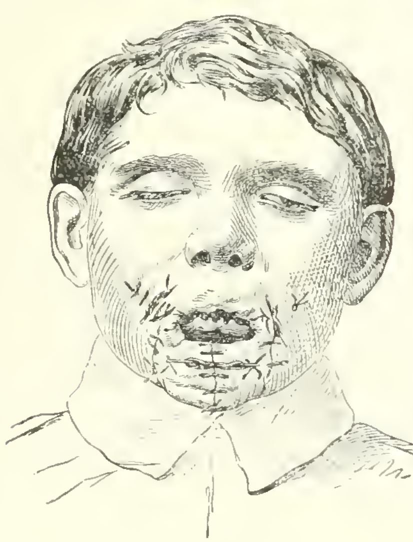

FIG. 4006.

the median line of the lip; and a third pin on each side is inserted into the integument of the cheek, about an inch and a half above and without the angle of the mouth. The points indicated by the first and third pins are then to be united by an incision through the entire thickness of the cheek, and in like manner the points indicated by the second and third pins. A triangular flap is thus formed, with its base toward the angle of the mouth. From the point indicated by the first pin, a vertical incision is now made to the base of the jaw. The integument in this region being in a state of great tension, the edges recede and form a space for the reception of the

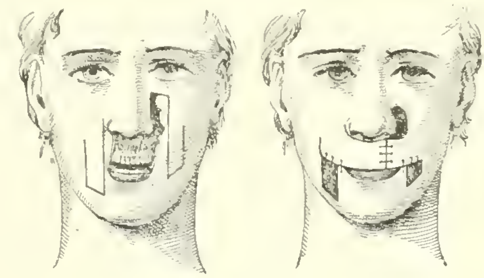

FIG. 4007.

triangular flap, with its apex toward the base of the jaw, and its base, including a portion of the vermilion border of the upper lip, supplying the deficiency of the corresponding side of the lower lip. When the operation on both sides is completed the configuration of the mouth is nearly normal. (Figs. 4005 and 4006, from Buck.)

Estländer's operation differs from that of Buck in that the outer incision is curvilinear, and that the plastic operation at once follows the extirpation of the tumor.

(2) In reconstructing the upper lip, the operator has the choice of a number of methods. In cases of total deficiency, the method of Bruns, already referred to (Fig. 3984), yields excellent results. Bérard utilized two lateral flaps from the cheeks, including them between parallel horizontal incisions, carried outward to the masseter, the upper from the angle of the nose, the lower from the angle of the mouth. The flaps thus formed are brought into position by gliding, and united by pin sutures in the median line. A better operation for severe cases is that of Sédillot (Fig. 4007), which is performed as follows: On each side of the oral angle a quadrilateral flap, of the width and half the length of the lip, is outlined by two perpendicular incisions and one horizontal incision on each side. The inner of the perpendicular incisions is carried higher than the outer. When the flaps have been thus outlined, they are raised from the underlying tissues. The entire thickness of the cheek is

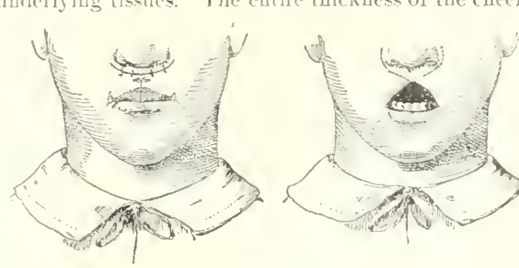

FIG. 4008.

included in the flaps, which are therefore lined with mucous membrane. When the flaps are brought into position, their lower borders meet in the median line, the inner borders are sutured to the upper margin of the defect beneath the nose, while the outer borders assume the position of the free border of the lip. With a little traction the mucous membrane and the integument of this border can be united by a number of very fine sutures.

When the defect of the upper lip is central and not very extensive, the method of Dieffenbach presents much to recommend it. It consists in transfixing the cheek on each side of the angle of the nose, and forming a flap on

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each side by a curvilinear incision (Fig. 4008). When these flaps are raised from their attachments to the alveolar border, they are easily brought into apposition by their internal margins in the median line. The method of fixing the flap beneath the nose is also shown in the illustration. The advantage of this method, when it is applicable, is in the greater height given by the curvilinear incision into the flap in the median line, and in the fact that its free border is naturally covered by mucous membrane.

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FIG. 4009.

Ledran and Roux utilized one-half of the lower lip for repairing deformities in which the outer half of the upper lip was lost. Both of these operators transplanted a quadrangular flap with its pedicle outward. This method was greatly improved upon by Buck, who, placing the pedicle internally, temporarily reduced the length of the oral fissure. This method of operation is shown in Fig. 4009. The extremity of the lower lip, where it joins the right cheek, is divided through its entire thickness at right angles to its border, and for a distance of an inch (*a b*). A second incision is made from the end of the first, parallel to the labial border, for a distance of one inch and a half (*b c*); from *c* a short incision (*c d*) is made toward the free border of the under lip, and parallel to the incision (*a b*). The quadrilateral flap thus formed from the lower lip is now turned upon its pedicle to meet the remaining portion of the upper lip, to which it is attached by its free extremity (*a b*). Fig. 4010 shows the result of this operation, and the method of overcoming the deformity of the angle of the mouth which results.

3. STOMATOPLASTY.—Destructive ulcerative processes about the lips and angles of the mouth occasionally give rise to deformities which, by greater or less closure of the oral aperture, interfere with the process of mastication, and eventually threaten the life of the individual. In extreme cases the labial fissure is contracted to a degree which compels the patient to live on liquid food alone. Until Dieffenbach's remarkable contributions to plastic surgery, it was customary to treat these cases by the insertion of a seton of silk or of wire. As in cases of syndactylism treated in this way, the result was generally unfortunate. Dieffenbach's method, which, unless the mucous membrane is everywhere adherent to the alveolar border, is as a rule successful, is performed as follows: On each side of the contracted oral orifice a narrow triangular strip is excised from the skin. The base of the triangle is internal, its rounded apex external and at the point where the angle of the mouth is to be. The excised triangular portion should include everything down to the mucous membrane, which remains intact in the floor of the wound. The mucous membrane is then divided in the floor of the triangle, thus forming an upper and a lower flap, which, when everted, will clothe the free borders of the new lips and meet externally at the angle of the mouth. The excess of mucous membrane is thus utilized in forming the vermilion borders of the lips.

Buck's method of stomatoplasty, already alluded to, differs somewhat from that of Dieffenbach. He makes an incision along the line of the vermilion border circumscribing half of the mouth, and extending to an equal distance above and below (Fig. 4010, *a b*). This incision should divide the skin and subcutaneous tissue, but not involve the mucous membrane. A sharp-pointed double-edged knife is then inserted between the skin and the mucous membrane, and these parts are separated from each other as far outward as the point proposed for the angle of the mouth. The skin alone is then divided with strong scissors along the line which is to separate the upper from the lower lip (*c d*). The mucous membrane is next divided along the same line, but not so far outward, the difference in the length of the division of skin and mucous membrane being a little less than the thickness of the cheek. The angles at the outer ends of the two incisions are then carefully united by a single-thread suture, and the operation is completed as in Dieffenbach's method. To accommodate the mucous membrane to the borders of the lips, thin slices of integument must, as a rule, be pared from the upper and lower borders of the wound.

RHINOPLASTY.—The nose gives character to the face by its prominence and central position. Its absence or deformity is therefore more naturally observed than that of any other feature. It is only through familiarity with the nasal defects caused by syphilis or lupus that one without unusual vanity can understand why Tagliacozzi devoted a special chapter to the "dignity of the nose," and can appreciate the saying of Lavater, that "a beautiful nose is worth a kingdom." Passion, disease, love of honor, and punishment for crime, have all, in times past, contributed to producing the greatest facial disfigurements by attacking the nose. Hence the surgical art was taxed early to repair the deformed part, and rhinoplasty became the foundation of plastic surgery in general. In previous centuries, when the loss of a nose was a punishment for crime, or was voluntarily inflicted to preserve virtue, rhinoplasty was doubtless a more common operation than now. Sixtus V. freed Rome of its bandits by cutting off the noses of all who were caught. The Abbess of St. Cyr disfigured herself and forty of her nuns in the same manner, to preserve their virtue when the Saracens raided Marseilles. In our more civilized times, nearly every case requiring rhinoplasty is one in which the defect is the result of disease; although, in exceptional instances, a vicious bite or, as in Germany, a duel, is the cause for plastic interference.

Notwithstanding the accumulated experience of generations of surgeons, and the closest attention to every technical detail that could further the results of rhinoplasty, it must still be admitted that the best nose that can be formed by a plastic operation is hardly as presentable as the natural feature that is even far removed from the ideal. It is far preferable, however, to the artificial nose formed of vulcanized rubber, and retained in position with collodion or by means of a spring. After a rhinoplasty that is at all successful, the catarrhal condition of the nose and pharynx is improved, the senses of smell and of hearing return, and the irritating cough which so often is present in extensive defects of the nose, rapidly disappears. A successful rhinoplasty is productive of benefits which cannot follow the use of any nose fashioned by prosthetic skill.

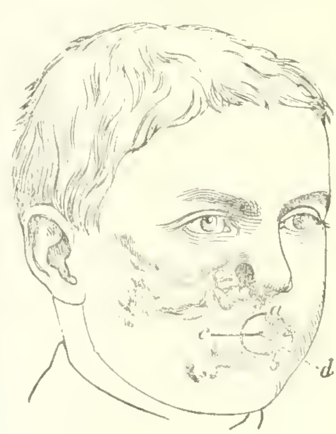

FIG. 4010.

Since the time of Dieffenbach, rhinoplastic operations have been divided into the total and the partial. It is particularly in partial rhinoplasty that great strides have been made within the last half century. To consider systematically the different operations for repair of the

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nose, nasal deficiencies, according to Gross, may be classified as follows: (1) Loss of the entire organ, bones as well as soft parts. (2) Destruction of the whole or greater portion of the cartilages, the bridge remaining intact. (3) Mutilations of the tip, as when a small piece is cut or bitten off, including a part of the wings. (4) Loss of one wing, either www.libtool.com.cn the nasal column. (5) Perforation of the nose, either on top or at the side; in the latter case with or without participation of the cheek. (6) Sinking of the organ from destruction of the cartilaginous septum of the nose, the soft structures being but little, if at all, affected. (7) Loss of the column. (8) Mutilation of the nose and upper lip, or the nose, lip, and cheek.


FIG. 4011.

When the entire nose has been lost, there is generally a large pyriform aperture which allows free inspection of the nares and nasopharynx. For the alleviation of this condition, it is always best to fashion the nose from a flap taken from the forehead, by what is known as the Indian method. Before proceeding to a total rhinoplasty, the defects should be covered with a model of clay, wax, or dough, which should approximate as much as possible in size and form an ideal nose. Over this is accurately fitted a piece of soft leather or moleskin plaster, the lower margin of which is pressed into the nostrils and made to cover the nasal column. The shape of this piece of leather or plaster, when removed from the model, is pyriform, with its base below and apex above. A second piece of leather or of plaster, one-third larger in all its dimensions, should then be prepared from the first, the increased dimensions being allowed for shrinkage. The model thus prepared, when applied to the forehead, is shown in Fig. 4011 (Linhart). The plastic operation proper is preceded by freshening the edges of the defect. This must be done as liberally as possible, in order to procure a wide surface of contact for the flap. The vivified border should everywhere measure one-third or even half an inch in width. When this step of the operation is completed, the leather or moleskin model is applied either perpendicularly or obliquely to the forehead. The latter is probably the better method, since less rotation of the flap is required to bring it into position. When the forehead is decidedly low, no alternative is presented to the operator, since the central excision of the flap would necessitate the inclusion in it of a considerable portion of the hairy scalp. König and others maintain, however, that the frontal scar resulting from central location of the flap is less disfiguring than that which follows the other procedure. Lisfranc, Linhart, and von Langenbeck prefer to take it from the side. When the operator has applied his model in the desired position, an incision down to the periosteum is carried around it. The incision, as shown in the figure, begins at the right margin of the defect, is carried obliquely over the right eyebrow, and descends on the left side of the model, terminating above the internal end of the left brow. In terminating this incision, it is essential not to interfere with the angular artery, since the vascular supply of the new nose, in a large measure, depends upon the integrity of this vessel. The pedicle left between the ends of the incisions should measure from one-half to three-fourths of an inch in width. The flap thus outlined is now rapidly raised, being made to include, besides the integument, the aponeurosis and fibres of the occipito-frontal. In the lower part of the flap the periosteum can safely be included. Langenbeck included it in the entire width of the flap, except in the parts of which the column and alæ of the nose were to be formed. When hemorrhage from the edges and raw surface of the flap has been controlled, it is rotated into position in such a way that the raw surface looks backward, and its base naturally comes in contact with the freshened margin of the upper lip. The next step of the operation is the formation of the septum and alæ. This is readily accomplished by two oblique incisions, one inch in length (dotted line in Fig. 4011), which, running toward each other, are separated at their central ends by an undivided interval nearly an inch wide. When the triangular flap included between these incisions is doubled upon itself, the column and septum of the nose are perfectly formed. By an upward duplication of the lateral parts of the flap, the alæ and nostrils are next formed, and maintained by transfixing sutures. To facilitate the closure of the frontal wound and to obtain larger nostrils, Langenbeck does not remove the small triangular portions seen on each side of the base of the flap, but makes the central portion, from which the septum is made, rectangular and one inch wide. When the nose has thus been formed and the raw surfaces have been thoroughly cleansed, the new organ is brought into position and retaining sutures are applied. The most important sutures are those which hold the alæ of the nose to the cheek and the septum to the upper lid. For each wing and the septum three sutures are requisite; for the wings one externally, one internally toward the nostril, and one beneath toward the lip. Since it is the septum that most frequently fails to unite with the upper lip, unless extraordinary care be taken, it is advisable to make a special groove in the central part of the upper lip, three to five lines in length, into which the lower end of the septum is firmly implanted after it has been divested of cuticle. The operation is then completed by suturing the lateral margins of the new nose to those of the cheek, particular care being given to securing a good apposition of the pedicle in the upper end of the defect. If the wound in the forehead is very large, it may in part be closed by sutures, although the greatest caution must be observed to prevent traction on the pedicle. If the entire wound of the forehead is left to granulate no harm results, and the scar is probably not more ungainly than that which follows what is ordinarily an unsuccessful attempt at obtaining its closure by primary union. To maintain the patency of the nostrils, and at the same time to further adhesion of the double integumentary folds, it is well to introduce portions of a drainage tube into the nostrils after the operation is complete. The new nose may then be lightly covered with oiled silk and antiseptic gauze or lint, care being taken that no foreign material becomes adherent to the sutures.

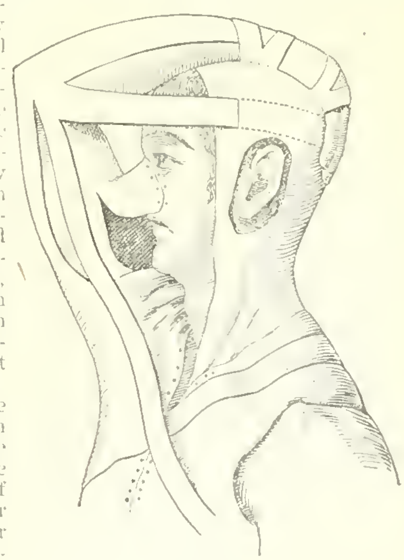
FIG. 4012.

There are rare cases in which previous disease has unfitted the integument of the forehead or of the cheek for rhinoplastic purposes. Under such circumstances only is one justified in resorting to the Italian operation of rhinoplasty from the arm. The first step in this procedure is to outline a flap of integument from the inner surface of the middle of the arm, measuring four inches in length and three in width. The flap is raised between two parallel longitudinal incisions, but retained above

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and below in relation with the remaining integument. To prevent reunion a piece of oiled lint is placed underneath the flap. The inflammatory process which follows the elevation of the flap causes this greatly to increase in thickness, while its interior surface, in from two to three weeks, becomes clothed with granulations and eventually cicatrized. When, [illegible]ne, the flap is sufficiently thickened, its upper connection with the arm is severed by a transverse incision which leaves a wide raw margin at the upper end of the flap, which is sutured to the vivified margins of the nasal defect. This part of the operation Tagliacozzi usually performed in the fourth week after the first operation. Since it requires from one to two weeks before the lower end of the flap can be safely severed from the arm, the latter must be supported in relation with the head and face. Fig. 4012 shows Tagliacozzi's method of accomplishing fixation of the arm by means of a cap and jacket. Wutzer's apparatus for obtaining a similar end is shown in Fig. 4013. In taking the skin from the forearm or back of the wrist, he found it necessary to support the arm and forearm in splints. When such an apparatus has been worn for from one to three weeks, the upper end of the flap will have become firmly united to the apex and sides of the triangular nasal defect, and it is then safe to sever its brachial connections, when the formation of the wings and septum can be completed as in the Indian method. Graefe modified the Taliacotian operation by at once fixing the flap to the vivified edges of the defect, thereby apparently curtailing the period of fixation of the arm. This, which is known as the German method, has found even fewer followers in recent times than the older operations. It manifestly gives greater opportunity of shrinkage of the flap and subjects the patient to the annoyance of a large suppurating surface near the mouth, which by the older operation is cicatrized before it is transplanted. Dieffenbach exceeded both Tagliacozzi and Graefe in the extent to which he reformed the nose from a brachial flap, in that the entire nose, with the exception of one ala, was formed as the first step of the operation. After shrinkage and cicatrization had followed, the actual transplantation of the nose was effected in from six to eight weeks.

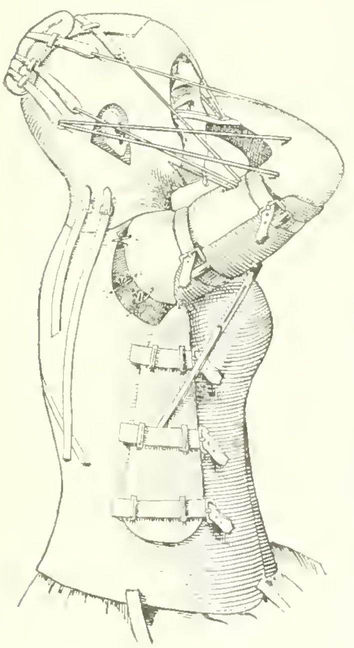

FIG. 4013.

The operations thus far described, unless gangrene supervene in the flap, effectually close the nasal defect. For the most part, however, the newly formed nose, irrespective of its original prominence, sinks and contracts until eventually little more than an integumentary curtain closes the defect. To obviate this result a number of procedures have been adopted, among which that of Thiersch probably deserves most prominent mention. As the first step of the operation, he forms on each side of the defect a rhomboid flap from the cheek, the attached base of which is in relation with the freshened edge of the defect, its free border being external. When these flaps are raised from the cheek on each side they are inverted, so that the cutaneous surfaces look toward the nares, the raw surfaces outward, and in the median line are in contact with each other. The nostrils and septum being thus formed, a frontal flap is brought down to cover the flaps from the cheeks, the operation being completed in the ordinary way. Verneuil procured a permanent elevation of the bridge of the nose by a somewhat similar operation of superposition of the flaps. In this case the frontal flap was taken from the median line, and deflected in such a manner that the cutaneous surface looked backward. Over the raw surface two quadrilateral flaps from the cheeks were brought by a process of gliding and united along the median line. Finally, Langenbeck and Ollier have given the new nose an osseous substructure by sawing a strip one-fourth of an inch wide from the nasal processes on each side. This strip, after being broken through its attachments below, is deflected toward the median line, where it meets its fellow of the opposite side. If the nasal bones are present and only depressed, which they generally are, they must be brought into position by the free use of the elevator.

FIG. 4014.

Quite recently König (*Langenb. Arch.*, vol. xxxiv., p. 165) presented to the Congress of German Surgeons a method of obtaining an osseous framework for the repair of sunken noses, and for the permanent elevation of the nose after total rhinoplasty. The method is virtually one of superimposed flaps, both being taken from the forehead. A median flap of the requisite length and half an inch in width is formed from the forehead in the median line. The incisions bounding this narrow strip are carried down to the bone. When this flap is raised the external table of the frontal bone is raised with it as far as the root of the nose. The flap thus elevated is inverted, so that the cutaneous surface faces the nasal fossæ. Over the raw external surface a second frontal flap is then placed and fixed as in the ordinary Indian operation. In four cases in which König performed this operation for a sunken condition of the nose, the repaired organ retained its solidity after from one to nearly four years had elapsed from the time of the operation.

The partial destruction of the nose also presents many interesting peculiarities that require partial rhinoplasty. When the tip and alæ of the nose are intact, while the body and bridge are lost, the defect should be closed by a frontal flap (Figs. 4014 and 4015). In this case Linhart removed an epithelioma involving almost all the cartilages and a portion of the bony framework of the nose—only the margin of the nostrils on each side was preserved. Mutilations of the tip of the nose can also be repaired by a frontal flap. Figs. 4016, 4017, and 4018 illustrate the defect and the results of operation in a case of Buck's, in which the tip of the nose was bitten away. In this case the freshening of the edges of the defect was followed by the elevation of the patch of skin above the defect as far as the root of the nose between the eyebrows. A frontal flap of requisite length and width was then brought into

FIG. 4015.

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Reparative Surgery.

the breach, the skin previously displaced from the nose being fitted into the frontal wound. In Fig. 4017, *a* and *b* indicate the disfiguring prominences resulting from rotation of the flaps. When these were excised the admirable result shown in Fig. 4018 was obtained.

The tip of the nose may also be repaired with a flap from the cheek (Linhart, Fig. 4019). The pedicle of this

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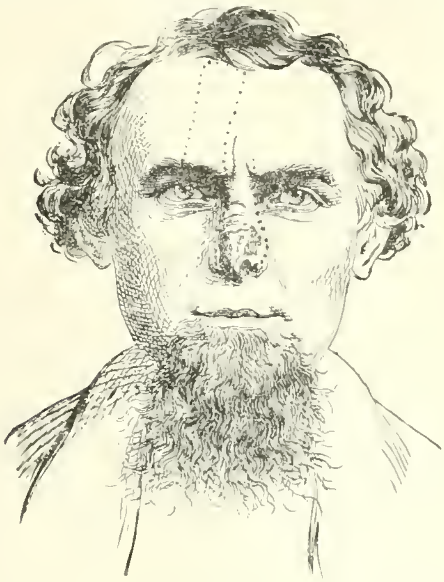

Fig. 4016.

flap extends quite to the root of the nose; its broad end may be divided by two incisions (dotted lines) for forming parts of the nostrils and septum, as in total rhinoplasty. Before the flap can be inserted, the remaining integument of the nose must be divided in the median line and reflected on each side. It frequently happens that with the tip one of the nasal alæ and the column are

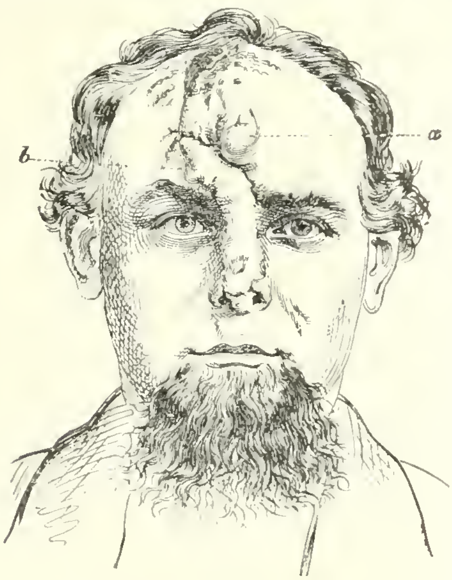

Fig. 4017.

lost. To repair this defect the integument of the root of the nose, of the glabella, and of the internal angle of the orbit was utilized by Busch (Fig. 4020). The pedicle of the flap is placed on the healthy side of the nose, low down, and on a level with the defect. When the flap is brought into position, its lower portion forms the tip and column of the nose, while its upper part, when duplicated, replaces the lost ala. The repair of defects of the nasal wings can be accomplished by a number of procedures. When the defect is long but narrow, it is prob-

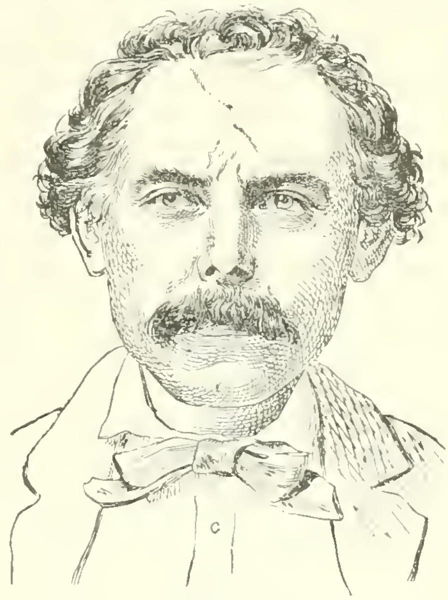

Fig. 4018.

ably best, as Dieffenbach taught, to refrain from attempting a plastic operation, and to produce a similar defect on the opposite wing. In some cases it is advisable to excise the defect in a triangular way, and to close the breach with a flap from the side of the nose. Fig. 4021 illustrates the method of obtaining it and the incisions (dotted lines) necessary for placing it in position. In larger defects of a nasal wing it is advisable to procure

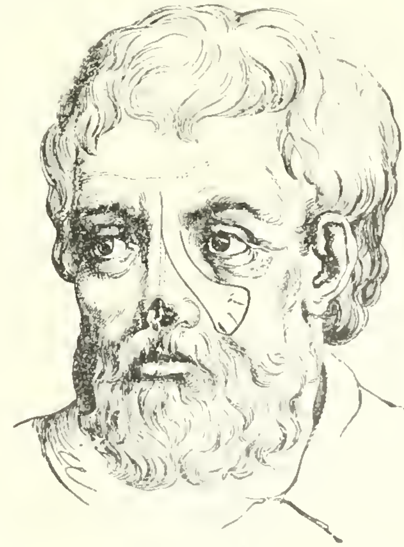

Fig. 4019.

a flap, quadrilateral in shape, from the cheek or from the upper lip. In Figs. 4022 and 4023 the method of Bonnet is shown; to give the angle of the nose a more shapely

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form, and to facilitate the rotation of the flap, a wedge-shaped portion (*b*) may be excised from the base of the flap. In this operation the vermilion border of the flap must be removed, and the fissure in the lip is to be closed at once. Perforations of the nose resulting from wounds or ulcerations are generally seated at the sides of the nose. They may readily be closed by flaps of suitable shape and size, taken from the forehead, from the cheek, or from the opposite side of the nose.

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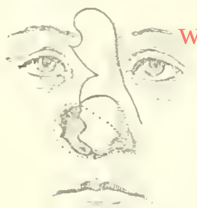

FIG. 4020.

The nasal column, when it alone is defective, can be admirably repaired from the central portion of the upper lip, which must be included between parallel perpendicular incisions. When the flap thus formed is brought in contact with the nasal septum, its mucous surface is of course exposed and is eventually converted into skin.

In the most complicated of nasal defects, finally, other parts of the face are also, as a rule, deficient. This is particularly true of the upper lip, of portions of the palate, and of the cheek. In such complicated cases, as has already been intimated, many operations are required before the face can be made at all presentable. In cases of this character the lip, the angle of the mouth, and the nose all require separate operative treatment. If, however, from one to three years be devoted to the judicious management of such a case, the result will in every way repay patient and operator for the patience displayed.

Paraffin Injections in Reparative Surgery.—In order to fill up the scrotum of a very sensitive young man, which had been left empty after a castration, Gersuny[15] in 1900 devised the ingenious method of injecting vaseline. Encouraged by the good result obtained in this case, he extended the procedure to cases in which other than the distinct cosmetic effect was desired. The result which Gersuny[16] obtained in a case of urinary incontinence in a female, which had resisted all other methods of treatment, was so brilliant that other surgeons at once took up the new procedure, and so its use soon became widespread. A considerable amount of good work has been done at von Bergmann's Klinik by Stein.[17] He prepares paraffin, which should have a melting point between 42° and 43° C., by melting and filtering with a hot water funnel, such as is used in the filtration of bacteriological culture media. The filtered paraffin should be put into wide-mouthed flasks, such as Erlenmeyer's, and plugged with cotton wool. In these it is sterilized in the hot air oven at a temperature of 200° C. for a half hour, and can then be preserved indefinitely, ready for use at any time. Before using, the flasks containing the paraffin are heated in a water bath to the melting point. The injection is made with a Pravaz syringe, wholly made of glass, holding about 1 gm. The object is to have a syringe devoid of all sharp corners and edges, so that the paraffin does not so easily congeal. Before injecting the paraffin, the filled syringe is again put into hot water and then the needle is screwed on. The injection is made by lifting up a fold of skin with the left hand and with the right inserting the needle and injecting slowly until the desired amount has been used. The needle is then withdrawn and a small piece of plaster fastened over the puncture. The paraffin is now moulded into the desired shape, while an assistant allows the ethyl chloride spray to play upon the part. Several injections may be made at different times, but care must be used not to insert the needle over the area previously injected, as it should be inserted to the side of it. According to Juckoff[18] paraffin after its injection acts like any foreign body, and causes a reactionary inflammation with the formation of new tissue. Some of the paraffin is absorbed here and there, so that finally we have the mass pervaded by connective-tissue strands, which emanate from a fibrous capsule around the whole. This capsule is fused with the adjacent tissue.

FIG. 4021.

This excellent method is not without a small amount of danger. The following unfortunate occurrences have taken place: Embolism of lung and intestinal organs from the accidental insertion of the needle and injection into a vein; infection from faulty asepsis; gangrene and sloughing from the introduction of too much paraffin, as a result of which obliteration of the blood-vessels has occurred.

FIG. 4022.

The method is applicable to cases in which the normal contour of the body is lost. It has been used with distinct benefit in saddle nose following caries of nasal bones. In one case treated at von Bergmann's Klinik, the result was striking. Several injections were made at different places and the nose was thus gradually built up. The injection should be made with care so that none of the paraffin shall find its way into the orbit. Cleft palate may be treated by this method, which is chiefly applicable to those cases in which a small foramen has remained after staphylorrhaphy. The contour of the cheek might be re-established after removal of the superior maxillary bone. The scrotum may be filled up after castration. The method is applicable to another class of cases, namely, those of urinary incontinence, especially in the female, in which condition a ring of paraffin is injected about the neck of the urethra so as to replace the sphincter. A cystocele has also been treated, with distinct benefit, by injections between the vagina and bladder wall. By establishing a paraffin depot around the rectum fecal incontinence has been cured. The method is still new and sufficient time has not yet elapsed to establish the permanency of cure in many of the brilliantly successful cases; nor have there been many opportunities to examine the changes produced in the tissues, beyond those produced experimentally on animals in the laboratory. The method promises much in the future, and certainly is a valuable aid to our surgical technique.

FIG. 4023.

Joseph Ransohoff.

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[9] O. Weber: Pitha und Billroth, Bd. iii., i., p. 148.
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[12] Arch. f. klin. Chir., 5, p. 33.
[13] Gaz. hebd., i., p. 416.
[14] Chir. Repar., p. 118, 1851, Verneuil, p. 311.
[15] Gersuny: Zeitschrift f. Heilkunde, 1900, Bd. i., Heft 9.
[16] Gersuny: Centralblatt f. Gynäkologie, 1900, No. 48.
[17] Stein: Deutsche med. Wochenschrift, 1901, Nos. 39 and 40.
[18] Juckoff: Ueber die Verbreitungsart subcutan., etc. Arch. f. exp. Pathologie, Bd. xxxii.

REPRODUCTION.—The various processes by which new organisms are produced are included in the general term, *reproduction.*

It was thought by the ancients that many organisms of complicated structure, such as worms, insects, plants, etc., could be formed from mud, decaying material, and other dead matter by a process of spontaneous generation, or *abiogenesis.* It was proved by Redi in 1688 that abiogenesis does not occur in insects, but it remained for Pasteur and his colleagues in the latter half of the nineteenth century to show that even the minute and simply

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organized bacteria are always produced by division of the living substance of pre-existing individuals of the same species; that is, reproduction in the present condition of the world is always a process of *biogenesis*. Not only is every organism produced by a pre-existing organism, but every cell arises by division of a pre-existing cell, and every nucleus by division of a pre-existing nucleus. (See *Cell.*) Moreover, there is good evidence for the belief that the minute but apparently important elements of the nucleus, known as *chromosomes* (*q. v.*), are also produced only by division of pre-existing chromosomes. So reproduction, like all other vital functions in health and disease, must be regarded as essentially a cellular phenomenon.

Reproduction may be either sexual or asexual. The essential feature of *sexual* reproduction is the development of an embryo from a *fertilized* egg, that is, a germ produced by the union of an *ovum* and a *spermatozoon*, or their equivalents (see articles *Ovum*, *Spermatozoa*, and *Impregnation*). The capacity to produce one or the other of the reproductive elements, together with the associated peculiarities, constitutes the quality of *sex* (*q. v.*). Both of the reproductive elements are cells derived from apparently indifferent germ cells by an interesting process of development, which is discussed under the heading *Reduction-Division*. This process takes place in certain special organs, for which the general name is *gonad*, the female gonad being called the *ovary* and the male gonad, the *testis*. When the eggs or spermatozoa are ripe they are discharged from the gonad, and fertilization may take place outside of the body, as in most fishes, or within the oviduct (Fallopian tube, uterus, etc.), as in man. In man and other mammals the discharge of the ova is associated with certain peculiar physiological phenomena described in the article on *Menstruation*.

Fertilization having taken place, the egg proceeds to divide by the usual process of cell division, and by repeated divisions forms a mass of cells which becomes the embryo. The details of this process vary in different animals, as will be seen by reference to the article on the *Segmentation of the Ovum*. Sooner or later the cells of the embryo begin to differ among themselves in accordance with their destiny in the formation of organs. The causes of these changes are discussed under the title *Differentiation*, and the development of the embryo in form and structure is described in detail in the articles *Fœtus* (in THE APPENDIX), *Area Embryonalis*, etc.

Both during development and in the adult condition there is a noticeable similarity between parent and offspring at corresponding stages. This is a fact of great importance, and is fully treated in another place (see articles *Heredity* and *Reversion*).

When reproduction takes place by some method without the aid of a fertilized egg, it is said to be *asexual*. In the bacteria and some of the lower animals the reproducing individual divides into two or more nearly equal parts. This is called *fission* (*q. v.*). In the yeasts, the higher plants, and some animals, a small part of the parent grows more rapidly and becomes differentiated into a new individual. This is *budding* (*q. v.*). A third form of reproduction occurring normally in some species is known as *parthenogenesis* (*q. v.*), which may be regarded either as an asexual or as a degenerate sexual process. In such cases the offspring is produced by the development of an egg without fertilization. *Robert Payne Bigelow.*

RESALDOL is a light-brown powder prepared by the action of chlormethyl-salicyl on resorcin by means of acetylization. It is insoluble in water, ether, chloroform, benzol, and acids, and soluble in alcohol, acetic ether, and alkalies. Its taste is insipid and astringent. On account of its insolubility in acid media it causes no derangement of the stomach (Hermann), but in the intestines sets free the diresorcyl radical and acts as an astringent and antiseptic. Hermann recommends it in acute and chronic diarrhœa, colitis, the early diarrhœa of typhoid fever, intestinal putrefaction, and infantile diarrhœa, and he finds it useless in nervous diarrhœa or that due to mechanical irritation. Brochocki employed it in twelve cases of tuberculous enteritis, four of acute gastro-enteritis, three of catarrhal dysentery, and three of typhoid. All except the typhoid cases improved, though xeroform, bismuth, and opium had failed. The dose is 1-1.5 gm. (gr. xv.-xxiv.) three times a day. *W. A. Bastedo.*

RESECTION OF THE JOINTS.—The history of this operation dates from the year 1783, when Henry Park formally proposed the operation for the removal of disease. In 1786 Moreau first performed it, and became its stanch advocate as a method of treatment. Little was done, however, until Syms in 1831 in the elbow, and Ferguson in the hip, knee, and wrist, made use of this operation as a conservative method of treatment ("Excision of Joints," R. M. Hodges, Boston, 1861). Since this time this method of treatment has been wonderfully advanced and has been adopted by the ablest surgeons.

A resection is the removal of a portion of the skeleton without great sacrifice of the soft parts. Applied to joints it has for its object the more or less complete removal of the bones forming the joint, the preservation of the sensibility, contractility, and vitality of the soft parts influencing the joint, and the ultimate restoration of motion or the production of ankylosis.

When motion is desired—the ideal object of articular resections—the ends of the bones left in contact must be adapted to one another, and so fashioned in shape as to reproduce the joint surfaces removed. The muscles which move the joint must be left undisturbed in their attachment; or, if disturbed, restored so that their functional action is not compromised.

The ligaments and fibrous bands which subsequently develop and unite the bones must be analogous to those present before operation. To obtain this end, all ligaments must be preserved with their bony or periosteal attachments.

To attempt a nearthrosis with a sacrifice of the muscular and ligamentous attachments often results in a useless pseudarthrosis, inferior in every respect to a useful ankylosis.

To obtain mobility with steadiness and strength in action the preservation of the muscular and ligamentous attachments to the periosteum and the continuity of the articular capsule with the periosteum must be made the main object of the operation. Such a method of operating is known as the subperiosteal or subcapsulo-periosteal resection. Its object is motion with strength and steadiness in action.

In case a solid union—ankylosis—is desired, two conditions arise which influence the result. The first is seen when the divided ends of the bones can be brought into apposition and their fusion takes place directly. In this case ankylosis is assured, provided the disease is removed. The second condition exists when the divided ends of the bones cannot be brought into apposition, but are separated by an appreciable distance from one another. The union here takes place principally through the agency of the periosteum, and ankylosis, more or less doubtful and dependent upon the osteogenic power of the periosteum, results. It is in this latter variety that the pseudarthrosis and flail joints occur.

When ankylosis is desired and is reasonably attainable, the preservation of the muscular, ligamentous, and capsular attachments to the periosteum are of secondary importance.

When bone or a bony prominence is separated and replaced *in situ* in order that diseased tissue can be more thoroughly removed, the resection becomes an osteoplastic one.*

Again, resections are either complete or partial: complete when the component bony surfaces are removed; partial when one or more, but not all the articulating surfaces are removed.

Resections may therefore be partial or complete, par-

* This term is sometimes used and applied to operations in which bones not normally apposed are brought together after removal of the intervening bone or bones.

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osteal or subcapsulo-periosteal. They may also be osteoplastic.

The Incision.—They should avoid nerves and vessels. When possible, tendons and muscles should be spared. This is attained by using the intermuscular septa in approaching the joints.

Fig. 4024.

Incisions should be made to expose the joints without forcible retraction. They should be so situated that the entrance through the capsule and into the joint is the most direct one. Gentleness should be exercised by all throughout the operation. Maltreatment of the soft tissues not only interferes with the process of repair, but destroys an otherwise successful result. Care should be used in protecting the soft parts from the saw. The tendons, if possible, should be left undisturbed within their sheaths. Their insertions should be left in continuity with the periosteum, or a small piece of bone (Vogt) may be removed with the insertion. If it is necessary to divide tendons, they should be carefully sutured.

If muscles must be divided, they should be cut in the direction of their fibres, the nerve being avoided. If this is impossible, they may be divided transversely or obliquely as near their origin or insertion as possible.

The management of the periosteum is still in dispute. Some advocate the subperiosteal, others the parosteal method.

It must be remembered in any given case that the value of the periosteum in procuring bone is very variable, and is dependent mainly: (*a*) Upon age. The healthy physiological periosteum has but little osteogenic power except in youth. (*b*) Its power to develop new bone depends upon the thickness of the different bones. (*c*) Pathological processes involving the periosteum and causing a thickening of the osteogenic layer will increase its osteogenic power. In but few cases can a comparison be made between these methods in reference to these three points; and since many subperiosteal operations are very imperfectly performed, it is not surprising that a division of opinion should exist.

Ollier, Langenbeck, Sayre, and others have long insisted that the traumatism produced by the subperiosteal (*i.e.*, subcapsulo-periosteal) method was less than by the parosteal method, and have maintained that the reparative process itself was less impaired because of the protection to the soft parts afforded by the capsule and periosteum.

Fig. 4025.

My own opinion favors the subperiosteal method, both for the protection to the tissues, for the production of new bone, and for the aid to the reparative process.

Time is not sacrificed in the subperiosteal method, for the separation of the periosteum can be rapidly accomplished by a to-and-fro motion of the rugine. When one approaches a prominence of bone or a tendinous insertion is met, a small piece of bone may be separated with the periosteum by the chisel or the rugine; such a piece may act as a centre of bone growth. During the separation the rugine is to be pressed against the bone, separating the periosteum entire and not injuring its connection with the overlying tissues.

In the management of the bones, we strive to remove the smallest amount of bone which will remove the disease or correct the deformity. Where the bones can be protruded through the incision and the soft parts sufficiently protected, the butcher, the Emmerich, or the broad flat-bladed saw (carpenter) may be used. When the bones cannot be displaced and the protection of the soft parts can be secured by gentle traction, the Gigli saw can be used. Other varieties of saw seem scarcely necessary in resections.

The sawing is usually done in plane surfaces at right angles to the line of pressure. In some instances, especially where an attempt to obtain motion is made, mortises and tenons are fashioned, which tend to favor retention of the fragments and to preserve the shape of the joint ends of the bones.

Fig. 4026.

Fig. 4027.

In pathologically involved joints after removal of the articular ends, further removal of foci may be required with the gouge or spoon. After removal of the disease from the bones their fixation is necessary, either in the attempt to obtain motion or in that to secure ankylosis. For this purpose, silver, copper, aluminum bronze, wire, steel and steel-plated nails, bone pins (Marsh, *Brit. Med. Journal*, 1887, i., p. 389), and steel drills (Wyeth's) have been used. My own experience teaches me that fixation is not necessary for a longer period than ten to fourteen days, and that in the majority of cases in which good appliances are obtainable the fixation is not required, in aseptic cases, for a longer period than that during which the first dressing must be kept applied. I have therefore relied completely upon chromicized catgut, which is prepared to resist absorption for from two to three weeks. This has been my practice for fifteen years, and I see no need of subjecting the tissues to the presence of a foreign body, which, if pathological deposits exist in the bone, only offers a *locus resistentiæ minoris* for infection from within or without. I must add, however, that in some instances, as in the hip-joint, it is not always feasible to produce fixation by the catgut suture. In these instances the steel nails, drills, or bone pins may be used. The bone pins are absorbable.

The management of the synovial membrane, capsule, and ligament requires the removal of all pathological deposits affecting them, even if it include the entire removal of these parts. When possible, the synovial membrane, the capsule, and the ligaments should be saved in part or entire, since the perfection of motion in nearthrosis depends in no small degree upon the presence of these structures.

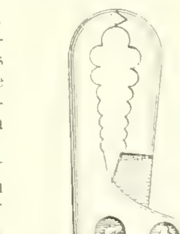

Fig. 4028.

The instruments which are specially used in resections are: 1. Those which divide the soft tissues immediately investing the bone, or joint-knives. These should have strong handles and short-cutting blades to insure precision and force in action (Figs. 4024 and 4025). 2. Those intended to detach the periosteum from the bones—rugines (Figs. 4026 and 4027). 3. Those intended to fix the bones while the soft parts are being detached and the bones sawed (Fig. 4028). 4. Those intended to divide the bones. When the bones can be displaced and a straight saw can be applied, either a bow saw with a rotating blade (Fig. 4029), or a solid straight back saw (Fig. 4030) may be used. When the bones cannot be displaced so that a straight saw can be used without injuring the soft parts, the chain saw (Fig. 4031), or the Gigli saw should be used. The former is used when the surface to be cut is in one plane; the latter when the cut surface is to be concave or convex. Electrically

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Resection of Joints

propelled saws seem to have no advantages in resections. 5. Those intended to cut away spicula or prominences of bone with the periosteum attached: (*a*) Bone forceps (Figs. 4032 and 4033); (*b*) chisels (Fig. 4034). 6. Those intended to remove diseased foci in the bone after the sections are made: (*a*) Gouges (Fig. 4035); (*b*) spoons (Fig. 4036). 7. Those intended for drilling the holes required for the wire nails or catgut suture (Fig. 4037).

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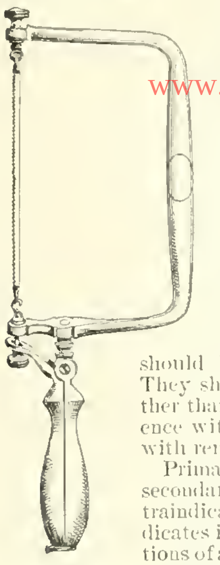

FIG. 4029.

The Indications for the Resections of the Joints.—In tuberculosis resections are usually looked upon as a sequel to rather than as a substitute for the conservative treatment. In the young, resections should be partial rather than complete. They should be subcapsulo-periosteal rather than parosteal, with as little interference with the epiphysis as is consistent with removal of the disease.

Primary tuberculosis of the lung with secondary joint involvement usually contraindicates operation, while the reverse indicates it. The mortality following resections of all varieties performed upon 117 patients was 21.3 per cent., with 15.3 per cent. of this number from tuberculosis (König). Whether early resection or the expectant treatment gives better results as regards mortality, function and a cure, must remain in doubt until similar cases are treated by each method and are compared. Undoubtedly many

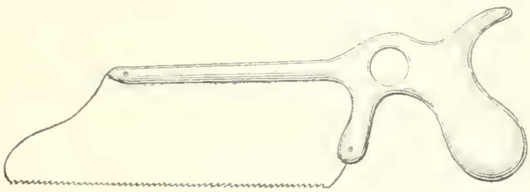

FIG. 4030.

cases treated expectantly and regarded as tuberculous are not so. The same cannot be said of resections, since the cases resected are proven before or after operation by microscopical or bacteriological examination as tuberculous in almost all instances. My own experience leads me to the expectant as the initial treatment, while resection is reserved as a secondary method.

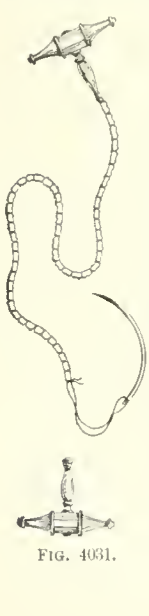

FIG. 4031.

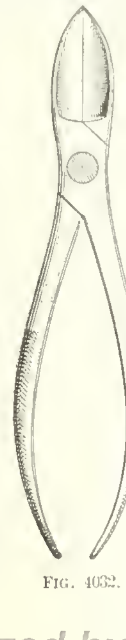

FIG. 4032.

In acute suppurative arthritis and synovitis, arthrotomy, not resection, is indicated. In chronic suppurative arthritis, resection is indicated for the removal of the disease and the relief of the deformity. In arthritis deformans, resection may be indicated for the flail joint. The rarefying osteitis must here run its course, however, in order to give a solid ankylosis. In chronic rheumatoid arthritis, resection is indicated in appropriate cases. In syphilitic arthritis, resection is indicated for the removal of gummatous foci, which have not given way to medicinal treatment. In gunshot and other injuries, resection is preferable to amputation. With the present weapons, the expectant treatment is the initial method, to be followed, in case of failure, by the partial or the complete resection. In malum senile, arthritis nodosa, urica, or neuropathica, resections are practised only in exceptional instances.

The functional results of resections are usually classed as: (1) Bad. This includes cases in which the bones remain at a distance from one another and are held together by fibrous bands only. The limb is without muscular control and cannot be used. (2) Mediocre. This includes cases in which there is also a pseudarthrosis, but the fibrous union is short and strong. The joint is flail, but nevertheless it obeys the muscles in many ways and can be made useful by apparatus. (3) Good. This includes those cases in which there is a nearthrosis and a sufficiently perfect one to differ from a normal joint only in the extent of the motions.

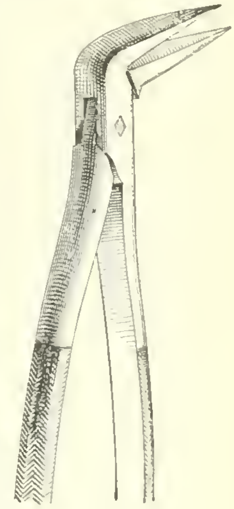

FIG. 4033.

In most resections ankylosis is the common result and is in some joints to be preferred to any other result than the ideal one (3). Flail joints are rare. Mediocre results are common.

During the operation the Esmarch bandage is a great help in exsanguinating the field of operation. It allows a complete inspection and renders possible careful dissection of the tissues. It must be used with discretion, and must not be employed in those whose arteries are diseased. Again, the exsanguination of the tissues should not be extended over a great length of time. This can be avoided in a measure by the more rapid work which it renders possible. After removal of the bandage there is some vaso-motor paralysis, but it soon yields or is corrected by elevation of the limb. In applying the bandage, care must be used to avoid direct compression of the motor and sensory nerves between the bone and the bandage.

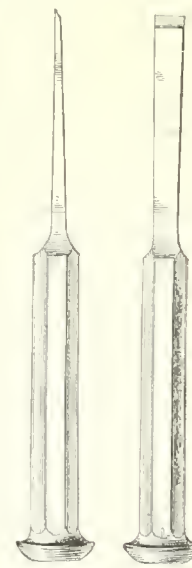

FIG. 4034.

The limb should be completely exsanguinated as regards both the arteries and the veins.

RESECTION OF THE INTERPHALANGEAL JOINTS OF THE FINGERS (Fig. 4038).—The most important of these joints is that of the thumb.

Indications.—Complete destruction; chronic tuberculous arthritis; chronic suppurative arthritis; chronic non-suppurative arthritis.

The preferable situation for the incision is the dorso-lateral aspect of the joint, somewhat nearer the dorsal than the palmar surface. The incision may be a single one upon the internal surface of the thumb and forefinger and upon the external surface of the little finger. Wherever fistulæ are present the incision may best be made so as to include them. The preferable method, however, is that of two incisions placed dorso-laterally, one upon each side of the extensor tendons. By means of these two the denudation of the bones and the

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exposure of the joint are easily accomplished. Each incision is carried through the capsule and the periosteum for the full length of the skin incision, which should extend above and below the joint sufficiently to expose and to dislocate the articular ends of the bones. With a straight and curved rugine, the denudation of the bones is made from both incisions. Fine blunt retractors are used to expose the bone and to protect the separated periosteum and capsule and the tissues covered by them. When the capsule and periosteum have been freed sufficiently (subcapsulo-periosteal method), the ends of the bones are luxated without force through the more convenient of these incisions. The articular ends are now removed by the saw or cut away piecemeal by the bone-cutting scissors or rongeur forceps. After this is accomplished, the synovial membrane of the joint and the pathological foci in the soft parts about the joint are removed, preferably by dissection. The ends of the bones are now drilled, and one or two ten-day chromic-acid catgut sutures are inserted, bringing them in close apposition if ankylosis is desired. They are only loosely tied if an attempt at pseudarthrosis is made. In case a nearthrosis is desired, no sutures are necessary, as the suture of the divided periosteum and capsule will sufficiently hold the bones in their normal layer of tissue.

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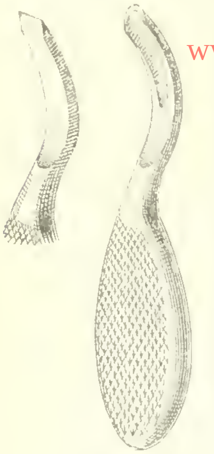

FIG. 4035.

If an Esmarch bandage has been used, it is now removed. The larger vessels are secured. The periosteum and capsule are sutured with catgut or silk. The remainder of the wound is closed, with catgut for the subcutaneous tissue and silk for the cutaneous. Drainage is not employed unless suppuration is already present. An aseptic dressing is applied. A fixation splint is applied over the dressing. The splint dressing is removed in ten days. At the end of two weeks all splints are removed. At the end of three weeks gentle passive motion is employed, unless ankylosis is desired.

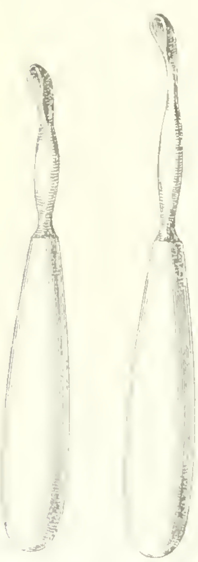

FIG. 4036.

RESECTION OF THE METACARPO-PHALANGEAL JOINTS (Fig. 4038).—Here also a single or two incisions may be used. When one is used it is placed upon the external dorso-lateral aspect of the thumb and index finger, upon the internal for the little finger, and upon either side for the other fingers. If two incisions are used, they are made as in the interphalangeal joints, on each side of the extensor tendons. For the metacarpo-phalangeal joints a single incision will often suffice. If feasible the operation should be the subcapsulo-periosteal one. The incision is carried directly through the skin and subcutaneous tissue to the periosteum and capsule of sufficient length to expose the joint well above and below. The digital nerves are avoided if seen. The short muscles passing between the metacarpal bone of the thumb and its phalanx, as well as the aponeurotic canal for the extensor and flexor tendons in the fingers and thumb, are also avoided. The capsule and periosteum are now exposed and are incised. The denudation of the periosteum and the elevation of the capsular attachments are carefully made, especially at the metacarpo-phalangeal joint of the thumb, in order that the muscular insertions may be preserved.

When this is accomplished, the bones are dislocated through the incision and are divided with the saw or by the rongeur forceps. In some instances the Gigli saw can be used without dislocation of the bone. If the operation has been a subcapsulo-periosteal one, no sutures in the bones are needed, provided a nearthrosis is attempted. If not, and a pseudarthrosis is desired, a retention bone suture is used, with a small interval between the fragments. When ankylosis is desired, the bones are held in apposition by the bone sutures.

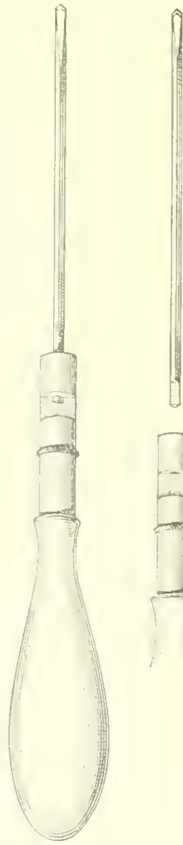

FIG. 4037.

RESECTION OF THE WRIST.—The history of this operation dates back as far as 1750, when Cooper, of Bungay, removed the lower end of the radius and ulna for injury. In 1762 Bagien excised the joint for a gunshot wound. In 1794 Moreau excised the joint for disease. Lister in 1865, Boeckel in 1867, Langenbeck in 1874, and others gave a great incentive to this operation by admirable papers; yet in spite of these papers the operation has never been a popular one. Its unpopularity was not due to its mortality, for this, according to Culbertson, amounts only to from one to 1.73 per cent. for all cases (Prize Essay, p. 628), and, according to Gurlt's "Military Surgery," to sixteen per cent. It was due to the failure to arrest the disease or because of the utter worthlessness of the hand after recovery. At the present time, with an improved technique and the aseptic treatment, these bad effects are to an extent avoided, and as a result the operation is again being strongly advocated.

Anatomy of the Wrist (Fig. 4039).—The anterior or palmar surface of the wrist is so well covered with tendons, arteries, and nerves that an approach from this side is not feasible. Upon the dorsal or lateral surfaces the bones are more easily exposed. Upon the back one can enter between the tendons without coming in contact with arteries, unless upon the external and posterior surfaces of the trapezium. The usual places selected are those between the extensor indicis and the extensor secundi internodii pollicis upon the outer side, and between the extensor carpi ulnaris and extensor minimi digiti upon the inner. In this interval one encounters only the extensor carpi radialis brevior before entering the joint. None of the tendons to the fingers passing over the dorsum of the wrist is attached to the wrist, so that they can be easily retracted to either side without injury.

FIG. 4038.

Upon the outer side of the dorsum the extensor carpi radialis longior and brevior and the flexor carpi radialis are intimately connected with the joint and bones to

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Resection of Joints.

be removed. Upon the inner side the extensor and flexor carpi ulnaris are inserted into the base of the fifth metacarpal bone, and are intimately associated with the capsule and ligaments.

The bone which plays the most important part in this operation is the trapezium, which conceals and retains upon its anterior surface the flexor carpi radialis, and is covered by the radial artery upon its dorsal surface. From its crest it gives origin to the annular ligament, and by its articulation with the metacarpal bone of the thumb it becomes very necessary for the function of the thumb.

Provided the tendons are not incised, any incision which will enter the joint upon the dorsum, either to the inner or to the outer side of the mass of tendons made up of the extensor communis digitorum, extensor proprius pollicis, and extensor minimi digiti, will be found sufficient.

The bones of the carpus are united by a capsular ligament, of which the anterior is the strongest portion. The carpus itself may be regarded as one short and wide bone, articulating above and below with the bones of the forearm and those of the hand. The lower epiphyses of the radius and ulna join their shafts at twenty years. The radial epiphysis is entirely within the joint. The ulnar epiphysis reaches as high as the top of the radio-ulnar articulation.

A total resection of this joint includes the removal of the articular ends of the bones of the forearm and those of the metacarpal bones besides the bones of the wrist. Any resection short of this is a partial one.

Indications.—In both civil and military practice partial rather than complete resections are indicated. This holds good in most gunshot wounds, in compound and complicated fractures and dislocations. For tuberculosis, chronic suppurative arthritis, syphilitic arthritis, resection is indicated after medicinal and expectant treatment fails. Such is the case in other forms of joint disease where resection, partial or complete, is used to relieve deformity or increase motion.

Resection, especially the complete, is not permissible before the fifth year of life. It is rarely demanded before puberty. When it is demanded, the epiphyses of the bones of the forearm are not interfered with, and the operation is an informal or incomplete one. The object is to remove the diseased tissue and nothing else. After puberty the operation has its best results, and it is here that complete resections are made with good chances for functional results.

When, in an adult, tuberculosis exists in the carpus, with tuberculosis elsewhere in the body, the question to be decided is between amputation and complete resection. The general rule is that amputation should be selected if the local process succeeds the pulmonary, and that resection should be preferred if the local antedates the pulmonary. This must be taken with reserve, however, as many such cases of primary wrist involvement do best with amputation.

The older the subject the more we must consider amputation in preference to resection.

The methods of incision for entering this joint are:

1. The radio-dorsal incision, which, commencing at the centre of the ulnar border of the metacarpal bone of the index finger, is carried upward to the middle of the dorsal surface of the radial epiphysis between the tendon of the extensor indicis and that of the extensor carpi radialis brevior, and thence between the tendons of the extensor indicis and the extensor secundi internodii pollicis. The length of this incision varies between 8 and 12 cm., of which one-third should be above the articulation (Boeckel, *Gazette Médicale de Strasbourg*, 1867, and Langenbeck, *Archiv für klin. Chir.*, No. xvi.).

2. The dorso-ulnar incision. In abduction and slight flexion an incision of 7 to 8 cm. is made from the lower third of the fifth metacarpal over the ulna and vertically upward. In the lower part the incision passes between the tendons of the extensor carpi ulnaris and the extensor minimi digiti; over the ulna it passes in the interstice between the extensor carpi ulnaris and the extensor indicis muscles (Kocher, *Archiv für klin. Chir.*, No. 37).

3. Both radial and ulnar incisions. Both are upon the dorsum (Ollier, "Mètral Thèse," 1882, p. 45). One is dorso-radial and the other ulnar (Lister, *Lancet*, 1865).

Where two dorsal incisions are used: The radial commences opposite the centre of the shaft of the second metacarpal bone, and is continued upward along the extensor indicis tendon until it meets a line joining the two

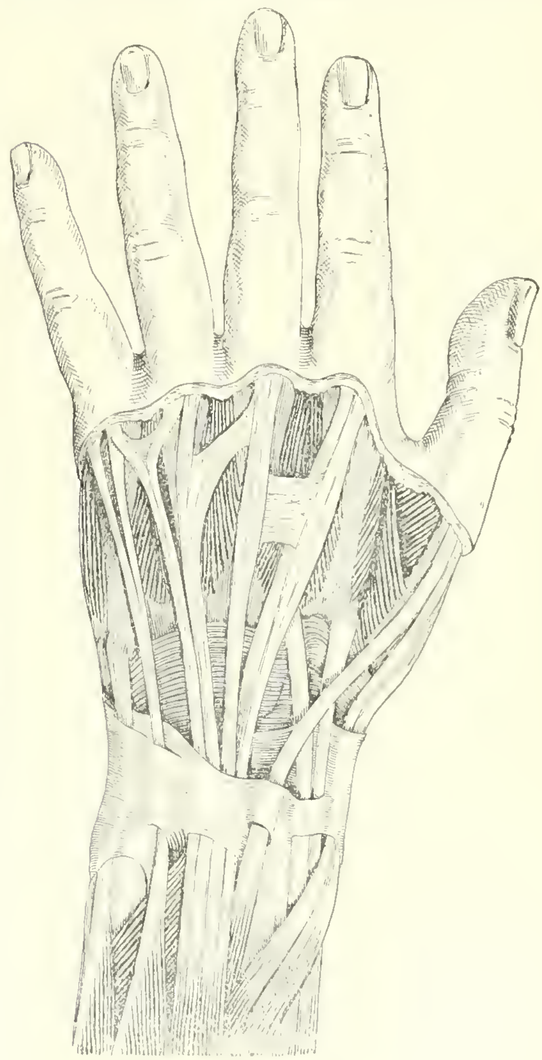

FIG. 4039.

styloid processes. From this point it passes upward in the axis of the forearm. The ulnar incision extends from the centre of the fifth metacarpal bone along the radial side of the extensor carpi ulnaris and the ulnar side of the extensor minimi digiti until it reaches the ulna. From this point it passes between the muscular bellies of the extensor carpi ulnaris and the extensor indicis. One third of both incisions is above the radio-carpal articulation; two-thirds below it.

Where one dorsal and one lateral incision is used: The radio dorsal commences at the middle of the dorsal aspect of the radius at a level of the styloid process, and is carried toward the inner aspect of the metacarpo phalangeal joint of the thumb, running parallel to the tendons of the secundi internodii pollicis. When the radial border of the second metacarpal bone is reached, the incision is carried along this border for one half its length. The ulnar incision commences 5 cm. above the extremity

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of the ulna, and passes behind but parallel to the flexor carpi ulnaris as far as the middle of the fifth metacarpal bone.

Which of these incisions is the best depends largely upon the position of the fistulæ or the degree of development of the disease. When the disease is mainly upon the ulnar side, Kocher's incision is the best to commence with (Fig. 4040); if the disease is upon the radial side, Langenbeck's incision (Fig. 4041). If the disease is extensive and requires a complete arthrectomy, no method makes so perfect an exposure as the Ollier, *i.e.*, the two dorsal incisions. We will therefore describe first the Langenbeck and then the Kocher method, and will expect the reader, from these two descriptions, to imagine that of the double dorsal incisions.

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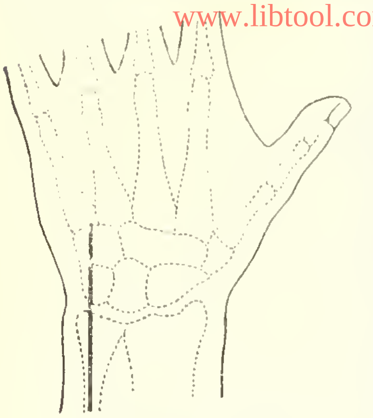

FIG. 4040. – Kocher's Incision.

Method by the radio-dorsal incision (Boeckel-Langenbeck): An Esmarch bandage is applied. The hand and wrist are placed upon a cushion with the thumb abducted and extended. The radio-carpal interspace is noticed by the position of the styloid processes. The tendons of the extensor indicis and the extensor secundi internodii pollicis are also seen.

The incision usually begins above the wrist between these tendons and descends along the tendon of the index finger to the middle of the second metacarpal bone. One-third of this incision is above the radio-carpal articulation; two-thirds is below it.

This incision is made through the skin and exposes the cutaneous terminal branches of the radial nerve, which are often cut. The external border of the tendon of the extensor indicis is recognized and is retracted with the inner flap out of the way. Incise toward the capsule of the wrist-joint and recognize the tendons of the extensor carpi radialis brevior attached to the third metacarpal bone. Above the joint carry the incision between the tendons of the extensor secundi internodii pollicis and the extensor indicis, separating them without entering their sheaths. The periosteum of the radius is now incised and the capsule of the wrist-joint is divided along the inner side of the extensor secundi internodii pollicis. Avoid cutting the tendons of the radio-carpal extensors. With the rugine (curved or straight), the periosteum of the radius and the capsular fibres of the wrist-joint (including the radio-carpal extensors) are respectively separated from the outer half of the posterior surface of the radius and from the bases of the second and third metacarpal bones.

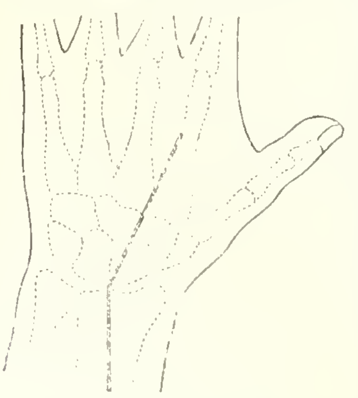

FIG. 4041. Langenbeck's Incision.

The capsule is now retracted outward and the scaphoid and trapezoid are separated from their attachments to the capsule on their posterior surfaces. The trapezium is not detached until a later stage. The capsule is now retracted inward and the periosteum and capsule are separated from the inner half of the posterior surface of the radius, the triangular cartilage, and the posterior surface of the ulna. It is detached also from the posterior surfaces of the semilunar, cuneiform, os magnum, unciform, and the bases of the remaining metacarpal bones.

If the soft parts are not extensively infiltrated and the movements of flexion and extension can be made, the radius and ulna may be luxated and sawn at this time and before the carpal bones are removed.

If this can be done, the hand is flexed and pronated and the external flap is retracted. The rugine now separates the periosteum upon the anterior surface of the radius. The hand is now flexed and supinated and the remaining portion of the radius and the ulna are denuded upon their anterior surfaces. The hand is now forcibly flexed, the flaps are retracted, and the radius and ulna project through the wound. These can then be sawn transversely. This section should be as narrow as possible, usually within 2 cm. of the cartilage (Fig. 4042). A retractor is now placed in the external wound, the wrist is flexed, the scaphoid bone is seized with the forceps, and its anterior and external surfaces are freed from the periosteum and ligaments.

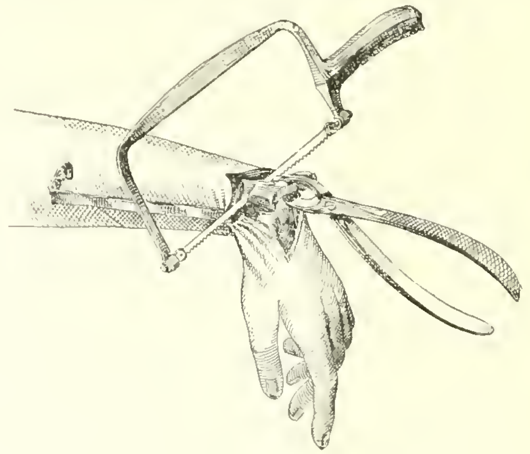

FIG. 4042.

The bone is next separated from the semilunar and is torn away easily. The internal flap is then retracted to the inner side and the semilunar and cuneiform bones are separated and removed in the same way, leaving the pisiform. The os magnum is now seized with the forceps, its anterior surface is denuded with the rugine, and its connections with the unciform, trapezoid, and metacarpal bones are severed. The trapezoid is finally removed in the same manner.

With more extensive wound retraction, the unciform may be seized and its anterior surface denuded until the base of its process is reached. This process is now separated with the cutting forceps, and a freeing of the bone upon its internal surface allows its removal.

If the trapezium is to be removed, a retractor draws outward the external flap, the left hand seizes the thumb, and the rugine clears the posterior and then the anterior surfaces of periosteum. The trapezium is now seized with the bone forceps, its external border is denuded, and the bone is removed.

Provided the pisiform and the hook of the unciform are to remain, and provided also the synovial membrane has been removed, the Esmarch bandage should be loosened and the larger arteries tied. In many instances, where one is certain of not injuring the larger vessels, the bandage is not removed until after the first part of the permanent dressing is applied.

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Sutures between the ends of the bones have always been used by me, because I have always believed that a mobile pseudarthrosis with mobility of the fingers was the best obtainable result. Two chromicized catgut sutures

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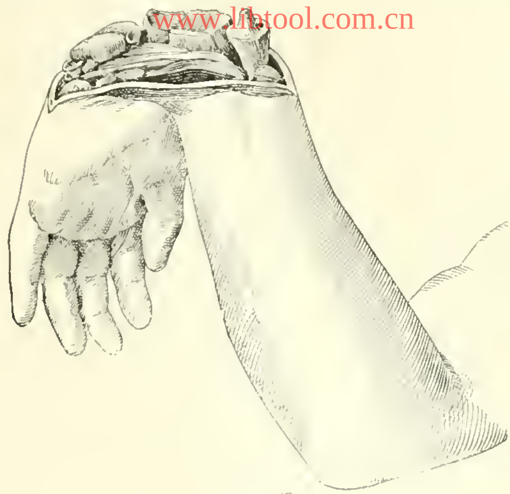

FIG. 4043.

are inserted, bringing the bones within one-fourth to one-half inch, or 0.6 to 1.25 cm., of one another. If the tendons of the extensor secundi internodii pollicis or the extensor carpi radialis longior and brevior have been divided, they are to be carefully resutured or reinserted if separated from their insertions.

The capsule is sutured with catgut. The skin is sutured with silk or catgut.

Provided the operative field is an aseptic one, catgut is employed for the skin. No drainage is used except that which occurs at the lower portion of the wound, near the index finger, where the skin and capsule are not sutured in order that any undue tension in the wound may be relieved. If the process is infective, drainage is employed through the incision by gauze packing.

The method by the dorso-ulnar incision (Kocher): The disadvantage of the preceding method, in Kocher's opinion, is the necessary separation of the radio-carpal extensors and the imperfect dorsal flexion, and possibly the volar subluxation resulting. The advantages of the dorso-ulnar incision are seen in the less important action of the extensor carpi ulnaris as a dorsal flexor and its greater importance as an adductor. Hence when it is separated its loss of action is favorable to the better position and action of the hand. Though the extensor tendon of the little finger is liable to be negative in action, this danger is not so great nor is its loss of function so important as that of the proprius pollicis in the preceding method. Hence he selects an ulnar and dorsal incision.

The incision is made as described above. It avoids the dorsal cutaneous branch of the ulnar nerve. The fascia and the dorsal annular ligament are divided and the sheath of the extensor minimi digiti is incised. This tendon is drawn outward, and, following its ulnar border, the capsule of the joint is divided, and with the insertion of the extensor carpi ulnaris it is loosened from the base of the fifth metacarpal bone. Along this latter tendon the incision is carried upward upon the ulna in the interstice between the extensor carpi ulnaris and the extensor proprius pollicis. The tendon of the extensor carpi ulnaris is now retracted inward and the capsule surrounding the ulna is separated by the rugine subcapsulo-periosteally, if possible and if indicated; but, if not indicated, it should be divided by the knife, which should sever the attachments of the capsule to the ulna and to the base of the fifth metacarpal bone, leaving the flexor carpi ulnaris attached. The joint is now entered and the articulation of the pisiform and cuneiform and the process of the unciform come into view.

The tendons upon the volar surface are retracted and the attachments of the capsule to the fifth, fourth, and third metacarpal bones are divided. The attachment of the flexor carpi radialis to the base of the second metacarpal bone is preserved. In like manner the attachment of the capsule to the radius is separated.

Upon the dorsum, the extensors of the fingers are easily exposed and the capsule beneath the radio-carpal extensors and the extensors of the thumb is loosened from the radius. The two radio-carpal extensors attached to the bases of the second and third metacarpal bones are not separated from their insertions.

The hand is now carried outward and in slight flexion until the thumb touches the radial side of the forearm. The lower ends of the radius and ulna appear in the wound to the inner side, while externally is seen the first row of carpal bones (Fig. 4043). The removal of the carpal bones and a removal of thin sections from the radius and ulna and metacarpal bones are now easily carried out. It is only in the region of the trapezium and the trapezoid that the field is restricted when the bones of the forearm and the third metacarpal bones are being removed. When the bones have been removed and the capsule extirpated, the bones of the forearm and the metacarpal bones are placed in apposition if a nearthrosis is wished. If a pseudarthrosis is desired, the bones are held in apposition more or less closely by chromic-acid catgut. The capsule and skin are now sutured. Drainage in aseptic cases is secured by leaving a small portion (1 to 2 cm.) of the incision open; or, if the wound be septic or hemorrhage be imperfectly stopped, by gauze packing through some portion of the incision.

When the disease is upon the radial side of the carpal or metacarpal bones, or when the radial side of the joint is exclusively the seat of the disease, the radio-dorsal incision is the incision of choice. When the disease is confined to the ulnar side or the joint as a whole is involved but not greatly infiltrated and swollen, the dorso-ulnar incision is the incision to be selected. When the whole joint is involved and the tissues are greatly infiltrated in front and behind the joint, both dorsal incisions are preferable to either singly. Hence we would select for these cases the incisions recommended by Ollier. These incisions are the same as those already mentioned as Langenbeck's and Kocher's. The direction of the skin incision varies somewhat, but the route to the joint is between the same structures. Excellent results have been obtained by Drs. Mynter and Taylor by means of a method suggested by Professor Stuckgaard, of Copenhagen, in 1891. This method consists in splitting the hand between the second and third fingers. The incision is both palmar and dorsal. The incision upon the dorsum begins at the radius and extends to the interdigital fold between the second and third fingers. The palmar incision extends from the interdigital fold not farther than the superficial palmar arch.

The dorsal incision divides the skin and the subcutaneous tissue, but no tendons. It avoids, in passing between

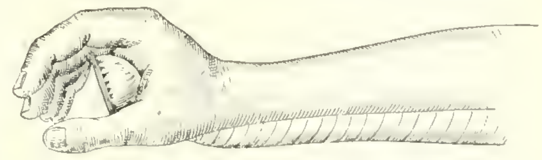

FIG. 4044.

the metacarpals the annular volar ligament, the flexor tendons and the superficial arterial arch. The wrist is now split between the trapezoid and os magnum in the second row and between the scaphoid and semilunar in the first row. Retraction of each side now allows of a complete exposure of the wrist-joint (*Annals of Surgery*, September, 1900). This operation has never been performed by the author upon the living. Upon the cadaver it is feasible and gives an excellent exposure without

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injury to the dorsal tendons. It is here mentioned because of its apparent value.

No matter which method of resection may be chosen, (1) the trapezium should be saved if possible, so that the motions in the metacarpo-carpal joint of the thumb may be preserved; (2) the section of the bones of the forearm should be made within 2 cm. of their articular cartilages; (3) in so far as is feasible the operation should be a subperiosteo-capsular one.

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The After-Treatment.—The limb is to be placed upon a properly padded splint in such a manner that the hand shall be sustained in the position of dorsal flexion (Figs. 4044 and 4045). These splints fix the wrist-joint but allow

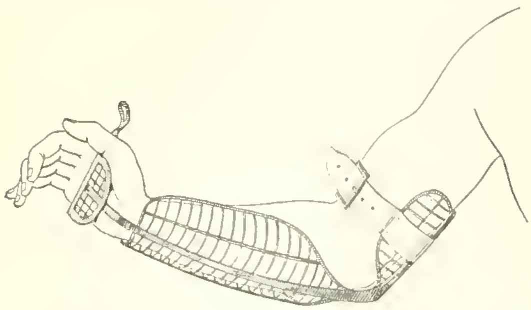

Fig. 4045.

passive motion of the fingers. They pass from above the elbow to the fingers and thumb. The latter pass beyond the splint and can be easily grasped for passive motion.

Where the wounds are aseptic and no drainage is required, as in a case of simple injury, the wound usually heals in from ten days to two weeks.

Where the operation is done for disease, the cavity is often packed with gauze, and, as it requires often two or three revisions with the curette, the healing of the wound may be delayed for from four to six weeks.

As soon, however, as the tissues are solid, though the splint is to be continued for a long period to prevent palmar dislocation and adduction, passive motion at the wrist must be assiduously practised if we desire a nearthrosis or a mobile pseudarthrosis (Ollier, "Traité des Résections," 1888). If we desire an ankylosis at the wrist, passive motion may be interdicted.

Passive and active motion of the fingers is practised as early as possible, in some instances at the third to fifth day after operation. After removal of the splint, a prothetic apparatus must be worn. This apparatus should allow flexion and extension at the wrist if desired.

From this time on, the patient's aim must be to increase the range of motion in his fingers and in the wrist. Much depends upon his own exertions in securing a good result.

The functional results after this operation vary. Culbertson, in 58 cases of gunshot wounds, reports the following results: Good, 1.7 per cent.; indifferent, 27.5 per cent.; bad, 13.7 per cent.; amputated, 3.4 per cent.; not stated, 53.4 per cent. In 11 cases of injury the results were as follows: Good, 28.5 per cent.; indifferent, 57+ per cent.; not stated, 14+ per cent. In 79 cases in which resection was performed for disease the results were: Good, 7.5 per cent.; indifferent, 45.5 per cent.; bad, 13.9 per cent.; amputated, 12.6 per cent.; not stated, 20.2 per cent. In our own civil war ("Med. and Surgical History of the War of the Rebellion," part ii., vol. ii., Otis), 6 cases of complete resection gave an indifferent result in 83.3 per cent.; amputation and death in 16.6 per cent. Gurlt's statistics of military surgery give ideal results in 6.25 per cent.; good results in 50 per cent.; indifferent results in 37.5 per cent.; bad results in 6.25 per cent. Nepveu (*Revue de Chirurgie*, 1883, p. 291) gives a collection of 36 cases. The results were satisfactory in 41.6 per cent.; indifferent in 36.1 per cent.; bad in 22.2 per cent. Ollier (*Gaz. méd. de Paris*, 1882, "Traité des Résections," 1888) believes, and has shown in two cases following a traumatism (partial resection), that ideal results may be obtained by carefully performed operations and long-continued after-treatment. The mortality statistics are about ten per cent. for all cases of resection. For gunshot wounds the mortality is about fifteen per cent. For disease, a death following operation is a rarity.

Resection of the Elbow-Joint.—Wainman in 1759 and Filkin in 1762 excised portions of this joint for injury or disease, but the first methodical operation is ascribed to Moreau in 1794. This method was enthusiastically accepted in England by Syme, and has since been established by numerous surgeons both in civil and in military practice. Resection of the elbow consists in removing the inferior extremity of the humerus and the upper extremities of the radius and ulna. In all cases the insertions of the brachialis anticus and of the biceps must be preserved, or if detached they must be replaced in order to insure the function of the joint.

Usually less than 2 cm. should be removed from the radius and ulna. More can be removed from the humerus without destroying its function. Usually the line of section is at the upper border of the epitrochlea, *i.e.*, the section is made well above the articular surface (Ollier, "Traité des Résections," t. ii., p. 203). When more is removed than is here recommended, one must expect a flail joint, unless special precautions against it are taken. When the section is below the epitrochlea—*i.e.*, just above the articular cartilage—one can expect a nearthrosis, a pseudarthrosis, or an ankylosis. If ankylosis results, the bones must be placed at a right angle with the radius in semipronation. This will give a very useful and serviceable extremity. If a nearthrosis follows, then the following condition most frequently occurs: The bones become fashioned so as to fit one another. They become smooth, polished, and shaped so as to allow flexion and extension. The lateral ligaments prevent any lateral displacement at the new articulation, and the movements of supination and pronation, though limited, are sufficiently supplemented by rotation at the shoulder-joint. The movement of the elbow, hand, and fingers is sufficiently strong for all ordinary work. Such a condition is the best result attainable, and should be considered ideal.

If pseudarthrosis exists, the union of the bones is by means of connective tissue. Such a union, if the bond is not too long, gives a good result. Where the union is short and where no lateral displacement at the point of union occurs, if the muscular power is sufficient, quite as useful a limb can be obtained as by the development of a nearthrosis.

The Indications.—For *gunshot injuries* in young and healthy persons in whom the articular cartilages are intact and in whom the tissues about the joint are not extensively damaged, the conservative treatment or at the most restricted operation should be made use of.

In *severe* bone injuries of the elbow-joint, including the articular cartilages with slight or no injury to the vessels and nerves, a partial or a complete resection is indicated, provided the age of the patient or his general condition does not demand an immediate amputation.

In *severe injuries* of the articular cartilages and of the bones, with severe injury to the vessels and nerves, amputation is required, especially in the aged.

In old *injuries* to the joint, resulting in ankylosis or pressure upon the main vessels or nerve trunks, a complete rather than a partial resection is indicated, because the tendency to secondary ankylosis is great by reason of the marked reparative power in all the tissues set up by previous injury. In old dislocations it has been my practice to reduce the dislocation by operative means, unless the contracture of the soft tissues demands a resection rather than a reduction. The earlier the old dislocation comes into the surgeon's hands the more successful will be the reduction by operative interference.

Ankylosis in a faulty position, resulting from injury or disease, is curable by complete resection only when the age

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Resection of Joints.

of the patient (from twenty to thirty-five), the condition of the muscles, the presence of cicatricial bands about the joint, or the new bone production in and around the joint, will not interfere with the after-result.

In cases in which these conditions exist and the tendency to new bone production is a marked one a partial operation with a correction of the faulty position is alone indicated.

Tuberculosis.—After conservative treatment has failed, a complete resection is usually indicated. During the first three or four years of life resection is not recommended. At this time curetting is sufficient. After three years, make partial operation, if possible, or a complete one if necessary. In either case, however, we must remove the disease. Resection is indicated in some cases of *suppurative arthritis* (chronic), in *arthritis deformans* in a single joint, and in *tumors* involving the bones of the joint (exostoses).

It must be remembered that only one-tenth of the total growth of the arm and forearm is contributed by the epiphysis at the elbow (Ollier), so that earlier resections may be attempted here than elsewhere. In general we say that in injury and gunshot wounds, partial rather than complete operations are indicated. For disease, complete rather than partial operations are indicated. For ankylosis, complete rather than partial operations are indicated.

In youth much can be expected in the production of pseudo- or nearthroses. In the adult, unless some chronic irritation (inflammation) is present or the amount removed is small, the joint is liable to be a flail one.

Anatomy.—The elbow is a pure hinge-joint. The re-establishment of its function demands that the bones be so shaped as to flex and extend easily while in contact, that the lateral ligament holding the joint be short and not yielding, and that the attachment of the muscles which move the joint in flexion and extension, as well as in supination and pronation, be preserved.

As the anterior portion of this joint is not used for entrance into the joint, we will consider only its lateral and posterior aspects.

The posterior branch of the radial nerve, which is a motor nerve for she extension of the hand and fingers and for extension and abduction of the thumb, enters the supinator brevis muscle about 2 cm. below the articular surface of the head of the radius and passes obliquely through its fibres around the radius until it emerges 3 to 4 cm. below the interarticular line in the posterior interosseous space. Upon the inner side the ulnar nerve passes behind the internal condyle between the extensor carpi ulnaris and the periosteum covering the internal lateral surface of the ulnar. These two nerves are to be avoided. Both the brachialis anticus and the biceps are attached at points sufficiently removed to be saved in the more typical and complete operations. The supinator longus, because of its attachment to the external intermuscular ridge, can be preserved in its attachment even when a large extent of the humerus is removed.

The short supinator, which is so necessary for supination, is rarely injured because of its ready separation from the humerus with the periosteum. Such is the case with the muscles attached to the internal and external condyles of the humerus, which can with care always be separated from the bone and kept in relation with the periosteum of the humerus and the fascia, forming the intermuscular septa and the lateral ligaments of the joint. The triceps, however, is an important muscle. The major part of its tendon is inserted into the olecranon process of the ulna. It has, however, lateral attachments connecting it with the deep fascia of the posterior surface of the forearm. Of these connections, that with the fascia covering the anconeus and the posterior surface of the forearm is very strong, while that with the fascia covering the internal surface is thin and not strong. It is necessary, therefore, to maintain this connection with the deep fascia of the forearm when the attachment to the olecranon is removed, if we wish to obtain after resection the full power of extension.

The arterial supply of this joint is carried on by the circle formed by the radial and ulnar recurrents, the interosseous recurrent, and the anastomotica magna. These may be avoided by the subperiosteal method.

The interarticular line of the elbow-joint is represented by the middle two-thirds of a line joining the tips of the two condyles.

The humero-radial articulation is represented by a horizontal line; the humero-ulnar, by an oblique line, passing from without inward and above downward.

The external condyle of the humerus is less than 2 cm. above the articular line. The internal condyle is more than 2.5 cm. above it.

The lower epiphysis of the humerus joins the shaft at the seventeenth or eighteenth year.

The epiphysis of the radius joins the shaft at the sixteenth or seventeenth year.

The epiphysis of the ulnar (olecranon) joins the shaft at the seventeenth year.

These epiphyseal cartilages have finished their growth by the seventeenth year, and resections of large portions may be made at this age, although the muscles mentioned as important must be preserved to obtain the best results. When they are sacrificed, prothetic apparatus must be used to supply the deficiency.

THE METHODS OF INCISIONS.

The incisions used in resections of the elbow joint may be divided into: (1) those which enter the joint upon the ulnar side; (2) those which enter upon the radial side; (3) those which enter upon both sides or from behind. To the first belong the incisions of Liston, Langenbeck, Gurlt, and Jaeger ("Manuel Opératoire," Farabœuf, p. 715). To the second belong those of Ollier ("Traité des Résections"), Stimson ("Operative Surgery"), Roux and Nélaton ("Manuel Opératoire," Farabœuf), Kocher (*Archiv für klin. Chir.*, No. 37, p. 787), and Cavazzani (*Centralblatt für Chir.*, 1889, pp. 708 and 1121). To the last belong the H-shaped incisions of Moreau and Dupuytren ("Manuel Opératoire," Farabœuf), the lateral incisions of C. Hueter ("Gelenksresectionen") and of Vogt (Löbker: "Operationslehre"), and the posterior triangular flap of Textor ("Manuel Opératoire," Farabœuf).

Of all these incisions we find that four are sufficient for all resections, complete or partial. In ankylosed joints and in old dislocations a combination of the Kocher's radial incision and the ulna incision of C. Hueter will be found in the severer cases to be most satisfactory. In injury and in disease other than the above the Langenbeck, the Cavazzani, and the Kocher incisions are preferred.

These latter incisions are superior to the rest because they do the least injury to the fibrous expansion of the triceps insertion and no injury to the nerves supplying the triceps or the anconeus muscles.

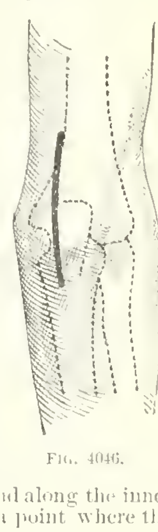

FIG. 4046.

The Langenbeck or dorso-internal incision is recommended when the disease involves particularly the internal segment of the joint.

The Kocher, or dorso-radial, incision is especially useful when the disease involves more especially the radio-humeral in addition to the humero-ulnar articulations.

The bilateral incisions above recommended are useful in old dislocations and in severe ankylosis following disease, injury, or operation. I will describe these methods.

1. *Langenbeck's Method.*—The Esmarch bandage is to be applied, if not contraindicated. The top and crest of the olecranon process having been determined, an incision is commenced 4 to 5 cm. above the olecranon, passing through the tendon of the triceps and along the inner border of the crest of the olecranon to a point where the

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process disappears in the shaft of the ulna (Fig. 4046). Usually this point is 4 to 5 cm. from the tip of the olecranon. This incision is carried down to the bones throughout. A retractor is placed in the external flap, and, with

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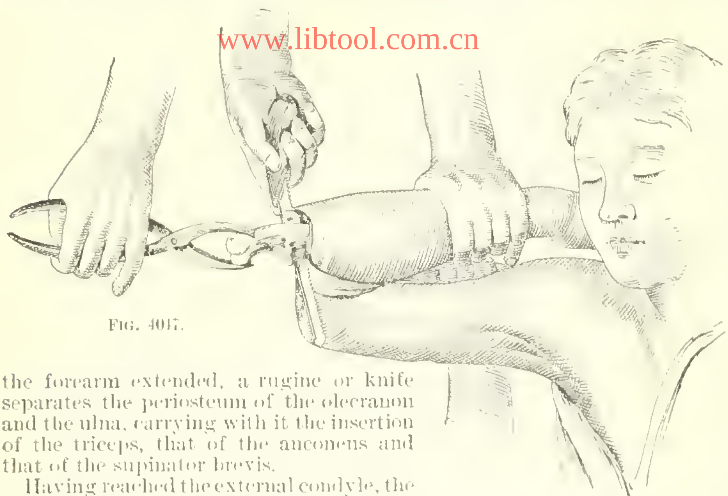

Fig. 4047.

the forearm extended, a rugine or knife separates the periosteum of the olecranon and the ulna, carrying with it the insertion of the triceps, that of the anconeus and that of the supinator brevis.

Having reached the external condyle, the surgeon should separate the external lateral ligament and the common origin of the extensors and supinators from the condyle subperiosteally or by removing with these structures a part of the epicondyle (P. Vogt). When this is sufficiently free and the humero-radial joint is exposed, the forearm may be flexed to complete the subperiosteal separation upon the anterior surface of the humerus. This completed, the internal flap is detached with the periosteum, while the forearm is extended until the internal surface of the olecranon is free and the coronoid process below and the internal condyle above are fully exposed. With the retraction of the periosteum of the humerus and olecranon, the ulnar nerve and the lateral ligament are carried away and are free from all danger. When the lower part of the humerus is sufficiently free, the forearm is again flexed and the ulna and radius are separated from it. The periosteum and capsule of the joint are separated from the anterior surface of the humerus as far as is necessary. The latter is then seized with the lion-toothed forceps and the bone is sawn transversely, just above the articular cartilage or, better, in a line joining the epicondyle and upper part of epitrochlea (Ollier, "Traité des Résections," t. ii., p. 203). The olecranon process is seized with the forceps and the periosteum and capsule are separated from the coronoid process to its base, as much of the insertion of the brachialis anticus as possible being saved. The anterior fibres of the annular ligament are separated with the periosteum of the ulna and are displaced downward so that the head of the radius can be removed close to the shaft if desired. The olecranon and coronoid process are now removed together from the shaft, if desired and if thought necessary (Fig. 4047). Otherwise, if sufficient bone can be left to form a new olecranon process, the bone is sawn as in Fig. 4048. This will give a projecting portion representing the former olecranon, which is very useful in preventing forward dislocation of the ulna during the after-treatment. After removal of the extremities of the bones the synovial membrane is dissected out completely, and such sinuses as appear are excised or curetted.

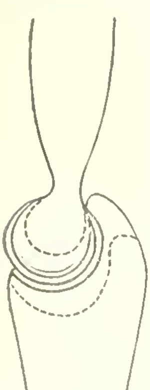

Fig. 4048.

The sawn surfaces of the radius, ulna, and humerus are placed in apposition and at an angle of 135°—*i.e.*, in nearly complete extension. In this position the tendency to forward dislocation of the radius and ulna through contraction of the flexors is avoided. If firm ankylosis is desired, the humerus and ulna are drilled and sutured with two-weeks chromicized catgut sutures. If a mobile pseudarthrosis or a nearthrosis is desired, chromicized catgut sutures are used only for the purpose of retaining the position of the bones during the application of the primary dressing. Such sutures should not last longer than a few days. The Esmarch bandage is removed and the larger arteries are ligated.

The capsule and the periosteum are sutured with catgut in position over the ends of the bones. The skin is sutured with catgut, providing the case is an aseptic one, and a small portion of the wound (2 cm.) at its highest point is not sutured, in order that leakage of blood may take place easily during the next few hours. If one so desires, a small piece of rubber tissue may be inserted through this opening to prevent its closure. What I prefer is to hold apart this small opening in the wound by two catgut sutures, one upon each side of the wound. These sutures will be absorbed within a few days (Maas' method) and will allow the wound to close before the first dressing is changed. The forearm is slightly flexed and semipronated. It is retained in this position by a splint, either plaster of Paris reinforced by sterilized basswood strips or the Esmarch's wire splint (Fig. 4049). With either of these the arm and forearm are elevated and retained in this position by suspension.

Kocher's Method.—By the Langenbeck incision, disease in the radio-humeral articulation is not so easily attacked as by the Ollier bayonet incision. Ollier's incision, which passes in the interstice between the external head of the triceps and the anconeus, must divide the nerve supplying the anconeus, since it is a branch of the division of the radius supplying this portion of the triceps. Hence Kocher planned an incision which avoids this nerve division and does not negative this portion of the triceps.

The forearm is flexed at an angle of one hundred and fifty degrees, and a stirrup-shaped incision is made, which begins 3 to 5 cm. above the epicondyle and over the external border of the humerus, and descends to the head of the radius. From this

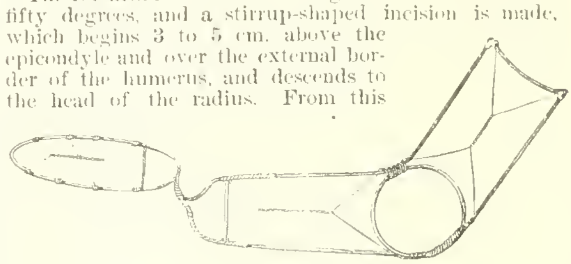

Fig. 4049.

point it descends downward and slightly inward, following the external border of the anconeus until it reaches the ulna at a point from 4 to 6 cm. from the tip of the olecranon. From this latter point it curves over the posterior surface of the ulna inward and upward for a distance of from 1 to 2 cm. (Fig. 4050). This incision above the epicondyle passes in the interstice between the supinator longus, extensor carpi radialis longior, and the common tendon for the supinators and extensors of the hand and wrist and fingers in front and the triceps and anconeus behind. From the epicondyle to the lateral surface of the ulna, the incision passes in the interstice between the anconeus and the extensor carpi ulnaris until it reaches the ulna at a point 6 cm. below the tip

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of the olecranon. The latter part of the incision usually divides the lowest fibres of the anconeus, as they often extend a longer distance up on the shaft of the ulna. This incision passes in the interval between those muscles innervated by the posterior muscular branch of the musculo-spiral and those supplied by the external muscular and posterior interosseus branches of the same nerve. The external ridge of the humerus, the epicondyle, the radio-humeral joint, and the supinator brevis muscles are now exposed, and the capsule of the radio-humeral and humero-ulnar joints are in view.

If the olecranon is diseased, the chisel may be placed upon its base and the process be removed from the shaft together with the attached triceps and anconeus muscles. This flap is retracted inward and the joint is exposed to its full extent. If the olecranon is not diseased, the periosteum beneath the external head of the triceps and the capsule are separated from the posterior surface of the humerus. In like manner the anconeus is separated from the epicondyle and the outer surface of the ulna, including with it the posterior humero-ulnar ligament. This dissection is continued over the ulna and olecranon, separating the triceps from the olecranon and a small part of the flexor carpi ulnaris from the internal surface of the ulna. The epicondyle is now fully exposed by separating the common tendon of the supinators and extensors subperiosteally and retracting the flap inward. This exposes the external lateral and the anterior ligaments passing from the condyle to the annular ligament of the superior radio-humeral joint. These are divided. The forearm is now extended and adducted. The joint is then brought into full view and the internal lateral ligament can be loosened from the inner surface of the ulna and of the trochlea (Fig. 4051). With this separation, the humerus is easily cleared of all muscles anteriorly and posteriorly and the bone section made as recommended in the preceding operation.

The annular ligament is now divided and the head of the radius is removed separately from the ulna. If possible, the section of the ulna should be such as will leave a process simulating in slight degree the olecranon. Such a method is useful in preventing the anterior subluxation of the ulna. The section is the same as is shown in the former operation.

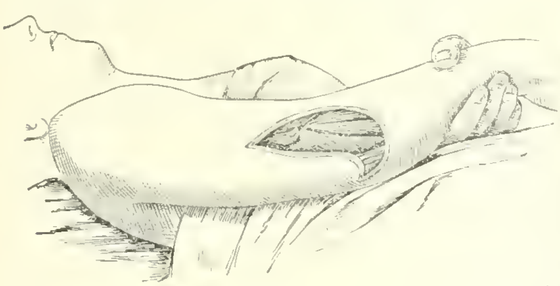

FIG. 4050.

When the disease is tuberculous, it is best not to incise the synovial membrane until the dissection of the soft parts is completed and the dislocation of the radius and ulna from the humerus is ready to be made. When the synovial membrane has been completely removed and the sinuses, if any, are excised or curetted, the parts are brought into apposition and sutured. Drainage, if necessary, is made with gauze at the lower angle of the wound beneath the anconeus. If drainage is necessary for only a few days, the Maas method is the preferable one (see Langenbeck's operation).

Sutures, both deep and superficial, are made with catgut if the wound is to be an aseptic one and if it is to heal under one dressing; if not, silk is used for the skin. If ankylosis is desired, suture the bone with two-weeks chromicized catgut. If a nearthrosis or a mobile pseudoarthrosis is desired, suture with catgut, which will last but a few days and will simply retain the bones in position during the application of the primary dressing. The extremity is placed in such a splint as has been previously recommended and is suspended and elevated.

These two methods are undoubtedly the methods of choice for both injury and disease in the vast majority of cases.

There is a method very similar to Kocher's, except in the skin incision and in some of the minor details, which may be used for it in cases of exploration, partial resection, and synovial extirpation. This is the method of Cavazzani. In two of my cases of synovial arthrectomy this method was found to be exceedingly valuable.

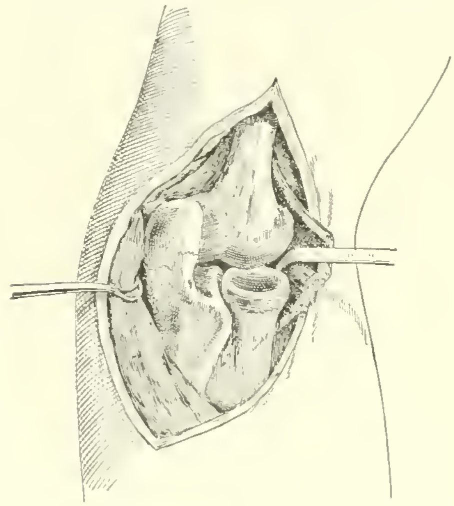

FIG. 4051.

Method of Cavazzani.—Three landmarks are taken—one the tendon of the biceps, one the head of the radius, and the third the olecranon process. Two centimetres below the epicondyle upon the outer border of the tendo bicipitis an incision through the skin and subcutaneous tissue begins and passes transversely outward parallel to the interarticular line of the joint. At the outer side of the forearm it passes obliquely from behind upward and ends at the inner border of the ulna near the tip of the olecranon (Fig. 4052). During the first half of this incision the forearm is extended. During the last half it is in half-flexion. This stretches the skin and prevents slipping. The upper flap is dissected up sufficiently to expose the interval between the anconeus and the muscles arising from the epicondyle, *i.e.*, the interstice between the anconeus and the extensor carpi ulnaris.

The epicondyle being exposed, the aponeurosis covering this interstice is divided over the neck of the radius and above the epicondyle. The epicondylar muscles are now loosened subperiosteally and are retracted inward. The capsule is thus exposed as far as the coronoid process. Upon the posterior surface the anconeus is also separated subperiosteally from the humerus and the ulna together; the tendon of the triceps is separated over the external half of the olecranon process. If one wishes to disregard the anconeus nerve supply, one may cut transversely in the interstice of the triceps and anconeus from the epicondyles to the outer surface of the ulna. The posterior capsule is now exposed. The joint is next opened by dividing the external lateral

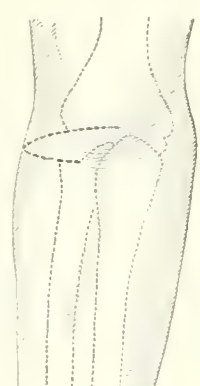

FIG. 4052.

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ligament from the coronoid process anteriorly to the tip of the olecranon posteriorly. A movement of adduction will now dislocate the forearm from the arm.

After the operation is finished, the forearm is replaced, the lateral ligaments are sewed, and the muscles about the epicondyle sutured in place. No vessels or nerves are injured. The rad[illegible] www.libtool.com.cn The tendon of the triceps is preserved in half its detachment. The epicondylar muscles are preserved.

For exploration and synovial extirpation, Cavazzani's method is very satisfactory, for the reasons above stated.

For *ankylosis* and for the reduction of *old dislocations*, the method of Jeffrey, which has been more precisely described by Marangos (Thèse de Lyon, 1883), and that of Hueter ("Gelenkskrankheiten," vol. ii., p. 552) are undoubtedly the best. This is especially so in fractures with dislocation, where the reduction requires the removal of the callus with or without a partial resection; in old dislocations which require the removal of the callus and the adhesions in order to effect reduction; in all impractical ankyloses following disease, injury, or operation, which are to be made practical ankyloses or in which arthrolysis is to be attempted; and, lastly, in cases in which redislocation has followed the operative reduction of an old dislocation (Bunge, *loc. cit.*).

With the posterior incision or the single lateral incision, one comes upon the joint at a disadvantageous side for the correction of an ankylosis or for the removal of callus.

In ankyloses it is not possible to dislocate the bones, and the removal of the necessary wedge or piece of bone must be done without displacement. For this reason, Hueter and others accepted the bilateral incisions which Jeffrey formerly used in all resections. These incisions have been greatly modified by subsequent operators, but the method here described will, I think, be found to approach the ideal method. It consists of the radio-humeral incision of Kocher and the ulnar incision of the bilateral methods. The incision upon the radial side commences 5 or 6 cm. above the external condyle, and penetrates between the triceps and the supinator longus and extensor carpi radialis longior, until it reaches the external humeral border and descends to just behind the epicondyle. It here passes obliquely downward and inward in the interstice between the anconeus and external carpi ulnaris for a distance of from 2 to 3 cm. Unless the radius is involved, the annular ligament is avoided. Now clear the anconeus and the triceps from the capsule or tissues beneath them and retract them inward. Clear the supinator and extensor group from the epicondyle and retract them inward.

An ulnar incision is next made upon the internal border of the epitrochlea or at the place where it had been broken off or displaced. This incision is from 8 to 10 cm. in length. The ulnar nerve is freed and displaced backward. The pronator and flexor groups of muscles are displaced outward and in front after being freed from the internal border of the humerus and the epitrochlea. These incisions descend to the bone, and one separates subperiosteally with the rugine, or supraperiosteally with the knife, the soft parts from the bone upon both surfaces of the humerus. In the reduction of old dislocations the method pursued must be extraperiosteal (Bunge, *Archiv für klin. Chir.*, No. 60, p. 557). A blunt retractor is now inserted in front of and behind the humerus, for the purpose of guarding and lifting the soft tissues from the bone. If one desires, the bone section may now be made with the saw. If it is thought better, the adhesions between the humerus, olecranon, ulna, and radius may be divided and the humeral extremity first and the radius and ulna afterward displaced through the external incision. They may then be sawn and replaced. If the case be an old dislocation, the fibrous bands between the internal condyle and olecranon must be divided. The epitrochlea, if torn off and displaced, must be loosened and returned. The trochlea of the humerus and the sigmoid cavity of the olecranon must be cleared of all fibrous or bony tissue. When this is accomplished, a movement of adduction of the forearm will expose the humeral extremity in the external wound and allow the removal of the new formation in the olecranon fossa. When this is finished the radius and ulna may be exposed in the same manner and the process of clearing their articular surfaces completed. With the completion of the work upon the bones the extremities are apposed, sutured if desired, and immobilized at an angle sufficient to prevent dislocation. In the reduction of old dislocations, this is usually a right angle, with the forearm in full pronation to prevent redislocation. In resections in which motion is desired, the position is one of nearly complete extension, with semipronation. In cases in which an ankylosis is desired, the forearm is left at an angle a little less than a right angle.

The After-Treatment.—It is to be borne in mind that there is always a tendency to displacement of the fragments, that too wide a distance between the extremities of the bone tends to a flail joint, and that too close a distance tends to ankylosis. The usual distance for obtaining a false joint is between 1 and 2 cm. In children ankylosis is to be especially feared; consequently, as soon as possible passive motion must be enforced. Usually upon the third day passive motion is begun, and is repeated daily in the wrist and fingers. On the twenty-first day the forearm is moved in flexion every second day, and returned to the original position of extension. In from four to five weeks the forearm can be easily moved to ninety degrees and returned to the original position of extension.

The movements of supination and pronation are made at the same time as those of flexion and extension.

At the end of from six to eight weeks a splint can be dispensed with, when massage and electricity are used. The daily use of the arm must be secured. At four months the movement in the new joint should be sufficient to allow the patient to feed and dress himself and to carry quite heavy weights. It will require one year before one can see the best results in motion and stability.

If large quantities of bone have been removed and the operation has been subperiosteal and subcapsular, it is best to be satisfied with an ankylosis at a right angle and in semipronation rather than run the risk of a flail joint.

If ankylosis is attempted, passive motion in the wrist, fingers, and shoulder is daily practised, in order to preserve their full power.

If the amount of bone removed has not been great, say enough to allow from 1 to 2 cm. between the bones of the arm and forearm, and if the operation was subcapsulo-periosteal or partly so, it is best to attempt a nearthrosis or a pseudarthrosis. After the third week, when the wound is healed and passive motion at the elbow is begun, an angular hinged splint should be applied, which will prevent, during the exercises of flexion, extension, supination, and pronation, any lateral displacement of the bones. Very great care must be given by the patient and the surgeon to obtain the ideal result.

One factor must not be lost sight of during the after-treatment, and that is that an angular ankylosis with movement at the fingers, wrist, and shoulder is more useful to a laborious occupation than the excessive mobility often resulting from these resections. Another fact to be borne in mind is that in the young motion is to be begun early. In the adult, in whom there is less danger of ankylosis than there is of a flail joint, passive motion need not be begun until some firmness is present in the joint.

The mortality, according to Culbertson, is as follows: *Gunshot wounds:* Partial resection, 27.02 per cent.; complete resection, 25.30 per cent. *Injury:* Partial resections, 7.4 per cent.; complete resections, 21.05 per cent. *Disease:* Partial resections, 11.11 per cent.; complete resections, 9.94 per cent.

In the Franco-German war (1870–71), resections for gunshot injuries gave a mortality of 27.41 per cent. (Gurlt). In our own civil war, gunshot injuries, when resected, gave a mortality of 23.70 per cent. Salzman, quoted by Ollier, gives the mortality of resections for

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ankylosis as 1.47 per cent. Functional results are in the main good, especially in civil practice.

For disease, Culbertson gives 6 perfect and 32 useful joints in 40 cases of partial resection, and 32 perfect and 196 useful joints in 290 complete resections.

Gurlt's statistics, obtained from the German wars (1848–77), gives 5.63 per cent. as very good, 23.66 per cent. as good, 53.24 per cent. as moderate, 14.37 per cent. as bad, 3.09 per cent. as very bad.

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Nepveu ("Bulletin et Mémoire de la Société de Chirurgie," 1883, p. 591) presents 21 cases with extensive restoration of the parts. The general form of restoration is brought about by the osteophytic growth of the condyles of the humerus.

In Kocher's Klinik, 1872–97 (Oschmann, "Über die operative Behandlung des tuberculösen Ellenbogengelenks und ihre Endresultate," Berlin, 1897), where a large number of good functionating joints were obtained, it was noticed that rotation at this joint was better than flexion and extension. It was observed that much value is to be placed upon the preservation of the anconeus for obtaining full power in extension of the forearm. It was also observed in three cases that repeated resections were necessary to secure good function. Hence the importance of a thorough removal at the first operation is plainly seen in these cases. After healing had taken place, the most frequent impediment to flexion seemed to be enlargement of the internal condyle or of the coronoid process. For these cases secondary resections, removing the impediment to motion, are properly indicated.

The functional results of resection for old, unreduced dislocations show that 70 per cent. have good results, 30 per cent. have bad (Culhorst, *Beit. zur klin. Chir.*, Bd. xx.), while the bloody reposition of these old dislocations gave 76.9 per cent. of excellent results, with 23 per cent. of bad results, no one of which can be considered due to the method of operation (Bunge, *loc. cit.*, p. 594).

Resection of the Superior Radio-humeral Articulation.—This operation is occasionally made use of in old dislocations, in fracture of the head of the radius, impeding the motions of rotation, of flexion, or of extension.

Operation.—An incision of from 5 to 7 cm. is made in the same manner as the Kocher incision for the resection of the elbow-joint. This incision passes in the interval between the anconeus postero-internally and the extensor carpi ulnaris antero-externally. After their attachments to the epicondyle have been loosened, the tissues are retracted and the capsule is exposed. This is incised and the head of the bone is removed as close to the shaft as possible. The section should be at the point where the annular ligament is closely applied to the neck of the radius. With this incision there is no danger to the musculospiral nerve anteriorly. The posterior interosseous nerve, as it crosses within the fibres of the supinator brevis muscle, is distant from the epicondyle of the humerus 4 cm. on the external surface of the forearm. On the posterior surface, where it meets the interosseous artery in the interval between the supinator brevis and the extensor ossei metacarpi pollicis, the distance from the epicondyle is usually 6 cm. or over. Hence it is difficult to injure it unless the incisions are prolonged further than recommended. After the head is removed, the capsule and ligaments are sutured and a nearthrosis or pseudarthrosis is attempted.

At ten or fourteen days passive motion is begun and continued for several weeks. It has usually required three months to obtain the best results, and great assistance has been derived, as I believe, from the daily use of the hot air by means of the Sprague apparatus. In three cases of fracture of the head of the radius with abolition of supination and pronation in marked degree, removal of the head and conservative after-treatment have given almost perfect results.

Resection of the Shoulder-Joint.—*History.*—James Bent, England, 1774, probably did the first excision; the elder Moreau probably the first complete excision, 1786.

In the Schleswig-Holstein campaign (1848), in the Crimean War (1855), and in our own civil war (1861–65) the operation gained greatly in prominence and has since then become fully established.

To obtain a nearthrosis or a good pseudarthrosis, the line of section in the humerus must be below the tuberosities to which are attached the rotators and above the adductors. In all cases as little is sacrificed as is possible, in order that the functions of the forearm and hand may be preserved in their entirety. In children, in whom the growth is almost finished, operations with sacrifice of the muscular attachments and with little loss of the humerus give good functional results with either a nearthrosis or a pseudarthrosis. In adults, especially if the periosteum is not saved and the muscular attachments have been sacrificed, ankylosis or a flail joint will result, for the periosteal activity in adults is often wanting and no reproduction takes place.

In all cases the constant tendency to forward displacement of the humerus must be avoided. In all cases the humerus must be held in contact with the scapular border or the glenoid cavity in order to obtain a fixed but movable joint upon which the muscles may move the humerus. The mobility of the scapula compensates in great measure for immobility at the gleno-humeral union.

Indications for Resection of the Shoulder-Joint for Injury.—In slight injuries and in gunshot wounds, expectant treatment and at the most a partial resection are indicated. In severe injuries to the head of the humerus, and in comminuted fractures from gunshot wounds with the nerves and vessels intact, a primary resection is indicated. In severe injury to the head of the humerus and to the acromion process and the scapula, the operation is not necessarily contraindicated, provided the nerves and vessels are intact. In case the latter are involved, amputation is in all probability the only successful issue. In case the nerves are injured, the main vessels escaping, and provided the injured nerves can be sutured, amputation should give way to resection of the joint and suture of the nerves.

In some cases of compound dislocation or of old unreduced dislocations, with or without fracture through the surgical neck of the humerus, resection has been made necessary; yet these cases are becoming more and more infrequent, owing to the aseptic treatment and to the earlier reductions by incisions (confer here Dollinger, *Deut. Zeitschrift für Chirurgie*, No. 66).

1. I can quote no better authority on the unreduced dislocation of the shoulder-joint than Souchon (Trans. Amer. Surg. Association, 1896, p. 409). He maintains: I. That operation is justifiable only in recent cases in full-grown subjects of sufficient age to insure no great shortening from want of growth in the bone. II. That resection should be performed in all instances except when the head and glenoid cavity are in good condition; when reduction can be accomplished without great effort or extensive dissection; and when the head, once reduced, readily remains in place.

2. In fracture of the upper part of the surgical neck of the humerus and dislocation of the head reduction of the dislocated head and suture of the fracture will be preferable to resection in a recent case (McBurney, *Annals of Surgery*, 1894, vol. i., p. 399); but when union fails and the joint becomes useless, or if the dislocated head cannot be reduced without too extensive interference with its nutrition, it must be removed.

3. In recurrent dislocations resection has been performed not infrequently, yet attempts at more conservative methods are recommended (Burrell and Lovett, Trans. Amer. Surg. Association, 1897, p. 293). Such a conservative method is described in the above paper.

For Disease.—Here partial and complete resections are indicated, although the functional results are not much better than in cases of ankylosis following expectant treatment. 1. In tuberculosis and in the destruction of a joint following epiphysitis and suppuration, gonorrhœal infection, injury and infection, or from suppurative subdeltoid bursitis, partial or complete resection is indicated

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as soon as conservative surgical treatment fails to cure. 2. In ankylosis following acute rheumatic arthritis and acute traumatic arthritis with suppuration, resection is indicated in some instances.

For tumors involving the bones of the joint. A few (four) instances exist in which a part of the humerus has been removed for sarcomatous growths involving the joint.

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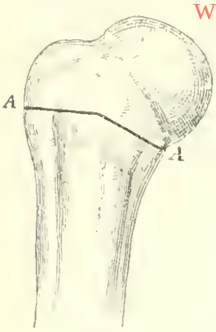

FIG. 4053.

Anatomy.—The anatomy of the shoulder joint is very simple. All the bony prominences in its vicinity can be easily felt. The groove between the pectoralis major and the deltoid, in which lie the cephalic vein and the acromiothoracic artery, are easily made out. The circumflex nerve and the posterior circumflex artery cross the humerus in a horizontal line one finger's breadth below the centre of a line drawn from the acromion to the deltoid insertion. These two structures usually pass just below the capsular attachment upon the internal surface of the anatomical neck, which point is opposite the so-called surgical neck of the humerus—the point above mentioned. The upper epiphysis becomes united to the shaft at twenty years. The deltoid muscle is so situated that the only place where it can be divided without injuring a portion of the nerve supply is close to the margin of the acromion process and of the spine of the scapula. This method of incision, recommended formerly by Nélaton, Neudörfer, Perrin, and Gurlt, avoids injury to the circumflex nerve and at the same time permits union of the muscle to the bones without atrophy of the muscular bundles. As a result, the humeral end is held in contact with the glenoid cavity or the border of the scapula in a firmer and stronger manner than can be obtained when atrophy of muscular fibres follows operation.

This method of entering the joint is not convenient for observation of all parts of the articulation, especially of the anterior portion.

Another method of entering the joint is by means of incisions which traverse the deltoid muscle anteriorly. There are two of these incisions. One (Baudens, Malgaigne, and Langenbeck, "Esmarch's Handbuch" and *Archiv fur klin. Chir.*, xvi.) divides the anterior fibres of the deltoid muscle and necessarily paralyzes the anterior fibres of this muscle. Its field of observation and manipulation is a direct and extensive one. The other anterior incision (Ollier, "Traité des Résections") passes nearer the interval between the pectoralis major and the deltoid muscles, paralyzes less of the deltoid muscle, and gives an operative field quite as good as that obtained by the Langenbeck incision. The posterior incision is anatomically the better one, but incisions must be made to expose diseased areas and to render possible a full inspection of other portions of a joint than those thought to be alone involved. For this reason incisions which traverse the anterior portion of the deltoid muscle have been selected by most surgeons as the best.

We will describe two methods of operation, one by the anterior incision, the other by the posterior incision. Both methods should be performed subperiosteally if possible, since the partial reproduction of bone greatly aids the function of the joint by giving a more perfect fulcrum for the muscles of the shoulder (von Langenbeck, *Archiv fur klin. Chir.*, 1874, xvi., and Ollier, "Traité des Résections," t. i. and ii.).

Operation by the Anterior Incision.—The patient is placed upon the back with the elbow slightly raised from the side and the hand resting upon the iliac spine of the same side. An incision is begun at the outer extremity of the coracoid process, and descends over the deltoid muscle parallel to its fibres (*i.e.*, slightly outward) for a distance of from 6 to 10 cm. (Ollier, *loc. cit.*; Hueter, "Gelenkskrankheiten," vol. ii., 587). The muscle is exposed in this incision. The muscle is incised parallel to its fibres, and the capsule, the humerus, and the coraco-acromial ligament are exposed. The borders of the wound are now retracted and the bicipital groove in the humerus is noted. The capsule is divided longitudinally and externally to the sheath containing the biceps tendon. This division of the capsule extends above as far as the glenoid ligament. Below, the capsule and the periosteum are divided close to but external to the commencement of the bicipital groove in the humerus. With the rugine when one can, and with the knife when necessary, the periosteo-capsular attachment of the internal flap is separated along the external ridge of the bicipital groove, across the groove, and beyond the lesser tuberosity. To facilitate this work the arm is rotated outward, and as one approaches this tuberosity the head is made prominent in the wound by lowering the elbow during the act of rotation. In this manner, with good retraction, the capsule and the periosteum, or the capsule alone, may be separated beyond the insertion of the subscapularis muscle. After this is accomplished the arm is returned to its original position and the separation of the periosteum and capsule of the external flap is commenced.

With a retractor beneath the capsule, the flap is raised and the separation of the capsule and the periosteum over the tuberosities and below upon the shaft is commenced. This is facilitated by rotating the arm inward while it is slightly adducted and the elbow is lowered. This manœuvre is continued until the attachments of the supra- and infraspinatus and teres minor muscles are passed.

The arm is now allowed to hang to the side of the table in a vertical position, and when the retractors separate the flaps and the biceps tendon is drawn aside the head is pushed upward through the wound and presents itself to view. The capsule and the periosteum are now cleared from the internal surface of the shaft, and when they are sufficiently so the saw is applied. During the section of the bone the head is held firmly with the long-toothed forceps while an assistant grasps the arm and steadies it.

Gigli's saw or a bow saw (Helferich's) is usually preferred in making the section. The line of section is from within outward and from below upward for one-half the diameter of the bone. For the rest the section is more horizontal (Fig. 4053, *A A*). As much of the shaft of the bone must be saved as is compatible with removal of the disease. The section should be made just below the articular surface if possible. In such a section, the whole length of the humerus will act as a fulcrum for the deltoid muscle in elevating the arm, and a greater power will be retained than when the section is nearer or through the surgical neck.

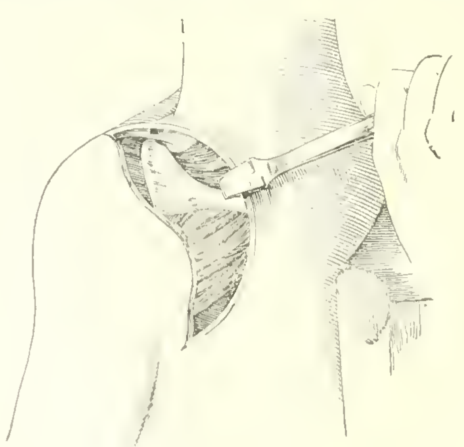

FIG. 4054.

The glenoid cavity is now examined and is curetted or

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cut away with the chisel or cutting forceps. If this is necessary, the capsule and the insertions of the triceps and biceps muscles should be freed from the bone before its removal.

In cases of bony ankylosis, the line of union may be divided, and when the humerus is movable the resection may be completed as already described, or one may saw through the humerus first and subsequently extirpate the head from its capsular and muscular attachments.

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In tuberculous diseases, much time must be spent in removing the synovial membrane and clearing up the sinuses and the bursæ involved. When oozing is present, these cases are best partially sewed and tamponed for several days, but when hemorrhage is fully stopped they should be sewed up completely. The same holds true for other infections and for tumors. When the hemorrhage has been checked, the capsule and the periosteum are sutured with catgut. The deltoid is held together by catgut sutures involving a few of its fibres, but sufficiently to close the opening. Drainage when required may be obtained by an opening through the capsule posteriorly. The skin is sutured with silk.

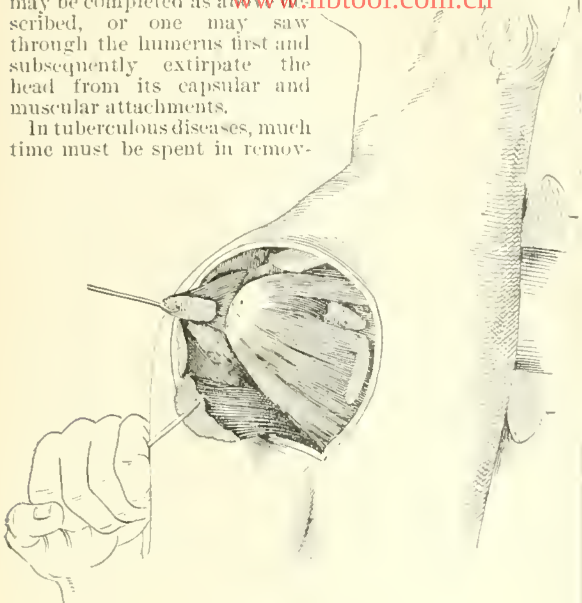

FIG. 4055.

The position of the arm should be one of slight abduction, with the humerus pushed upward and backward and in contact with the glenoid cavity or the border of the scapula, where it is retained during the dressing by chromicized catgut sutures inserted before closing the capsule.

The Method by the Posterior Incision.—This method of incision is recommended at the present time by McCormac and Kocher. McCormac ("Surgical Operations," Vol. ii.) recommends it when the site of section in the humerus is to be above the tuberosities. Kocher believes that this method is advantageous in allowing perfect drainage and in preventing a forward dislocation so frequent after resection by leaving intact all that part of the joint and muscle attachment between the biceps tendon and the lower border of the subscapularis muscle. His method of incision, he believes, overcomes the interference with the exposure of the joint produced by the prominent acromion, and likewise avoids the danger of injury to the circumflex nerve, as it passes close to the humeral attachment of the capsule and the teres minor muscle. His method leaves the deltoid practically uninjured, so that its action in elevation of the arm suffers in no degree (Fig. 4054).

An incision is made, passing from the acromio-clavicular articulation over the prominence of the shoulder, along the spine of the scapula to its middle. From here the incision inclines in a curve downward toward the posterior axillary fold, ending about two fingers' breadth before reaching it. The upper limb of this incision divides the tissue over the acromio-clavicular joint and the spine of the scapula, exposing each. The lower limb divides the tense fascia close to the posterior border of the deltoid muscle and exposes the muscle for a distance of from 2 to 3 cm. from the spine of the scapula. The muscular fibres of the deltoid muscle which are inserted into the spine behind this incision must now be divided. This is the only portion of the muscle which is divided and is deprived of action. The trapezius muscle is next separated subperiosteally as far as the acromio-clavicular articulation from the upper border of the spine of the scapula. Likewise, upon the lower border of the spine of the scapula, the deltoid insertion is separated subperiosteally as far forward as the spot marked by the junction of the acromion process and the spine of the scapula. At this point the spine is separated from the acromion process either with the chisel or, better, with the Gigli saw. (Fig. 4055). Care must be exercised not to injure the suprascapular nerve as it passes from the supra- to the infraspinous fossa. It is well also to make two drill holes before dividing the spine from the acromion process, so that they can be more easily sutured at a later date.

When this separation is completed, the acromion process with the attached deltoid muscle is luxated forward. The deltoid muscle is thus raised from the teres minor, the infraspinatus, and the supraspinatus muscles, to which it is but loosely attached by connective tissue. After the dislocation of the acromio-deltoid flap, the insertion and the muscular bellies of these three muscles which cover the humeral head are exposed (Fig. 4056). The elbow is now brought forward and the arm is rotated outward. Along the upper border of the supraspinatus muscle an incision is made from the margin of the glenoid cavity to the spine of the greater tuberosity, exposing the tendon of the biceps muscle in its whole length within the joint. The outward rotators are next loosened subperiosteally from the greater tuberosity, and, while still attached to the periosteum of the shaft, are retracted posteriorly. If one wishes, a small part of the tuberosity

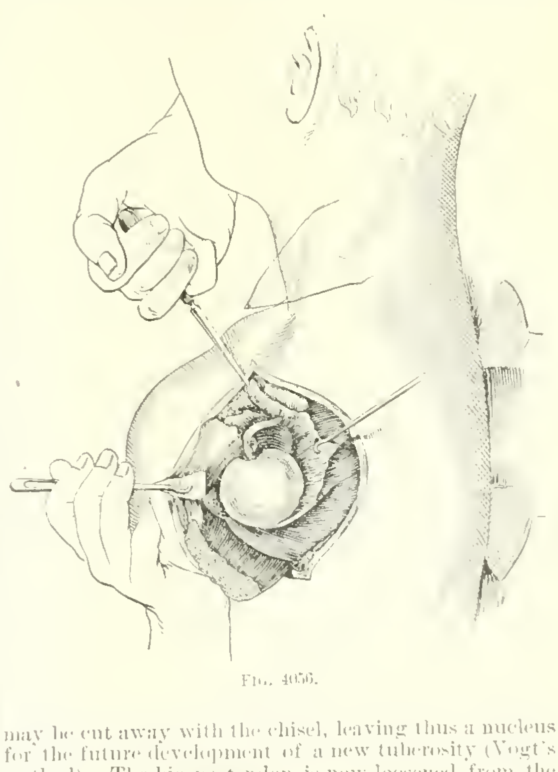

FIG. 4056.

may be cut away with the chisel, leaving thus a nucleus for the future development of a new tuberosity (Vogt's method). The biceps tendon is now loosened from the bicipital groove and is drawn forward. The insertion

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of the subscapular muscle is seen at its attachment to the lesser tuberosity and to the spine of this tuberosity. It should be separated subperiosteally and drawn forward and inward. The circumflex artery and nerve are to be avoided at the lower border of this muscle. As soon as the head is thus freed, it can be easily protruded through the wound (Fig. 4056). After it has been removed, the glenoid cavity should be freely exposed and to an extent which is unattainable by any anterior incision. This exposure is best accomplished, after the head has been removed, by exerting traction upon the elbow while it is held in the position of adduction. The importance of the exposure of the glenoid cavity in tuberculosis of this joint cannot be questioned, and therefore this method has its specific application.

After the synovial membrane, the bursæ, and the bones are removed, the capsule and the periosteum are sutured, and the wound is closed. If drainage is necessary, the capsule should be incised below the border of the teres minor, and care taken to avoid the circumflex nerve and artery as it emerges beneath the muscle. These are easily recognized, however, since the field is so well exposed. After this is accomplished, the spine of the scapula and the acromion should be sutured. The trapezius and the deltoid are sutured over the acromion or spine of the scapula if necessary; if it is not thought necessary, they are left unsutured. The skin should be sutured separately.

Sir William MacCormac prefers entering the joint between the teres minor and the infraspinatus muscles, clearing the infraspinatus, supraspinatus, and the subscapularis muscles and the biceps tendon forward, until the bone is free, and subsequently clearing the teres minor muscle with the capsule posteriorly. In some instances this is undoubtedly a good method of approach after the deltoid has been retracted forward ("Surgical Operations," part ii.).

After-Treatment.—The main point in the after-treatment seems to be the retention of the head in contact with the glenoid cavity or with the border of the scapula. This contact may be secured by the use of chromicized catgut, which lasts long enough to insure no slipping during the primary dressing. A large pad made like the Stromeyer's cushion is now placed in the axilla, and the arm resting upon this pad is secured to the side, while the forearm is supported by a sling. This pad supports the humerus, fixes it, and prevents the tendency which the pectoralis major and the latissimus dorsi have, to displace the upper end of the humerus in an inward direction, beneath the coracoid process. This tendency will be more difficult to counteract if the external rotators have been divided.

The first dressing is not changed for from six to ten days if possible. The movements of the fingers, wrist, and elbow are gently exercised daily from the very first. It is useless to begin moving the shoulder until the deep parts of the wound are sufficiently healed, *i.e.*, usually in the second or third week. In this manipulation abduction must be made with care, for fear of dislodging the head and forcing it beneath the coracoid process. Daily application of massage, electricity, and superheated air (Sprague apparatus) to the muscles of the shoulder is very useful in preventing too extensive ankylosis.

The deltoid and the rotator muscles should be daily exercised by appropriate manipulations. This should be continued for from four to six weeks, after which the patient must carry out his own exercises, such as bringing a gun to the shoulder, lifting weights with the arm abducted, and appropriate exercises upon the various kinds of gymnastic weights and pulleys.

The after-treatment must be maintained for a long time in order to obtain the best results. Langenbeck refers to a case (*Archiv für Klin. Chir.*, xvi., p. 393) in which the arm increased in strength for two years following the operation.

Results.—According to Culbertson, the mortality was as follows: For gunshot wounds (855 cases), 31.44 per cent.; for disease (116 cases), 15.84 per cent. According to Otis, the results were as follows: Out of 2,369 cases of gunshot wounds, 577 of which were treated by the expectant method, there were 951 cases which were treated by excision, with a mortality of 36.6 per cent., and 841 cases which were treated by amputation, with a mortality of 29.1 per cent. The mortality for the 2,369 cases was 25.1 per cent. According to Souchon, the results, in cases of old irreducible dislocations, with or without fracture of the humerus, were as follows: In those treated by reduction, the mortality was 10 per cent., and in those treated by resection it was 12 per cent.

The Functional Result.—Usually flexion and extension are good; adduction is also usually good. Rotation and abduction are usually feeble. The tendency in this joint is toward ankylosis rather than toward a flail joint. The subperiosteal method (Ollier) gives the most perfect functional result, and should be practised whenever feasible. According to Gurlt ("Ueber Gelenksresectionen nach Schusswunden," Berlin), the results in 213 cases were as follows: Very good, almost perfect, in 1.87 per cent.; good, not perfect, but useful, in 42.25 per cent.; moderate, of limited use, in 47.88 per cent.; bad, useless, in 7.98 per cent. In the German wars (Langenbeck, *Archiv für Klin. Chir.*, xvi.), conservative treatment gave at least as good results as the resections which were then performed. Thus, in 44 cases of resection of the head of the humerus, the results were good in 2 instances, while in 31 cases the shoulder hung like a flail, and the elbow, hand, and fingers were more or less useless. On the other hand, in 54 cases treated conservatively, there was ankylosis in 43 instances, but the elbow, hand, and fingers continued to be useful. "When the subperiosteal method is employed and the supraspinatus, the infraspinatus, the teres minor, and the subscapularis muscles remain in connection with the periosteum of the shaft of the humerus, a flail joint will not result." "The good results are obtained when the subperiosteal method is carried out." He reports 8 cases with excellent results. Wegner (*Charité Annalen*, 1901, Bd. xxv.) also reports an excellent result following resection of this joint for caries sicca (tuberculosis).

THE RESECTION OF THE LOWER EXTREMITY.—The small joints of the foot occasionally require resection. Corresponding joints in the toes are removed in the same manner as those in the fingers. As a matter of fact, resection of the toes is seldom done, since their deformations do not demand it.

Resections of the metatarso-phalangeal joints are performed in the same manner as in the hand. The incisions are placed to either side of the extensor tendon in the second, third, and fourth metatarso-phalangeal joints, to the inner side of the tendon in the first metatarso-phalangeal articulation, and to the outer side of the tendon in the fifth metatarso-phalangeal joint.

Of these joints, the metatarso-phalangeal articulation of the great toe is not infrequently resected for hallux valgus. As these cases are quite often complicated with a bunion which requires removal at the same time, this incision is a semilunar one. It extends from a point on the metatarsal bone, 2.5 to 3.5 cm. above the joint. It descends in a curve over the lower quadrant of the bunion until it reaches its mid point, whence it ascends in a curve to the centre of the outer border of the first phalanx. This flap with the deep connective tissue is dissected from the bunion until its base is reached. The adventitious tissue and the bunion are now removed, after which the subperiosteo-capsular method is pursued in freeing the ends of the bones. When the periosteum and the capsule are loosened to beyond the centre of the articular surfaces, the ends of the bones may be made to protrude through the wound. (Fig. 4057.)

They may now be removed completely or partially as desired. Since it is very necessary to retain the sesamoid bones the separation of the periosteum and of the capsule upon the inferior surface of the joint must be done with care. After removal of the articular ends of the bones they are placed in apposition and sutured with catgut if one desires an ankylosis. If a pseudarthrosis or nearthrosis is desired, no suture of the bones is made.

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Resection of Joints.

Ankylosis is obtained by maintaining the bones in apposition. Pseudarthrosis or nearthrosis is obtained when the ends of the bones are left within the capsule which is closed over them. Many deformities in hallux valgus, where the bunion and the deformity are not great, may be

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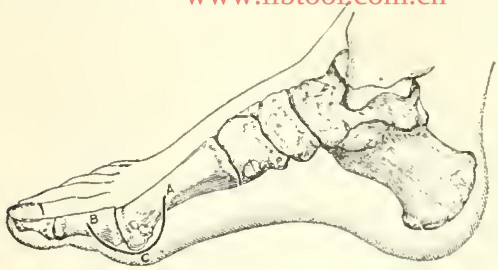

FIG. 4057.

corrected by a cuneiform osteotomy of the lower third of the metatarsal bone, and such an operation is to be advised in the minor cases of this condition.

Resections involving either the metatarso-tarsal, the tarsal, or the talo-tarsal joints, are rarely performed, because disease is scarcely ever confined to any one of these several joints. It is rare to have only one of the seven* articular synovial cavities of the foot involved.

Disease or infection from injury commencing in any one of these seven cavities soon spreads through the cancellous tissue of the bone to the neighboring synovial cavities, so that the process rapidly becomes a diffuse synovial, parasynovial, and periosteal one (Fig. 4058).

For this reason resections of single joints are rarely made on account of disease. In injuries to these joints and in deformities congenital or acquired, resections of single joints can rarely be performed in even minor grades of the injury or deformity. We must look upon the foot as a whole and operate without regard to the joints, with the sole idea of removing the condition for which we operate.

FIG. 4058.

There are several procedures which are applicable to injury or disease of this region: (1) Those of Bardenheuer and P. Bruns; (2) those of Wladimiroff-Mikulicz and Kümmell. For disease or injury situated between the bases of the metatarsal bones and the calcaneus and talus, Bardenheuer's method is especially applicable. In the majority of cases the involvement of the tarsal bones and the periosteal tissues is so great that an extensive exposure must be made in order to remove the diseased tissues completely. Where the disease involves the metatarso-tarsal, the talo-calcaneo-navicular, and the calcaneo-cuboid articulations, the method of H. P. Watson (Jacobson's "Surgery," vol. ii., p. 707) is not satisfactory and a more extensive exposure is required. It is here that Bardenheuer's method is most applicable.

Anterior Tarsectomy (Bardenheuer, "Mittheilungen aus dem Kölner Bürger-Hospital," 1-4).—An Esmarch bandage is applied. An incision is made through the skin, subcutaneous tissue, tendons of the extensor communis longus and brevis and proprius pollicis, and the cutaneous nerves, down to the bones from the first to the fifth metatarsal bones at their bases (Fig. 4059). From the extremities of this incision, two incisions are curved upward along the internal and external borders of the foot to beyond the medio tarsal joint. These incisions also extend through to the bone, dividing the tendons of the peroneus tertius and of the tibialis anticus. If necessary, these lateral incisions may be prolonged upon the metatarsal bones, the U-shaped incision being converted into an H-shaped one. This flap as marked out is dissected from the periosteum and the ligaments of the bones until it can be reflected above the level of the medio-tarsal joints. Here it is best to enter the joint, dividing the ligaments upon the anterior and lateral surfaces, when, if the forefoot is firmly held and depressed, the plantar ligaments holding the calcaneus and scaphoid and the calcaneus and cuboid can be divided. This division frees the tarsus, and allows, as in Lisfranc's amputation, an easy separation of the tendons of the tibialis posticus, the peroneus longus, and the less important muscles from the tarsus as far as the bases of the metatarsal bones. At this point a blunt retractor is passed between the bones and subjacent tissues, and the bases of the metatarsal bones are sawn at the distal side of their articular surfaces. The articular surfaces of the calcaneus and of the talus are now sawn off (Fig. 4060). The disease involving the muscles and the sheaths of the tendons is next removed. The vessels are ligated, the Esmarch bandage is removed, and the sawn extremities of the bones are apposed and sutured with chromicized catgut. If the disease is not thoroughly removed, or if

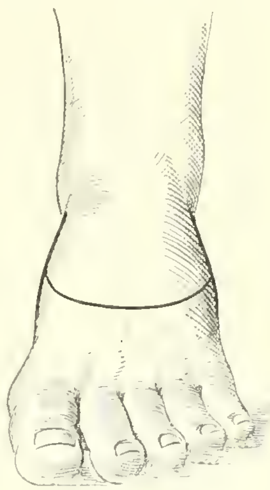

FIG. 4059.

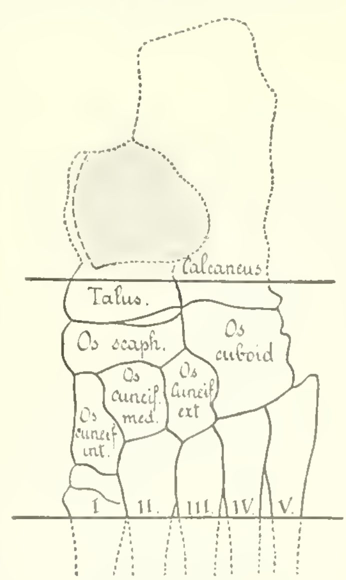

FIG. 4060.—Diagram Illustrating Bardenheuer's Operation.

* I. Between the first metatarsal and the internal cuneiform bones. II. Between the second and third metatarsal and the middle and external cuneiform bones which communicate with IV. III. Between the fourth and fifth metatarsal and the cuboid. IV. Between the three cuneiform and the scaphoid bones which communicates with II. V. Between the cuboid and calcaneus. VI. Between the navicular and the calcaneus and the talus. VII. Between the talus and calcaneus.

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one so desires for any other reason, the wound may be packed until granulation appears, when a secondary suturing is done.

In this operation the tendons are rarely sutured. It has been found that in healing by granulation the fibrous tissue unites the tendons so that motion in the toes is often good. It is, however, advisable that the tendons be sutured whenever the wound treatment allows it. If possible,

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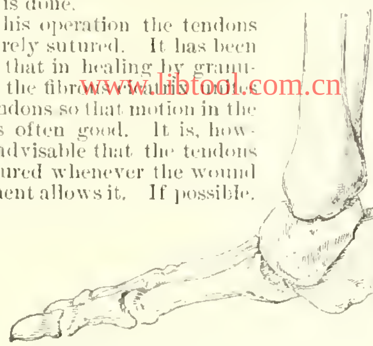

Fig. 4061.—Lateral View of the Bones after Bardenheuer's Resection of the Tarsus.

the tendons to the first toe should be sutured in all cases. In some cases sensation has returned though no suture of the nerves was attempted.

O. Wolff (Verh. d. deut. Ges. f. Chir., 1896) has presented 53 cases operated on by this method, in which the anterior tibial artery was cut. In 5 cases the posterior tibial artery was also cut. In 3 of these cases gangrene followed and required amputation. Of these cases, 42 were tuberculous in character, for which 9 complete tarsectomies, 7 partial with subsequent complete tarsectomies, and 13 partial tarsectomies were performed, with 29 complete cures. Two cases escaped subsequent observation. Three cases were amputated for gangrene and 8 cases remained under treatment at the time. In all the cured cases the foot remained a "flat" one, but the functional results were good.

Fig. 4062.—Anterior View of the Bones after Bardenheuer's Resection.

The after-treatment is mainly devoted to maintaining the forefoot in position and in apposition with talus and calcaneus.

Bardenheuer ("Mittheilungen aus dem Kölner Bürger-Spital," 1886) reported 17 cases of tuberculosis, in which none died as the result of operation. Twelve cases were cured with one operation, and of these 3 died subsequently of tuberculous meningitis; 3 required subsequent revisions before a cure was effected; 1 required amputation. One case of resection was due to loss of substance from injury; a cure resulted. (Figs. 4061, 4062, and 4063.)

Fig. 4063.—View of Cicatrix after Bardenheuer's Resection of the Tarsus.

Tibio-Calcanean Resection.—The statistics of Audry ("Sur les tuberculoses au pied," *Revue de Chirurgie*, 1890) show that tuberculous disease involves the ankle, the talo-calcanean, and the talo-calcaneo-navicular joints in fourteen per cent. of the tuberculoses in the foot, and that unless amputation be performed at the ankle (Syme's or Pirogoff's) some method must be found by which all of these joints can be opened and resected. Such a method has been elaborated by P. Bruns in 1890 (*Beiträge zur klin. Chir.*, No. 7, p. 223). This operation, made a typical one by Bruns, was previously done in an atypical fashion by Textor, 1852, and Mulvaney, 1866, and has subsequently been elaborated by Heidenhain, Helferich, Cramer, Küttner, and Kummer.

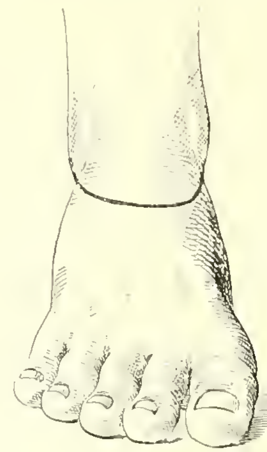

Fig. 4064.

The indications for this operation are the same as those for Pirogoff's amputation; namely, disease involving the talo-calcanean, talo-navicular, and talo-crural joints, with foci within the bones. Its advantage rests in the fact that it preserves the forefoot and gives a more useful member than is obtained by an amputation.

The method is as follows: An Esmarch bandage is applied. In order to obtain sufficient exposure an incision is made from one malleolus to the other in a broad curve over the dorsum of the foot in the neighborhood of the metatarso-tarsal joints (Fig. 4064). This curved dorsal incision, first made by Houssey (Heyfelder, "Resectionen," 1861) and subsequently used by Bardenheuer in his excision of the tarsus, is no disadvantage because of the division of the tendons and nerves. The flap thus marked out is deepened, passing above the peroneal tendons on the outer side and dividing upon the dorsal and internal surfaces the peroneus tertius, extensor longus digitorum, proprius pollicis, and tibialis anticus tendons, together with the branches of the anterior tibial and musculocutaneus nerves and the dorsalis pedis artery. This flap is dissected from the bones until the anterior tibial margin is reached. The talo-crural joint is opened by a transverse incision which divides the anterior fasciculi of the lateral ligaments. The foot is pulled forward and depressed, when the middle and posterior fasciculi of the lateral ligament are divided as close to the astragalus and os calcis as possible. With further depression, the posterior ligament of the ankle-joint is divided transversely, exposing the flexor longus pollicis tendon. The talo-navicular and the calcaneo-cuboid articulations are next entered and the superior and lateral capsular bands divided. If the astragalus

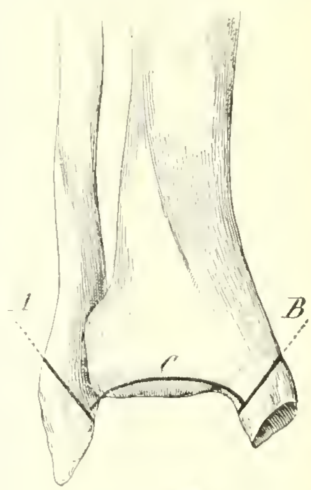

Fig. 4065.

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Resection of Joints.

is now cleared upon its lateral surfaces and the knife is passed into the sinus tarsi and carried from before backward and toward the sustentaculum tali, the interosseous ligament will be divided. The astragalus is now held only by a few undivided capsular fibres of the posterior talo-calcanean articulation and can be easily removed. The navicular, calcaneus, and cuboid bones, the tibia and the fibula, are now inspected for disease, and if they

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FIG. 4066.

are involved they should be treated as follows: The tibia and fibula are sawn so as to preserve their mortise shape. This is usually accomplished by cutting away the articular end of the tibia with the chisel or gouge, preserving its hollow shape, and by sawing the malleoli obliquely, leaving a small projecting edge beyond the surface of the tibia (Fig. 4065). The superior surface of the calcaneus is made to fit accurately the space between the malleoli. This will not infrequently require a removal of the sustentaculum tali. The calcaneo-navicular and the inferior calcaneo-cuboid ligaments are now divided or separated from the interior surfaces of the cuboid and scaphoid bones, so as to allow a vertical section with the saw. After this section, the anterior surface of the calcaneus is sawn in the same plane. The tendons, their sheaths, the ligaments and the muscles are next inspected, and if involved by disease they should be removed, after which the calcaneus is apposed to the tibia and fibula and to the cuboid bone. These bones are held in apposition by catgut sutures. The scaphoid bone will be seen to rest against the anterior margin of the tibia. The Esmarch bandage is now removed. The hemorrhage is controlled. The tendons, the nerves, and the deeper tissues are sutured to one another as far as is possible. As regards this point it may be said that most surgeons do not suture the several tissues to one another, but while no bad results may follow the adoption of this course, yet the time required for healing is undoubtedly lessened by a perfect apposition of like tissues. In the face of severe infections, the wound is left open and is packed until granulation appears, when secondary suture is made.

The after-treatment consists in absolute rest and elevation of the foot for from three to five days in an immovable splint, which holds the foot at right angle to the leg. At the end of ten days any deviation of the foot can be corrected with ease.

This operation can also be performed by a posterior curved incision which exposes the malleoli. The incision is deepened and is carried through the tendo Achillis, after which the joint is opened, the malleoli are sawn, and the talus is extirpated. The operation is completed as in the operation by the anterior incision.

The time required to obtain healing by first intention (5 cases) was from 28 to 48 days; for cases healing by second intention, 35 to 60 days (2 cases). If recurrences take place (2 cases) the time is naturally more extended, *i.e.*, 81 to 397 days—an average of 210 days (Küttner, *Beiträge zur klin. Chir.*, ii., p. 749). The mortality from the operation is nil.

The Final Result of Operation.—The shortening in the leg is usually from 1 cm. to 1.5 cm., and that of the foot about 1 cm. The appearance of the foot after operation is seen here (Figs. 4066 and 4067).

The function of the foot is good It allows use all day and requires only an ordinary shoe.

The pseudarthrosis between the calcaneus and the forefoot gives elasticity to the gait, which is wanting in artificial limbs.

The talo-calcaneus resection is to be preferred to amputation, either Pirogoff's or Syme's, because it preserves the foot. It is preferable to the Wladimiroff-Mikulicz resection because it is easier of execution and requires no subsequent prothetic apparatus.

Posterior Tarsectomy.—(Kümmell, *Centralblatt f. Chir.*, 1893, No. 47; Verhandl. der deuts. Ges. f. Chir., 1889, i., 57.) When disease involves not only the ankle-joint but the medio-tarsal and tarsal joints as well, one of three things must be done: either an extensive atypical resection (Kümmell and Cramer), or a Wladimiroff-Mikulicz resection, or an amputation at or just above the ankle-joint.

A priori, it may be thought that a removal of the calcaneus, talus, tarsal bones, the malleoli, and the articular surface of the tibia would give a bad functional result. This is not the case, however (Cramer, Verhandl. der deutschen Gesellschaft f. Chir., 1895, i., 16). The extensive removal of these bones, leaving a foot formed of a part of the tarsus, the metatarsus, and phalanges, gives a better result than the equinus position of the foot seen in the Wladimiroff-Mikulicz resection. It is true that the foot is shortened, but a foot with a sole is better than the equinus of the Mikulicz operation, because a movable foot is obtained and because the pressure-bearing surface is a natural one and greater in area than is obtained by the Mikulicz resection.

Indications.—Tuberculosis involving the ankle-joint, the calcaneus, talus, and tarsal bones, with fistulæ. In children and in young adults the operation is indicated. In adults who have tuberculosis elsewhere and are not holding their own against the disease, and in the old and anæmic, amputation is preferable. No matter whether the fistulæ are upon the dorsum or upon the plantar surface of the foot, the operation with the dorsal incision is equally indicated.

The incision for exposure of the bones is similar to that used in the P. Bruns method. The removal of the talus is similarly carried out; after which the bones of the tarsus are removed *en masse*, as is recommended in the Bruns method. This removal of the tarsus is often complete, so

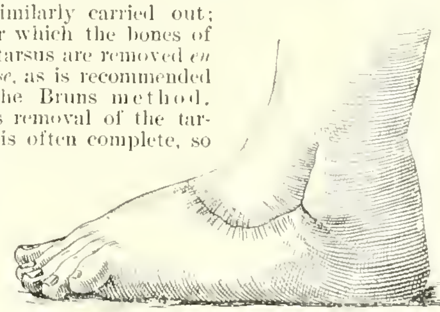

FIG. 4067.

that the section of the bones includes the bases of the metatarsal bones. The lower ends of the tibia and fibula are removed with a transverse section, unless the calcaneus can be partly saved, when the section is similar in shape to that recommended in the preceding resection. No matter how little of the calcaneus is saved, the resulting shortening and the functional result are much improved. After removal of the diseased bone the bases of the metatarsal or tarsal bones are apposed to the anterior sur-

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face of the lower end of the tibia, where they are fastened with sutures if possible. In Kümmell's first case, in which 2.5 cm. of the tibia and fibula and all the tarsal bones were removed, the resulting shortening was about 3 cm. In two of Cramer's cases the resulting shortening was less.

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After-Treatment.—Frequently the large cavity left after extensive removal of the bones cannot be closed, and must be packed with gauze and treated as an open wound because of the presence of fistulæ. The cavity left between the tarsus and the tibia and fibula closes rather quickly. The soft parts of the planta pedis draw up between these bones and a pillow is formed under the tibia. The time required for this is usually two months. During this time the wound is dressed as required, and the proper position of the forefoot in its relation to the tibia is maintained by appropriate right-angled splints.

FIG. 4068.

The results of this operation show that the gait is elastic and not "hobbling," as is the case with the equinus position of the foot after a Wladimiroff-Mikulicz resection or the amputations or disarticulations. This elastic gait is due to the pseudarthrosis between the tibia and fibula, or the calcaneus, and the forefoot. Another advantage claimed for this procedure is to be found in the fact that prothetic apparatus will not be needed after the cure. Six cases reported by Cramer gave two cures in children of three and four years of age. Two cases of adults of ten and twenty years of age were still under treatment at three and four months. Two cases died of generalized tuberculosis following operation. A view of a foot following such an operation is seen here (Figs. 4068 and 4069).

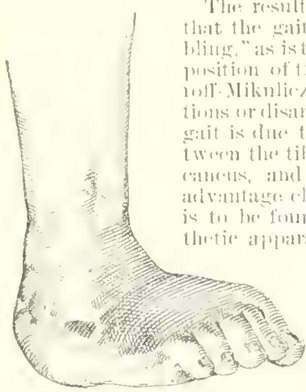

FIG. 4069.

When the disease is of the same extent as would lead one to perform the foregoing operation, while at the same time the greater part of the heel is the seat of destructive disease and of fistulæ, the resectio tarsea totalis of Wladimiroff-Mikulicz may be considered.

The indications for this procedure are: (1) Caries of the talus, calcaneus, and tarsus (Mikulicz); (2) extensive loss of the tissues of the heel (Mikulicz); (3) injuries destroying the heel (Mikulicz); (4) new growths involving the bone (calcaneus) or tissues of the heel (Schliffosowsky and Wahle); (5) to increase the length of the extremity, as occurs in infantile paralysis (Caselli); (6) for paralytic equino-varus (Bruns).

The object of the operation is to secure an artificial pes equinus. The toes and metatarsus are preserved and are apposed, in a vertical plane, to the tibia and fibula. The patient walks upon the heads of the metatarsal bones with the toes bent at right angles to the leg. The operation was first performed by Wladimiroff in 1871 and by Mikulicz in 1880 (*Archiv für klin. Chir.*, xxvi., p. 497).

Complete Tarsectomy (Resectio Tarsea Totalis).—An Esmarch bandage is applied. The patient is placed upon the abdomen with the foot extended. Just in front of the tuberosity of the scaphoid bone, upon the inner side of the foot, there is made an incision which passes transversely across the planta pedis to a point just behind the tuberosity of the fifth metatarsal bone. From each extremity of this incision, upon each side, an incision is carried upward and backward to the malleolus. The extremities of the latter incision upon the malleoli are now united by a transverse incision across the posterior surface of the leg. When the bones of the leg must be denuded at a higher level than is usual, the lateral incisions must be carried beyond the malleoli (Fig. 4070).

All incisions pass directly down to the bones, dividing the muscles, tendons, nerves, and arteries. The posterior capsule of the ankle-joint is divided, together with the posterior, middle, and anterior fasciculi of its lateral ligaments.

The foot is now thrown in dorsal flexion and the talus and calcaneus are carefully separated from the soft parts

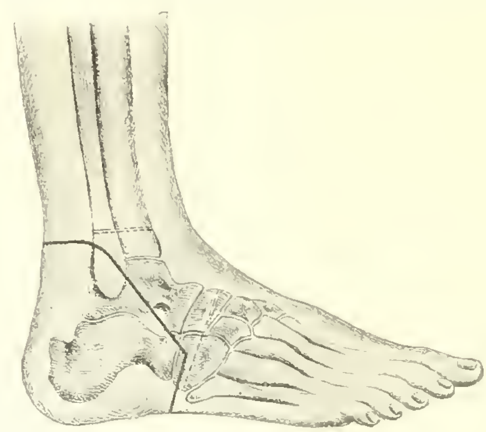

FIG. 4070.

of the dorsum of the foot until the medio-tarsal joints are reached. Here these bones are separated from the cuboid and navicular, and are removed with the heel flap. The lower ends of the tibia and fibula are now sawn across. The cuboid and navicular bones are likewise sawn transversely (Fig. 4071).

The Esmarch bandage is removed and the arteries are tied. When hemorrhage is completely stopped, the cuboid and navicular bones are apposed to the tibia and fibula and are retained in position by chromicized catgut sutures (Fig. 4072). The wound is now closed with deep catgut sutures and over the aseptic dressing is placed an immovable plaster dressing holding the parts firmly.

Sometimes in placing the bones in apposition the folding of the anterior bridge of soft tissues displaces the forefoot. When this occurs, the bridge of tissue must be folded and retained by a few mattress sutures.

The after-treatment consists in elevating the foot and retaining

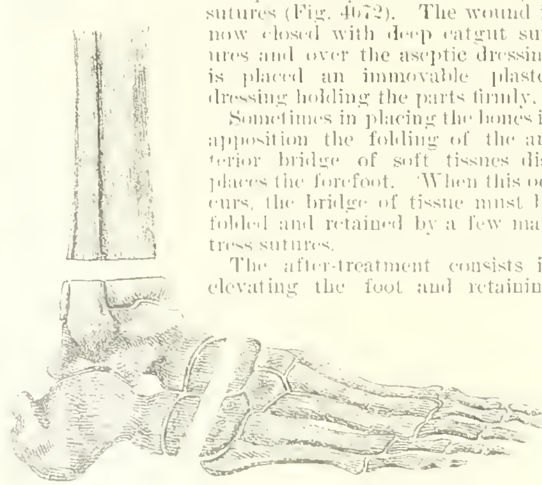

FIG. 4071.

this position for from three to five days; after this it may be lowered. In from six weeks to two months the union is complete. The lengthening of the limb is usu-

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Resection of Joints.

ally 1.5 cm., which can be easily overcome by a heel upon the opposite foot. Fig. 4073 shows the foot healed.

Kohlhaas (*Beiträge zur klin. Chir.*, viii.) has collected seventy-three cases of this operation with one death from

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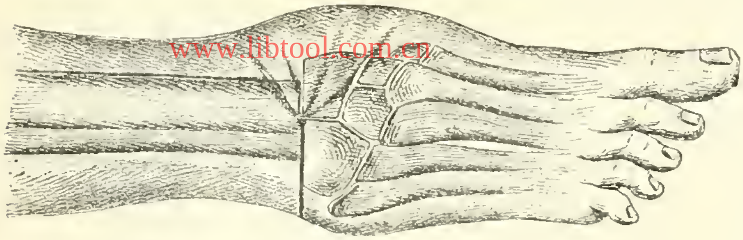

FIG. 4072.

pyæmia and one requiring amputation for gangrene. Several cases presented localized areas of gangrene, but did not require other than simple treatment. Three cases failed to have a firm union between the bones of the leg and foot and required subsequent operations. Fifty-six cases gave good results and required no extra prothetic apparatus or shoe. Nine cases gave moderate results and required special prothetic shoes.

To avoid the division of the posterior tibial artery and nerve, and the disturbances in nutrition and the gangrene which may result therefrom, Lotheisen (*Beiträge zur klin. Chir.*, xviii.), P. Bruns (*ibid.*), and Ollier ("Traité des Résections") have devised various modifications in the incisions. Lotheisen's incision is as follows: The patient lies upon the back. The extremity is raised and the foot is dorsally flexed. Upon the other surface an incision, commencing 1.5 cm. above the attachment of the tendo Achillis and between the fibula and the tendon, is carried obliquely forward and downward below the malleolus, ending 2 cm. behind the tuberosity of the fifth metatarsal bone (Fig. 4074). Upon the inner side a similarly placed incision is made, beginning above upon the same level and to the inner side of the tendo Achillis, descending forward behind the internal malleolus, and ending just in front of the tuber calcanei (Fig. 4075). The extremities of these lateral incisions are united across the sole by an oblique incision (Fig. 4076) and across the leg by a horizontal one. The enucleation of the talus and the sawing across the tarsus and the bones of the leg are accomplished as in the former method. A very similar method was described by Jaboulay and Lagaite ("Nouveau procédé pour pratiquer l'amputation ostéoplastique de l'arrière-pied,"

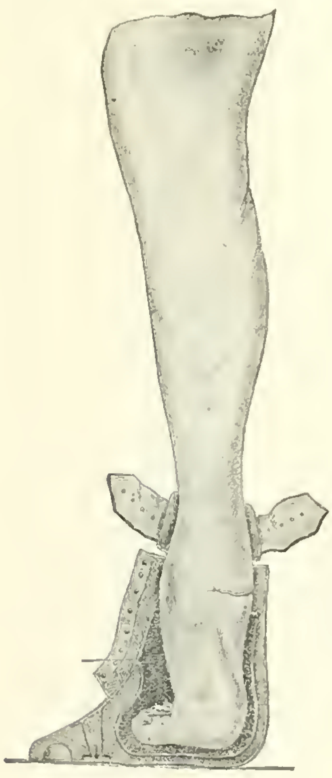

FIG. 4073.

Lyon médical, 1889, No. 11), but it offers no advantages over the above. The result of Lotheisen's method is seen in Fig. 4077.

To avoid the same result, P. Bruns has recommended strongly the simple median posterior incision, especially in cases in which the heel is intact and free from ulceration. Bruns' incision begins on the posterior surface of the leg, four fingers' breadth above the tubercles of the calcaneus, passes downward over the centre of the heel and to the centre of the sole of the foot. This incision extends immediately down to the bones. The talus and the calcaneus are removed subperiosteally after opening the ankle-joint. The bones are sawn and apposed and held by suture. Bruns meets the objection made by Lotheisen and by Ollier to the enormous mass of tissue left in the heel, which forms an ugly, thick, projecting hump on the posterior surface, by showing the photograph of his case of paralytic talipes equino-varus operated upon by his method (Figs. 4078 and 4079).

Ollier ("Traité des Résections," iii., p. 691) has described a similar incision, but he had not performed it upon the living subject at the time when Bruns used his incision.

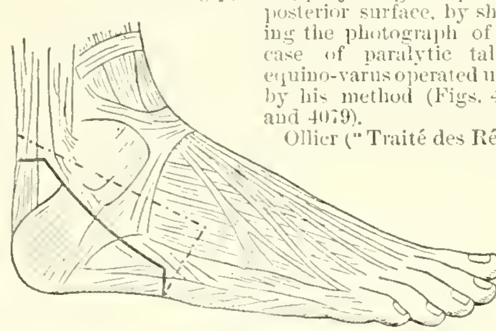

FIG. 4074.

Of the incisions used for the total tarsectomy, none seems to meet the surgical requirement so well as Lotheisen's, which avoids injury to the posterior tibial artery and nerve and allows the tissues of the leg and sole of the foot to be easily apposed and sutured one to another. In cases of paralytic equinus or equino-varus with extreme shortening, the posterior incision of Bruns or Ollier has given as good results as the methods of Lotheisen and Mikulicz. In this particular class of cases the objections to be raised

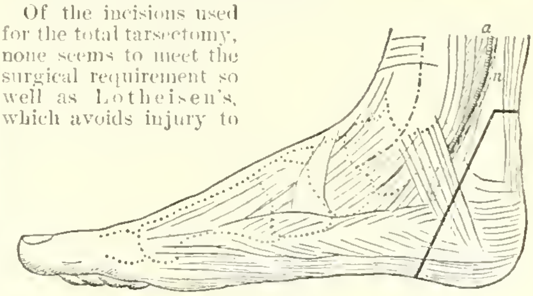

FIG. 4075.

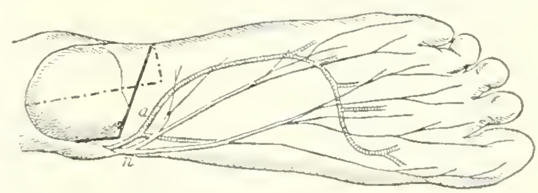

FIG. 4076.

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against the incision, the subperiosteal enucleation of the bones, and the projecting mass of the heel when the parts are apposed, do not hold as they do in disease or injury.

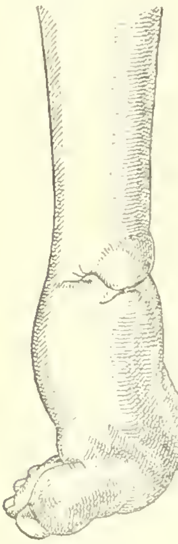

FIG. 4077.

It may be said with truth that the total tarsectomy (Wladimiroff-Mikulicz) and the extensive resections of Kümmell will rarely appeal to many surgeons, when they compare the time spent in obtaining these results, the extent of the procedure, and the drain upon an already worn-out subject. An amputation (Syme's, Pirogoff's, Guyon's) with the rapid healing and the practical prothetic appliances made in this country will, I doubt not, cause most surgeons to advise amputation whenever the patient can obtain an artificial limb. Only in the very poor and in those of moderate age and good health (especially such as have congenital and paralytic deformities or injuries) will the extensive procedures of Kümmell and Mikulicz be adopted. On the contrary, the anterior and posterior tarsectomies of Bardenheuer and Bruns give such excellent feet after operation that no question can be raised as to their advisability in suitable cases and their superiority to amputations.

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RESECTION OF THE ANKLE-JOINT. This operation was first performed by Moreau in 1792. Subsequently, owing to the complicated character of the joint, the presence of tendons and sheaths in the immediate neighborhood, and the relapses following operation, surgeons gave up the method and resorted to amputations.

Better methods of approach, more complete removal of the disease, and the aseptic treatment of the wound have so lowered the mortality that amputation now presents no advantage in this respect. At the same time the patient is left with a foot which is more useful and æsthetically better than the stump of an amputation. (See Fig. 4080.)

Partial resections are those which remove the whole or a part of the articular surfaces of the tibia, the fibula, or the talus. Complete resections do remove all of these surfaces.

FIG. 4078.

The talo-crural articulation is best approachable from the sides. In front, it is covered by the tibialis anticus, the extensor longus digitorum and proprius pollicis and the peroneus tertius, the nerves, and the anterior tibial artery. Behind, it is covered by the tendo Achillis in the centre, and upon either side of this by the peroneal tendons or the tibialis posticus, flexor longus digitorum, longus pollicis, together with the nerve and the posterior tibial artery. For this reason the lateral surfaces are much used for incisions. The ankle-joint is a powerful joint because of its bony construction as well as by reason of its strong ligaments.

The ligaments uniting the malleoli to the tarsus are strong. Those for the internal surface are three: the deltoid uniting the malleolus with the sustentaculum tali, the anterior uniting it with the scaphoid, and the posterior uniting it with the talus. Those for the external surface are: the anterior, uniting the external malleolus with the talus; the middle, uniting it with the calcaneus; the posterior, uniting it with the talus. The anterior and posterior ligaments are thin and insignificant. The synovial membrane lines the capsule, and extends beyond the limits of the articulation both in front and behind. At the sides it is delimited by the articular surfaces.

FIG. 4079.

The epiphysis of the tibia includes the lower end and the internal malleolus. It unites with the diaphysis at about the nineteenth year. The epiphysis of the fibula unites with the diaphysis at about the twenty-first year. The outlines of the malleolus are easily felt and seen.

The head of the astragulus is felt in full extension of the foot. The ankle-joint lies opposite a transverse horizontal line 1.25 cm. above the tip of the internal malleolus.

The Indications.—Partial resections are indicated in gunshot wounds; in compound fractures and in dislocations when the nerves and vessels are intact; and in suppuration following injury and infection when this resec-

FIG. 4080.

tion removes and drains the focus of infection. For tuberculosis in childhood, expectant treatment and iodoform injections may precede the partial resections, *i.e.*, the erosions or the arthrectomies, but delay must not be too long before resorting to the resection. In adults formal

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resections are used. In older people, with other tuberculous foci, amputation is preferable to resections. As a general rule, when tuberculosis is apparently primary in the joint, resection is to be preferred. When the ankle-joint is involved, secondarily to other well-defined deposits in the lungs and elsewhere, amputation is preferable.

There are about thirty

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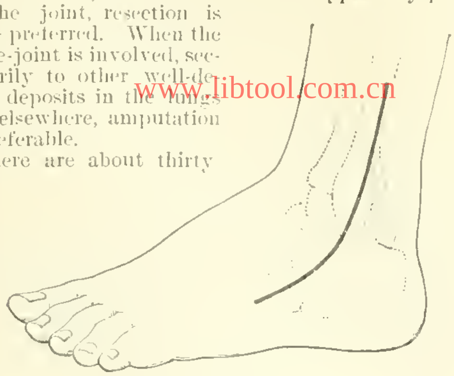

FIG. 4081.

six incisions (Farabœuf, "Manuel Opératoire"; Ollier, "Traité des Résections"; Karewski, "Chirurgische Krankheiten des Kindesalters"; Kocher, *Archiv für klinische Chirurgie*, No. 37) which have been recommended for entering this joint. All surfaces of the joint have been made use of to gain an entrance. Even the sole of the foot, *i.e.*, the heel, has been included in the incisions. No incision has so many advantages as that of Lauenstein. This incision resembles Kocher's incision (*Langenbeck's Archiv*, 1887 and 1888), but it gives a better exposure of the posterior angle of the ankle-joint and of the neighborhood of the internal malleolus. Kocher's incision was an improvement upon Reverdin's (*Revue Médicale de la Suisse romande*, 1883, Mars). Lauenstein's (Verhandl. der deutsch. Gesellsch. für Chir., 1890, ii. 71) is an improvement upon Kocher's.

The method is as follows: An Esmarch's bandage is applied. The foot is placed upon its inner side. An incision is begun upon the fibula at the point where the fibula appears between the peroneus brevis and the peroneus tertius muscles. This incision is carried through the skin to the tip of the malleolus, where it bends forward in a broad curve to the talo-navicular joint, passing over the heads of the extensor brevis digitorum and exposing the tendons of the peroneus tertius (Fig. 4081). It is now deepened, exposing the periosteum of the fibula, the anterior fasciculus of the lateral ligament, and the capsule of the ankle-joint. Upon the posterior border of the fibula the sheath of the peroneal tendons is opened, and the tendons are retracted posteriorly. The knife now separates from the periosteum of the tibia and fibula, the muscular fibres of the peronei and the flexor longus pollicis until one-half the transverse diameter of the tibia is freed.

The retractors used in retracting these structures are now removed and are inserted into the anterior flap. The ankle-joint is opened in front of the external malleolus and the blunt retractor is inserted, lifting and protecting the capsule and the superjacent tissues. The upper and lower attachments of the capsule to the talus and to the tibia are severed until the median line of the tibia and the talus are both of them reached. The foot is now supinated and the three fasciculi of the external lateral ligament are divided. When they have been divided, if the foot be placed in the equinus position and be gently thrown into supination, it will turn upon the internal malleolus as an axis, provided the tissues in front and behind the joint have been freed to a point beyond the median line of the joint. With a little force the foot can be completely inverted, so that the planta pedis looks upward and the articular surfaces of the talus and tibia are upon the same plane, separated by the internal malleolus (Fig. 4082). By means of blunt hooks every part of the articular surfaces of the talus, tibia, and fibula can be reached: every pocket of the synovial cavity, including the inferior tibio-fibular prolongation and the posterior surface of the synovial membrane; the sheaths of the tendons of the tibialis posticus, flexor longus digitorum and pollicis, as well as the bursa and fat in front of the tendo Achillis. When these are inspected and all foci of disease have been removed by curettage or excision, the foot is easily pronated and thrown into proper position. The only structures injured are the vena saphena parva and the arteria perforans peronea. The advantage of the incision over Kocher's is that it allows a greater stretching of the borders of the incision and an easier dislocation of the foot. It moreover parallels the sheaths of the tendons and permits a surgical treatment of them when involved. If in operating by this method it becomes necessary to remove the talus, it can be accomplished easily by dividing its ligaments which are exposed to view. Indeed, the method renders the extirpation of the talus a very easy matter.

If disease involves the medio-tarsal and the talo-crural joints together with the neighboring bones, or if this is only recognized by the operator after he has entered the talo-crural joint by the Lauenstein incision, the suggestion of Heidenhain (Verhandl. der deutschen Gesell. f. Chir., 1894, ii., p. 137) may be adopted for the treatment of the case. This suggestion consists in continuing the lower end of the Lauenstein incision across the dorsum of the foot below the medio-tarsal joint and dividing the tendons

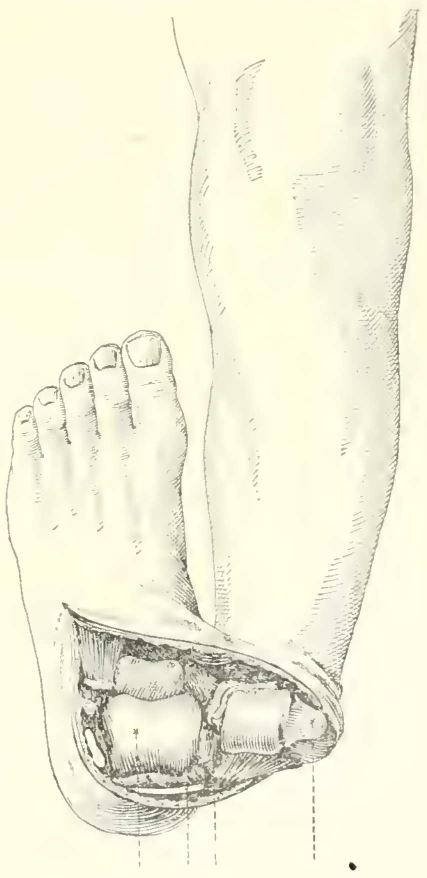

FIG. 4082. Lauenstein's Method. Parts exposed ready for resection. *t.*, Talus; *p. t.*, peroneal tendons; *e. m.*, external malleolus.

of the peroneus tertius and longus digitorum but preserving if possible the tibialis anticus and proprius pollicis. This incision gives all the advantages of the Lauenstein

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and P. Bruns resections, and opens to view for easy attack the medio-tarsal articulation.

Again, if the talo-calcanean or the talo-navicular joint is alone involved, we can adopt the following suggestion of Lauenstein and approach these parts with the same skin incision: Instead of opening the talo-crural articulation, we divide the calcaneo-tibular division of the external lateral ligament, and then, passing a thin knife into the sinus tarsi, carry it backward and inward to the sustentaculum tali, dividing the interosseous ligament. After this division the anterior talo-calcanean capsular ligament is made tense by everting the calcaneus and is divided. This is followed by division of the muscular fibres of the extensor brevis digitorum and the talo-navicular ligaments upon the outer and superior surfaces of this joint. If strong supination is now made upon the foot, the calcaneus will be luxated or rotated upon its inner side over the malleolus internus. In this manner the talo-calcanean and the talo-navicular joints may be exposed without opening the ankle-joint. During the luxation of the calcaneus the peroneus tendons are retracted posteriorly and do not obstruct the field. From this position of the foot the talus may be easily removed by division of its lateral ligaments. In extensive disease in this region the Lauenstein incision permits an entrance into the talo-crural articulation, and if desired allows an exposure of the medio-tarsal and talo calcanean joints with removal of the talus. The medio-tarsal and talo-calcanean articulations may be entered first, and if suspicion exists as to an involvement of the talo-crural articulation this may be exposed by removal of the talus. This incision gives the best approach to the ankle-joint. It allows of such modifications as will insure successful results in spite of unsuspected foci of disease, since through one incision the talo-crural, the talo calcanean, and the medio-tarsal joints can be approached and the talus removed. In a pure resection of the ankle-joint the synovial membranes and the articular surfaces of the talus and of the tibia and fibula are removed, their shape being preserved as far as possible. For this reason the section of the tibia and fibula is usually made concave from side to side, while that of the talus is made convex. If the talus is removed on account of disease, this concavity in the tibia and fibula is made so as to fit the calcaneus, while the scaphoid rests upon the anterior border of the tibia. When but little of the articular surfaces of the tibia and fibula is removed, it is best to shorten the malleolus so that the tibia may rest upon the calcaneus directly. It has been my custom to suture the scaphoid, tibia, fibula, and calcaneus together with two or three chromicized catgut sutures. It is rare that a single artery requires ligature, and if any bleed excessively they will stop upon elevation of the limb. I usually blood-clot these cases, excepting where it is impossible to remove all tuberculous material. In the latter instance the wound is packed until healthy granulation tissue appears.

The after-treatment is a matter of importance. When the wound is sewed up and blood-clotted the foot is elevated at an angle of forty-five degrees for from three to five days, after which it is lowered. In this method the first dressing is made about the tenth day. Where wounds are packed, the foot is usually elevated for twenty-four to forty-eight hours, after which it is lowered. The dressings should be changed every two or three days.

A suitable splint is difficult to find. A splint which will maintain the foot at a right angle with the leg and will prevent lateral deviation of the foot is the one desired. Upon the whole, a plaster-of-Paris dressing properly and carefully applied is the best. This plaster-of-Paris dressing may be used alone or in conjunction with the McCormac splint (Jacobson's "Operative Surgery," vol. ii., p. 699). If it is applied alone, it is well to place this dressing within a Volkmann's posterior splint, where it will be held firmly. After two weeks' treatment the other splints may be discarded and a splint plaster-of-Paris dressing will be sufficient until union is complete.

Results.—The mortality, in the different classes of cases, was as follows: *For gunshot wounds* (45 cases) it was, according to Culbertson, 26 per cent.; according to Otis (33 cases in the civil war), 29 per cent.; and, according to the same authority (150 cases from all sources) 33 per cent. *For injuries in civil practice* (152 cases) it was, according to Culbertson, 12.5 per cent. *For disease* (124 cases) it was, according to Culbertson, 8.06 per cent. for complete resection, and 6.55 per cent. for partial resection; while, according to Isler and Kappeler, it was almost nothing in cases of tuberculous disease.

Functional Results.—Some say that a flail joint is very rare, some that it is unknown. Ankylosis is often obtained, and when it occurs the medio-tarsal joint compensates in great measure for the stiffness in the ankle. In seventy-five per cent. of the cases recovery takes place with a useful limb, and in many instances, especially in the subperiosteal method, the nearthrosis is a remarkable one, giving a most useful joint (Langenbeck).

According to Isler, the results of resection functionally are divided as follows: Very good, 40.8 per cent.; good, 26.8 per cent.; moderate, 7.6 per cent.; indefinite, 8 per cent.; bad, 6.2 per cent. In children the good results are more frequent than in adults, since the disease is usually less extensive.

Schmidt Monnard gives the good results as 74 per cent. for the first fifteen years of life. In Bardeleben's clinic good results were obtained in 81.2 per cent. of the cases. Karewski in 30 cases had 25 good results, 2 deaths from scarlet fever and tuberculosis respectively, and 3 cases with recurrences ("Chirurgische Krankheiten des Kindesalters").

Resection of the Knee-Joint.—In 1762 Felken attempted a partial resection of this joint. Park in 1781, and Moreau and Roux before 1820, operated, performing a complete resection, but the unfortunate results obtained by their imitators deterred many surgeons until W. Fergusson in 1850 restored the operation. From this time the operation has been practised extensively and remarkably good results are now obtained in every country (Hodges, "Excisions of Joints," Boston, 1861).

The cases operated upon are divided into those which are typically resected and those which are atypically treated. The typical operation consists in the extirpation of the synovial membrane and the removal of the bones intra- or extra-epiphyseally. The atypical one consists in the extirpation of the synovial membrane without removal of the bone except where diseased. This is the arthrectomy of Volkmann (Verhandl. d. deut. Ges. f. Chir., xiii.) and the erasion of Wright (*Lancet*, 1881, vol. ii., p. 992).

The atypical operation is undoubtedly the operation for children, since in eighteen per cent. of the cases in which the bones were not at all or only very slightly involved, movable joints have been obtained. In the second place, no shortening, at least no more than follows conservative methods, takes place (Maudry, *Beiträge zur klin. Chir.*, iii., p. 235).

A comparison of these atypical cases with the intra-epiphyseal resections (Hoffa, *Archiv für klin. Chir.*, 1885, xxxii., p. 795) shows that the only real advantage is the possibility of obtaining in the most favorable cases a movable joint, and since this occurred in nearly eighteen per cent. of the seventy cases collected (Maudry), it offers a substantial advantage in favor of the atypical operation. The disadvantages of the atypical method consist (1) in the liability of leaving beneath the articular cartilages foci of disease, (2) in the greater tendency to contracture of the flexor muscles. The first disadvantage is more apparent than real in the cases of children, because in making an intra-epiphyseal section one must cut the bone below the level of the articular cartilage. "Every bone section in children must be surrounded by a line of articular cartilage to be certainly intra-epiphyseal" (König). This section is so thin that foci may not be revealed by it, just as when the articular cartilage is present. The advantage which belongs to the typical intra-epiphyseal method, and which does not belong to the atypical method, is the firmer union which takes place

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between the bones and the slighter tendency to deformity. The lack of this advantage in the atypical method is compensated for by prolonged mechanical after-treatment.

When the bones are slightly involved and the synovial membrane is the principal seat of disease, the atypical operation is indicated because of the eighteen per cent. of movable joints which have been secured by its employment. If in addition to the synovial membrane the bones are involved, the intra- or extra-epiphyseal resection is indicated, according to the extent of disease in the bones. This is because of the firmer ankylosis in the extended position which is obtained by the section of the bones, and also because it is not possible to obtain motion on account of the destruction of the articular cartilages. It is to be remembered that in resections shortening is greater if done before than after the fourteenth year.

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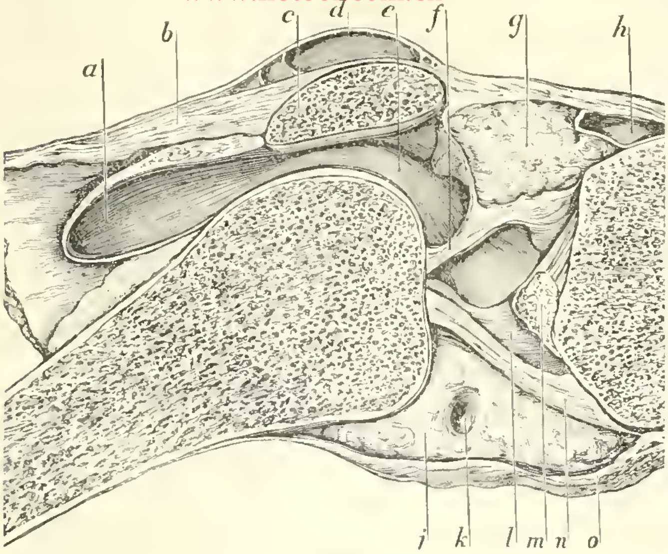

FIG. 4083.

Indications.—For disease: 1. Tuberculosis. Excision in these cases should be performed (*a*) in all cases in which the articular cartilage is found eroded, whether suppuration is present or not; (*b*) in cases with backward dislocation of the tibia; (*c*) in cases that have lasted over six months, in which the expectant treatment has been tried and has failed and in which the disease is in all probability an epiphyseal osteitis; (*d*) in cases of synovial tuberculosis which has extended over the articular cartilages. In the child before fifteen years, this operation affects the growth of the limb. In adults of twenty years and over, the length of the limb need not be considered, but the conditions of the viscera and the general health become important considerations. In all cases the presence of amyloid degeneration; tuberculous disease of the lungs and other viscera; great emaciation and extensive involvement of the soft parts about a joint demand amputation rather than resection. 2. Chronic arthritis, with caries of the bones. 3. Chronic osteo-arthritis in a single joint in middle life. 4. Ankylosis of the knee in a bad position after osteotomy has failed. 5. In infantile paralysis for the production of ankylosis. In these cases the resection is usually a complete one.

For injury: Gunshot wounds and other compound and complicated wounds. In these cases the resection is usually partial rather than complete.

Anatomy.—The axis of the femur is directed inward at the knee. That of the tibia is straight, *i.e.*, in the axis of the body. The joint obtains no strength from the shape of the bones. It derives its strength from its crucial and posterior ligaments rather than from its lateral and anterior ligaments. The cavity of the synovial membrane is extensive and the bursæ about the joint are numerous. Of these bursæ, that between the inner condyle, the semimembranosus, and the inner head of the gastrocnemius communicates with the joint. The bursa beneath the tendon of the poplitens communicates with both the knee-joint and the superior tibio-fibular articulation. In like manner, the bursa beneath the vasti and the rectus communicates in eighty per cent. of the cases with the joint (Fig. 4083). The popliteal artery and vein are quite closely associated with the ligament of Winslow, and care must be given in dissecting out diseased tissue in this region in order to avoid injuring them (Fig. 4083). The articular arteries should if possible be avoided, but, if they cannot be avoided, they should be tied before closing the wound, even when the blood-clot method is used. The superior articular arteries are situated just above the condyles, while the inferior pass beneath their respective lateral ligaments, the internal below the tibial tuberosity, the external above the head of the fibula. It is to be remembered that the upper limit of the femoral epiphysis is represented by a line passing across the femur at the tubercle of the adductor magnus. This epiphyseal line is intracapsular. The tibial epiphysis is marked at the sides by a line just including the fibular articular surface, and the depression for the semimembranosus tendon behind this line just includes the tuberosities. In front the epiphysis descends to the lower margin of the tubercle. This epiphyseal line is extracapsular. The femoral epiphysis joins the shaft at twenty, the tibial at twenty-one years (Fig. 4084, *a* and *b*). In a child, scarcely more than 1 cm. of the tibia and

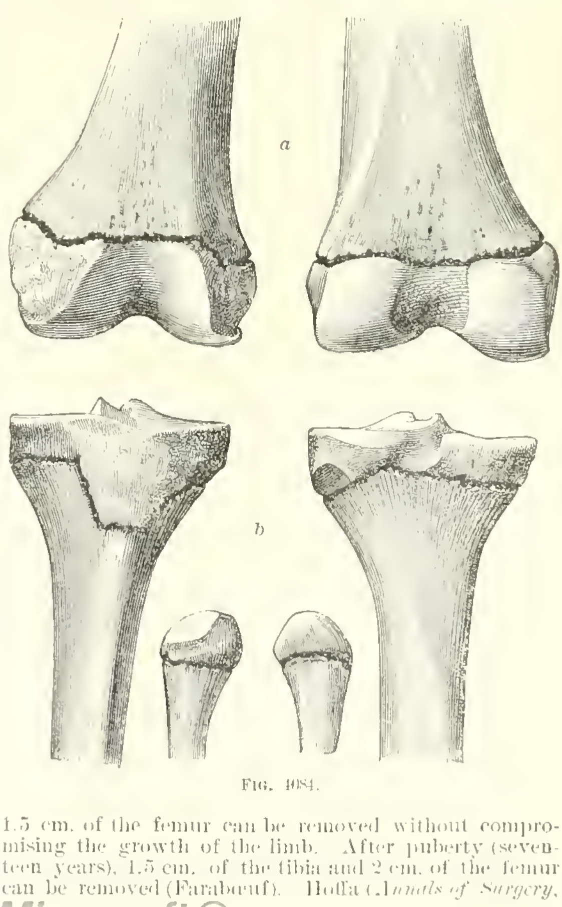

FIG. 4084.

1.5 cm. of the femur can be removed without compromising the growth of the limb. After puberty (seventeen years), 1.5 cm. of the tibia and 2 cm. of the femur can be removed (Farabeuf). Hoffa (*Annals of Surgery*,

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Resection of Joints.

March, 1886) says that (1) in one case the removal of both epiphyses at the end of ten years gave 25.5 cm. shortening; (2) in one case at the end of two years there was 10 cm. shortening; (3) the loss of the femoral epiphysis alone in one case gave 17 cm. shortening at the expiration of six years; (4) the loss of the tibial epiphysis alone in two cases gave respectively 15.5 and 6 cm. shortening in six years; *i.e.*, an average of 10.7 cm. Petersen (*Archiv f. klin. Chir.*, xxxiv., p. 445), in a child of six years of age, at six years from the time of the resection, found a shortening in the femur of 10.2 cm., of which 8.5 cm. was due to the loss of the lower femoral epiphysis. In the tibia, there was 5 cm. shortening, of which 3 cm. was due to the loss of the upper tibial epiphysis.

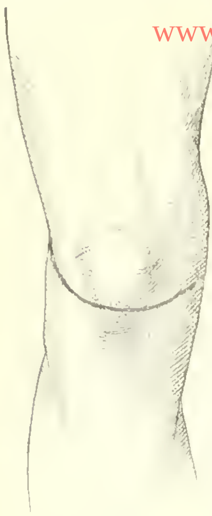

Fig. 4085.

It is to be remembered that when the knee is flexed the extension of the synovial membrane above the femur and beneath the quadriceps femoris tendon scarcely reaches above the articular cartilage of the femur; when the leg is extended, the same rises to a much greater distance.

Incisions.—Many incisions have been recommended for this operation, and of the great number variously used by Park, Moreau, Fergusson, Mackensie, Bird, Volkmann, Langenbeck, Ollier, Textor, Sanson, and Bégin, no one seems to me to be as advantageous as that recommended by Mackensie, Farabeuf, Erichsen, and Kocher, *i.e.*, the transverse curved incisions of Textor.

The object of this resection is usually to produce ankylosis without considerable shortening, *i.e.*, without shortening over 10 cm., which can be corrected by a high shoe and by the inclination of the pelvis. For this reason only such incisions are useful which will expose all parts of the joint and enable one accurately to remove only the diseased tissue. To obtain this exposure, the transverse incision is preferable to the longitudinal. The longitudinal incisions were designed to save the patella and to aid in producing mobile joints, but the best results are usually those in which ankylosis exists, and in these the patella is not necessary.

The operation by the longitudinal incision is difficult and tedious and in disease fails to expose all parts of the synovial membrane. For this reason alone, in disease, the transverse is to be preferred to the longitudinal incision. In some few cases of injury with partial resection of the bones, the longitudinal incision is indicated, but in the vast majority of cases no incision is so satisfactory as the transverse.

Method of Operation.—Typical resection. The patient lies upon the back, with the leg at the end of the table, so that in flexion at the knee the foot may rest on the table. The surgeon stands upon the side to be operated. One assistant, opposite the surgeon, manages the thigh, another manages the leg. A third manages the sponging, etc. During the skin incision, the leg is held firmly flexed upon the thigh. The incision, at first involving the skin and subcutaneous tissue, passes from the epicondyle of one side to that of the other in a broad curve, which crosses the ligamentum patellæ midway between the tubercle of the tibia and the lower margin of the patella (Fig. 4085). This incision avoids, as it approaches the internal epicondyle, injuring the saphena magna vein and the internal saphenous nerve. The flap marked out is dissected from the capsule and the patella and is reflected above the upper border of the patella. An oval-shaped piece of the anterior capsule, including the patella and the synovial membrane, is now excised by two incisions passing from the posterior borders of each lateral ligament across the upper and lower extremities of the patella (Fig. 4086). With the removal of this piece the joint is fully exposed. This is the method of procedure in non-tuberculous processes, in injuries, and in deformities, where the ultimate aim is ankylosis. In tuberculosis Kocher's suggestion is the proper one. After reflection of the skin and subcutaneous tissue as above, an incision is carried through the lateral ligaments, the fascia of the vasti muscles, and the quadriceps tendon in a curve above the patella down to but not through the synovial membrane. The flap above is cleared from the synovial membrane until the attachment of the latter to the femoral articular cartilage is reached. In like manner, the flap below is separated from the synovial membrane as far as the latter's attachment to the tibia, the ligamentum patellæ being divided at its attachment to the patella. In this manner the tuberculous synovial membrane, together with the patella, is removed in one piece. Whichever way one has proceeded the joint is now open and the crucial ligaments are seen. With increased flexion by the assistant, the crucial ligaments are rendered more evident and the division of the anterior and then the posterior close to the femur is made. The leg now hangs loosely upon the femur. It is flexed to a right angle, with the foot resting upon the table and the femur raised. In this position the femur is cleared of its soft parts—including the periosteum if desired and if indicated by the local condition—up to the line of intended section. The popliteal space is protected by a broad retractor and the bone is sawn with a solid-bladed saw. The plane of section is sagittally at right angles to the axis of the femur. Frontally it is parallel to the plane of the articular surfaces of the condyles.

The tibia is now pulled forward while the foot still rests upon the table. The popliteal tissues are put upon the stretch and brought into a lower plane than the articular surface of the tibia. This is exaggerated by freeing the tibia posteriorly where the ligament of Winslow is attached. The tibia is now held firmly in this position and is cleared of all tissues to the line of bone section. It is sawn at right angles to the axis of its shaft. The section in the bones is in the young always within the epiphyseal line; in the adult, the section is made as often extra-epiphyseally.

The tissues in the popliteal space are in no danger, since they are placed at a lower level than the bone section, owing to the traction upon the leg held in the vertical position. In non-tuberculous cases and in cases of deformity, the synovial membrane is now dissected from the bones and the capsule. It is usual to begin with that above the femur and beneath the quadriceps tendon. This with the bursa is removed as a continuous membrane and can in almost all instances, except where disease has advanced beyond its limits, be removed without further incisions. In the more extensive cases a vertical incision must be added to the transverse one. So infrequently is this the case and so thoroughly can one, by means of this additional incision, approach without excessive injury the space beneath the vasti and quadriceps muscles, that I have rejected entirely all incisions with their curve upward (Hahn, Verhandl. der deutschen Gesell. f. Chir., No. xi.) which are designed more fully to expose this region.

Fig. 4086.

The advantages obtained by this method of procedure are, taken all in all, more than those derived from inci-

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Resection of Joints.

sions destined to expose the space beneath the quadriceps muscle at the expense of the rest. The areas next in importance are the immediate neighborhood of the tibia and the popliteal space. The synovial membrane about the sides and front of the tibia and the adjacent synovial membrane are now removed, including the bursa beneath the ligamentum patellæ. At this stage an assistant places his hand in the angle formed by the tibia and femur, and by pushing apart these bones puts the tissues in the popliteal space upon the stretch, which renders the removal of the bursæ already referred to an easier matter than when their tissue is not firmly stretched. If removal of the disease in the rest of this region is now undertaken and if sinuses exist here, it is best to locate first the position of the artery and vein and then to proceed to the removal of the diseased parts. Providing the resection has been an extensive one, it is my custom at this time to remove the Esmarch bandage and to tie the articular, the anastomotica magna, and the recurrent tibial arteries. All hemorrhage from the bones stops when they are apposed. If the operation has not been so extensive, then in all probability these vessels have not been cut or at most only one or two of them; under these circumstances I do not remove the Esmarch bandage, but rely entirely upon the firm dressing and the elevation of the limb for controlling the hemorrhage. Two openings are now drilled in the femur and in the tibia, and through them are passed large-sized chromicized catgut sutures, which, after the popliteal tissues are held away from the bones and after the bones are apposed, are tied tightly. These stitches are not for the purpose of holding the bones after the operation is completed but rather at the time of applying the primary dressing. They enable the assistants to feel that the bones remain *in situ* and have not slipped from their original position. Complete reliance is placed upon the dressing for holding the bones in position.

If large sections of the femur and tibia have been removed a piece of the circumference of the femur may be sawn out and transplanted to the space between the tibia and femur, as in a flap operation upon the soft parts. Sykow was successful in one case in preventing shortening and in having the consolidation of the limb perfect in three months. His success may well be imitated in suitable cases (*Centralblatt für Chir.*, 1902, No. 15).

After the suture of the bones the capsule, the ligamentum patellæ, and the tendon of the quadriceps femoris are united with catgut. For the tendon and the ligament I use the chromicized catgut, which lasts for from fourteen to twenty days. For the capsule, I use simple catgut. The skin is sutured also with catgut.

Drainage is established only to give exit to the excess of blood, so that the employment of Maas' method or the insertion of rubber tissue into the incision wound is quite sufficient.

In operating upon joints which are flexed, it is best to straighten them as much as possible before operating. In this way one avoids removing too much bone and at the same time removes enough, so that the tissues in the popliteal space are not too much stretched. This stretching tends to displace the fragments, and by closing the vessels tends to produce gangrene of the foot and leg.

The author's method of dressing these cases has been most satisfactory. It consists in applying an even and not lumpy dressing of gauze from the ankle to the upper third of the thigh. Upon the outer side of this gauze dressing eight to twelve thin bass or white wood splints, cut in strips 2 to 3 cm. wide and boiled until they are not only aseptic but perfectly pliable, are applied over the joint and are bandaged quite loosely in position. Over this is placed a sufficient cotton dressing which is fixed with plaster-of-Paris bandages. This plaster of Paris is not thick; it is scarcely more than two bandages thick, except where it covers the knee. It extends from the toes to the upper third of the thigh. The limb is now placed in a Volkmann's splint, which can be suspended or raised in bed to the required height. No dressing nor splint which I have seen used holds the knee so firmly and without undue pressure as does this combination. The wood splints or strips, applied directly over an evenly applied gauze dressing, can be trusted, when they harden, to render slipping of the bone surfaces impossible. The plaster of Paris applied outside of the cotton and from the toes to the middle of the thigh holds the foot, leg, and thigh immovable, and exerts an even pressure upon all these parts. The Volkmann's splint protects and sustains the plaster-of-Paris dressing, which on this account need not consist of more than two thicknesses of bandage. This suffices for the immediate dressing, but fixation must be continued for a varying period after operation. Some have placed the period when ankylosis becomes complete at two months (Riedel, *Deut. Zeits. für Chir.*, Bd. xv.), others at from six to eight months (Volkmann's klin. Vorträge, 51), and still others at one year (Hoffa, *Arch. für klin. Chir.*, Bd. xxxii.). During this period the limb must be kept perfectly straight, and for this purpose plaster-of-Paris dressing is still used with perfect satisfaction. Windows can be made where necessary and the wound kept clean and healthy. There seem to me to be no advantages in the Howse or Hodgson splints which are not found in the above plaster-of-Paris dressing. Almost all the splints employed have the disadvantage of being complex and difficult to adjust. After splints have been removed, a leather support is usually applied. In children a support should be worn for from two to three years.

Results.—The age of the patient is important. The results are best, for either injury or disease, between five and fourteen years. Esmarch ("Beiträge zur Statistik der Kniegelenksresectionen," Kiel, 1883) had no deaths in 30 cases, Volkmann (Verhandl. der deutschen Gesell f. Chir., xiii.) no deaths in 20 cases. Hahn, Maas, and Schede have had similar results. In 1898 Napalkow reported 26 cases operated upon between seventeen and twenty-five years old, with no deaths ("Chirurgie," 1898, p. 345). These statistics for tuberculosis bring the mortality very low. The general mortality for all cases and under all conditions is at present about ten per cent. (Bothe, *Beitr. z. klin. Chir.*, vi., p. 282). The former high mortality of 7 per cent. for gunshot wounds, 40 per cent. for injury, and 30 per cent. for disease is being gradually reduced by a better selection of cases and an improved technique.

The final results of resections in children up to the fourteenth year show (Hoffa, *Archiv f. klin. Chir.*, xxxii., p. 763) that 6 per cent. of failures occur, most of which require amputation; that 7 per cent. die of tuberculosis in other organs at a subsequent period; that 58.47 per cent. have an ankylosis in the straight position, with neither genu valgum nor genu varum; that 41.53 per cent. have a flexion contracture due (1) to a faulty position of the leg and thigh at the time of operation, (2) to contracture of the flexors and atrophy of the quadriceps femoris, and (3) to the weight transmitted through the limb in faulty position. All of these conditions are avoided by obtaining a bony ankylosis in the extended position before the limb is used. Eighty-seven per cent. of the cases were permanent cures (54 per cent. without subsequent fistulæ, 33 per cent. with fistulæ requiring from one to twenty-one months to cure). One hundred per cent. of the cases show some interference in the growth of the limb, yet in 92 per cent. this is not greater in the intra-epiphyseal resections than in the conservatively treated cases (*loc. cit.*, p. 791). In 8 per cent. of the cases measured by Bothe (*Beiträge zur klin. Chir.*, vi., p. 208) lengthening had taken place. The final results in resections in which the subjects are older and in which the operation is either intra- or extra-epiphyseal, in so far as the bone section is concerned, are as follows:

In operations for tuberculous disease (443 cases) (Bothe, *l. c.*). Healed and useful limbs, 67.4 per cent.; incompletely healed, 13.7 per cent.; amputated, 8.8 per cent.; useless, 17 per cent.; mortality, 10.1 per cent.

In operations for gunshot wounds. Useful, 60 per cent.; required amputation, 24 per cent.; unknown, 16 per cent.

In operations for relief of deformity. Perfect, 19.5 per cent.; useful, 68 per cent.; unknown, 13.5 per cent.

The Atypical Resection.—By this is meant the method

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employed by Wright under the name of erasion and by Volkmann under the name of arthrectomy. It is an operation in which the synovial membrane and bursæ are removed entire and in which the bone foci are gouged out, scraped out, or chiselled out, while all that is healthy is left intact. An operation of this kind in more favorable cases consists of a synovial extirpation with the goug-

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FIG. 4087.

ing out of one or more small osseous foci; in the more extensive cases it consists of a nearly complete removal of the articular cartilage, *i.e.*, of an almost typical resection.

The operative technique is usually carried out by a transverse incision through the skin, subcutaneous tissue, lateral ligaments and fibrous capsule, down to the synovial membrane; reflection of this flap upward; and extirpation of the synovial membrane as recommended by Kocher for typical resections. It is now my custom, after the crucial ligaments are divided and the menisci removed, to examine the bones carefully, in order to determine from the beginning whether I can be content with a limited destruction of the articular cartilage, or whether this must be removed in greater part. It is at this stage that I determine whether my operation is to be the erasion or the intra-epiphyseal resection. Provided the former is the selection, the foci in the bones are removed by a gouge or chisel, and as much of the articular cartilage is saved as is possible. If two-thirds of the articular surface is intact, I then attempt to obtain a movable joint (eighteen per cent. in seventy cases, Maudry), and after dissecting away the posterior synovial membrane and the bursæ I suture carefully the capsule, the ligamentum patellæ, and the skin. I treat the joint subsequently as in fractured patella, with absolute rest for from four to six weeks. If one-half to two-thirds is removed by the gouge or chisel I remove the remaining articular cartilage by sawing intra-epiphyseally and I attempt to obtain an immediate bony union in the extended position. In my opinion the atypical and the typical intra-epiphyseal operations should be combined in this manner to obtain the best possible result of each method. Kocher, in order to avoid the cutting of the quadriceps tendon, makes the usual curved anterior incision, dividing the skin, subcutaneous tissue, and the fasciæ of the vasti muscles. He then makes upon each side of the quadriceps tendon two vertical incisions, which, meeting the incision in the fasciæ of the vasti, form two right-angled flaps which are retracted outward (Fig. 4087). The capsule and synovial membrane are now cleared as in the typical resection, and are removed together with the menisci and ligamenta alaria (Kocher). The crucial ligaments having been previously separated at the tibial eminence, the femur is dislocated outward or inward in order that the posterior and postero-lateral portions of the capsule be rendered accessible for removal. The condyles are now examined, and if necessary foci are removed. The patella is at last turned completely upon itself and cleared of all tuberculous or diseased tissue.

Either of these methods of exposure may be selected. For myself, I prefer the former method, dissecting out the synovial membrane in the manner recommended by Kocher for the typical resection.

RESECTION OF THE HIP-JOINT.—This operation was first performed by Whyte for deformity in 1818, for disease by Hewson in 1822 or by Brodie in 1836, and for gunshot injury by Oppenheim in 1829. The resections are classed as complete when the acetabulum is partially removed together with the femur, as partial when only the femur or the acetabulum is removed. They are typical or atypical, according to the modifications in the method of approach and the manner of attacking osseous tissue.

The indications for the operation are:

1. Gunshot wounds, where partial and atypical resections rather than typical and complete methods are undoubtedly indicated. With the new projectiles, conservative methods rather than operative should be employed unless the operative interference is confined to a correction tending to production of better wound healing.
2. Tuberculosis, where operative procedure is not to be delayed, but earlier interference recommended.
3. Deformities from injury or disease. Here partial or complete resections are alone indicated when osteotomy cannot correct.
4. Old dislocations from disease or traumatism, where partial operations are quite sufficient.
5. Intracapsular fracture of the neck of the femur followed by disability and pain. Here the partial resection confined to the femur is beneficial.
6. In dislocation of the head and fracture of the neck of the femur. Here removal of the dislocated head is sufficient.
7. Congenital dislocation in adults which have failed of reduction by manipulation. (Lorenz and Hoffa.)
8. In acute infectious arthritis. Here arthrotomy rather than resection will be found to be more beneficial.

Results.—The mortality of resections for gunshot wounds is, according to Culbertson, 89.07 per cent., while according to Gurlt it is 88.23 per cent. Gurlt classifies this mortality as follows: 92.68 per cent. for primary resections; 94 per cent. for intermediary resections; 89.39 per cent. for secondary resections; 60 per cent. for late resections. Otis gives a mortality of 90.9 per cent. in the primary resections, while similar cases treated conservatively give 98.8 per cent., and by exarticulation 83.3 per cent.

The mortality for disease is low. Culbertson gives 44.8 per cent., of which 6.93 per cent. represented deaths from operation directly, leaving 37.89 per cent. for deaths from the disease and its complications. Grosch (*Centralblatt für Chir.*, 1882, p. 228) gives a mortality, in 120 cases of tuberculosis treated antiseptically and observed to the end, of 36.7 per cent., which, compared with the results of Culbertson in pre-antiseptic times, shows that the cases dying from operation have been excluded by the present methods of operation, but that the deaths from the disease have not been diminished. Nor can it be said that the time of after-treatment is shortened, nor is the functional result better. These statistics include only cases operated upon late in the disease. The results of the operative treatment are better in proportion as the operation is early performed, and better in children than in adults. The mortality in the first stage, *i.e.*, in the

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Resection of Joints.

stage in which the changes in the joint are slight and in which sinuses have not formed, is 0 per cent. The mortality in the second stage, *i.e.*, in the stage in which fistulæ have formed and pus is present, is 24.1 per cent. The mortality in the third stage, *i.e.*, in the stage in which the patients are already debilitated by long-standing suppuration and fistulæ, is 67.5 per cent. Two-thirds of the deaths following operation are due to general tuberculosis or tuberculosis of other organs; one-third is due to septic infection, suppuration, and amyloid degeneration (Bruns, *Beiträge zur klin. Chir.*, xxii., 1894). The mortality at present is in the neighborhood of five per cent. (Wright, 3 : 100).

Functional Results.—Baehr reports 44 cases of resection which were able to walk: 8 with perfect motion = 18 per cent.; 23 with restricted motion = 52 per cent.; 11 with ankylosis = 25 per cent.; 1 with a flail joint = 2.5 per cent. Baehr also found that resection of the head alone gave 0.9 cm. shortening; of the head and neck, 1.5 cm. Subtrochanteric section gave a shortening of 4 cm. His views substantiate Riedel's: namely, that the early resections give less shortening than the continuance of the disease will give, and that motion in the joint is equally good or better (*Deut. Zeits. f. Chir.*, No. 30, p. 349). Mauninger (*Deut. Zeits. f. Chir.*, No. 65, p. 1) gives the statistics of 41 cases carefully observed. The shortest time during which a patient was kept under observation after operation was one year and six months. The following are the classified results: 41.02 per cent. were healed without fistulæ; 17.07 per cent. were healed after treatment for fistulæ or after subsequent operations; 9.75 per cent. were healed, but now and then a fistula would open and close. The general health of these patients was good. In 67.84 per cent. the results were good. In 11.195 per cent. of the cases the health was bad, and the wounds suppurated profusely; 21.95 per cent. of the patients died. The results were bad in 33.145 per cent. of the cases. Of the deaths (21.95 per cent.), 1 was due to fat emboli in the lungs. In about 10 per cent. the cause was miliary tuberculosis, which followed the operation in from one to five months, and the development of which was probably hastened by the operation. In another 10 per cent. of the cases death was due to tuberculosis of internal organs, the disease developing from one to ten years after the operation.

Functional results in these cases must be considered in reference to the condition of the extremity at the time of operation. In no case had the disease in the hip lasted less than two and three-fourths years, so that the operation had to do with (1) the shortening of the extremity due to an atrophy from inaction—4 to 8 cm.; (2) slipping upward of the head of the femur upon the ilium—2 to 3 cm.; (3) contracture of the soft parts (muscles, etc.), usually a flexion-contracture of thirty degrees and an adduction-contracture of twenty degrees; (4) atrophy of the musculature of the pelvis and femur. Yet, in spite of this condition of affairs, in 50 per cent. of the cases in which good results were obtained good motion was present; in 50 per cent. of these cases a cane with or without a high shoe was used in walking. With the exception of one case, all limped more or less; *i.e.*, most patients walked from two to four hours without pain or special fatigue. All followed their vocations. In 50 per cent. their general health was good; in 50 per cent. it was very good. With the exception of one case in which multiple caries existed, no case was suspected of having tuberculosis in other organs. Mauninger collected, in addition to these cases, 304 cases which were operated in the aseptic period of surgery. Permanent healing took place in 65.8 per cent. The mortality was 17.4 per cent. The question to-day is whether conservative treatment will give as good or better results than the operation.

The statistics of Gibney, Waterman, and Reynolds, of 114 cases examined five years and upward after leaving the hospital, show that 107 were cured and able to follow an occupation without trouble; 7 cases were cured, but with considerable deformity, for which osteotomy or excision was done. About 14 per cent. showed perfect motion, 20.5 per cent. good motion, 38 per cent. limited motion, and no motion in about 8 per cent. Shortening of the limb averaged 1.75 in. (*i.e.*, 4 cm.) in all the cases except in 21 in which it was absent, *i.e.*, 19.5 per cent. (*Annals of Surgery*, 1897, vol. ii.).

The statistics of Mauninger (*loc. cit.*), obtained for the conservatively treated cases, give the following results as regards the cures and deaths: purulent cases, 27.1 per cent. healed, 48.8 per cent. mortality; non-purulent cases, 74.2 per cent. healed, 16.5 per cent. mortality.

The results of conservative treatment are therefore, in reference to mortality, no better than those obtained by the operative method, for even if the cases of death due to operation alone or induced by the operation be included, still the operative cures present a mortality of only 17.4 per cent. as against 16.5 per cent. in the non-suppurative cases and 48.8 per cent. in the suppurative cases treated conservatively. If in this comparison cases be deducted in which the disease is attacked early before suppuration exists, the mortality ranges from 0 (Bruns) to 3 per cent. (Wright)—a result far superior to that shown by the statistics of the cases treated conservatively, and even better than the results obtained by Gibney—8.8 per cent.—or by Marsh—6 to 8 per cent.—("Diseases of Children") for the conservative treatment.

The functional results are quite as good—perfect motion being obtained in 18 per cent. of the operative cases (Baehr), in 14 per cent. of the conservative (Gibney, *et al.*). Even in the cases reported by Mauninger, operated after two and three-fourths years of the disease, 67 per cent. were good results; one-half of these patients had motion and one-half walked with a cane. All could follow their vocations. These excellent results obtained by both methods of treatment depend much upon two factors. In the first place, in the conservatively treated, some cases of *restitutio ad integrum* are due to the fact that the disease was non-tuberculous (Karewski). Again, in the cases treated by operation much will depend upon the time at which the operation is performed. Operations are not to be performed because conservative treatment has failed, but at an early stage when fistulæ and suppuration are not present, or, if they are present, only to a small extent (Wright, "Diseases of Children"; Barker, *Lancet*, 1900, vol. i., 1099).

The shortening in the limb is less by the operative treatment than by the conservative treatment. In the older cases the average shortening from operative procedures is not increased over that which is present at the time of operation and which is due to the atrophy of inaction, the slipping upward of the head of the femur, and the contracture of the limb. In the early cases, the statistics of Baehr show that shortening for any section made on a line situated higher up than below the trochanter is very slight (0.9 to 1.5 cm.), while average shortening in the conservative treatment is 4 cm., with 19 per cent. of the cases showing practically no shortening (Gibney), *i.e.*, less than ½ in. or 1.25 cm. Our view is that operation should be carried out as soon as it is clear that conservative measures cannot prevent suppuration. A resection is indicated so soon as suppuration exists in the joint and before fistulæ are present (König, "Das Hüftgelenk," Berlin, 1902).

In the wealthy class, where long-continued mechanical treatment can be carried out and where iodoform injections can be made as indicated, suppuration can oftentimes be prevented and a result obtained which, as we have seen, gives perfect motion in fourteen per cent. of the cases. In the poorer class, who cannot afford or will not carry out this long-continued mechanical treatment, suppuration is more frequent, the deformity is greater, and the destruction of the bones is more marked than is the case in those who have been able to command mechanical treatment and have followed it faithfully. In these latter cases operative treatment is frequently indicated and will give results superior to those offered by the conservative treatment both in respect to function and in respect to mortality, when like degrees of disease are compared.

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Anatomy.—The hip-joint is deeply placed and is immediately surrounded by the psoas and iliacus muscles; by the quadratus femoris, the obturator internus, the gemelli, and the pyriformis behind; by the gluteus medius, gluteus minimus, and rectus femoris externally; and finally by the pectineus and obturator externus internally. Beneath these muscles is the thick capsule, the auxiliary bands of which are the ilio-femoral, the pectineo-femoral, and the ischio-femoral, the border of which latter is known as the zona orbicularis. Between the ilio- and ischio-femoral bands the capsule is strong; opposite the lower and back part of the femoral neck and opposite the cotyloid notch it is thin. Within the joint is the ligamentum teres, a flat band extending from the acetabular notch to the depression in the head of the femur. The marginal fibro-cartilage and the transverse ligament complete the ligamentous structures. The synovial membrane lines the capsule and passes over the border of the acetabulum to cover the round ligament. The bursæ are numerous and of frequent occurrence; upon the outer and anterior surfaces there are five, while upon the posterior surface there are four.

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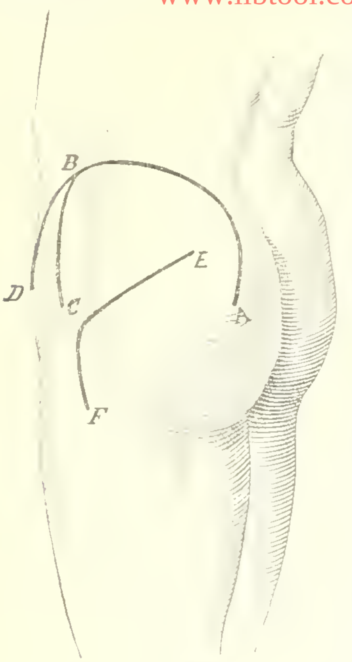

Fig. 4088.

The bones consist of the innominate and the femur. The former contains the acetabulum, a hemispherical cavity which receives the femur. The latter consists of a rounded head and a neck, which latter is long and joins the shaft obliquely, *i.e.*, at an angle of one hundred and twenty-five degrees.

Ossification occurs in the head of the femur and in the greater and lesser trochanters, respectively, at the first, fourth, and thirteenth years. They join the shaft in the reverse order at the eighteenth, eighteenth and a half, and nineteenth years.

The acetabulum ossifies at the sixth year from the Y shaped cartilage occupying its centre. At the fourteenth the ilium and ischium unite with the acetabulum. The pubis does so at the fifteenth year. Ossification is completed in the acetabulum at the seventeenth year.

Owing to the obliquity and the length of the neck of the femur, the muscular attachments to the bony prominences have great leverage and a wide range of motion is possible. When the head is removed these muscles tend to draw the femur upward unless the neck is engaged in the cotyloid cavity. If the neck is also removed, the abduction and rotation of the femur are lost. The pelvi trochanteric and all muscles passing between the pelvis and the femur cause the femur to ascend, which ascension is limited only by the tension of the capsule. The shortening, then, in any resection will depend upon: (1) The loss of the epiphyseal cartilage. This is slight. (2) The amount of bone removed. (3) The muscular displacement of the femur. (4) The atrophy of the limb from disuse.

This shortening is partly corrected by the inclination of the pelvis on the side operated. The object to be acquired in a resection is a nearthrosis or a tight pseudarthrosis. They give the best results in walking. To obtain either, the neck must be retained in the acetabulum or in apposition with the bone at this level, and not allowed to ascend. Owing to the inclination of the pelvis after shortening, the femur must be retained slightly flexed and abducted upon the pelvis. The main points, then, are to preserve the greatest possible length, to obtain a solid, slightly mobile union with the acetabulum, and, lastly, to preserve the proper position in the limb.

Methods.—The hip-joint has been removed by several methods of incision.

1. By the external incision. First proposed by Charles White in 1769, and modified by Langenbeck in 1867 (*Langenbeck's Archiv*, No. 16, p. 24), by Sayre in 1874 (personal communication from son), and still later by Ollier ("Regénération des Os," t. ii., p. 384) and Kocher (*Correspondenzblatt f. Schweizer Aerzte*, 1887, Dumont).

2. By the anterior incisions. (*a*) The longitudinal (Schede, Verhandl. der deut. Gesell. f. Chir., i., p. 68, 1878; Lücke, *Centralblatt für Chir.*, 1878, p. 681; Hüter, 1878, "Chirurgische Operationslehre," Löbker; Parker, Transactions of the Clinical Society, vol. xiii., 1880; Barker, *British Med. Journal*, vol. i., p. 1326, 1888). (*b*) The transverse (Roser, "Chirurgisch-anatomisches Vademecum," 1870).

3. Posterior incisions, Hueter ("Die Gelenkserkrankungen," 1877); Guérin ("Manuel Opératoire" of Farabœuf); Bidder (*Langenbeck's Archiv*, No. 39).

4. Superior incisions, Bardenheuer (*Langenbeck's Archiv*, No. 41), H. Schmid (Verhandl. der deut. Gesell. f. Chir., 1891); Sprengel (*Festschrift Braunschweiger Aerzte*, 1898).

In addition to these, there are from fifteen to eighteen other modifications of these methods of approaching the joint ("Manuel Opératoire," Farabœuf). They are of little value. Of these methods of entering the joint three are selected: 1. The external incision. 2. The anterior longitudinal incision. 3. The superior incision.

1. *Operation by the External Incision.*—The patient lies upon his sound side with the thigh flexed upon the pelvis at an angle of forty-five degrees. It is also rotated inward. One assistant holds the limb with one hand upon the knee and the other upon the foot and produces the required positions during the operation. The operator stands behind the thigh and is usually aided by two assistants.

An incision is made which may correspond to that of Langenbeck, Sayre, Ollier, or Kocher. If Langenbeck's is selected, it passes from the posterior superior iliac spine over the great trochanter behind its centre and follows the axis of the femur. Two-thirds of this incision is above the trochanter one-third is below it. If Sayre's incision is selected, it passes from a point mid-

Fig. 4089.

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Resection of Joints.

way between the anterior inferior spine and the trochanter across the top of the great trochanter behind the centre, and curves thence forward and inward. If Ollier's incision is selected, we flex the thigh on the pelvis at one hundred and thirty-five degrees. From a point four fingers' breadth behind the anterior superior spine

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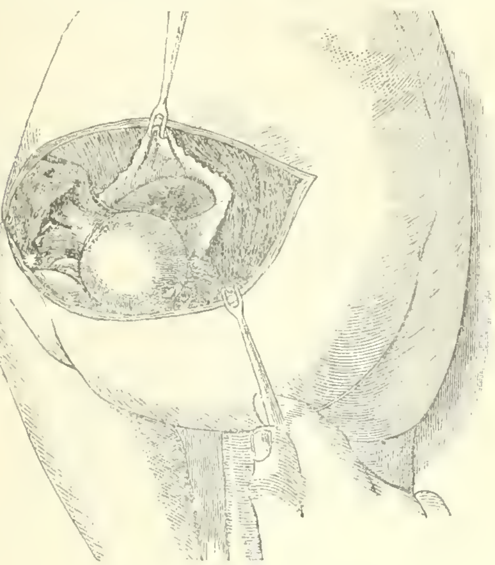

FIG. 4090.

and the same distance below the crest of the ilium, the incision passes downward and forward in the direction of the fibres of the gluteus medius to the trochanter, thence forward and downward in the axis of the femur. If Kocher's incision is selected, it commences at a point opposite the upper border of the great sciatic notch in a line connecting the posterior superior spine of the ilium and the centre of the trochanter major, and descends parallel to the fibres of the gluteus maximus to the trochanter major on its external surface. From this point it bends backward and downward. The upper limb of this curve is usually 8 cm. in length, the lower 6 to 8 cm. (Dumont, *Correspondenzblatt f. Schweizer Aerzte*, 1887).

Of these incisions I prefer Kocher's, because of the ready exposure of the parts which it affords, and the easy access which it gives to the joint through the muscular interstices, thereby avoiding the arterial and nerve supply of the muscles (Fig. 4088, *E F*).

Having selected the latter incision, the surgeon should divide the skin and deep fascia and thus expose the fibres of the gluteus maximus in the upper two-thirds of the cut. These are divided parallel to their length and in the line of the skin incision. Two or three branches of the gluteal artery are usually cut here in their middle. Two retractors are introduced, the gluteus medius and pyriformis are exposed beneath this muscle internally, while externally the trochanter is felt. The knife now divides the strong fascial attachment of the gluteus maximus, passing over the trochanter and descending in the interstice between the vastus externus and the quadratus femoris (Fig. 4089). In this incision the tendon of the gluteus maximus is in part divided, and this division, by reason of the resulting retraction, exposes the muscles covering the joint behind and the trochanter in front. It is here that the external circumflex artery is sometimes cut. The interstice between the pyriformis behind and below, and the gluteus medius above and in front, is seen in the anterior part of the exposed area. Below this is seen the interstice between the pyriformis above and the gemelli and obturator internus below. It is between the latter muscles that the incision is deepened, since in the upper retracted flap will be the gluteus medius and pyriformis supplied by the superior gluteal nerve, while in the lower retracted flap will be the obturator internus and gemelli supplied by the inferior gluteal artery. The joint capsule is now exposed throughout its length and should be divided by an incision which runs parallel to the axis of the neck of the femur, and at the same time divides the periosteum of the neck, the orbicular zone of the ischiofemoral band, the capsule and the circumferential fibrocartilage of the acetabulum. This incision is usually sufficient to allow dislocation of the head of the femur, but, if it does not suffice, a transverse incision may be added near the acetabular margin. The internal circumflex artery is usually cut here as it passes over the capsule. The incision in the periosteum of the neck is now continued over the trochanter major upon its posterior border, and the periosteum, together with the attachment of the gluteus medius above, the pyriformis internally, the gluteus minimus, the vastus externus, and the Y-ligament anteriorly, is separated with the rugine. This separation is greatly facilitated by flexion and rotation outward of the thigh. It is here that the external circumflex artery is often cut a second time. This flap can now be pulled forward over the trochanter. It contains within, if we exclude the small portion of the vastus externus, only those muscles which are supplied by the superior gluteal nerve. The thigh is now less flexed, adducted, and rotated inward. The tendons and the periosteum are separated with the rugine from the apex and posterior half of the trochanter as far as the origin of the quadratus femoris from the linea quadrati. These tendons, namely, the gemelli, the obturator internus and externus, and as much as is necessary of the quadratus femoris, are now retracted backward and downward with the capsule. These muscles are all supplied from the inferior gluteal or sciatic, whose branches are uninjured.

When these capsulo-periosteal flaps are freely retracted, the posterior surface of the head of the femur, its neck, and the trochanter are in view. The sciatic nerve is free from danger, being carried away from the joint when the obturator internus, the obturator externus, and the quadratus femoris are divided and retracted.

The thigh is now strongly flexed, adducted, and rotated inward. The round ligament is divided if intact and the head is luxated (Fig. 4090). The remaining periosteum and capsule upon the neck is separated with the rugine. The head is now held firmly with the lion-toothed forceps, the soft parts are protected by the retractors, and the bone is sawn with the Gigli saw just below the level of disease or injury.

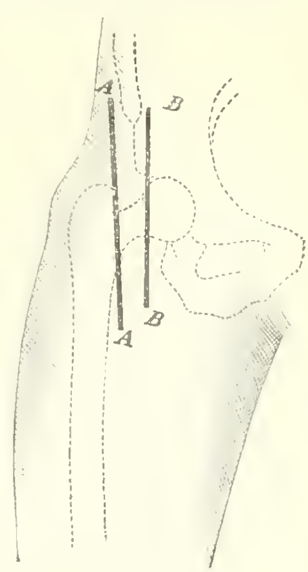

FIG. 4091.

The acetabulum is next removed with the gouge, chisel, or Volkmann's spoon, according to the indications. The synovial membrane and parts of the capsule are removed after the bones are cleared of disease. If sinuses are present they must be excised or curetted. Hemorrhage usually consists of oozing, and can be stopped by hot saline solution; if it is very troublesome the wound may be packed with gauze. Where no oozing is present and no sinuses exist the wound may be closed directly. If, however, abscesses, sinuses, or great oozing is present, it is best to pack with gauze, for a time at least.

The section in the bone should be made in the neck if

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possible, if not, through or beneath the trochanter major, because of the shortening which is liable to ensue.

A nearthrosis is best secured when the section passes through the neck near the head, yet subtrochanteric sections have given as good results in the restoration of the joint. Such cases are seen in the autopsy shown by J. Israel (German Surgical Congress, 1883) and in the collection made by Sach (*Deutsche Zeitschrift für Chir.*, xxxii.). In some of these cases a newly formed head covered with fibro-cartilage, a new trochanter, and synovial membrane were reproduced to a considerable extent. To obtain the best results, one must operate early in the disease, early in life (three to fifteen years), and subperiosteally, and must preserve as much of the bones as possible, so as to diminish the shortening.

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FIG. 4092.—Löbker's Spoon-Elevator. (About ½ natural size.)

When a nearthrosis is not attainable or is inadvisable, the after-treatment should secure the retention of the limb in abduction with the slightest flexion. This gives a very good and useful limb.

2. *Operation by the Anterior Incision.*—The only incisions here considered are those which are longitudinal. The transverse are too destructive of the soft parts.

According to Lücke and Schede, the incision commences one finger's breadth below and to the inner side

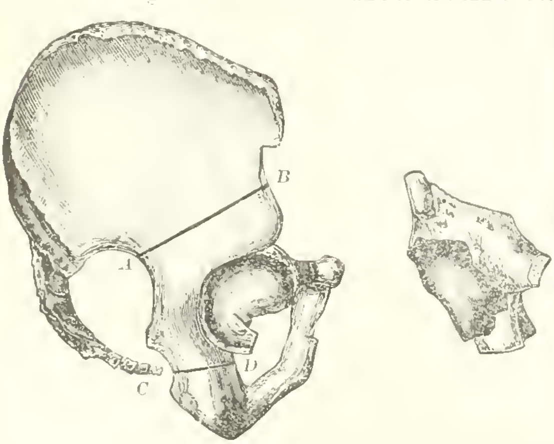

FIG. 4093.

of the anterior spine and descends in the long axis of the femur for a distance of 10 to 12 cm. (Fig. 4091, *BB*). As it is deepened it passes to the inner side of the sartorius and the rectus muscles and to the outer side of the ilio-psoas muscle. The crural nerve and the external circumflex artery are avoided. The assistant flexes, abducts, and rotates outward the thigh. The sartorius and rectus muscles are drawn outward, the ilio-psoas muscle and the crural nerve inward. The capsule of the joint is exposed and is divided by a crossed incision, the transverse portion parallel to the neck passing from the acetabulum over to the anterior intertrochanteric line, while the vertical portion crosses this line at a right angle. The neck is now sawn with a Gigli saw and the head is extracted after dividing the ligamentum teres by Löbker's spoon-elevator (Fig. 4092) or by a lion-toothed forceps. For the extraction of the head alone this incision may suffice, but if we wish

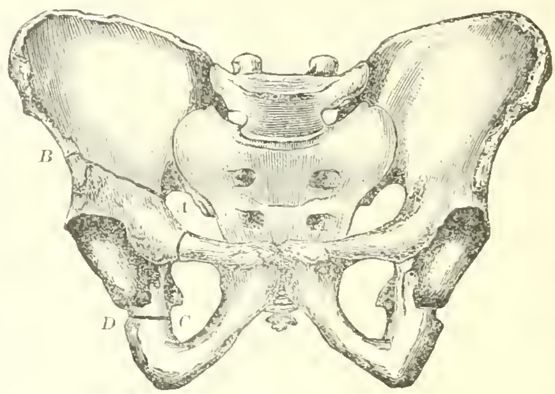

FIG. 4094.

to reach the trochanter in addition we must advocate the incision of Hueter which has been much used and strongly advocated by Barker. In this latter method, the patient rests supine with the thighs extended; the surgeon makes an incision which, according to Hueter, passes from the middle of a line drawn from the anterior superior iliac spine to the trochanter major, downward and slightly inward along the outer border of the sartorius. In children the incision is 6 to 8 cm., in adults 10 to 15 cm. in length. According to Barker, the incision commences in the anterior surface of the thigh, one-half inch below the anterior superior spine of the ilium, and runs downward and inward for three inches (Fig. 4091, *AA*). With either incision, the dissection is carried in the space between the sartorius, anteriorly, and the tensor vaginæ femoris and the gluteus medius behind. The incision is deepened to the bone and some fibres of the vastus externus are divided. In the lower angle of the wound is seen the external circumflex artery, which may be divided. These muscles are retracted, the joint capsule is seen and is incised by the same cross incision mentioned in the Schede-Lücke method. After this exposure of the head and neck, the spoon-elevator may be used and the trochanter freed of its muscles sufficiently to allow an easy exposure of the joint. The diseased head is now removed after encircling the neck and dividing it with the Gigli saw. The removal of the head is often difficult unless it be much diseased. With the lion-toothed forceps the removal is often very difficult and the soft parts and the head are often crushed. The easier method is to pry the head out of the acetabulum by introducing a strong, gently curved elevator or Löbker's spoon in the space between the head and the acetabulum, and after the ligamentum teres has been divided the head is then easily removed.

The bleeding by this anterior incision is small in amount if one avoids the anterior circumflex artery. Drainage of the wound will require not infrequently a posterior opening, but in many cases operated early all necessary drainage can be secured through the anterior incision.

In neither of these methods by the anterior incision are muscles cut. Neither nerves nor vessels are injured. In both methods the route to the joint is a direct one. The advantage of the Hueter incision over the Lücke-Schede

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incision is that the trochanter, as well as the head and neck, can be reached.

When the acetabulum is primarily involved, or the x-ray and the clinical symptoms show that the disease which affects it must be especially attacked, the methods introduced by Bardenheuer (*loc. cit.*) and Schmid (*loc. cit.*) give the best chances for radical cure. As usual methods, these procedures are considered at present too extensive. In Bardenheuer's hands, the mortality due to the operation alone was 4.3 per cent. In Schmid's hands, the recurrences were not lessened by the procedure, two of the four cases dying of continued tuberculosis. In the large majority of cases the Kocher incision will give sufficient exposure to enable us to chisel or gouge away the diseased acetabulum; and as this method is less extensive and more easily accomplished it should be preferred.

Operation by the Superior Incision.—In a few cases, Kocher's operation is not sufficient, and we recommend for these the suggestion of Sprengel ("Zur operativen Nachbehandlung alter Hüftresectionen," *Festschrift*, 1898), which consists in making an extensive incision along the crest of the ilium from the posterior superior spine of the ilium to the anterior superior spine of the same. This incision divides the muscles and the periosteum. At the border of the gluteus medius and the tensor vaginæ femoris this incision descends to the trochanter major. (Fig. 4088, *ABC*.) This quadrilateral flap is removed subperiosteally from the ilium until the joint is opened and the head and neck of the femur are exposed. As the nerves and vessels are avoided by this, the muscular paralysis and hemorrhage are practically nil. If the disease is well forward in the acetabulum and pubis, especially if a flexion-contracture exists, the incision is made in front of the tensor vaginæ femoris, sartorius and rectus, and these muscles are separated with the rest (Fig. 4088, *ABD*). After exposing the head of the femur, it is rotated inward or outward, as occasion demands, and adducted strongly. If the acetabulum alone is to be removed, this can be easily accomplished with the chisel or gouge through the incision first recommended (*ABC*). If the disease requires a resection of the acetabulum and the surrounding bone, the second incision is used (*ABD*). In this latter case the outer surfaces of the ilium, the acetabulum, and the outer margin of the great sciatic notch are bared of their periosteum. In like manner the internal surface of the ilium, the iliac fossa, is freed from the pelvic fascia and muscles until the great sciatic notch is reached. A Gigli saw is then inserted through the sciatic notch beneath the iliac muscles and over the anterior inferior spine of the ilium and the bone is sawn (Figs. 4093 and 4094, *AB*). The horizontal ramus of the pubis is next cleared of its periosteum, carrying with it the vessels, which are displaced from 1 to 2 cm. internally. An aneurism needle now carries a Gigli saw around the ramus and out of the obturator foramen (Fig. 4091, *CD*). The bone is sawn. As the bone is now cut upon two sides, it can be displaced outward somewhat. The periosteum is next removed from the descending ramus of the ischium from above downward with great care to avoid injuring the vessels and nerves as they pass out of the pelvis. The Gigli saw is again passed around this ramus at a point one finger's breadth beneath the acetabulum (Figs. 4093 and 4094, *EF*). The bone is sawn. The acetabulum and surrounding bone can now be quite easily removed with the heavy lion-toothed forceps. If the head of the femur is to be removed with the acetabulum, it is best removed before we attempt the resection of the acetabulum.

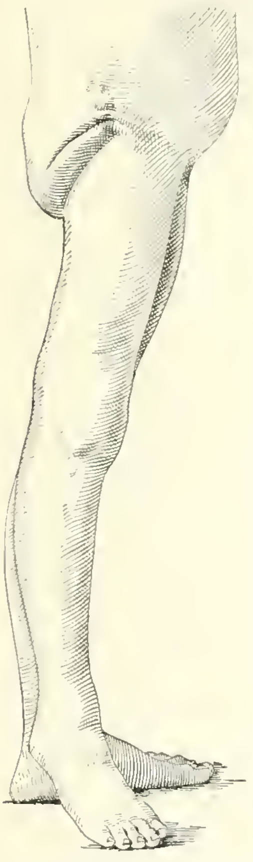

FIG. 4095. A Patient Three and a Half Years After Removal of One-Half the Pelvis and the Head of the Femur. (Kocher.)

After the hemorrhage has been controlled the wound is closed with sutures except in some portion where the packing emerges. It is best in all cases to pack the large wounds for from twenty-four to forty-eight hours, in order to control hemorrhage completely. After this, that portion from which the gauze emerges can be left for drainage or it may be sutured at this time.

After-Treatment.—The after-treatment in resection of the hip is important. An aseptic dressing, equable compression and rest for the wound are the first desiderata. The position to be maintained is that of extension and abduction of the thigh, with the neck or the trochanter closely applied to the acetabulum or ilium. During the first three weeks, since these wounds are packed with gauze and require secondary suture or dressings, a Buck's or Volkmann's extension apparatus with plaster-of-Paris spica passing to the knee is most frequently used. After this period, when the packing is removed or the wound is healed in great part, a Thomas splint or the plaster-of-Paris dressing may be used for the next three weeks. If the patient is up and about upon crutches (children), a Thomas splint is very inexpensive and satisfactory. If the patient is confined to bed, a plaster-of-Paris splint which can be readily removed for the active exercise of the joint is the more useful form of splint. During this period of three weeks, active exercise in the new joint is made every two or three days.

During the following three to six weeks patients are allowed to walk with their splints, and during this time the Taylor hip splint or some modification of it is substituted for the former apparatus. These splints allow flexion, extension, and abduction when applied, and the surgeon must continue the extension and abduction of the limb for a long time to overcome the constant tendency to flexion and adduction. It is only by this careful after-treatment that a good functional result can be obtained. *Frank Hartley.*

RESECTION OF THE SUPERIOR MAXILLA.—HISTORY.—Partial removal of the superior maxilla for alveolar growths, necrosis, disease of the antrum of Highmore, etc., has probably been practised for a very long time, but the complete, formal resection of this bone appears to have been first proposed by Lizars in 1826.

In the following year Gensoul, quite independently of Lizars' suggestion, performed the operation, and therefore seems entitled to the credit of having first executed this procedure.

The indication for resection of the upper jaw is almost invariably the presence of a new growth. Hueter states that the jaws are more frequently the seat of tumors than any other bones of the skeleton. Almost every variety of neoplasm is found in connection with these bones.

Benign tumors such as cysts, epulis, adenomas, fibromas, chondromas, osteomas, etc., require partial resections only; merely enough of the bone being removed to give access to the tumor or to effect the complete removal of the latter.

Complete resection of the superior maxilla is usually done for malignant growths, *i.e.*, carcinomas and sarcomas, affecting the bone. They occur with about equal frequency. The majority of the former begin in the alveolus.

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Anatomy.—The superior maxilla is the largest bone of the face, the lower jaw (mandible) excepted, and with its fellow forms the whole of the upper jaw. Each bone forms a part of the wall of three cavities: the mouth, the nasal fossæ, and the orbit. It is hollow, its cavity being known as the antrum of Highmore, which communicates by an aperture with the middle meatus of the nasal fossa. Either of these cavities may be the seat of new growths which involve the maxilla; the mouth and the antrum being most frequently affected. The mucous membrane of the antrum is frequently the seat of a catarrhal or purulent inflammation, giving rise to an excessive discharge through the nose, or if the fluid is prevented from escaping, the thin walls of the bone yield, and protrude toward the cheek, toward the mouth, or in both directions, the appearances then simulating those observed in solid growths of the bone.

Instruments Required.—Mouth gag, sponge holders, scalpels, toothed dissecting forceps, hæmostatic forceps, scissors, keyhole saw, Hey's saw, tooth forceps, bone-cutting forceps of different angles, chisels and mallet, lion-jaw forceps, sequestrum forceps, Paquelin cautery, tracheotomy tube, needles, straight and curved, ligatures, sutures, marine sponges.

Partial resection for alveolar tumors and necrosis may be carried out through the mouth in most instances, without making any external incisions. The removal of other benign growths must be carried out on general surgical principles. The affected part is approached by incisions designed to avoid important structures and to give the best exposure with the minimum resulting deformity, and the neoplasm, together with the bone to which it is attached, is then removed.

If the tumor is open to the suspicion of being malignant, a generous portion of the adjacent bone in all directions should be removed, or the complete resection may be advisable.

The dangers of resection of the superior maxilla are: hemorrhage, the entrance of blood into the air passages, and septic pneumonia.

Various means have been adopted by different operators with the view of controlling the hemorrhage. The internal maxillary and temporal arteries, and the external carotid artery have been ligated as a preliminary step in the resection. The common carotid has been compressed and subjected to temporary and permanent ligation. Crile has devised a clamp to be applied to one or both common carotids, as may be necessary, for the temporary control of bleeding during operations on the head and face if serious hemorrhage is probable.

With the view of preventing the blood from flowing into the air passages, Rose advises that the patient's head be allowed to project beyond the end of the table, and to drop well down so that the vertex points vertically to the floor. In this position the mouth and nose are on a lower level than the larynx and the blood would escape from them before it would enter the latter.

The objection to this position is that the surgeon is obliged to work at a great disadvantage, and the hemorrhage is greater when the head is dependent than when it is elevated.

Some surgeons perform a preliminary tracheotomy, introducing a tube, and continue the anæsthesia through this, so that the pharynx may be packed with marine sponges to which stout strings have been attached to assist in their withdrawal. The sponges absorb the blood that finds its way to the pharynx and prevent any from flowing into the trachea.

Of this procedure it may be said that while a carefully performed tracheotomy that is well cared for afterward does not add much to the dangers of the operation, it is an additional complication, and is usually unnecessary.

The use of Trendelenburg's tampon cannula for the trachea answers the same purpose as the tracheotomy, and is open to none of its objections.

The methods which are employed in preventing the entrance of blood into the lungs do not diminish in the least the amount of blood lost. By having the patient only partially anæsthetized, he will be able to spit out the blood and thus keep his air passages free. In this way the necessity for adopting the measures spoken of will be avoided, and if the operation be expeditiously performed, the amount of blood lost will not be great.

To summarize, it may be said: (1) That Rose's position is not to be recommended. (2) If no complications are to be expected, the operation may be done with the patient but partially anæsthetized. If this plan be adopted, everything that may be needed should be at hand, and there should be an ample number of assistants, so that not an unnecessary moment shall be lost after the operation has actually begun. (3) In performing the operation for vascular tumors affecting the bone, or when for any other reason unusually free bleeding may be expected, it will be advisable to pass a loop of silk about the external or common carotid, traction upon which will occlude the vessel, or, if at hand, one of Crile's clamps may be applied. In either case, especial care must be exercised to prevent infection of the wound exposing the artery, as such an occurrence may readily be more serious than the resection of the bone. (4) If there is no reason to expect serious hemorrhage, these precautions become unnecessary. On the other hand, if a more deliberate operation is required, as in cases in which tumors have passed the limits of the maxilla and must be followed in whatever direction they have taken, the advantage of having a dry wound, so that every portion may be inspected without being obscured by blood, cannot be overestimated. In these instances some method of controlling the circulation is of inestimable value.

Septic pneumonia is best prevented by having the nasopharynx treated before the operation by cleansing sprays, douches, and gargles, and by keeping the cavity sweet and clean after the operation.

Operation.—A number of methods have been devised for resecting the superior maxilla, and many of them have been named after the operator who devised them. The chief variation is in the skin incisions employed to expose the bone, the mode of actually removing the latter being essentially the same in all.

In the classical resection the incision variously known as the median, Fergusson's, Nélaton's, Liston's, Weber's, etc., is beyond question the best. It gives ample exposure and is followed by less disfigurement than is any other incision. For partial resections and special cases some of the other incisions may be more suitable.

The incision from the angle of the mouth to the malar bone has been ascribed to Lizars and to Velpeau. Langenbeck exposed the bone by a U-shaped flap, beginning at the side of the nose, at the point of junction of the nasal cartilage and bone, and carried downward, outward, and upward, terminating at the middle of the malar bone. Liston's incision extended from the angle of the mouth to the external angular process of the frontal bone. Gensoul made three incisions: the first from just below the inner canthus, down the side of the nose, and through the upper lip; a second at right angles to this, on a level with the floor of the nose, as far out as a line perpendicular to the external angular process of the frontal bone; and a third, from the termination of the second to the external angular process.

The anæsthetic may be either ether or chloroform, according to the custom of the surgeon. If the thermocautery is to be employed to control bleeding, chloroform should be administered on account of the inflammable character of the vapor of ether.

The patient should be placed on his back, with the head and shoulders raised on pillows, the affected side being uppermost. His face should have been cleanly shaven.

The median incision is made in the following manner: The knife should enter the skin about half an inch below the inner canthus, and the incision should then be carried downward in the line of junction of the nose and cheek to the ala nasi, around and close to the latter, and it should stop just short of the middle line of the lip, from which point it should be extended vertically through the lip to its free border. The incision should be carried down to

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the bone at once, all bleeding points being caught by pressure forceps. Finally, a second incision is to be carried along the lower border of the orbit from the beginning of the first to the malar bone.

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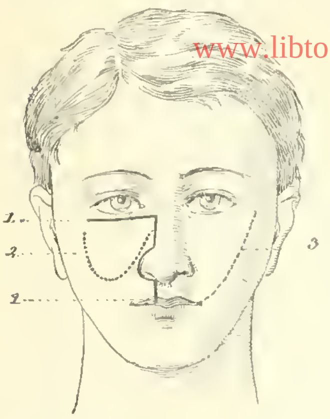

FIG. 4096.—Resection of the Superior Maxilla. 1, The median incision (also called Fergusson's, Nélaton's, Liston's, and Weber's); 2, Langenbeck's incision; 3, Lizars' or Velpeau's incision.

The flap thus outlined should be rapidly dissected from the bone, all bleeding points being secured by forceps or by sponge pressure.

At this stage it is well to tie off such forceps as interfere with the subsequent steps, and to arrest all bleeding as far as possible. The malar bone is next divided at about its middle by Hey's saw. If it is proper to leave the orbital plate a second saw cut is made in the line of the second incision, beneath the orbit as far as the nasal process. If the orbital plate is to be removed, the periosteum is incised along the lower border of the orbit and carefully separated from the bone as far back as necessary, and the floor of the orbit divided at the proper line with a chisel and mallet; or if it is necessary to remove the orbital plate entire, the periosteum is fully separated and it is wrenched from its connections at the time of removing the maxilla.

The nasal bone and nasal cartilage are next separated from the maxilla by means of a saw or chisel. The upper central incisor tooth in the affected maxilla must now be extracted and the mucoperiosteum covering the hard palate divided near the middle line from before backward; the soft palate should also be separated by a transverse incision along the posterior border of the hard palate on the diseased side. By means of a keyhole saw introduced into the nostril the hard palate is divided in the line of the incision in the mucoperiosteum as rapidly as possible. The bone is then grasped by lion-jaw forceps and wrenched from its remaining attachments, the principal one being the pterygoid process. At this stage the use of the bone-cutting forceps bent at an angle may be required to sever any firm connections. Sponges should be instantly thrust into the cavity and pressure exerted to check the bleeding, and the patient's throat should be cleared of any collection of blood. The sponges may now be removed one by one, and the bleeding points dealt with by ligation or by the thermo-cautery. Usually the hemorrhage will cease after a few moments' pressure.

It will be necessary to pack the wound with gauze which will effectually arrest oozing, but it must not be depended upon to control spurting vessels. Each piece of gauze introduced should have firmly attached a strong thread to assist in its removal. After the operator has assured himself that the hemorrhage is controlled, he should replace the flap and should suture it in position by means of silkworm gut. Especial care should be observed in adjusting the free margin of the lip.

If the bone is much diseased it is apt to break, and must then be removed in fragments. In such cases every portion should be examined for evidences of remaining disease and all such tissue removed.

The advantage in leaving the floor of the orbit when possible is that the eye is not disturbed. When it is removed, the eye drops somewhat, and the lower lid is apt to remain red, swollen, and distorted.

The removal of both superior maxillæ becomes necessary in rare instances. The technique is the same as that described above save that it is duplicated on the opposite side.

After-Treatment.—The gauze tampon should be removed on the day following the operation unless there is reason to expect free hemorrhage, when it may be allowed to remain another twenty-four hours. The mouth must be kept as clean as possible by the frequent use of washes, douches, and sprays. These should consist of mild antiseptics like solutions of boric acid, salicylic acid, etc.

Nourishment during the first few days is maintained preferably by nutrient enemata, and later by milk, broths, and other liquid foods given by the mouth.

Mortality.—This varies in different collections of cases. Butlin in 1887 found the mortality to be about 30 per cent. Bryant's collection (1890) showed 14 per cent. of deaths. Of 66 more or less complete unilateral and 5 bilateral resections, collected by White and Wood (1896), but 6 per cent. died as a result of the operation. The records of St. Bartholomew's, St. Thomas', and University Hospitals, London, have been examined by Butlin (1900), who found 127 cases of resection for malignant disease with 16 deaths (12.6 per cent.). Martens (quoted by Butlin) reports from the Clinic of König, in Göttingen, 74 total resections, from 1875 to 1896, with nearly 30 per cent. mortality.

Osteoplastic resection of the superior maxilla is occasionally performed for the purpose of removing nasopharyngeal tumors. Nélaton's method consists in the division of the soft palate antero-posteriorly, and the removal of the posterior half of the hard palate after the mucous membrane and periosteum have been separated from the middle line toward the alveolus on either side. After the removal of the polyp the palate is closed by sutures.

Chalot separated the upper lip from the superior maxilla until the nasal fossæ were opened, then extracted the two upper canine teeth and made an incision through the mucoperiosteum of the hard palate from the point occupied by the extracted teeth, along the alveoli, to the posterior border of the hard palate. The alveolus and palate were next divided by a mallet and chisel and the fragment was separated from the vomer and turned down into the mouth, being attached only to the soft palate. After the removal of the tumor the bone should be replaced and held by sutures.

Several methods have been proposed by different surgeons for reaching these tumors by temporary resection of portions or all of the nose, the most useful perhaps being that of Rouge. This consists in separating the upper lip from the maxillæ by dividing the mucous membrane close to the bone; the septum and the alæ are also detached from their attachments to the bone and turned upward by inverting the upper lip and making traction. After the removal of the tumor the parts fall naturally into place.

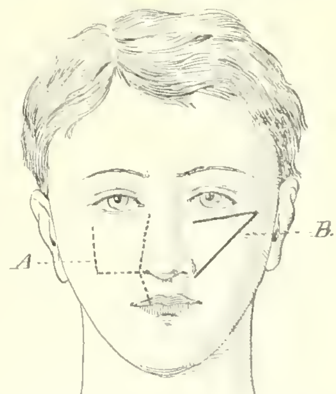

FIG. 4097.—Resection of the Superior Maxilla. A, Gensoul's incision; B, Langenbeck's incision for osteoplastic resection.

This procedure is suitable for tumors situated anteriorly chiefly. Some means must be adopted for preventing the blood from getting into the larynx. Langenbeck makes two incisions: one from below the inner canthus to the malar bone, and another from the nostril to join the outer extremity of the first. The bone is sawn through in the lines of the incisions. The bone still attached to the soft parts is then raised

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and thrown over on the opposite cheek. The parts are restored and sutured in place after the tumor is removed.

Alfred C. Wood.

RESINS. See *Active Principles.*

RESOPYRIN. See *Antipyrin.* www.fbtool.com.cn

RESORBIN is a readily absorbable ointment base made by emulsifying expressed oil of almond with yellow wax, soap, gelatin, and water, and adding lanolin to give it a proper consistency. It was introduced by Lebermann, who used it as a vehicle for mercury, as more readily absorbed and less greasy than blue ointment. He also employed it in various skin diseases. In course of time it tends to become rancid. *W. A. Bastedo.*

RESORCIN: RESORCINOL.—Resorcin, chemically *metadioxybenzene*, $C_6H_4(OH)_2$, is one of a trio of isomeric diatomic phenols, of which pyrocatechin and hydroquinone are the other two members. It is official in the United States Pharmacopœia under the title *Resorcinum*, Resorcin.

Resorcin occurs in colorless, needle-shaped crystals, having a peculiar smell, resembling that of carbolic acid, and a bitter-sweetish taste. Resorcin dissolves readily in water, and still more readily in alcohol and in ether. In its effects resorcin resembles its congener, carbolic acid, but is, in general, less active than that substance, and, in particular, very much indeed less poisonous, constitutionally. Resorcin inhibits bacterial growth, but probably less potently than carbolic acid. Locally, the drug is without effect upon the sound skin, but applied, undiluted, to a moist mucous membrane, it is mildly caustic, while at the same time anæsthetic and healing. By reason of the anæsthesia it produces, resorcin may be applied even to such sensitive parts as the mucous membrane of the larynx (Andeer). Internally, resorcin may be given in very considerable doses, as compared with carbolic acid, and such doses, administered to a fevered subject, will show to a marked degree the peculiar antipyretic effect so characteristic of the phenols. After a dosage of from 2 to 3 gm. (from gr. xxx. to gr. xlv.) there set in, in a few minutes, quickening of heart action and of breathing, reddening of the face, and buzzing in the ears, with giddiness. Within fifteen minutes sweating begins, speedily becoming active, whereupon the antecedent derangements abate, and at the same time the pyrexial temperature rapidly falls—so rapidly as perhaps to reach the normal point within an hour. The sweating does not last long, so that after the lapse of an hour from the time of dosing, the fever patient may have a naturally moist skin only, with temperature and pulse rate reduced to the normal. But while defervescence by resorcin is quick to occur, it is also quick to give way to the natural tendency of the fever to regain its former height. Within from two to four hours, therefore, the temperature often begins its succeeding rise, and within a single additional hour may have attained its original height. Such rapid after-risings of temperature may be attended by a chill. Resorcin is variable in its action; sometimes the fall of temperature is slight, and sometimes the by-effects are excessive and even alarming. Thus, after medicinal doses, there have been observed delirium and illusions, with muttering speech and convulsive trembling of the hands, and, in one case at least, a deep comatose sleep. In overdosage resorcin is competent to induce constitutional poisoning after the general type of poisoning by the phenols—producing giddiness, insensibility, profuse sweating, great reduction of temperature, and general collapse, with olive-green coloration of the urine. Such alarming condition has followed a succession of doses increased from half a drachm to two drachms. Therapeutically, resorcin has been used for both local and constitutional medication. Locally, resorcin is possibly available for a simple "antiseptic" effect, but is surpassed in this therapeusis by so many other agents as to be little used for the purpose. But for a combined antizymotic and *healing* effect the local application of resorcin may be quite serviceable. Thus injections of a five-per-cent. aqueous solution have been made into the bladder, in cystitis, and into suppurating cavities, with good effect, and salves of resorcin have abated malignant and syphilitic ulcerations. A spray of a two-per-cent. solution has been used in whooping-cough; and a ten-per-cent. solution has been praised for local application to the throat in diphtheria. Internally, resorcin has been used for its antipyretic action, in which application the medicine presents the feature of a fair degree of safety and efficiency combined; but the action is evanescent and attended by disagreeable excitement and sweating. The dose of resorcin for an antipyretic effect ranges from 2 to 4 gm. (from gr. xxx. to xlv.), best given in divided doses and administered, dry, in a wafer or capsule, or in solution in water, sweetened and aromatized. Constitutional effects are also asserted (Andeer) to be procurable, in diseases attended by an affection of the skin, by inunction of resorcin in admixture with vaseline, in proportion of from five to eighty per cent., such effects being the abatement of symptoms in so-called zymotic diseases. Andeer claims thus to have produced striking amelioration in such diseases as smallpox, scarlet fever, measles, and leprosy, by inunctions, over the whole body, of resorcin vaseline. Resorcin has been used as an intestinal antiseptic, under a variety of conditions, in doses of one or two grains every two hours. *Edward Curtis.*

RESPIRATION, PHYSIOLOGY OF.—Respiration is the function by which living cells obtain oxygen and get rid of carbonic-acid gas. It is an essential factor in the existence of both animals and plants, being a necessary accompaniment of the chemical processes underlying life. In the higher animals respiration is a very complicated process, consisting of many stages, but in lower forms it is comparatively simple and may be studied to advantage.

COMPARATIVE.—*Protozoa.*—Simple one-celled organisms like the amœba, live in a fluid medium, water, which surrounds them on all sides. From this surrounding medium the dissolved oxygen is absorbed by the general surface of the body, and distributed to all parts by diffusion or by currents set up by the contracting vacuoles, or by some unknown form of cell activity. The carbon dioxide is got rid of by a reverse process. This simple form of respiration is probably very similar to the process by which the cells of the higher animals obtain their supply of oxygen and return their carbon dioxide to the surrounding lymph, constituting the so-called "internal or tissue respiration."

Cœlenterata.—In this group each animal consists of a central cavity surrounded by two layers of cells (see Fig. 4098). Oxygen is taken in to some extent by the external surface, but also by the central body cavity, which serves the double purpose of food absorption and respiration. This prepares us to find the lungs of higher animals having a common embryological origin with the organs of digestion, and suggests the close relationship of the two processes. The currents set up to and from the central cavity by the movements of the body wall and of the tentacles facilitate the respiratory processes by bringing fresh fluid with a new supply of oxygen within reach of the absorbing cells.

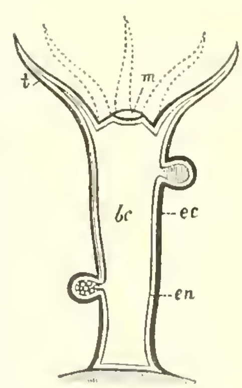

FIG. 4098.—Hydra, diagrammatic, showing Body Cavity *bc*, body wall in two layers *en* and *ec*, tentacles *t*, and mouth *m*. (After Bell.)

Worms.—In this heterogeneous division of the animal kingdom we find a circulating fluid or blood capable of

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carrying the oxygen from the surface of the body where it is absorbed, to the cells in the interior which have need of it. In some cases the blood contains a special substance, hæmoglobin, with which the oxygen can enter

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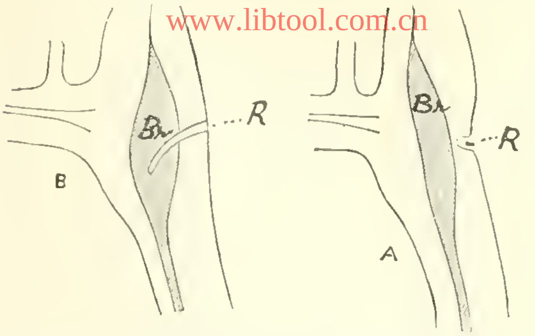

FIG. 4099.—Two Types of Nemertinea showing Rudimentary Respiratory Organs, *R*, Leading in toward the Brain, *Br*. In *A*, *R* is a simple pit and in *B* it is a duct ending blindly among the cells of the brain. (After Bell.)

into loose combination while being carried about. In the worms we find for the first time special organs of respiration. Sometimes these are little more than grooves or pits supplied with cilia to favor the renewal of the oxygen-containing medium. In other cases we find these pits becoming deeper so as to form ciliated ducts (Fig. 4099).

Insects.—In insects we find a system of tubes (tracheæ) adapted for air breathing. These are distributed through the body, and the renewal of the air within them is favored by movements of the legs and wings.

Higher Animals.—As we ascend the scale we find further developments of the organs of respiration, such as to offer the greatest respiratory surface in the smallest possible space. This is seen both in the gills of fishes and the lungs of air-breathing animals. The arrangements for the renewal of the oxygen-containing medium are elaborated and reach their highest development in the bony thorax of the higher vertebrates with their costal and diaphragmatic breathing. The blood-vascular system also becomes better adapted for taking up oxygen and carrying it rapidly all over the body.

The human embryo in its respiratory function, as in other things, passes through many of the stages represented in lower forms. The one-celled ovum, like the amœba, takes in oxygen by its general surface from the fluids which surround it in the uterus. As growth proceeds it develops a blood-vascular system, but for a time continues to take in its oxygen by the general surface of the surrounding membranes. When the placenta is formed, the fœtus has a special organ of respiration, but obtains its supply like a fish from a fluid medium, the mother's blood. At birth the tying of the cord shuts off the placenta, and the consequent deficiency of oxygen stimulates the centre in the medulla to initiate the first respiratory movements. The opening up of the lungs diminishes the pressure in the pulmonary vessels, and thus determines an increased blood supply to these organs. The foramen ovale closes and the adult condition is rapidly established.

THE ORGANS OF RESPIRATION.—These include the *air passages* leading into the lungs from outside and comprising the nose, pharynx, larynx, trachea, and bronchi; the *lungs* which contain the respiratory surfaces (air sacs or alveoli) in which the interchange of gases takes place, the divisions and ramifications of the bronchi leading down to the alveoli, and the supporting connective tissue in which run the blood and lymph vessels and the nerves; the *pleuræ* which cover the lungs and line the thoracic walls with a smooth slippery membrane facilitating movement; the *thoracic walls* which enclose the lungs and which are strong enough to protect them and yet mobile enough to be the medium through which the expansion of the lungs is effected; the *muscles of respiration*, including the diaphragm and the muscles acting upon the ribs; the *nervous mechanism* through which all the respiratory processes are initiated and regulated.

The *nose* serves a useful purpose in warming the inspired air and thus protecting the other air passages from too sudden changes of temperature. The *larynx* is especially concerned in speech and voice production. It also plays an important part in preventing dust particles and noxious gases from entering the lungs by the cough and spasm which these substances excite when they come in contact with its mucous membrane. The *trachea* and *bronchi* consist of tubes of fibrous and elastic tissue supported at regular intervals by incomplete rings of cartilage. The portion behind, where the cartilage is absent, is supplied with plain muscle tissue by which the tubes can be somewhat constricted. The mucous membrane consists of loose lymphoid tissue. It is supplied with mucous glands, which keep the surface moist, and is lined with ciliated columnar epithelium. The cilia carry the mucous secretion and inhaled dust particles up toward the larynx. The *lungs.* As the bronchi enter the lungs they divide and subdivide, forming the bronchial tubes, to the smallest of which the name bronchioles is applied. The structure of the trachea and bronchi is continued into the bronchial tubes with certain modifications. The cartilaginous rings are replaced by irregular plates of cartilage distributed at intervals around the tubes, and even these are not found in the very smallest bronchioles. The unstriped muscle becomes relatively more abundant as the size of the tubes diminishes and it forms a continuous layer of circular fibres. The epithelium changes from columnar to cubical, and in the smallest tubes mucous glands are not found. The lungs may be seen to be divided into innumerable tiny sections known as lobules, of which each has a diameter of 1–3 cm. They are of pyramidal shape, and are divided from one another by a little fibrous tissue. A bronchial tube entering such a lobule divides several times, forming tiny bronchioles. If we follow the bronchiole along we will find the epithelium changing from cubical to pavement, and we will see an occasional air sac or alveolus opening out from the side. These tubes supplied with alveoli are known as respiratory bronchioles. Each respiratory bronchiole ends in a dilated passage called an alveolar duct, into which open a number of infundibula. An infundibulum is a cone-shaped expansion with the apex toward the duct. Extending out from it are numerous hemispherical expansions known as air sacs or alveoli which very greatly increase the total surface (see Fig. 4100).

The wall of an infundibulum consists of a thin basement membrane lined by epithelium, the so-called "respiratory epithelium." The cells composing this epithelium are of two kinds: non-nucleated platelets resting upon the blood capillaries and smaller nucleated cells between. Around the infundibula is spread out a network of capillaries so dense that the meshes are narrower than the vessels themselves. Between the air in the air sacs and the blood in the capillaries nothing intervenes but the two layers of epithelium belonging to the alveoli and the capillaries respectively. In some cases the capillary may be in contact with the epithelium of two contiguous alveoli (see Fig. 4101).

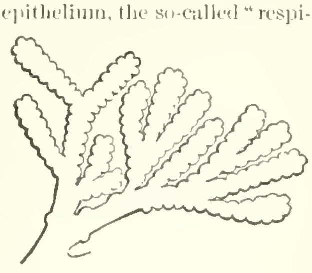

FIG. 4100.—Diagrammatic Representation of the Ending of a Bronchial Tube in Sacculated Infundibula. (After Schaefer.)

The capillaries distributed to the air sacs are from branches of the pulmonary artery. The walls of the bronchial tubes and the connective tissue of the lungs are supplied by the bronchial arteries belonging to the systemic circulation. The connective tissue which inter-

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venes everywhere between the infundibula and under the pleura is rich in elastic tissue. The nerves of the lung come from the anterior and posterior pulmonary plexuses, which are formed by branches from the pneumogastric and sympathetic. The sympathetic fibres come off from the inferior cervical ganglion, annulus of Vieussens and stellate ganglion, and can be traced back to the upper thoracic nerves. See also *Nasal Cavities, Larynx*, etc.

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Physical Relations of the Lungs to the Chest Wall and the External Atmosphere.—Before birth the lungs are solid organs; that is to say, the opposite walls of the alveoli and bronchial tubes are in contact, and form merely potential spaces communicating through the respiratory passages with the outside. At birth the thoracic cavity is enlarged by the action of the muscles of respiration. The additional space which results must be filled up as it is formed, for "nature abhors a vacuum." The only avenue through which anything can enter the thorax to fill it is through the respiratory passages, and so air enters, expanding the lungs and keeping them in contact with the receding chest wall. Throughout life the lungs continue to follow the movements of the chest wall. If the chest is enlarged, air enters the lungs, expanding them sufficiently to fill it up. In doing this the air has to overcome the elasticity of the lungs. During rest the air exerts upon the inside of the lungs the same pressure as upon the external surface of the body, 760 mm. of mercury or fifteen pounds to the square inch. When the chest is suddenly expanded, as in inspiration, the air within the lungs is rarefied and the pressure within the lungs, *the intrapulmonary pressure*, is diminished. During expiration the thorax diminishes in size, compressing the air in the lungs, and the intrapulmonary pressure rises. In either case movement of air in or out of the lungs takes place till the intrapulmonary pressure is again equal to atmospheric when equilibrium is established.

The pressure in the pleural cavity and in the mediastinum is known as the *intrathoracic pressure*. It is always less than atmospheric because the elasticity of the lungs tends to pull them away from the chest wall, and protects the latter from part of the intrapulmonary pressure. The more the chest is expanded the more is the elasticity of the lungs brought into play, and the more does intrathoracic pressure fall below atmospheric. The intrathoracic pressure is often spoken of as *negative*, meaning that it is less than atmospheric. The fact that it is so may be seen when an opening is made in the chest, as in this case air is drawn into the pleural sac and the lungs collapse. During ordinary breathing intrathoracic pressure varies from 758 to 752 mm. of mercury, which is 2–10 mm. below atmospheric. This is expressed by saying that there is a negative intrathoracic pressure of 2–10 mm. During forced inspiration, when the lungs are very much on the stretch, there may be a negative intrathoracic pressure of 30 or 40 mm.

Renewal of the Air in the Alveoli is effected by the movements of respiration supplemented by diffusion. The respiratory movements are primarily movements of the thoracic walls, which lead to changes in the capacity of the thorax and indirectly to expansion and contraction of the lungs. The size of the thorax can be increased or diminished in three directions—vertical, antero-posterior, and transverse. The vertical diameter can be increased by the descent of the arched diaphragm and by the backward and downward movement of the lower ribs. It can be diminished by the passive return of the diaphragm to its arched position of rest, assisted by the contraction of the abdominal muscles, which force the viscera up against the diaphragm and increase its arch.

The antero-posterior diameter is increased by the raising of the ribs from the resting position, in which they slant downward, to one in which they extend more directly forward, carrying the sternum with them. In quiet breathing the upper end of the sternum acts as a fulcrum and the lower end is pushed out; but in very deep inspiration the upper end is also raised and extended forward. The antero-posterior diameter is diminished by the thorax returning to a position of rest as a result of gravity and elastic recoil.

The transverse diameter is increased by the outward and upward rotation of the ribs. Any tendency of the contracting diaphragm to draw in the lower ribs is overcome by the fact that the abdominal viscera are compressed by its descent and tend to press the ribs outward.

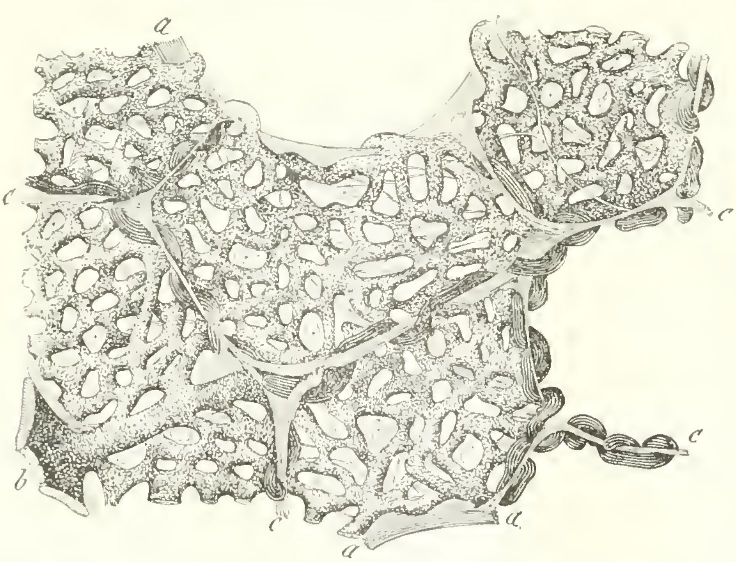

Fig. 4101.—Section of Injected Lung, Including Several Contiguous Alveoli. (F. E. Schultze.) (Highly magnified.) *a*, *a*, Free edges of alveoli; *c*, *c*, partitions between neighboring alveoli, seen in section; *b*, small arterial branch giving off capillaries to the alveoli. The looping of the vessels to either side of the partitions is well exhibited. Between the capillaries is seen the homogeneous alveolar wall with nuclei of connective-tissue corpuscles and elastic fibres. (Schaefer.)

Muscles of Respiration.—In ordinary inspiration the vertical diameter is increased by the descent of the *diaphragm*, assisted by the *quadratus lumborum* and *serrati postici inferiores*, which fix the lower ribs. The antero-posterior and transverse diameters are increased by the *scaleni*, *levatores costarum*, and *serrati postici superiores*, which fix the two upper ribs and assist the elevation and eversion of the others, and by the *external intercostals* which raise the lower ribs. Both the *external and internal intercostals* by their contraction give strength to the intercostal spaces and enable them to withstand the atmospheric pressure. Expiration is largely passive, being brought about by the influence of gravity and the elastic recoil of the thorax, and by the relaxation of the diaphragm which allows it to be forced up again by the pressure of the abdominal viscera. Some claim that the descent of the ribs is assisted by the contraction of the interosseous portion of the *internal intercostals*.

In forced inspiration a great number of additional muscles are called into play, first those having attachments to the ribs or sternum, and later a very great number which indirectly assist the enlargement of the chest or the opening up of the respiratory passages. Forced expiration is assisted by the action of the abdominal muscles, which press on the viscera and so push up the diaphragm, and also by those muscles

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of the abdomen and back which pull down the lower ribs.

Types of Respiration.—An infant breathes mostly with its diaphragm. Such breathing is spoken of as the *diaphragmatic* or *abdominal type.* In adults we find a

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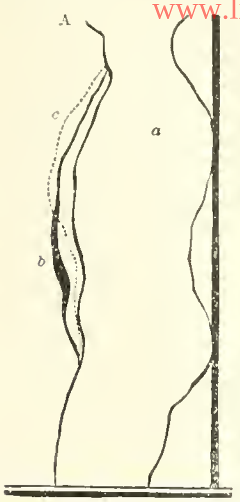

Fig. 4102.—*A*, Inferior Costal and *B*, superior Costal Type of Breathing. *a*, *a*, Outline of body in forced expiration; *b*, *b*, heavy continuous line. The outer margin indicates the contour of the body in ordinary inspiration and the inner margin that of ordinary expiration. The relative thickness of this line in the two sexes shows that in the male the greater movement takes place in the abdomen and lower thorax (inferior costal) and in the female in the upper thorax (superior costal). *c*, *c*, Contour of forced inspiration. Note that forced inspiration is of the superior costal type in both sexes. (After Hutchinson.)

difference in the manner of breathing between the male and female. In the male the movements of the abdomen and lower part of the thorax are more pronounced, forming the so-called *inferior costal type*, while in the female movements of the upper chest predominate, and we speak of the *superior costal type*. This difference in the sexes is not found in all races, and so is ascribed by some to the influence of dress, but others see in it an adaptation of woman for her sexual life, pregnancy, through natural selection (see Fig. 4102).

The Quantity of Air Breathed.—During ordinary quiet breathing about 300 c.c. of air is taken into the lungs with each inspiration and expelled with each expiration. This is called the *tidal air*. By a forced inspiration an additional quantity, known as the *complemental air*, may be taken in. Its volume is about 1,700 c.c. The air that can be expelled by an effort after an ordinary expiration is the *supplemental air*, and measures about 1,500 c.c. The air remaining in the chest after the most powerful expiration is the *residual air*, amounting to about 1,000 c.c. The total quantity that can be taken in after a complete expiration or breathed out after the fullest inspiration is called the *vital capacity*, and includes the complemental, tidal, and supplemental air. It measures therefore in a typical case about 3,500 c.c. *Lung capacity* is the total quantity of air in the lungs after a forced inspiration, and is equal to the vital capacity plus the residual air, or about 4,500 c.c. All these quantities naturally vary very much in different individuals and under different conditions, but the above numbers may be taken as more or less typical.

The quantity of air breathed in any given case can be estimated by means of an instrument known as a spirometer (see Fig. 4103).

The Changes that Take Place in the Air.—In the lungs certain things are taken from the air and others added, as shown in the following table, in which the quantities are given in volumes per cent.:

	Inspired air.	Expired air.
Nitrogen	79	79
Oxygen	20.96	16.03
Carbonic acid	.04	4.4
Aqueous vapor	Variable.	Saturated.
Argon, etc.	Traces.	Traces.

It is to be noted that the volume of oxygen lost, 4.93, is slightly greater than the volume of CO_2 added, 4.36, so that the total volume of the expired air is slightly less than that of the inspired air.

The expired air is warmed to the temperature of the body and is also fouled by organic emanations given off from the lungs and respiratory passages. The principles on which the analysis of expired air is carried out may be conveniently studied in the apparatus designed by Waller, which is one of the simplest and yet sufficiently accurate for most purposes (see Fig. 4104).

In other methods the carbon dioxide is absorbed by soda lime or by baryta water instead of by sodium hydrate, and arrangements may be made for passing the air through a chamber containing sulphuric acid for the arrest and estimation of the aqueous vapor.

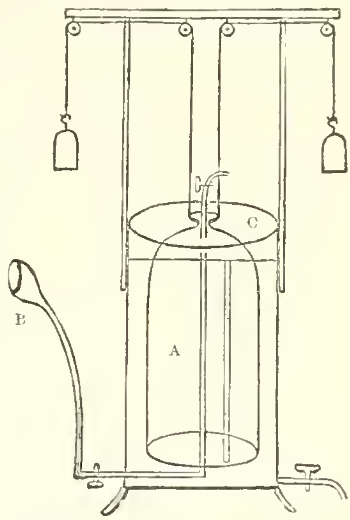

Fig. 4103.—Diagram of Hutchinson's Spirometer. (Landois.) *A*, Graduated cylinder serving as a receiver for the breath; it is supplied with a stopcock at the top for the ready expulsion of air, and is balanced by weights passing over pulleys. *B*, Mouthpiece with tube reaching nearly to the top of the graduated receiver (*A*), when the latter is sunk in the reservoir ready for an experiment; there is a stopcock in this tube near the first angle to prevent regurgitation of air. *C*, Reservoir for the graduated receiver. In using the spirometer the reservoir and graduated receiver are filled with water, or, to prevent the absorption of carbon dioxide, with a saturated aqueous solution of common salt (NaCl). When ready for an experiment, the stopcock at the top of the receiver is closed and that in the tube of the mouthpiece opened, and the breath forced into the receiver. The receiver rises as fast as the breath displaces the water. After the breath is forced into the receiver the stopcock in the tube of the mouthpiece is closed, and the water outside and inside the receiver brought to the same level, so that the air within the receiver shall be at the atmospheric pressure. The amount of breath within the receiver is then read directly from the scale attached to the receiver. For accurate measurement the breath should stand a few minutes to acquire the temperature of the liquid over which it is collected, then the various corrections for aqueous vapor tension, and the variations from the standard temperature and pressure, should be made.

Respiratory Quotient or Respiratory Coefficient.—As is shown in the table given above, the volume of oxygen absorbed is greater than the volume of carbon dioxide excreted. The relation of one to the other is expressed as $\frac{CO_2}{O_2}$ and is known as the respiratory quotient. If all the oxygen taken into the body reappeared in the expired air as CO_2, the volumes would be equal and the respiratory quotient $\frac{CO_2}{O_2}$ would be 1. Some of the oxygen, however, combines with hydrogen to form water, and is excreted as aqueous vapor by the lungs, or as water by the skin and kidneys, and thus does not leave the body as CO_2 at all, but as H_2O. The respiratory quotient varies with the relative proportions of carbon, hydrogen, and oxygen in the food. Carbohydrates contain in themselves just enough oxygen to sat-

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isfy all the hydrogen present, so that only the oxidation of the carbon has to be provided for by the oxygen taken in by the lungs. Thus the presence of a large amount of carbohydrate in the diet tends to make the respiratory quotient approach 1. Fats and proteids, on the other hand, contain a relative excess of hydrogen, and require oxygen for combination with it, so that the CO_2 excreted represents only part of the oxygen absorbed and the respiratory quotient falls below 1.

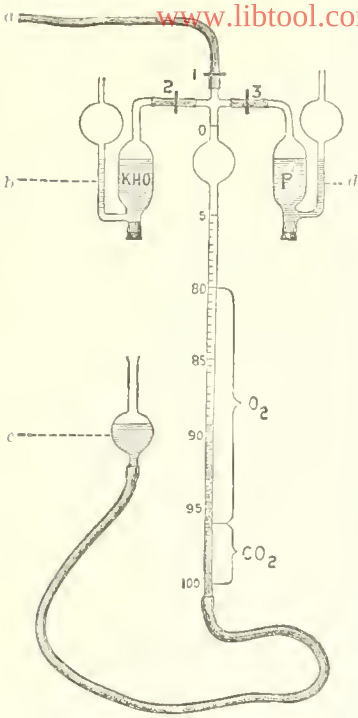

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Fig. 4104.—Estimation of O_2 and of CO_2 in Expired Air. (Waller.) A 100 c.c. measuring tube graduated in tenths of 1 c.c. between 75 and 100. A filling bulb. Two gas pipettes. The measuring tube communicates by three tubes guarded by simple taps 1, 2, 3, with the inlet and with the gas pipettes. It is first charged with acidulated water up to the zero mark by raising the filling bulb, tap 1 being open; it is then filled with 100 c.c. of expired air, the filling bulb being lowered until the fluid in the burette has fallen to the 100 mark. Tap 1 is now closed, the measuring tube containing 100 c.c. of expired air with unknown quantities of CO_2 and of O_2. The amount of CO_2 is ascertained as follows: Tap 2 being opened, the air is expelled into a gas pipette containing KHO by raising the filling bulb until the fluid has risen to the zero mark of the measuring tube. Tap 2 is now closed, and the air left in the gas pipette for about a minute, during which the CO_2 present is entirely absorbed. The air is then drawn back into the measuring tube by lowering the filling bulb while tap 2 is open. The volume of air (minus the CO_2, which is being absorbed) is read, the filling bulb being adjusted so that its contents are at the same level as the fluid in the burette. The amount of O_2 is next ascertained in a precisely similar manner by sending the air into a second gas pipette containing sticks of phosphorus in water, and measuring the loss of volume (due to absorption of O_2) in the air when drawn back into the tube. A gas pipette works thus: fluid in its lower half is displaced into its upper half, when air is driven in from the measuring tube, and returns to its original place, when air is drawn back. If desired, the apparatus can be connected with a vessel in which a frog or mouse or excised muscle has been placed and the consequent alterations of the gases O_2 and CO_2 measured in a similar manner. *a*, Inlet or outlet; *b*, gas pipette for absorption of CO_2; *c*, filling bulb; *d*, gas pipette for absorption of O_2.

Temporary variations in the respiratory quotient may be due on the one hand to oxygen being absorbed in excess and stored up as tissue oxygen, or on the other hand to tissue oxygen taken in long before being made use of for oxidizing some of the carbon. The former tends to lower the respiratory quotient and is seen during rest; the latter raises it and is seen in conditions of activity and quickened metabolism.

Ventilation.—The withdrawal of oxygen from the air and the addition of CO_2 and organic matters that takes place during respiration renders it vitiated or unfit to be breathed again. When a room has been breathed in until the amount of CO_2 has risen to 0.07 volume per cent., the air becomes more or less stuffy, although in very badly ventilated rooms the proportion may reach ten times this figure. The closeness or stuffiness is due principally to the organic emanations, of which some are of an odorous nature. This is shown by the fact that much larger quantities of CO_2 can be added to the air of a room in other ways without causing any inconvenience to the inmates. Air containing even as much as twenty-five per cent. of CO_2 can be breathed safely for a short time if there are no other impurities in it, and if it contain plenty of oxygen. An ordinary individual requires about 2,000 cubic feet of air per hour if the proportion of CO_2 is not to rise above 0.07 volume per cent. This may be supplied by allotting 1,000 cubic feet of space to each individual, and providing ventilating arrangements for renewing the air twice every hour. The smaller the space allotted to each individual the more frequently must the air be changed by ventilation.

The following table may be useful for ready reference on some of the points discussed above, although the exact numbers vary very much in different people. The proportions given in cubic centimetres and litres are somewhat less than those usually given, but are probably more correct than the larger quantities given in inches and feet.

Amount of	One Breath.		Twenty-Four Hours.	
	Cu. in.	C.c.	Cu. ft.	Litres.
Air breathed	30	300	350	7,000
Oxygen absorbed	1.5	15	17.5	350
CO_2 excreted	1.3	13	15	300
Air rendered close (Proportion of CO_2 raised to 0.07 volume per cent.)	5,000	50,000	50,000	1,000,000

The Blood and Its Gases.—While the air on one side of the respiratory epithelium is being constantly changed by the movements of the chest and by diffusion, the blood on the other side is being changed by virtue of the circulation. The blood is brought in a venous condition by the pulmonary artery and its branches, and is carried away in an arterial condition by the pulmonary veins. The gases of the blood are the same qualitatively as those of the atmosphere, but are not present in the same proportions. The proportions naturally vary somewhat, but the following are approximate in volumes per cent. of blood:

Blood.	O.	CO_2.	N.
Arterial	20	40	1-2
Venous	10	46	1-2

In considering the nature of the connection between the blood and its gases it is necessary for us to keep in mind the various constituents of blood and their power of taking in gases. The *plasma* may for our present purpose be considered as made up of water, salts, and proteids. *Water* is capable of holding a certain quantity of gas in solution, the exact amount depending on the nature and tension of the gases surrounding it, and on the temperature. If water be exposed to a mixture of gases it will absorb and hold in solution a quantity of each, which will depend on the quantity of that particular gas in the mixture. Each gas present in a mixture exists at a certain tension, and exerts what is called a *partial pressure*. This partial pressure is not affected by the amount of any other gas that may be present. Thus if a jar were half full of water and the rest of it occupied by air, the water would take up from the air a certain amount of nitrogen and a certain amount of oxygen. If now pure nitrogen were pumped into the jar without allowing any of the air already there to escape, the tension or partial pressure of the nitrogen in it would be increased and the water would take a proportionately larger amount into solution. The tension or partial pressure of the oxygen would remain, however, what it was before, and the water would not absorb any more. If now pure oxygen were pumped in, the partial pressure of oxygen in the jar would be increased and the water would take a proportionately larger amount of this gas into solution.

The nitrogen of the blood is held chiefly in simple solu

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tion in the water of the plasma. The oxygen and carbon dioxide, however, are present in much larger proportions than water could take into solution at the tension or partial pressure of these gases prevailing in either the lungs or the tissues. These gases must therefore be attached to the other constituents of the plasma or to the corpuscles. *The salts of plasma* include among others considerable quantities of sodium carbonate. This salt is capable of combining with carbonic acid gas to form sodium bicarbonate. There is reason to believe that the carbonic acid is principally held in the blood in this chemical combination. Sodium phosphate, another constituent of the plasma, may combine with carbonic acid too, forming sodium bicarbonate and sodium biphosphate. *The proteids* of the plasma, especially the globulins, are also claimed to have some power of combining with carbonic acid gas. *The corpuscles*, both red and white, may similarly carry a certain amount of CO_2 in combination with their salts and proteids.

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The chief interest of the corpuscles for respiratory purposes, however, is connected with the colored proteid hæmoglobin of the red corpuscles.

Hæmoglobin makes up about ninety per cent. of the solids of the red corpuscles. It is a substance possessing a remarkable property of forming loose chemical combinations with various gases. As it exists in the blood it is combined with oxygen to form oxyhæmoglobin. One molecule of hæmoglobin can combine with one molecule of oxygen or 1 gm. of hæmoglobin can attach to itself 1.34 c.c. of oxygen. In arterial blood the hæmoglobin is nearly saturated with oxygen, and in venous blood it still has some oxygen associated with it. Oxygen-free hæmoglobin or reduced hæmoglobin is not usually present in the body, but can be demonstrated in parts where the circulation has been stopped for from forty to three hundred seconds (Vierordt).

There are a number of compounds and derivatives of hæmoglobin which can be most readily distinguished by the absorption bands in their spectra. In the article on *Blood* in another volume of this HANDBOOK, they are described in some detail, and their spectra are figured.

Oxyhæmoglobin is the bright red substance which gives the color to arterial blood. In this compound the oxygen is present in a very loose chemical combination, and may be readily taken up by the tissues of the body or by reducing agents.

Methæmoglobin is a brown substance formed by the action of oxidizing agents on oxyhæmoglobin. It is found in the blood in cases of poisoning by chlorate of potash and similar substances. Methæmoglobin is of no use for respiratory purposes, as the oxygen is too firmly united to be abstracted by the tissues, although it is readily taken up by strong reducing agents, such as ammonium sulphide, with the formation of hæmoglobin (reduced).

Carbonic-Oxide Hæmoglobin.—If illuminating gas be inhaled the carbonic oxide which it contains unites with the hæmoglobin of the blood in place of the oxygen by virtue of the fact that CO possesses the stronger affinity of the two for hæmoglobin. This quite destroys the oxygen-carrying properties of the blood and results in death.

Other gases, such as NO, H_2S, etc., may also destroy the oxygen-carrying power of the blood by replacing the oxygen, or by otherwise changing the hæmoglobin molecule.

Hæmatin.—Hæmoglobin may be decomposed under the action of heat and acid or alkali into two parts, a proteid of unknown nature, usually referred to as globin, and a brown coloring matter rich in iron and designated hæmatin.

Hæmochromogen, or reduced alkaline hæmatin, may be formed by the action of reducing agents on hæmatin, or by breaking up hæmoglobin in the absence of oxygen. Hæmochromogen has the same power of uniting with gases as hæmoglobin has, and in fact has been shown to be able to attach to itself the same quantity (of CO) as the corresponding amount of hæmoglobin. Hoppe-Seyler taught that hæmochromogen existed as such in hæmoglobin, and lent it its gas-carrying property. This is disputed, however, by Gamgee (Schaefer's "Textbook").

The proteid part of the hæmoglobin molecule is believed by many to be of the nature of a globulin. It is probable that the small quantity of CO_2 that can be carried by hæmoglobin is attached to this proteid part.

The Mercurial Pump.—The gases of the blood are obtained for analysis by subjecting the blood to the vacuum of a mercurial pump. One of the simplest and best is that of Leonard Hill (see Fig. 4105).

A is a reservoir filled with mercury which may be raised or lowered. By raising it and manipulating the various taps the whole apparatus is filled with mercury. By lowering it the blood chamber *F* is made a vacuum. *F* is separated from the apparatus, weighed, and partly filled with blood. It is then reattached and the gases are drawn off from the blood into the reservoir *B*. By raising and lowering *A* repeatedly with manipulation of the taps, the gases are all drawn off from the blood in *F* into the reservoir *B* and then forced over into the eudiometer tube *H*, where they are collected over mercury and measured. The amount of CO_2 is measured by inserting potassium hydrate which takes up the CO_2 to form a carbonate. The diminution which takes place in the total volume of gas is the amount of CO_2 which was present. The amount of oxygen can similarly be measured by using a solution of pyrogallic acid, which unites with it. The gas remaining unabsorbed is nitrogen.

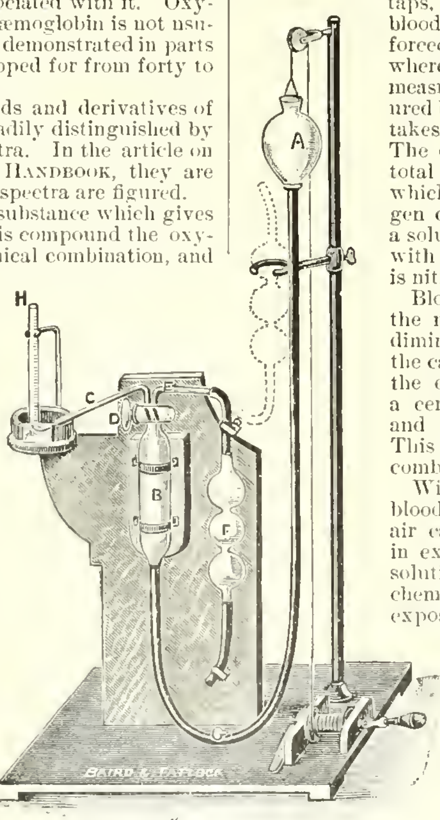

FIG. 4105.—Hill's Mercurial Gas Pump.

Blood does not give off its oxygen in the mercurial pump in proportion to the diminution in the pressure as would be the case if it were in simple solution. On the contrary, very little comes off until a certain degree of vacuum is reached, and then large quantities are given off. This points to its being in loose chemical combination.

With regard to the CO_2, the fact that blood even when exposed freely to the air can retain an amount of CO_2 greatly in excess of what it could hold in simple solution proves that this gas too exists in chemical combination. Now if plasma be exposed to the mercury pump and the pressure sufficiently lowered, much of the CO_2 is given off, and must therefore be quite loosely combined. Another portion is not given off without the addition of an acid or hæmoglobin (red corpuscles), which seem able to liberate it from some more stable compound.

The nitrogen is given off in proportion to the diminution in the pressure, and the view generally held is that it is in simple solution in the plasma.

THE INTERCHANGE OF GASES BETWEEN THE BLOOD AND AIR.—Here we find ourselves face to face with the fundamental question of the relation of epithelial cells to the processes taking place through them. Does the

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interchange of gases between the blood on the one side of the respiratory epithelium and the alveolar air on the other side take place by a mere process of diffusion, or does the functional activity of the epithelial cells exert some controlling or modifying influence? Our answer to this question must be determined by a consideration of what we know of the properties of epithelium elsewhere, and by the possibility of explaining the interchange on a purely physical basis.

There is an increasing tendency to attribute more importance to lining epithelium in the absorption and secretion of liquids and solids. This is seen in the change that has recently taken place in the teaching of the text-books with regard to intestinal absorption and the process of secretion. The fact that epithelium may also play an active part in the secretion of gases has been amply demonstrated by a number of investigators in connection with the secretion of gases in the swim bladder of fishes. Bohr has shown that this process is under nervous control.

With regard to the possibility of explaining the interchange of gases in the mammalian lung on a purely physical basis, it might be explained by the laws of simple diffusion and osmosis if the partial pressures on the two sides of the epithelium were always such as to favor the exchange that takes place. This question has been investigated as follows: First air is drawn off from the alveoli by one of the instruments devised for the purpose, of which *Pflüger's lung catheter* is the best known. Then this air is analyzed and the partial pressure of each gas in the alveoli can be calculated. Next the partial pressures of the gases in arterial and venous blood are estimated by some form of *aerotonometer* or *hæmataerometer*, and a comparison of the results obtained from the alveolar air and the arterial and venous blood in any given case will show whether the partial pressures are favorable to the interchange or not. The principle of the *aerotonometer* is as follows: It is an apparatus in which blood is brought into close relation with two gaseous mixtures, in one of which the CO_2 tension is above, while in the other it is below the anticipated tension of the blood. As blood flows through the apparatus an interchange of gases takes place between it and the gaseous mixtures contained. By analyzing the latter before and after, the tension of gases in the blood can be approximately determined.

Fredericq gives the following as a typical result of such an investigation in a dog:

	External air.		Alveoli.		Arterial blood.		Tissues.
Tension of oxygen..	20.95	>	18	>	14	>	0
	External air.		Alveoli.		Venous blood.		Tissues.
Tension of carbon dioxide..........	.03	<	2.8	<	3.81-5.4	<	5-9

In this case the tensions or partial pressures of the gases are such that oxygen would tend by mere diffusion to pass in from the air to the blood and CO_2 in the reverse direction.

Other workers, however, notably Bohr, and Haldane and Lorraine Smith, employing somewhat different methods, have obtained results which seem to show that oxygen may be taken in and CO_2 excreted even when the partial pressures are such as to oppose the process. If these experiments are reliable, as seems probable, we must look to some active secretory power of the respiratory epithelium for the explanation.

Dr. Wesley Mills has maintained this view for many years, and his text-book, published in 1889, was one of the first to recognize it in the following terms: "The view expressed by some physiologists to the effect that diffusion explains the whole matter so far at least as carbonic anhydride is concerned, and that the epithelial cells of the lung have no share in the respiratory process, does not seem to be in harmony either with the facts of respiration, or with the laws of biology in general."

The Seat of the Oxidation which Occurs in the Body.—At the beginning of the last century physiologists were divided in opinion as to the principal seat of oxidative processes in the body. Some, who followed Black, believed that these processes took place exclusively in the lungs, while others, led by Le Grange, regarded the blood as the seat of these changes. During the past fifty years Pflüger and others have shown that neither of the old views was correct, but that oxidation is continually taking place in all the tissues, and that it varies to a great extent with their functional activity. It has been shown, moreover, that the taking up of oxygen and giving off of CO_2 do not necessarily run parallel, but that the former may be stored up in excess during rest as tissue oxygen, and may remain in some more or less stable combination until a time of functional activity, when a dissolution of the molecule occurs with the setting free of CO_2. Some of the facts on which these views are founded are the following: If the blood of a frog be replaced by saline solution, the animal may live for hours or days, and continue to take up oxygen and excrete CO_2 (Oertman). Bleeding, although diminishing the quantity of blood in the body, has no effect on the amount of gaseous interchange (Pembrey and Gürber). If a muscle be made to contract *in vacuo*, it will give off CO_2, derived from its tissue oxygen, in sufficient quantity to be determined (Hermann). If a solution of fresh blood be supplied to a frog's heart, the oxyhæmoglobin will be reduced more quickly during activity than during rest (Yeo).

"The avidity of the different tissues for oxygen varies greatly, and the differences are doubtless expressions, broadly speaking, of the relative intensities of their respiratory processes" (Reichert).

Quinquaud records the following absorption capacities for 100 gm. of different tissues submitted for three hours to a temperature of 38° C.:

	C.c.		C.c.
Muscle	23	Spleen	8.0
Heart	21	Lungs	7.2
Brain	12	Adipose tissue	6.0
Liver	10	Bone	5.0
Kidney	10	Blood	0.8

Internal or Tissue Respiration is the term applied to the interchange of gases between the blood and the tissues. The partial pressures of the gases in the tissues, lymph, and blood are said to be such as to favor the taking up of oxygen by the tissues, and the giving off of CO_2 in accordance with well-known physical laws, but this fact does not necessarily exclude some participation of the endothelial and tissue cells in the process.

Graphic Record of Respiratory Movements.—Innumerable devices have been employed for this purpose. Some, either because they require a cutting operation or

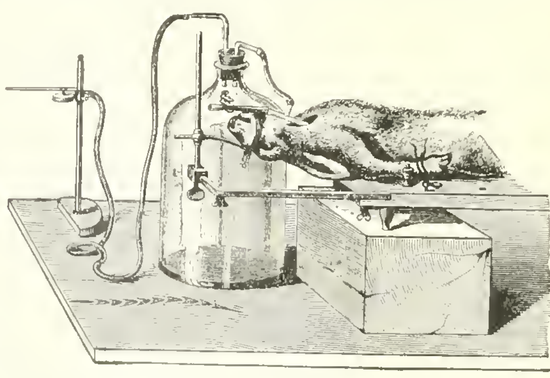

FIG. 4106.—Arrangement of Tracheal Cannula and Marey's Tambour for Recording Changes in Intrapulmonary Pressure. (Langendorff.)

for other reasons, are employed only on animals; and others may be used clinically on man. To the former category belong the *phrenograph*, by which the movements of the diaphragm are recorded by the use of a lever or rubber bag passed up between the liver and dia-

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phragm and connected with a recording lever; various forms of sounds and cannulas, which can be passed into the pleural cavity or the œsophagus and connected with a recording tambour to register the variations in intrathoracic pressure; a tracheal cannula or a nose cap from either of which the volume of air breathed can be recorded

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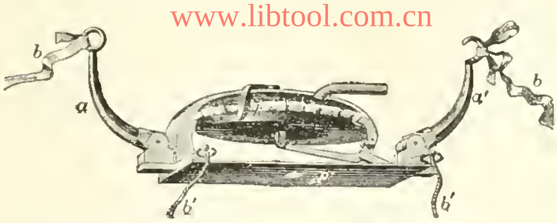

Fig. 4107.—Receiving Tambour of Marey's Pneumograph, New Form. (Langendorff.) *b, b*, Belt to go around chest; *b', b'*, strings to suspend the instrument from the neck.

by the *aërophthysmograph* of Gad, or the changes in intrapulmonary pressure can be registered by a Marey's tambour. In either case it is usual to have an air chamber between the animal and the recording apparatus, so that the same air will not be breathed over and over again (see Fig. 4106).

Among the methods which may be employed in man are the *pneumograph* or *stethograph*, in which a belt surrounding the chest is attached to some form of receiving tambour from which a rubber tube leads off to a recording tambour, and indicates the changes in the girth of the thorax (see Fig. 4107). In the *stethometer* of Burdon Sanderson the changes in the antero-posterior diameter of the chest are recorded.

Perhaps the simplest method of all is to connect a recording tambour through a piece of rubber tubing with a small funnel, and to press the latter into the episternal notch. A fair record of the respiration may be obtained in this way.

The curves obtained in these various ways differ in their details, but the tracing shown in Fig. 4108, and obtained with Marey's pneumograph, may be taken as a type.

As the figure shows, inspiration begins somewhat suddenly and advances rapidly, being followed immediately by expiration, which is carried out at first rapidly, but afterward more and more slowly.

Nervous Mechanism of Respiration.—The muscles of respiration act rhythmically under the influence of nervous impulses, which originate in the medulla oblongata and pass out by the motor nerves. The respiratory centre in the medulla sends out these impulses as the result of a constant stimulus imparted to it by the blood. The explanation of the rhythmic action of the centre under the constant stimulus of the blood is to be sought for in the fundamental properties of protoplasm. The action of the centre is modified by impulses reaching it by afferent nerves, of which some are constantly in operation and others only act occasionally.

The Respiratory Centre.—All the brain above the medulla may be removed without serious interference with the breathing. If the spinal cord be separated from the medulla all respiratory movements of the trunk cease, but some of the facial muscles, still in connection with the medulla through the cranial nerves, continue to exhibit movements of a respiratory character. Injury of the medulla in the lower part of the floor of the fourth ventricle (calamus scriptorius) is sufficient to cause cessation of respiration and death, all the rest of the nervous system being intact. These facts suffice to localize the respiratory centre in the floor of the fourth ventricle, but the exact nerve cells which constitute it cannot be pointed out. From the fact that cessation of respiration has followed injury to different parts in the hands of different investigators, the respiratory centre is probably made up of several separate groups of cells or nerve nuclei and bundles of connecting fibres.

If the medulla be carefully divided in the median line respiration continues; and if the pneumogastric nerve on one side be divided, the movements on that side will become slower than on the other, and we may have the two halves of the diaphragm contracting independently, each with its own rhythm. This shows that the respiratory centre consist of two halves, each more or less complete in itself. Normally, however, they act in harmony, being co-ordinated through commissural fibres, which cross the median line from one side to the other.

From the fact that certain influences affect especially inspiration and others expiration, it seems logical to assume that the respiratory centre is physiologically divided into an inspiratory and an expiratory centre, but we cannot separate these anatomically at present.

Subsidiary Centres.—Stimulation of various parts of the brain gives rise to modification of the respiratory movements. This fact has led to a number of structures, among which are parts of the cerebral cortex, the tuber cinereum, the optic thalamus, the pons Varolii, and the anterior and posterior corpora quadrigemina, being dignified with the name of "*subsidiary respiratory centres.*" As will be shown later, a tonic inhibitory influence seems to be exerted on the respiratory centre by the posterior corpora quadrigemina, but the other structures named are probably mere stations through which afferent impulses from the various sensory nerves may affect the respiratory centre in the medulla. Brown-Séquard, Langendorff, Wertheimer, and others lay great stress on the fact that after separation of the spinal cord from the medulla in young animals a kind of respiration is carried on by the cord alone. It is very different in its character, however, from normal breathing, being "rapid and irregular" (Wertheimer), and in many cases it does not occur at all. One, therefore, feels disposed to look upon these so-called spinal centres for respiration as rather coordinating centres for the respiratory muscles, which usually perform their functions under the control of the respiratory centre in the medulla. In some cases they seem to have retained a vestige of their original protoplasmic power of rhythmic activity.

The Influence of the Blood on the Respiratory Centre.—If the amount of oxygen in the blood be diminished or the proportion of carbonic oxide become higher, there follows increased activity of the respiratory centre. The respirations become deeper and often quicker, constituting the condition known as *hyperpnœa*. If the change in the blood be greater the respiratory movements become still more pronounced, additional muscles are called into play, and expiration, which is normally largely passive, becomes an active muscular act like inspiration; this condition is known as *dyspnœa*. Dyspnœa may pass into the condition known as *asphyxia*. The form of asphyxia caused by occlusion of the trachea and deprivation of oxygen is characterized by convulsions, followed by exhaustion and death. In asphyxia due to breathing an atmosphere in which carbonic acid gas is in excess, but where oxygen is not greatly deficient, the animal passes from dyspnœa into a state of stupor, and dies without passing through the stage of convulsions. The condition of the blood affects the centre directly, and not through

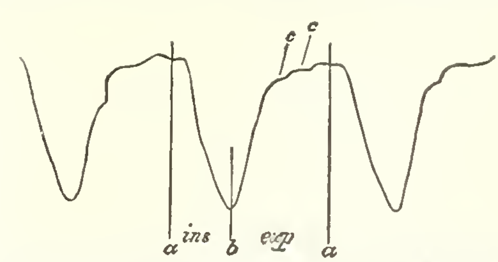

Fig. 4108.—Tracing of Thoracic Respiratory Movements obtained by means of Marey's Pneumograph. (Foster.) A whole respiratory phase is comprised between *a* and *a*; inspiration, during which the lever *descends*, extending from *a* to *b*, and expiration from *b* to *a*. The undulations at *c* are caused by the heart's beat.

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the afferent nerves, as is shown by the so-called "cross circulation" experiment. In this experiment the neck vessels of two dogs are joined in such a way that the head of each is supplied from the carotid arteries of the

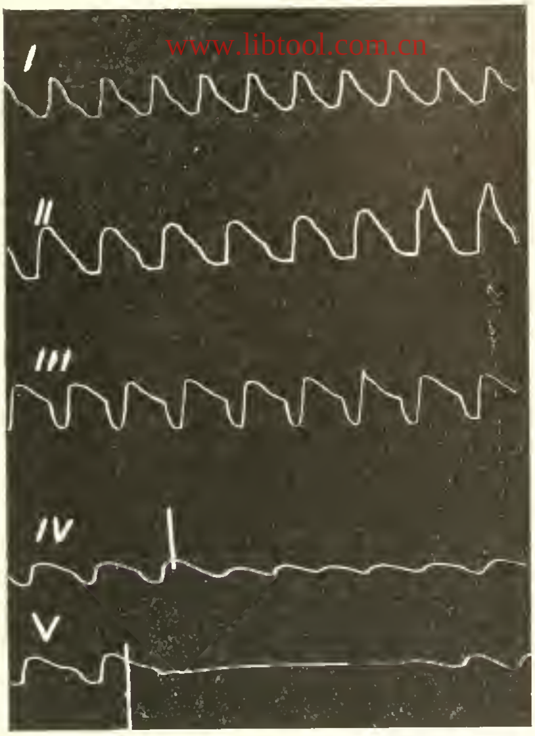

FIG. 4109.—Illustrates the Action of the Vagus on Respiration. Taken by the writer with an apparatus like that shown in Fig. 4107. *I*, Normal breathing of rabbit under ether; *II*, both vagi cut, respiration deeper and slower; *III*, cerebral hemispheres removed also; *IV*, weak stimulation of vagus opposite vertical line showing shallowing and quickening; *V*, stronger stimulation showing complete inhibition. Note: Downstrokes, inspiration; upstrokes, expiration.

other. The result is that the body of No. 1 and the brain of No. 2 receive the same blood and *vice versa*. If now the respiratory interchange of No. 1 be interfered with, the blood supplying his body will become venous, but his brain will continue to receive arterial blood from the other dog and his breathing will be unaffected. Dog No. 2, however, whose brain receives venous blood, will become dyspnœic, although the rest of his body is receiving good arterial blood.

Certain substances, other than carbonic acid, are produced in the muscles during activity, substances which also increase the activity of the respiratory centre. It has been shown that various acid substances have this effect, and the unknown substances formed in muscle are probably acid in nature.

The so-called automatic activity of the respiratory centre is believed to depend on a stimulus received from the blood, but it is yet undetermined whether the most important factor in this stimulus is a deficiency of oxygen, the presence of carbonic acid, or the action of the acid products of metabolism, although much can be said in favor of the last named.

The Influence of Afferent Nerves.—There is only one pair of nerves which have a tonic influence on the respiratory centre, as shown by a change in respiration when they are cut. These are the pneumogastrics.

On cutting one vagus (pneumogastric) the breathing becomes slightly deeper and slower for a time. Later the effect may pass off and the breathing become normal again. If both vagi are cut, the deepening and slowing of the breathing is more pronounced and the effect is more lasting.

The effects of stimulating the central end of one vagus are differently described by different writers. Nearly all agree that weak stimulation frequently produces shallowing and quickening, so that the breathing becomes more or less like what it was before the nerves were cut. With stronger stimulation various results are obtained according to the way in which the experiment is carried out, being influenced by the employment of anæsthetics and to some extent by the kind of stimulus used. This being the case, some writers believe that the pneumogastrics carry impulses which stimulate the respiratory centre to increased activity; and others, among whom is the writer, believe that it carries principally inhibitory impulses.

The impulses which normally ascend the vagus, exercising a constant inhibitory influence on the respiratory centre, are dependent upon the lung being distended, for Loewy has shown that opening the pleural cavity on one side so as to allow the lung to collapse has exactly the same effect on respiration as cutting the vagus on that side.

By rapidly inflating the lungs with a bellows the breathing may be entirely inhibited, the condition known as *apnœa* being produced. The result follows, no matter whether air be used for inflation, or some neutral gas, such as hydrogen. If air be drawn out of the lungs, diminishing their distention, very deep inspirations result. Hering and Breuer, who obtained these results, and also Head, who repeated their experiments, endeavor to explain them on the assumption that there are two kinds of fibres in the vagus, of which one set brought into action by distention of the lung favors expiration, and another set acting when the lung is collapsed favors inspiration. Their results are far more simply explained in the light of Loewy's work, by saying that the moderate distention of the lung normally present causes weak inhibitory impulses to ascend the vagus, which control the respiratory centre; increased distention gives rise to stronger impulses, which inhibit it altogether and produce a condition of apnœa; while during collapse of the lung the centre acts more powerfully in the absence of the usual inhibitory impulses.

In considering the effect of stimulating the fibres of the vagus directly we must remember that besides the respiratory fibres proper we can have passing up the vagus impulses of general sensibility and of pain, and these may cause changes in respiration through the sensorium like any other afferent nerve. The more completely we prevent the animal from feeling pain, the less likely are we to get pain effects and the more certain to see the direct action of the vagus on the respiratory centre. If an animal be experimented on without being completely narcotized, artificial stimulation of the vagus may produce almost any imaginable effect on the breathing, either inspiratory spasm (gasp), expiratory spasm (cry), or inhibition. If, on the contrary, the animal be well anæsthetized or decerebrated pain effects are eliminated and pure inhibition is nearly always seen, as shown by shallowing and quickening with weak stimulation, passing gradually, as the stimulus is increased in strength, into a state of complete inhibition or standstill in a position intermediate between inspiration and expiration (see Fig. 4109).

Even in unnarcotized animals the ascending constant current which stimulates without causing pain has almost always an inhibitory effect.

The other afferent nerves have no tonic action on the centre, for cutting any of them does not produce any change in the breathing. In special emergencies any afferent nerve may carry impulses that modify the action of the centre. If the nasal mucous membrane (fifth cranial nerve) be stimulated we get a *sneeze*, consisting of a gradual inspiration followed by a sudden spasmodic expiration through the nose. If the *glossopharyngeal* nerve be stimulated, as in swallowing, we get inhibition of respiration, which prevents food being drawn into the

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larynx. Certain kinds of stimuli applied to the mucous membrane of the pharynx and tonsils cause the complex act of vomiting in which the muscles of respiration play a part. Stimulation of the *laryngeal* nerves causes in some cases mere slowing of the breathing; but if the stimulus be strong, we see inhibition of inspiration and expiratory spasm or cough. Stimulation of the *splanchnics* inhibits respiration. Stimulation of the optic or auditory is said to increase inspiratory activity. Stimulation of other sensory nerves, such as the sciatic, produces in many cases one or more deep inspirations with weak stimulation, and a strong expiration or cry if the stimulation is strong; but the results are by no means uniform.

The Influence of the Posterior Corpora Quadrigemina.—Removal of the brain in front of the posterior corpora quadrigemina has little effect on the breathing; but separation of these from the medulla has an effect just like bilateral section of the vagi; that is, the respiration becomes deep and slow. If the vagi be cut as well and the animal has been protected from excessive hemorrhage the respiration becomes still deeper and very infrequent. Usually in this case inspiration and expiration are separated from each other by long pauses. Restoration of the respiration, to about its normal character, may be effected by a well-chosen stimulus applied either to one of the vagi or to the corpora quadrigemina.

Cheyne-Stokes Breathing.—If the upper part of the medulla itself be injured the breathing is sometimes seen to take on a periodic character; that is to say, the respirations occur in groups of three, four, five, or more, of which the first respiration in each group is the deepest (Markwald), and the groups are separated by intervals in which respiration is in abeyance. A similar kind of respiration is seen when a blood extravasation presses on the region of the alæ cinereæ near the respiratory centre. These facts are interesting in connection with the so-called Cheyne-Stokes breathing occurring in various diseases of the brain, heart, and kidneys, which bears certain resemblances to this experimentally induced periodic breathing (see article on *Dyspnœa*).

The Conditions under which the Centre Acts.—A rational interpretation of all the facts given above would seem to be as follows:

1. The respiratory centre is situated in the medulla, in the lower part of the floor of the fourth ventricle.
2. It receives a constant stimulus from the blood.
3. Acting alone it would expend all its energy by responding at long intervals with a very great respiratory effort.
4. It receives inhibitory impulses from the posterior corpora quadrigemina, and by the vagi nerves from the lungs which control its action and convert the deep infrequent respiratory acts into the shallower and consequently more frequent ones that we know as normal breathing.
5. In special cases the centre may be influenced by impulses reaching it by other nerves.

The Efferent Nerves are the phrenics to the diaphragm, the intercostals, and the motor nerves to the other muscles of respiration. If the spinal cord be injured above the first dorsal vertebra the intercostal nerves and muscles are cut off from the centre and thoracic respiration ceases. If the injury be as high as the fourth or fifth cervical vertebra the phrenic nerves and diaphragm are also cut off from the centre and death ensues.

For the effect of breathing air at various pressures and air containing impurities see articles on *Air*, *Aerotherapeutics*, and *Caisson Disease*. *William S. Morrow.*

REFERENCES.—In preparing this article use has been made of the books of Schaefer, Mills, Foster, "American Text-Book" (Reichert), Hall, Halliburton, Jeffrey Bell, Böhm and Davidoff, Quain's "Anatomy," Hermann's "Handbook" (Rosenthal), Langendorff's "Physiologische Graphik"; also of numerous journal articles and data from experiments performed by myself. Special acknowledgment must be made of assistance received from two papers by Max Lewandowsky in Du Bois-Reymond's Archives for 1896 on "Die Regulierung der Athmung."

RETINA, DISEASES OF.—The retina is seldom affected by disease which is limited to itself alone, or even to the eye alone, but most often lesions of the retina are part of a general disease and are frequently of assistance in the diagnosis of the latter. The diseases most apt to produce serious retinal complications are, diseases of the kidneys, syphilis, diabetes, septicæmia, and leukæmia. Among ocular affections choroiditis and optic neuritis almost always lead to retinal changes, the former because of the close anatomical relationship of the choroid and retina, and the latter on account of the interference of the retinal blood supply produced by the swelling of the disc. Both choroiditis and optic neuritis, however, are usually in turn dependent upon some general disease.

VASCULAR DISTURBANCES OF THE RETINA.—*Pulsation of the retinal veins* on the disc is frequently seen under normal conditions, and can readily be produced by a slight pressure of the finger upon the eye. It is particularly associated with increased intra-ocular tension from any cause, and hence is common in glaucoma. No better explanation of the phenomenon than that of Donders has been advanced. According to Donders it is due to the changes in arterial tension being communicated to the veins through the vitreous humor. True transmitted venous pulsation has been seen in valvular heart disease, arteriosclerosis, and anæmia, but never under normal conditions.

Pulsation of the retinal arteries is always pathological, and indicates either an increase in intra-ocular tension or decrease in the arterial pressure. It may occur in glaucoma, anæmia, syncope, senile arteriosclerosis, aneurism of the arch of the aorta, aortic insufficiency, and Basedow's disease. It may also result from compression of the central artery by tumors of the nerve or orbit.

Hyperæmia of the retina may be either arterial or venous in nature. The general redness of the fundus depends to such a great extent upon the degree of pigmentation of the choroid, and the tortuosity of the vessels varies so much under normal conditions, that it is impossible to diagnose retinal hyperæmia unless the disc is also reddened. *Arterial hyperæmia* manifests itself by distention and tortuosity of the arteries which sometimes lie in antero-posterior planes so that they project toward the observer. It may result from eye strain due to improper illumination or errors of refraction, irritation of the eye from any cause, such as the presence of a foreign body on the cornea, and from keratitis, choroiditis, and iritis. It is common in meningitis, and may be noted in Basedow's disease, plethora, and neurasthenia. Strangely enough, it may result from excessive loss of blood or from chlorosis, and in the former case it may be so intense as to give rise to retinal hemorrhages. *Venous hyperæmia* is characterized by dilatation and tortuosity of the veins, which appear darker than normal, and is always associated with hyperæmia of the disc. It is not infrequently accompanied by retinal hemorrhages. The arteries may show no change, or they may be narrowed owing to the same obstruction which is producing stasis in the veins. In general, venous hyperæmia is due to some hindrance to the outflow of venous blood from the eye, as, for instance, to compression of the central vein in optic neuritis or glaucoma. Sometimes the obstruction lies in the orbit, as in cases of tenonitis and orbital cellulitis, or even in the cranial cavity, as in intracranial tumors, thrombosis of the cavernous sinus, and meningitis. Rarely it is a part of a general venous stasis due to valvular heart disease. A few cases of particularly exaggerated venous congestion have been seen associated with congenital heart disease, the condition then being spoken of as *cyanosis retinæ*.

Thrombosis of the central vein of the retina, which produces the highest grade of venous hyperæmia, is very rare. It usually is monocular and occurs in patients affected with general arteriosclerosis, and hence most often between the ages of sixty to seventy, but sometimes it occurs as the result of orbital cellulitis. The affection comes on suddenly without prodromal symptoms, and though vision is much diminished, blindness

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is not produced at once. In marked cases the retinal veins are greatly distended and tortuous, the arteries are attenuated, and the fundus is covered with hemorrhages which are largest and most numerous around the disc. The disc itself is suffused with blood, and there is apt to be a small hemorrhage in the centre of the macula. In less marked cases the thrombosis may involve only a branch of the central vein, the disturbances then being confined to a limited portion of the retina. The intraocular tension is not increased. Ultimately the thrombus may break up, freeing the lumen, or organization may occur, producing permanent obstruction, though it would seem possible that even in the latter case canalization of the thrombus might take place so as to re-establish the circulation. Vision is not entirely destroyed for some time and may undergo marked temporary improvement, but relapses occur so that blindness is finally produced. If large extravasations of blood are poured into the vitreous body, as is sometimes the case, sight is early destroyed.

The *treatment* of hyperæmia of the retina must in every case be directed toward the cause, but the application of cold compresses to the eyes and the use of smoked glasses are often advisable. In thrombosis of the central vein treatment is of little avail, though strychnine has been advised, and potassium iodide and mercury may be given in the hope of hastening the absorption of the effused blood.

Anæmia of the Retina.—All degrees of this occur up to the complete cessation of the retinal circulation. Incomplete retinal anæmia may be either chronic or acute; in the former case it is usually dependent upon chronic general anæmia, either primary or secondary, and is not associated with any disturbance of vision, while in the latter it most often results from excessive loss of blood and frequently produces permanent blindness. It is rather remarkable that instead of anæmia, loss of blood may give rise to retinal hyperæmia and hemorrhages. Incomplete retinal anæmia is also an accompaniment and no doubt often the cause of retinal atrophy, and is constantly seen as the result of optic atrophy. The retinal changes seen in albuminuric retinitis are also in all probability dependent upon the anæmia resulting from sclerosis of the retinal vessels, and the impairment of vision in acute glaucoma is thought to be due to anæmia from pressure. Ophthalmoscopic examination in incomplete anæmia shows constricted arteries, dark veins, pallor of the disc, and sometimes arterial pulsation. As a matter of fact, however, unless the changes are quite marked, the condition is apt to be overlooked.

Ischæmia, or complete anæmia of the retina, is usually due to obstruction of the central artery, and may be the result of embolism, primary thrombosis, spasm of the muscle walls of the artery, hemorrhage into the optic sheath, direct injury to the artery within the nerve, or to pressure exerted upon the artery by a neoplasm. It was considered one of the earliest and most positive signs of death, but recent observations have shown that it cannot always be relied upon.

Embolism of the central artery is of very rare occurrence, probably more so than is generally believed, many cases diagnosed as such being due to some other cause. This view has recently been urged by H. H. Thompson, who states that the few anatomical examinations that have been made are unsatisfactory, and suggests that the majority of the cases of so called embolism are due to spasm of the central artery. Embolism is said to be more common in men than in women and to be almost always unilateral, occurring more frequently in the left eye. The diagnosis of embolism is practically always made when in addition to ischæmia of the retina there is reason to suspect the presence of emboli in the circulation, as in cases of endocarditis. The embolus may be carried to a branch of the central artery, the anæmia then involving only a portion of the retina. Sometimes the macular region alone escapes in this way. If the embolus is infected, suppurative panophthalmitis results. *Thrombosis of the central artery* has been diagnosed in a few cases, but usually upon insufficient evidence. In one case, however, Haab has recently demonstrated the process of thrombosis by means of serial sections. *Hemorrhage into the sheath of the optic nerve* has never been demonstrated by an anatomical examination to be a primary cause of obstruction in the central artery, but it occurs as a result of trauma to the eye or from a hemorrhage at the base of the brain, forcing its way along the nerve. (Plate L., Fig. 2.)

Spasm of the Muscle Walls of the Central Artery.—In migraine attacks of temporary blindness not infrequently occur, and naturally enough have been attributed to spasm of the central artery, especially so since the inhalation of amyl nitrite gives such prompt relief. Wagenmann observed one of these attacks ophthalmoscopically, and saw the retina become markedly anæmic and then return to its normal condition within an interval of about ten minutes. Six months later a similar attack occurred in this case, and resulted in permanent blindness with the ophthalmoscopic picture ordinarily considered characteristic of embolism. Quinine in large doses may also cause constriction of the retinal arteries, which may be seen with the ophthalmoscope. There is great impairment of vision together with contraction of the visual field. In some cases there is complete blindness, and a cherry-red spot has even been seen in the macula. Central vision is ultimately recovered, sometimes, however, only after many months, but the peripheral field is apt to remain contracted. Some recent investigators have maintained that the impairment of vision in such cases is due to the direct action of the drug upon the ganglion cells of the retina, but the ophthalmoscopic findings certainly point strongly to spasm of the arteries as the primary factor.

In ischæmia of the retina, no matter what the cause of the shutting off of the blood supply, the changes produced are always much the same. The disc is pale; the arteries are so much reduced in calibre that they can be followed only for a short distance, and interrupted columns of blood may be seen in them. If the case is seen early, a to-and-fro motion of the blood may be observed, such as is seen in the vessels of a frog's web when the circulation is beginning to stop. The veins are also contracted, but to a much less degree, and pulsation may still be brought out in them by pressure on the globe. The retina soon becomes opaque, first near the vessels, the opacity being most marked around the macular region. But the most striking as well as the most characteristic feature of retinal ischæmia is a cherry-red spot about one-third the diameter of the disc, which makes its appearance in the centre of the macula. This spot is not invariably present, however. The explanation usually given for its occurrence, which was first offered by von Graefe, is that it is due to the dark and congested choroid showing through the thin fovea, the general white opacity of the rest of the retina, especially the surrounding macula, rendering it unduly conspicuous. A later theory is that the spot is due to a hemorrhage, and a recent observation leads the writer to believe that this view is correct. A short time ago, at the Massachusetts Charitable Eye and Ear Infirmary, there was enucleated and submitted to the writer for examination an old glaucomatous eye upon which an optico-ciliary neurectomy had been performed ten days previously, the optic nerve and with it the artery and vein being severed close to the globe. It will readily be seen that such an eye presented an exceptional opportunity for the anatomical study of retinal ischæmia, since eyes affected by embolism, etc., ordinarily offer no indication for enucleation, or at least not sufficiently early to be of much value from the standpoint of pathological anatomy. The eye had undergone no outward change as the result of the first operation, but it was removed on account of an unsightly squint. On macroscopic examination there presented itself the typical sharply defined red spot in the centre of the macula, and on microscopic examination this proved to be a hemorrhage. The extravasation of blood was limited to the macula, and there was no hemorrhagic infiltration of the

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EXPLANATION OF
PLATE L.

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EXPLANATION OF PLATE L.

Fig. 1.—Hemorrhages into the Retina: Retinal Apoplexy. (From Noyes: "Diseases of the Eye," Wood's Library of Standard Authors, 1881.)

Fig. 2.—Ischaemia of the Retina (due to Embolism of the Central Artery?). (From Noyes: *Op. cit.*)

Fig. 3.—Serous Retinitis. (From Noyes: *Op. cit.*)

Fig. 4.—Albuminuric Retinitis. (From Noyes: "Diseases of the Eye," 1890.)

Fig. 5.—Albuminuric Retinitis at an Advanced Stage. (From Stellwag's "Diseases of the Eye," Translation of Hackley and Roosa, 1868.)

Fig. 6.—Separation of the Retina. (From Stellwag.)

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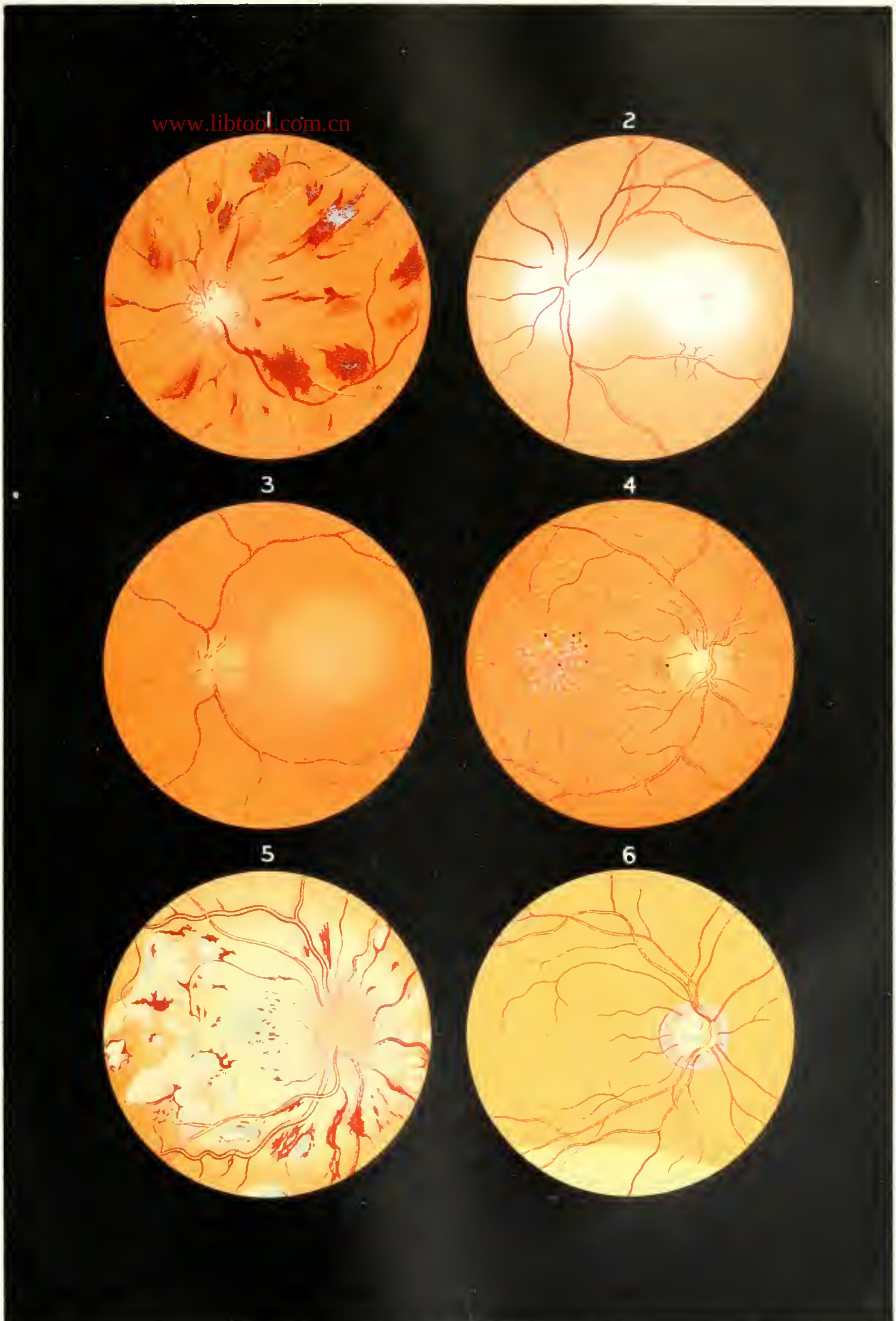

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Diseases of the Retina.

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choroid behind it, a fact which showed that the blood did not come from the choroidal vessels. The retina was almost completely necrotic, especially in its inner layers, and there were marked proliferation and migration of the cells of the pigment layer. In almost all of the retinal vessels the red blood corpuscles stained very feebly, but in the hemorrhage itself, and in a few of the vessels near the macula, the blood was well preserved, thus indicating that the source of the hemorrhage was the cilio-retinal vessels. The fact that the hemorrhage was comparatively fresh, and that there were no other retinal hemorrhages, went to show that it was not the result of the glaucoma but that it was dependent upon the cutting off of the circulation in the central artery.

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In a number of cases of supposed embolism the circulation after a time has been seen to return. This has possibly been due to the breaking up of an embolus, or more likely to the establishment of a collateral circulation through the cilio-retinal vessels, but on the other hand it certainly supports the view that the cases in which it occurred were really due to spasm. Sometimes the direction of the circulation is reversed. The return of the circulation gives rise to numerous hemorrhages, most of them in the macular region, and no doubt due to the injury to the vessels produced by the cessation of the flow of blood. The final picture is that of atrophy of the retina and optic nerve.

As a result of ischæmia of the retina, vision is almost instantaneously lost. Occasionally a part of the visual field may remain intact for a while, but later it also becomes blind. It is said that in some instances the macula is sufficiently well nourished by the cilio-retinal vessels to prevent impairment of central vision. If the circulation returns quickly, as in migraine, vision is completely restored, but in total embolism it is almost always permanently destroyed.

Treatment of Retinal Anæmia.—In the simple variety of retinal anæmia dependent upon general anæmia, treatment appropriate to the latter must be adopted. If the anæmia is very marked, lowering the head at intervals during the day may be practised. The acute retinal anæmia resulting from excessive loss of blood should be combated by saline infusions and general supportive treatment. Inhalations of amyl nitrite are of great value in spasm of the central artery associated with migraine. In embolism, paracentesis of the cornea, iridectomy, and massage of the cornea with the purpose of dislodging the embolus, have been recommended.

Retinal Hemorrhages.—Aside from trauma, which is of course a frequent cause, hemorrhages into the retina may occur as the result of a general disease, less commonly as the result of disease confined to the eye alone, or they may occur occasionally in young people without any assignable cause. As already noted, hyperæmia of the retina frequently gives rise to them, especially the venous hyperæmia resulting from thrombosis of the central vein, optic neuritis, or neuroretinitis. When they are the predominant feature in the latter, the condition is usually designated by the term *hemorrhagic retinitis.* Venous hyperæmia due to pressure on the central vein at the disc is also probably the cause of the retinal hemorrhages which sometimes occur in primary glaucoma, and the intense hyperæmia resulting from suffocation is also likely to produce them. Their occurrence as an after-effect of embolism has already been referred to. The retinal hemorrhages that occur as the result of general disease are dependent either upon alterations in the retinal vessels, associated in most cases also with high arterial pressure, or upon changes in the character of the blood itself. Thus they are seen with comparative frequency in general arteriosclerosis, Bright's disease, gout, diabetes, anæmia, leukæmia, purpura, and scurvy. When such predisposing factors are present the immediate cause is often violent exertion, such as coughing or straining at stool. In arteriosclerosis they may appear quite suddenly in great numbers, just as in cerebral apoplexy, and in such cases the condition is, in fact, often spoken of as retinal apoplexy. Retinal hemorrhages also occur as the result of menstrual disturbances, sometimes as one of the manifestations of vicarious menstruation. They frequently occur in new-born infants as the result of excessive pressure on the head during delivery, but they are quickly absorbed without leaving any macroscopic changes. In this way no doubt many obscure cases of congenital amblyopia are produced. Among other general causes may be mentioned poisons, especially lead and phosphorus, jaundice, pregnancy and parturition, malarial fever, septicæmia, and pyæmia. (Plate L., Fig. 1.)

Retinal hemorrhages vary greatly in regard to size, shape, number, and position. When few in number they are usually situated not far from the disc or near the macula. They occur in any of the retinal layers that contain blood-vessels, but most frequently in the nerve-fibre layer where they assume a characteristic striated "flame-like" shape, due to the fact that the blood insinuates itself in between the nerve fibres. Owing to the radial arrangement of the fibres around the disc, hemorrhages in its neighborhood tend to take the form of red radii. The extravasations of blood may break through the retina into the vitreous humor producing vitreous opacities, or they may force their way between the retina and choroid. Sometimes the blood collects beneath the hyaloid membrane, forming the *subhyaloid hemorrhage.* This most frequently occurs in the macular region, appearing as a sharply defined dark red disc. When recent, retinal hemorrhages are bright red in color, but they soon become darker, often almost black. The blood is absorbed rapidly, especially when the hemorrhage is small, but white spots in many cases are left to mark their sites. The white spots are due to necrosis of the retinal tissue and may contain fat globules and cholesterin crystals. They may finally disappear or they may remain permanently, not infrequently becoming more or less pigmented, owing to the migration of cells of the pigment layer into them. It is said that the pigment striæ, known from their resemblance to obliterated vessels as *angioid streaks in the retina,* are due to metamorphosis of retinal hemorrhages. Extravasations that have broken into the vitreous humor but that still remain attached to the retina, sometimes undergo organization and become converted into connective tissue. It is in this way that *retinitis proliferans* is thought to arise.

The disturbance of vision produced by retinal hemorrhages obviously depends upon their size and position, and of course is particularly great when one of the hemorrhages occupies the macula. Sometimes there is metamorphopsia, less often photopsiæ. Even small hemorrhages may produce a temporary clouding of vision if they break through the retina into the vitreous humor. The prognosis is favorable when they are small and the tendency to relapses can be successfully overcome. It is particularly unfavorable when they occur in connection with a general retinitis. The subhyaloid hemorrhages which occur at the macula are usually absorbed and vision is completely restored. When the hemorrhages are dependent upon a general disease the treatment must necessarily be directed chiefly toward the latter, but rest in bed, the application of cool compresses to the eyes, and the administration of mercurial inunctions or potassium iodide to favor the absorption of the effused blood, are usually indicated. Leeching, purging, and the production of diaphoresis by pilocarpine are also advised.

Phlebectasia retinæ is a name given to a rare condition in which the retinal veins show dilatations and constrictions, sometimes producing a decided beaded appearance. In some cases it is probably due to vaso-motor disturbances. Schöbl describes a case in which the condition was also present in the conjunctival veins and was evidently dependent upon suppression of the menses, the phenomenon disappearing when the menstrual flow was re-established.

Retinal aneurisms are of very rare occurrence, but they have been seen in the living subject and also in enucle-

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ated eyes. Most frequently they are multiple, miliary in size, and situated on the smaller retinal arteries; but sometimes a single large aneurism may form on one of the large arteries. An arterio-venous aneurism has been known to occur as the result of an injury. Treatment is of no avail.

Sclerosis of the retinal vessels probably always occurs where there is general arteriosclerosis, but the alterations in the retinal vessels are rarely sufficiently obvious to attract attention on ophthalmoscopic examination, owing, no doubt, to the fact that the vessels are much smaller than those in which marked atheromatous changes are apt to occur. Both the veins and the arteries may show white borders, due to an increase of connective tissue in their walls, and sometimes constrictions and spindle-shaped thickenings. Often, however, the first evidence of disease of the retinal vessels is the occurrence of retinal hemorrhages. In syphilis changes are met with in the retinal arteries similar to those seen in cerebral syphilis, so that they are of diagnostic significance as regards the latter. Owing to obliterating endarteritis, the arteries appear as thin white bands, and there may be hemorrhagic infarcts. The veins are broad and dark colored. Vision is unaffected for a long time.

RETINITIS.—This term strictly should signify inflammation of the retina, but as a matter of fact most of the retinal conditions to which it is applied are not of an inflammatory nature, but are due either to degenerative or to atrophic changes, or they are dependent upon obstructive œdema and hemorrhage. In fact, there is probably only one condition, suppurative retinitis, in which the retina is actively inflamed. When retinitis occurs in association with neuritis the condition is spoken of as neuro-retinitis. In not a few cases retinitis is secondary to optic neuritis, the swelling of the disc interfering to such an extent with the venous outgo as to lead to œdema and hemorrhage. On the other hand, in many general diseases, neuritis and retinitis may be produced independently, either one or the other predominating. The chief varieties of retinitis are as follows:

Suppurative Retinitis.—This most commonly occurs as the result of penetrating wounds of the globe or following operations, particularly those for the removal of cataracts, and almost always results in or forms a part of a general panophthalmitis. It is usually due to micro-organisms which have been introduced into the eye, but a comparatively mild form of it can be produced by chemical irritation due to the disintegration of a foreign body, especially if the latter contains copper. The condition may also be metastatic in origin, particularly in puerperal septicæmia and in the acute infectious diseases of children. In these metastatic cases the inflammation may be confined throughout to the vitreous chamber, and thus, in children, it may result in one of the conditions which gives the clinical picture known as *pseudo-glioma*. Contrary to what has been generally believed, in panophthalmitis it is the retina, not the choroid, from which the purulent exudation mainly arises. In a large number of cases of panophthalmitis examined microscopically by the writer, the retina has invariably been found densely infiltrated with pus cells, while the choroid showed scarcely any purulent infiltration. It might be thought that the pus cells in the retina came there from the choroid, but they can be seen in the act of emigrating from the retinal vessels around which, too, they are most abundantly collected. The choroid seems to play the part of an abscess wall, and is congested, more or less œdematous, and infiltrated with lymphoid and plasma cells. The choroid also early gives rise to a formation of granulation tissue. In the cases diagnosed clinically as metastatic choroiditis the condition is usually that of metastatic retinitis, although the micro-organisms no doubt often reach the eye through the choroidal vessels. If seen sufficiently early, the retina in these cases is found to be hazy and covered with hemorrhages, but the vitreous humor soon becomes so cloudy that the later stages of the process cannot be followed by means of the ophthalmoscope. Suppurative retinitis from any cause may pursue either an acute or a chronic course, and ultimately results in phthisis bulbi. The treatment is that suitable for panophthalmitis, and is of little avail. Recently the introduction of powdered iodoform in the vitreous chamber has been tried, sometimes, it is claimed, with successful results.

Retinitis Septica (Roth).—In pyæmia and septicæmia the retina frequently shows hemorrhages and white spots not unlike those seen in albuminuric retinitis. There are no signs of active inflammation and no pain. Vision is not much affected and the prognosis is favorable so far as the eye is concerned. Roth believes the condition is not due to the presence of micro-organisms in the retina, but to toxic substances circulating in the blood produced by the septic processes elsewhere. Some observers claim that the hemorrhages are due to the lodgment of septic emboli in the retinal vessels, but the absence of inflammatory symptoms and the mild course pursued by the affection are decidedly against this view.

Retinitis Simplex, Serous Retinitis, Retinal Œdema.—Under certain conditions not understood, the retina becomes hyperæmic and shows a haziness evidently due to œdema, which either may be diffuse or may occur in circumscribed patches. This mild form of retinitis is supposed to result in some instances from eye strain. It is also said to be an early manifestation of sympathetic ophthalmia. Vision may be considerably reduced and there may be megalopsia, micropsia, and metamorphopsia. Under complete rest the condition entirely disappears. A special variety known as *commotio retinæ* is due to a blow upon the eye. This also clears up, usually in about three days, with complete restoration of vision. (Plate L., Fig. 3.)

Albuminuric Retinitis.—In some cases of Bright's disease the retina shows changes which are met with under almost no other conditions, and which therefore may be regarded as practically characteristic of renal disease. Such plainly marked cases of albuminuric retinitis, as they are named, occur in only a small per cent. (about seven per cent.) of patients suffering from Bright's disease. On the other hand, if carefully searched for, less characteristic retinal changes—such, for instance, as alterations in the vessels and hemorrhages—will be found sooner or later in probably one-fourth of these patients. Typical albuminuric retinitis may occur in any form of renal disease, whether acute or chronic, but it is met with by far the most frequently in chronic interstitial nephritis and least often in amyloid disease of the kidneys. It is rarely limited to one eye, though the retinal changes may differ considerably in the two eyes, both in extent and in character. While the retinal affection appears only in cases of renal disease which have lasted some time, yet not infrequently it is by means of the ophthalmoscope that the serious condition of the kidneys is first discovered. The most characteristic feature of the affection is the presence of a "star-shaped figure in the macula," consisting of a greater or less number of white striæ which radiate from the centre of the macula, frequently, however, without completely encircling it. The fovea is usually not involved and stands out as a clear red spot. Other changes almost always present are hemorrhages, œdema, and irregular white patches of various sizes. The latter have ill-defined edges and are situated in the inner layers of the retina, often obscuring the vessels that cross them. The arteries are narrowed and frequently show white borders, while the veins are broad and tortuous. The narrowing of the arteries is not uniform, so that the same artery may show variations in width along its course. The arteries are also somewhat tortuous, and the light streaks in their centres are much brighter than in the case of normal arteries. When an artery crosses a vein the latter sometimes appears pale for a short distance on each side of the artery, due no doubt to compression. Optic neuritis is commonly present, and in some cases is the most prominent feature. In other cases hemorrhages predominate, while in still others the most striking change is that due to œdema. As just noted, the appearances may be quite different in the two eyes. Thus in one eye the principal change may consist in the

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star-shaped figure about the macula, while in the other this may be absent and the retina covered with hemorrhages. If at any time there has been severe optic neuritis the retina and optic nerve ultimately undergo atrophy. Rarely the retina shows folds or even complete separation, the latter especially in the albuminuria of pregnancy. (Plate L., Figs. 4 and 5.)

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The retinal condition most likely to be mistaken for albuminuric retinitis is that which results from a high grade of optic neuritis, especially that associated with brain tumor. In this the star-shaped figure may be present in a perfectly typical form, so that if at the same time there should be a trace of albumin in the urine and the general symptoms of brain tumor should not be plainly marked, the diagnosis might be difficult. In such cases, however, sight is almost always lost, whereas in albuminuric retinitis complete loss of vision rarely occurs. It should be remembered, too, that a high grade of optic neuritis does not occur in Bright's disease except in advanced cases in which the diagnosis is plain. Finally, renal disease could be excluded in most cases by a microscopic examination of the urine. In lead poisoning, too, the retina may present appearances identical with those seen in albuminuric retinitis (*saturnine retinitis*), but it is not certain that they are not due in reality to kidney lesions produced by the lead.

Anatomically the most important lesion in albuminuric retinitis, and one that gives the key to the other changes, is a widespread endarteritis and hyaline degeneration of the vessels. This is, of course, not limited to the retinal vessels, but it produces more serious damage in the retina than in the other structures of the eye. The atheromatous condition of the vessels associated with the general high arterial pressure results in numerous hemorrhages, while the insufficient blood supply leads to degenerative changes in the retinal tissue. Most of the white patches seen by the ophthalmoscope are produced in this way, but some of them are left by retinal hemorrhages that have undergone absorption. The degenerated areas show fatty degeneration of the retinal tissue, including the ganglion cells, nerve fibres, and fibres of Müller, and contain fibrin and granular detritus. Proliferation and migration of the cells of the pigment layer occur in the later stages. The degenerative changes make their first appearance at the macula because here the vessels are least numerous, but the fovea centralis ordinarily escapes, since it is well nourished by the choriocapillaris behind it. The star-shaped figure is said to owe its form to the radial arrangement of the fibres of Müller about the macula, though the degenerative changes are not limited to them. It seems to the writer more likely that its form is determined by the radial arrangement of the vessels in this region. The retina in general is apt to show marked œdema, usually in association with a high grade of optic neuritis, though the retinal œdema is sometimes quite marked where there is very little swelling of the disc. The cause of the optic neuritis is obscure; some observers attribute it to cerebral disturbances secondary to the renal disease. In addition to the other changes, the retina may show a certain amount of round-cell infiltration and hyperplasia of its connective tissue.

The disturbance of vision usually is slight when compared to the extensive retinal changes, and in the milder forms vision may be entirely unaffected. The fact that the fovea centralis is but seldom affected accounts for the almost constant preservation of central vision. Complete blindness is rare, and when it occurs it is usually the result of secondary atrophy of the optic nerve and retina or is due to separation of the latter. It should be remembered, however, that in Bright's disease, whether or not there is retinitis, attacks of blindness, *uræmic amaurosis*, may come on within a few hours as the result of uræmic poisoning, though they are more common in acute nephritis than in the chronic forms of renal disease. Here the blindness in all probability is due to the action of the uræmic poison upon the brain itself, the pupils in most cases still reacting to light. It is associated with other uræmic symptoms and disappears when the uræmia is overcome.

The prognosis of albuminuric retinitis depends chiefly upon that of the renal disease, and since the retinal affection occurs only in advanced stages of the latter, it is almost always bad. Conversely, the prognosis of the renal disease, and hence the prognosis in regard to life, is particularly bad when albuminuric retinitis has made its appearance. The prognosis in regard to sight is of little importance, because the patients seldom live long enough for the visual disturbance to become of serious moment, death usually occurring well within a year, rarely later than two years, after the discovery of the retinal disorder. The nephritis associated with pregnancy is an important exception to this rule, complete recovery being of frequent occurrence after it. Recovery also sometimes follows the nephritis which accompanies the acute infectious diseases. In these cases the retinal disease ceases to progress, and many of the retinal alterations disappear. The star figure at the macula, however, seldom entirely disappears.

Aside from the measures usually employed in severe cases of nephritis there is no treatment that will benefit the retinal disease in any way. It sometimes happens, however, that the retinitis may undergo decided improvement under treatment directed toward the kidneys and yet death ensue in the usual short time. In the albuminuric retinitis of pregnancy, especially if it appears early, the induction of abortion is often advisable.

Diabetic Retinitis, Glycosuric Retinitis.—This affection is certainly rare, though just how rare is not definitely known. It is a late manifestation of the general disease, and according to Hirschberg it is always present in diabetes which has existed for twelve years. In some instances the retinal changes are no doubt due, in part at least, to an accompanying interstitial nephritis; but it is generally believed that they may be entirely independent of kidney lesions, and there is no question but that in typical cases they differ decidedly from those seen in typical albuminuric retinitis. The affection is probably confined to diabetes mellitus, though it is claimed that diabetes insipidus has produced it. It is likely that the retinal changes that have been seen in supposed cases of diabetes insipidus have not been due to the latter disease, but that the polyuria and the retinitis have independently been due to a tumor of the brain. It is possible, too, that the polyuria of chronic Bright's disease may have been mistaken for that of diabetes insipidus.

In the form of retinitis most characteristic of diabetes, *central punctate retinitis of Hirschberg*, the retina shows great numbers of small bright shining spots, sometimes irregular in shape, which are most numerous near the disc and in the macular region, without, however, having a stellate arrangement. Scattered more generally over the fundus there are many punctate hemorrhages. Neither the retina nor the disc shows evidences of œdema, and the retinal vessels are apparently normal. Larger white spots are also occasionally seen. Sometimes in diabetes the white spots are entirely absent and the retina shows only various kinds of hemorrhages. This condition is the *hemorrhagic diabetic retinitis* of Hirschberg, though why it should receive the name retinitis is not evident. In diabetic albuminuric retinitis the changes characteristic of nephritis are associated with those of diabetic retinitis. Albuminuric retinitis may also occur alone in diabetic patients.

Diabetic retinitis is always sooner or later binocular. Vision is apt to be considerably impaired, especially central vision, and there may be contraction of the peripheral field. It is difficult to say in a given case, however, whether or not the disturbance of vision is due to the retinal changes, since amblyopia is common in diabetes even when the ophthalmoscopic examination is negative. In some cases the disturbance of vision is very slight. Not infrequently vitreous opacities due to hemorrhages occur and may produce total blindness, and glaucoma secondary to hemorrhage is also met with. Total blindness, however, is rare in diabetic retinitis.

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The prognosis of the retinal affection is bad, the latter seldom showing improvement under treatment, and occurring as it does in the later stages of the general disease, diabetic retinitis is of evil significance in regard to the duration of life. This is particularly true of the hemorrhagic form, since a tendency toward hemorrhage on the part of the cerebral vessels is indicated. The treatment is that suitable for the general disease.

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Leukæmic Retinitis.—In all severe cases of leukæmia the retina presents an abnormal appearance, but actual retinitis is relatively uncommon. The fundus is apt to appear light yellow in color owing to the altered color of the blood in the choroidal vessels, but where the choroid is highly pigmented this may not be noted. The arteries are pale and sometimes small; the veins are dilated, frequently tortuous, and their walls may appear thickened owing to infiltration with white cells. Retinal hemorrhages are extremely common, in fact, they are the most constant ocular lesion met with in leukæmia. In addition to these changes other lesions sufficiently marked to warrant the name of retinitis sometimes occur. These are confined almost entirely to the spleno-myelogenous type of leukæmia, and consist of haziness of the retina and the presence of white spots with red borders. The latter are most numerous at the periphery and in the macular region, and are due to collections of white cells in the centres of hemorrhages. Though not often seen, they are highly characteristic of leukæmia. Other white spots, due to degeneration, also occur. The disc may be practically unaffected, or it may be greatly swollen owing to œdema and to infiltration with cells. Both eyes are almost always affected, though in different degrees. The impairment of vision depends upon the position and number of the white patches and hemorrhages; a hemorrhage in the macular region will of course cause loss of central vision. This may be of the subhyaloid variety, however, and afterward clear up. A large hemorrhage into the vitreous humor may cause permanent loss of sight and in some cases glaucoma. Albuminuric retinitis may occur as a complication. The prognosis is hopeless as regards both the general and the local affection.

Syphilitic Retinitis is far less common than syphilitic chorioretinitis (see Vol. III., p. 64), but still it does occur. It is met with in both acquired and congenital syphilis, though in the latter only the final stages are seen. In the acquired form it may develop four to six months after the primary infection. The retina shows a grayish-white opacity which is most marked near the vessels, and along the latter small white spots are frequently seen. The vessels themselves are apparently not much affected, the arteries are somewhat thinner, and the veins thicker than normal. Dust-like opacities are almost always present in the posterior part of the vitreous humor, and may persist after the retinal affection is cured. Hemorrhages are rare. Microscopically the important changes found have been diffuse round-cell infiltration of the retina, endarteritis of its vessels, and nodular collections of round cells in the choroid. No distinct gummatous formations have been observed in the retina, but the nodules in the choroid are said to resemble gummata. Proliferation and migration of the cells of the pigment epithelium have been noted. An early subjective symptom of the disease is a constant shimmering of light, due, according to Hirschberg, to insufficient blood supply to the retina. Visual acuity is much reduced and there is frequently night blindness. Ring scotomata are sometimes detected. The retina and with it the optic nerve ultimately may undergo atrophy. The prognosis and treatment are similar to those of syphilitic chorioretinitis.

Relapsing Syphilitic Central Retinitis.—This is an extremely rare affection, first described by von Graefe, characterized by repeated sudden attacks of marked impairment of vision. At first the vision returns to normal during the intervals, but finally it becomes permanently impaired. The retina shows slight dimness in the macula around which fine dots are frequently seen, and in the later stages of the disease pigmentary changes occur in the macular region. Reduction in central visual acuity usually persists even after prolonged antisyphilitic treatment, owing to the structural alterations in the retina.

Retinitis Proliferans (Manz).—In this disease masses of connective tissue arise from the retina and extend out into the vitreous humor. They are usually attached near the disc, rarely directly to the latter. There is little doubt that the condition is brought about through the organization of retinal hemorrhages. The progress of the disease is slow, but it usually leads to total blindness. Iridocyclitis or separation of the retina may occur, and the globe finally undergoes atrophic changes. It is said that mercurial inunctions and potassium iodide are of benefit.

Retinitis Punctata Albescens (Mooren).—As indicated by the name, in this affection the retina is studded over with numerous small white spots which are most numerous around the disc and in the macula; the fovea, however, usually escapes. Central vision is reduced and there are sometimes night blindness and contraction of the peripheral field. The disease is extremely rare and occurs in young persons.

Consanguinity in the parents seems to be an important factor in its occurrence and several members of the same family may be attacked. Aside from the ophthalmoscopic picture, it is thus very similar to retinitis pigmentosa.

Retinitis Circinata (Fuchs), a very rare disease of unknown etiology, always occurring in elderly persons, is characterized by the presence of a number of small white spots situated around the macula in the form of a more or less complete circle, with a diameter two or three times that of the disc. Within the circle, but not quite reaching its circumference, the macula shows a grayish opacity. The white spots lie deeper than the retinal vessels and sometimes are slightly pigmented. Small retinal hemorrhages occasionally occur, especially in cases of long standing. Along with these changes there are diminution in central vision, limitation of the visual field, and a small central scotoma. Vision gradually becomes more and more defective, but absolute blindness does not occur. The affection may be either monocular or binocular. According to Fuchs, the spots sometimes disappear, but the disease is not benefited by treatment.

Retinitis Striata (Nagel), another very rare affection of the retina, owes its name to the presence in the retina of gray stripes situated in front of the pigment layer, but behind the vessels. The stripes vary in width, but may be three or four times as wide as a vein. They may run from the disc like radii, or they may have no special arrangement. In addition to these striæ the retina may show pigmentary changes. The disease appears at an early age, runs a chronic course, and although there is some reduction in visual acuity, blindness does not generally result. The etiology and pathology of the affection are unknown, though some observers hold the view that the stripes are due to metamorphosis of hemorrhages, as in the case of angioid streaks in the retina. L. Caspar maintains that they are the result of a retinal separation that has undergone spontaneous cure. Treatment is of no avail.

Retinitis from exposure to bright light is sometimes met with, occurring most often as the result of exposure of the retina to sunlight during an eclipse (*solar retinitis*), or less frequently to exposure to an electric arc light. There is produced a central scotoma which may or may not persist, and, later on, pigmentary changes may be seen in the macula.

Snow blindness, which results from long exposure of the eyes to the brilliant light reflected from large expanses of snow, is not dependent, as might be thought, upon retinal changes, but it is due to the photophobia and blepharospasm resulting from a peculiar form of conjunctivitis. It is said, however, that sometimes the retina may be hyperæmic, and that there may be some actual diminution in visual acuity.

Amaurotic Family Idiocy (Tay).—In this very rare disease the retina presents an appearance as striking as it is

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characteristic. There is a grayish-white patch in the macular region, about twice the size of the disc, the centre of which is occupied by a small red spot similar to that seen in embolism of the central artery. Otherwise the fundus appears normal. The disease makes its appearance within the first year of life, both eyes being affected in the same way and the child showing marked symptoms of idiocy. It occurs almost exclusively in children of Hebrew parentage, usually attacking several children of the same family. Optic atrophy followed by blindness gradually ensues, and death inevitably occurs within a very short time, most often before the child reaches the age of two years. Anatomically the chief lesion found is an extensive degeneration of the cells of the cerebral cortex. According to Holden, there is a similar degeneration of the large ganglion cells of the retina, which, he thinks, gives the explanation of the ophthalmoscopic findings, since these cells are absent in the fovea and most numerous in the macula surrounding it.

Retinal atrophy is the final outcome of embolism of the central artery, thrombosis of the central vein, and of the severe form of retinitis. It also occurs as the result of separation of the retina and in the late stages of glaucoma. It is characterized particularly by marked thinning of the vessels, which sometimes become almost invisible, and by secondary atrophy of the disc, the latter taking on a pale dirty gray color and presenting an atrophic excavation. Pigmentary changes not infrequently take place in the retina. An apparently idiopathic form of retinal atrophy is that known as *chorioretinitis pigmentosa* (see Vol. III., p. 69), or more commonly as *retinitis pigmentosa*.

Separation of the Retina, Amotio Retinæ.—Normally the pigment epithelium of the retina is adherent to the choroid, but not to the rest of the retina, the latter simply being held in contact with it by the pressure of the vitreous humor. In so-called detachments of the retina the pigment layer is, in general, always left behind and the condition should therefore be spoken of as a separation, not as a detachment, although the latter is the term almost universally used. In enucleated eyes, these two portions of the retina separate with the greatest ease, and indeed it is a difficult matter to obtain histological specimens of the retina with the pigment layer *in situ*. Notwithstanding this fact, however, separation of the retina, though not rare, seldom occurs except under conditions which in themselves are of a most serious nature. Thus the most common conditions which lead to it are advanced myopia, severe injuries, especially if accompanied by loss of vitreous humor, iridocyclitis, choroiditis, intra-ocular tumors, and hemorrhage. Idiopathic separation (that is, separation of the retina without obvious cause) does occur, however, and is most common in youth and in old age. An important though uncommon cause for retinal separation is albuminuric retinitis, especially that associated with pregnancy. (Plate L., Fig. 6.)

The large majority of separations are found below, though in many cases they no doubt started elsewhere and sank downward, the retina becoming reapplied at the site of the original separation. Owing probably to the position of the disc, separations are less frequent on the nasal than on the temporal side. Localized separations at the macula are rare. The best ophthalmoscopic view of a retinal separation is to be obtained by the indirect method, though it is advisable also to make use of the direct method, holding the instrument some distance from the eye of the patient. In large separations that have come far forward the retina can often be seen by oblique illumination alone without the aid of an ophthalmoscope. The retina, if the separation is recent, projects forward into the vitreous humor as a tremulous, translucent, gray membrane, showing a greater or less number of folds over which the blood-vessels are seen to take a tortuous course. The latter lose their light streaks and appear smaller and also much darker than normal owing to the reflection of light from the choroid behind. Ordinarily if the media are clear the condition is readily recognized, but when the separation is flat and extensive the diagnosis is sometimes difficult. If the separation continues to increase, as is usually the case, it ultimately becomes total, the retina remaining attached at the disc and ora serrata only, and forming a plaited funnel behind the lens. Most often, however, it cannot be seen with the ophthalmoscope at this stage owing to lenticular or vitreous opacities. In the case of intra-ocular tumors, distinction should be made between an actual separation of the retina and the lifting up of the latter, due to the growth of the tumor beneath it. While the retina is attached to the tumor it is of course not tremulous, shows no folds, and the color of the tumor may be recognized through it. Even very small tumors, however, may early cause complete separation of the retina, and when this takes place the separated retina differs in no way from that which occurs under other conditions. The portion of the retina first to become separated is usually that covering the tumor, but not infrequently this portion of the retina never becomes separated and is overgrown and destroyed by the tumor cells. Even when this is the case, the remaining portion of the retina usually undergoes separation.

The apparent color of the separated retina depends upon that of the subretinal fluid; if the latter is tinged with blood, the retina takes on a greenish color. Owing to degenerative changes, the retina very soon becomes opaque, but it finally becomes translucent again when atrophy sets in. Quite frequently ruptures can be detected in separated retinæ.

The tension of the eye as a rule is diminished and the anterior chamber is deep, the iris frequently showing iridodonesis. Where the separation is due to an intra-ocular growth, the tension is almost always increased, or at least not diminished, a fact of great diagnostic importance. Liquefaction of the vitreous humor in association with vitreous opacities is common, and in old cases cataract and a low grade of iritis are apt to occur.

The separated retina frequently is œdematous and shows hyperplasia. Calcification, more rarely ossification, may occur, and cholesterin crystals may form in it. Pigmentary changes and hemorrhages are not often seen. Rarely cysts are formed. The blood-vessels remain pervious for a considerable length of time, but many of them finally show sclerosis and thrombosis. The nervous elements of the retina atrophy, and the layer of rods and cones soon undergoes maceration owing to the lack of the nourishment normally furnished by the choroid.

The manner in which separation of the retina is brought about is apparent in a large number of cases, but in an equally large number it is a matter of dispute. Cyclitis produces separation by the contraction of exudates that have been poured in the vitreous chamber. Choroiditis may produce it in a similar manner, or by giving rise to exudates which collect in front of the rods and cones. Traumatic separations are produced in several ways. When occurring immediately or soon after an injury or operation they are usually due to hemorrhage or to the loss of vitreous humor, which by lowering the intra-ocular tension allows serum to collect behind the retina. In other cases the retina is ruptured by the injury and the vitreous humor passes behind it through the rupture. The separations that occur some time after the injury are due to the traumatic cyclitis and choroiditis that have been set up. Foreign bodies in the vitreous chamber may cause separation of the retina if they produce a severe inflammatory reaction; but, on the other hand, they may remain attached to the retina for years without separation resulting. Finally, spontaneous subretinal hemorrhages from any cause, glaucoma for instance, may produce separation of the retina.

To explain other cases of separation a number of theories have been advanced. In myopia it seems clear that the elongation of the eyeball plays the chief rôle, but the exact way in which it does so is not certainly known. Iwanoff found that in myopic eyes the vitreous body became separated from the retina posteriorly, and that the preretinal space thus formed was filled with serum; but he failed to explain satisfactorily how this led

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to retinal separation. De Wecker suggested that the latter was due to spontaneous rupture, permitting the serous fluid to find its way behind the retina. Leber and Nordensen maintain that in the large majority of cases retinal separation is due to a fibrillar condition of the vitreous body leading to its shrinkage and hence to traction upon the retina. The peculiar condition of the vitreous body is said to be dependent upon a chronic choroiditis. Suddenly developing separations, according to this theory, are due to rupture of the retina resulting from the traction. Rachlman, however, has called attention to the fact that the fibrillar condition of the vitreous body, noted by Leber and Nordensen, may be secondary to the separation, and that separations may occur when the vitreous body is perfectly fluid. He holds the view that a process of diffusion plays the most important part in the production of retinal separations. According to his diffusion theory, an albuminous exudate first collects behind the retina, and then fluid passes by diffusion from the vitreous body through the retina, gradually increasing the amount of fluid behind the latter, and separating the retina more and more from the choroid. It seems almost self evident that separation of the retina having once begun, the process of diffusion must play an important part in carrying it on to completion.

Among the early subjective symptoms of retinal separation are photopsiæ, chromatopsiæ, and metamorphopsia, followed by the appearance of a dark cloud which obscures part of the visual field and produces a positive scotoma. Vision at the macula is maintained so long as the separation has not involved this region, but it is apt to be impaired in any case. The separated retina may retain light perception for a short time, and if it soon becomes readapted, it may completely resume its function. Thus the macula may be separated at first and then become reapplied to the choroid and regain its function as the separation sinks lower down. But the prognosis in retinal separations is very unfavorable, though in rare instances a spontaneous cure has resulted. Small separations occurring after an injury or as the result of retinitis, such as albuminuric retinitis, offer the best prognosis so far as the separation itself is concerned. Usually the separation increases until it is complete and there is absolute blindness. The prognosis is particularly unfavorable in myopic cases because there is no way in which we may combat the myopia. Idiopathic separation also has a highly unfavorable prognosis.

Until recently the method of *treatment* considered most satisfactory was rest in bed and the administration of diuretics, diaphoretics, and purgatives, in the hope of causing absorption of the subretinal fluid; but of late much more brilliant results have been obtained by repeated subconjunctival injections of normal or physiological saline solutions. Unfortunately, however, even after this method of treatment recurrences are common. Many surgical measures have been tried, but with indifferent success; incising the retina, withdrawing the subretinal fluid by means of a syringe, and injecting iodine with the purpose of setting up an adhesive inflammation, have all been recommended, but it is likely that they will be generally replaced by the method of subconjunctival injections.

Subretinal Cysticercus.—The cysticercus has been found as a parasite within or beneath the retina, but the condition is an extremely rare one, especially in this country. At first the retinal separation produced is localized over the parasite, and the movements of the latter can sometimes be observed under it. The vitreous humor soon becomes cloudy and the retinal separation becomes total, producing complete blindness, and the eye finally undergoes atrophic changes. Sometimes the parasite works its way through the retina into the vitreous humor. Drugs given with the object of killing the parasite have always proved ineffectual. When the attempt is made sufficiently early, the entozoon may be successfully removed by operation with preservation of sight.

Tumors of the Retina. (See Vol. IV., p. 112.)

Frederick Herman Verhoeff.

RETROPERITONEAL TUMORS.—This subject has received its full share of attention during the past decade and with satisfactory results. That it is still at the present time a subject of much thought and earnest research cannot be denied. Thus far, investigations go to show that in the past there have been much confusion in the pathology of these growths, many errors in diagnosis, and not a very satisfactory record regarding operative interference. Like many other problems in this great field of surgery, an early, careful study of the case, a judicious weighing of all symptoms, subjective and objective, an experienced touch, no haste, are doing much to place on a more secure basis of classification these rare growths. Careful workers in the pathology of these tumors are doing much to clear up doubtful points, and establish on a more secure basis their true nature. Operating surgeons, when the tumor has obtained full size, have not found the work of removal at all encouraging, yet it is plainly to be observed that when the growth has been reached early, a fair percentage of recoveries has been secured.

A careful study of retroperitoneal tumors shows that many of them are of a mixed variety, containing the elements of both lipoma and myxoma, tissues which are, histologically, very closely associated.

Both of these tissues are found normally in the retroperitoneum, and doubtless many of these growths arise, under suitable conditions, from congenital neoplasms. These tumors are sometimes active in their growth, often become cystic, and at times reach immense proportions. Cases are reported of tumors of this kind weighing eighty pounds. The distribution of the elements is very diverse. The fat may be regularly distributed throughout the tumor or may occur as islands located here and there. These growths are very often œdematous, and by chemical analysis present a large percentage of mucin. The microscope, besides revealing the usual elements of lipoma and myxoma, very often reveals a numerous round-celled infiltration in the stroma of the growth, pointing to a sarcomatous element in their character. While not presenting all the features of active malignancy that carcinoma and sarcoma do, yet they often show a marked tendency to recur locally when removed.

Clinical histories and pathological research both show that tumors containing embryonal elements are very apt to be malignant; indeed, it may truly be said that they are always so.

The tumors found in the kidneys of young children are, for the most part, mixed tumors, chiefly myosarcomata. Many are surely congenital, and are an example of a new growth developing from embryonal tissue. They have, by Grawitz, recently been compared to a series of embryonal growths which spring from the suprarenal capsules, and have the appearance of adipose tissue, but are usually sarcomatous. (Orth, "Pathologische Diagnostik.")

Even though the tumor may not at first present the condition of true malignancy, yet the operative surgeon has learned to know that the semi-malignant growth is very apt to return either in the cicatrix or in the neighboring connective tissues, and to involve important structures, such as the large secreting glands or the lymphatics.

A careful investigation of the reported cases, together with an examination of all accessible works on pathology, impresses one with the belief that the most frequent origin of these growths is in the connective tissue of the capsular envelope of the kidney; the next most frequent seat being the suprarenal capsules.

Mr. Hulke, of Middlesex Hospital, reports a case of myxoma which enveloped the left kidney and upon which he operated. A median section was made through the tumor when it presented itself. The incision was continued through the posterior blade of the peritoneum, just beyond the descending colon. The tumor proved to be a myxoma, and, although the patient recovered from the operation, the growth returned locally. The kidney was not involved by the tumor, and could have been enucleated.

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The growths embraced in this class are peculiar in several respects. None can be said to be absolutely benign, even those which are made up entirely of the histological elements of either lipoma, fibroma, or myxoma, and notwithstanding the fact that they do not tend to the formation of metastases or to the infiltration of immediately surrounding tissues. It is true that they show no great tendency to recurrence when completely removed, yet from the great size to which they develop, and from their tendency to undergo degenerative changes, they cannot be classed as innocent growths.

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The late Dr. John Homans, of Boston, has called attention in two papers to the reported cases of pure lipoma, among which were some on which he had himself operated.

Subserous lipomas rarely of themselves reach a large size. However, those going out from the peritoneum may be of sixty pounds' weight. Lipomas are usually slow-growing, the subserous particularly so. Subcutaneous lipomas sometimes grow rapidly after remaining stationary for years. Lipomas seldom change to other varieties, but they may primarily be mixed in character—myxolipomas.

The character of the latter group can never be determined with certainty without careful microscopical examination, as many growths having the appearance of lipomatous tissue often have the elements of myxoma and sarcoma as well. They may reach great size, but show no disposition to return after removal.

Sir Spencer Wells reports, in his first edition of "Abdominal Surgery," a case in which the removal of such a growth was undertaken, with fatal results.

Sarcomas, either in typical form or in combination with myxomatous, lymphomatous, or fibromatous tissue, also occur, and have been observed quite often. Many of the tumors which have been described as sarcomas of the mesentery were doubtless retroperitoneal sarcomas, arising at the root of the mesentery and presenting themselves anteriorly, after separating its folds.

Carcinomas are very rare, and present the strongest type of malignancy. They are of the hard, solid variety, soon forming deep and firm attachments, and offering little to be hoped for from an operation.

Varieties such as fibroma and cystoma have been observed. It may be said of the latter, for the most part, that they either spring from the walls of the pelvis, or from the subperitoneal connective tissue of that region. Virchow looks upon this series of growths as being analogous to those tumors which arise from the deep tissues of the neck.

A few remarks may be made in regard to the starting-point and relations of all these growths. Those which spring from the walls of the pelvis encroach upon or involve the bladder, uterus, and rectum, very often presenting features which are exceedingly perplexing in diagnosis. The origin of a smaller number is reported respectively as from the retroperitoneal lymphatics, the bodies of the vertebræ and bones of the pelvis, and the root of the mesentery. In by far the greater proportion of the cases no exact origin is given; indeed, from the subsequent changes in anatomical relations, it would seem quite impossible to determine the exact point of origin of many of the very large retroperitoneal new growths. They have almost uniformly presented themselves in the line of the least resistance, that is, anteriorly. In my case, reported in the *American Journal of the Medical Sciences*, January, 1892, the tumor presented itself in the back—a condition which can be attributed to its origin from the extreme upper border of the kidney, where it was less completely bound down by the lumbar muscles and fascia. When the growths have reached a sufficient size to attract the attention of the patient, they are found presenting themselves at either side of the umbilicus, somewhere in the region of the lateral lines drawn in the arbitrary divisions of the abdomen into regions, although they may appear centrally. As the growths increase in size the viscera are displaced, not infrequently completely to the opposite side, although those growths which spring from the left kidney may have the descending colon externally. Owing to circulatory disturbances within them, and to their liability to a subsequent malignant infiltration, as well as to the development of cachectic conditions, they present, clinically, features which suggest a condition almost immediately hazardous to life.

As with any large abdominal growth, there is always a certain degree of encroachment upon the thorax and pressure upon other organs. In my second case, the tumor pushed the inferior border of the liver up to the fourth intercostal space, while the cæcum and ascending colon were displaced toward the left side of the abdomen.

Diagnosis.—Notwithstanding our constantly increasing experience in abdominal surgery, we must admit that an exact diagnosis as to the true nature of these growths is not always possible. Nor can it be said to be absolutely necessary, especially in the lesser and more movable varieties.

I cannot well imagine a more severe task for a writer than to attempt to outline the symptoms and diagnosis of a condition which, until the present time, has baffled, quite without exception, the skill of all who have met with it. Yet, recognizing the importance of the factor of exact diagnosis, especially in abdominal surgery, I wish to call attention to all such symptoms as may be associated with these growths, and, after carefully weighing them, put together what seems useful.

In the first place, there is not a single symptom that is pathognomonic, and we are dependent for diagnosis upon the process by exclusion. Diseases and neoplasms of the uterus and its appendages, of the liver and the gall bladder, of the spleen, pancreas, and kidney, are to be excluded, as well as aneurism of the aorta, tumors of the mesentery, and of the abdominal walls.

The sex of the patient or the history of the case may enable one to exclude the organs of generation at once, and bimanual examination will rarely fail to locate the uterus and its appendages and determine any pathological changes in them. Pelvic congenital cysts from the spinal cord or membranes should not be lost sight of. Subperitoneal fibroids are the only ones likely to be confounded with this condition; but then uterine fibromas are more easily movable within the abdomen, and their attachment to the uterus can be made out. Solid tumors of the ovary and broad ligament present greater difficulties, which at times cannot be surmounted.

Diseases of the liver, together with new growths of that organ, have very often been mistaken for retroperitoneal neoplasms. Hypertrophic cirrhosis, amyloid degeneration, hepatic abscess, hydatids, obstruction of the cystic duct, and distention of the gall bladder, together with carcinoma and sarcoma, present physical signs which may be confounded with retroperitoneal tumors. The history of the case, together with a painstaking weighing of general symptoms, will naturally assist in clearing a doubtful diagnosis.

Disturbances of biliary excretion may occur from pressure on the common duct by the tumor. Again, tumors of the liver always move synchronously with the respiration. Retroperitoneal ones do not, as a rule. Very often a line of resonance is found between liver and tumor, which at once shows that the growth is not connected with the former organ.

My own experience teaches me that growths connected with the spleen make the case at times very embarrassing.

It has been said that the differentiation from hypertrophy and tumors of the spleen presents less difficulty than does the differentiation from tumors of the liver. Here palpation and percussion will be quite sufficient, if employed to locate the spleen in its normal position. Tumors of the omentum lack the fixed position of these growths. The absence of digestive disturbances, with fatty stools, will serve to exclude the rare new growths of the pancreas.

As stated, many of these tumors have their origin in the capsule of the kidney, or in the connective tissues

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surrounding it. They present, at least in their earlier stages, physical signs differing in no respect from tumors of the nephritic parenchyma. An examination of the urine may give an exact clew to the diagnosis. In none of the cases reported had renal hemorrhage or albuminuria, with or without casts, occurred; conditions which are the rule with tumors of the parenchyma of the kidney.

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Regarding the use of the aspirator, while I must admit that up to the present time it has been of no special value in the diagnosis of my cases, yet I believe that in many instances the fluid withdrawn by this instrument and carefully examined, would enable us to make a diagnosis as to classification of the tumor. In a recent case of sarcoma of the kidney, by means of the medium-sized needle I was able to draw off sufficient fluid fully to demonstrate the nature of the growth, the diagnosis being confirmed later by the autopsy. All things considered, I believe that the instrument may of be value in the diagnosis of retroperitoneal tumors.

Dr. W. G. Macdonald's suggestion to insufflate hydrogen gas into the rectum, is, I believe worthy of trial, especially where a careful examination has been made before, and the percussion areas have been outlined with care upon the abdomen. The process of insufflation should be carefully watched, that the relation of the intestinal tube to the tumor may be established.

Treatment.—Without operative interference there is but one termination. The rapidity of the fatal termination varies somewhat with the character of the growth. Pure lipomas are slow growing until a certain volume is reached, when they proceed with great rapidity to a fatal termination. From a study of the clinical histories found in the literature, I am of the opinion that the mean duration of life, after the discovery of the tumor, is not more than nine months. Operative treatment offers to us much promise. Recovery has followed the removal of retroperitoneal tumors of great weight, even those weighing fifty pounds. The immediate mortality following operations is great, from necessity; yet from the hopelessness of the conditions an operation is to be urged with great earnestness upon the part of the surgeon. Incomplete operations have been immediately more fatal than those in which the tumor has been completely removed. Like all surgical lesions, these tumors illustrate the necessity of early diagnosis and prompt operation.

Czerny, in concluding a paper in which he had reported three cases, says: "In all cases operative interference can be safely undertaken; when the tumor is no longer encapsulated, the incision had better be closed, otherwise the growth should be enucleated."

Operations for the removal of retroperitoneal growths will, from necessity, be subjected to considerable modification in detail. The choice of incision will usually fall in the line of the linea semilunaris, on one side or the other; Langenbeck's incision for removal of the kidney may be made use of. Frequently, when the incision is at first exploratory it must be made in the median line. When the anatomical relations can be made out, and the operation continued by an extension of the cut, then the more favorable incision is in the linea semilunaris. By the separation of the peritoneum from the internal border of the tumor, it may be attached by sutures to the internal border of the abdominal wound, making the whole field of the operation extraperitoneal.

The incision of the posterior fold or blade of the peritoneum should be external to the attachment of the mesentery of the colon, although this is not absolutely necessary. The removal of the growth by enucleation must be accomplished with great care; particularly is it always desirable to determine the source of the blood supply and its relations to the great vessels. The vena cava has been wounded by accident in the enucleation of these growths. There are likely to be large, thin-walled veins located deeply in the wound, and requiring ligation. It will be found at times necessary to remove the kidney with the tumor, and here the danger of hemorrhage is very great. The supply vessels of the kidney will frequently be found very short and difficult to reach.

The length of time required for the performance of the operation will vary necessarily. As long a time as two and one-half hours has been consumed in a difficult operation. As in all strictly abdominal work, the operator must be prepared for any and every possible complication.

After enucleation, as well as when the kidney has been removed with the growth, the cavity must be thoroughly drained, either by full-sized drainage tubes or by tamponade with iodoform gauze.

The after-treatment presents no indications for management other than those of a severe case of abdominal section.

As in all other conditions in surgery, there is certainly at the present time a better understanding of these cases. A more correct and early diagnosis, as is the case in all that pertains to medicine and surgery, will surely bring a larger percentage of recoveries.

These are purely surgical cases; no medicines, no mineral waters, or baths, electricity, or other lines of therapeutics, have as yet been of any service.

A. Vander Veer.

REVERSION.—Reversion is a special case of heredity, and the term is usually applied somewhat loosely to include all cases in which the offspring does not resemble the immediate parents, but exhibits correlation with a more remote ancestor, or group of ancestors. Recently Pearson has sought to give greater precision to the use of the term. He distinguishes (1) regression, (2) reversion, and (3) atavism.

If we take any pair of characters, as, for example, the lengths of the thumbs of the right and left hands of the same person or the statures of father and son, and construct a correlation table from a sufficiently large number of cases, it will be found that for any given dimension in one group (the "subject," *e.g.*, length of right thumb or stature of father) the dimensions of the associated characters in the other group (the "relative," *e.g.*, length of left thumb or stature of son) will be on the average nearer the general average of the whole population. This is *regression*, and is a general phenomenon of correlation when the correlation is not perfect, as is almost always the case (see article *Heredity*, Table I. and Fig. 2606). But as every individual produced sexually has two parents, four grandparents, eight great grandparents, and 2^n grandparents of the nth degree, one need go back only a few generations, if there has not been much inbreeding, to find a group of ancestors sufficiently numerous to give a fair sample of the population as a whole. So, in cases of direct heredity, regression may be said to be a tendency of the offspring to depart from the peculiarity of the parent toward the general average of the ancestry.

Reversion, in the strict sense of Pearson, is a departure from the peculiarity of the parents toward the peculiarity of some particular ancestor. From the many recorded cases we may select for illustration two cases cited by Darwin. A pointer bitch produced seven puppies, four of which were marked with blue and white, a very unusual color for pointers. One of these puppies was preserved and it was found later that he was the great-great-grandson of Sappho, a pure bred pointer bitch, which he closely resembled. The other case is that of a black bull in Kincardinshire, the son of a black cow with white legs, white belly, and part of the tail white. In 1870 a calf was born which was the great-great-great-grandchild of the bull and had the same very peculiar markings as the bull's mother, all the intermediate ancestors of this calf having been black like the bull himself.

Atavism (Lat. *atavus*, an ancestor) in the strict sense, is a return to the peculiarity of the ancestral form of the species. As this ancestral form is generally unknown, the explanation of an unusual variation as due to atavism is in most cases merely conjectural. For example, the dark stripes that appear sometimes upon the back, shoulders, and legs of horses have been attributed to atavism by Darwin, Ewart, and others; the presence of these

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stripes being regarded as evidence of a striped ancestry when considered in connection with the coloring of other species of the genus Equus, like the zebra, quagga, etc. Another example of atavism is the occasional appearance of supernumerary mammæ and teats in women and in men. In women they have been observed to produce milk. These are regarded as atavistic because in the Lemuroidea, the lowest group of Primates, there are, in addition to the well-developed functional mammæ on the pectoral region, rudimentary teats upon the abdomen and groin. They thus approach the condition found in dogs and pigs, while in the apes and man there is normally but a single pair of mammæ.

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Sometimes it is difficult to determine whether a given unusual variation is a case of atavism or a sport. For example, it is known that the ancestors of the horses had three toes, and it is probable that the ancestors of the modern cats and dogs had five digits on all four feet, but dissections in some cases have shown, and it is probably true in most cases, that when polydactylism occurs in these animals the phenomenon is similar to polydactylism in man, which is certainly a sport and not atavistic.

Darwin showed that the crossing of distinct breeds of animals may result in the appearance of atavistic characters. For example, in his experiments with pigeons he found that when he crossed two distinct breeds, even when they showed no trace of blue color or of bars on the wings, the mongrel offspring would frequently exhibit some of the blue color or traces of the wing bars of *Columba livia*, the wild rock pigeon, which species he regarded as the ancestral form of the domestic pigeon. More striking results were obtained by again crossing the mongrels, the best case was the result of pairing a mongrel female barb-fantail with a mongrel male barb spot, neither of which mongrels had the least blue about them. The offspring exhibited the general blue color and every characteristic mark of the wild rock pigeon.

When individuals of separate races or species are crossed, the mongrel or hybrid offspring of the first generation may be more or less intermediate in character between the two parents, or they may resemble one parent only in some respects. But in subsequent generations there is greater diversity among the offspring, and reversion to one or the other parental type is common. The facts were noted by Darwin, but the first one to study them by statistical methods was Gregor Mendel, abbot of Brünn in Austria. Mendel's work was published in 1866 and 1870, but it remained practically unnoticed until 1900, when De Vries, happening to find a reference to it, looked it up and was surprised to discover that Mendel had anticipated results which De Vries himself was then about to publish. Mendel worked with varieties of garden peas and studied one character at a time, first testing the varieties to make sure that they would breed true. He found that when the parents possessed certain contrasted characters one character of each pair would fail to appear in the first generation of offspring, but would reappear in subsequent generations. He called the character that appears exclusively in the first generation *dominant*, while the one that reappears only in later generations he termed *recessive*. In peas he found that the rounded form of the seed is dominant and the wrinkled form recessive, the yellow color of the cotyledons of the ripe seed is dominant, the green color recessive, and the same is true of a number of alternative characteristics. Now the point of Mendel's work is that he found the dominant and recessive characters to reappear in succeeding generations according to a definite and simple numerical law.

If a certain dominant character be represented by A and the corresponding recessive by a, then all the offspring of the first generation will have apparently only the character A. But if the flowers of this generation are fertilized with their own pollen, the next generation will contain $1a$ to $3A$. These plants being again self-fertilized, all of the recessives, a, are found to breed true and to continue to do so during succeeding generations. One-third of the dominants also breed true in the same way, but the other two-thirds give rise to both forms, as the hybrids did, in the same proportion of one to three.

These relations may be represented by the following diagram:

Parents				A	a			
Hybrids				A				
Second generation	1 A			2 A				1 a
Third generation	A	1 A		2 A			1 a	a
Fourth generation	A	A	1 A	2 A		1 a	a	a
Fifth generation	A	A	A			a	a	a

If we represent pure dominants by A and dominants capable of producing both kinds of offspring by Aa, and suppose each plant to produce only four seeds, the following ratios will be obtained:

	A	:	A a	:	a
Second generation	1	:	2	:	1
Third generation	3	:	2	:	3
Fourth generation	7	:	2	:	7
Fifth generation	15	:	2	:	15
Sixth generation	31	:	2	:	31
1 + *n*th generation	$2^n - 1$	:	2	:	$2^n - 1$

If we consider two or more characters at a time, the results become correspondingly complicated, for characters that are not mutually exclusive may appear in the offspring in any possible combination. Thus the seed may be dominant in shape and recessive in color, or *vice versa*, or it may be dominant in both or recessive in both.

Mendel offered as an explanation of these relations the supposition that in cases of this kind the alternative characters are not combined in the germ cells, but each carries the pure heritage of one parent only with respect to any one character, *e.g.*, the shape of the seed. That this view harmonizes with recent studies of the maturation divisions was pointed out in a previous article (see *Reduction Division*). If the chromosomes transmit the bases of separate groups of characters, as is indicated by Boveri's recent work, we may represent a pair of homologous chromosomes in the hybrid by the symbol Aa. In the maturation of the germ cells with a reducing division the chromosomes would be separated into four cells thus:

$$A + A + a + a\ ;$$

and when fertilization takes place by union with an equal number of germ cells of opposite sex containing $A' + A' + a' + a'$, the following combinations are possible:

$AA' + Aa' + aA' + aa'$, the most probable proportion being $1\,AA : 2\,Aa : 1\,aa$.

This would give one recessive to three dominants, but only one dominant out of three would breed true, for the other two would contain recessive chromosomes in their germ plasm.

The difficulty with Mendel's theory is that the statistical results obtained by other observers do not always show the exact proportions required, and that the dominant and recessive characters are variable and therefore sometimes difficult to distinguish. And also for this reason it is not easy to determine whether a race is breeding true or not. The theory has been criticised on these grounds by Pearson and Weldon; while it is defended, and its results are confirmed, by De Vries, Correns, Bateson, Castle, and others. *Robert Payne Bigelow.*

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RHATANY.—(*Krameria*, U. S. P.; *Krameriæ Radix*, B. P.; *Radix Rhataniæ*, P. G.) The dried roots of several species of Krameria, especially of *K. triandra* R. et P., *K. Ixina* L., and *K. argentea* St. Hil. (fam. *Krameriaceæ*).

The last mentioned is not now official in the United States Pharmacopœia, but will doubtless be so in the forthcoming edition. The Kramerias are low or semiprostrate shrubs of tropical or warm temperate parts of America. They have very long, thick roots, noted for the thickness of their bark. Since the active constituent exists mostly in the cortex, the thicker-barked varieties are the better. The first-named grows in the higher Andes and yields Peruvian Krameria, the poorest variety. The second comes from the Santa Marta region of Colombia, and is about intermediate in quality between the first and the third, which latter comes from Northern Brazil. This is usually sold as Savanilla, the genuine Savanilla now reaching the market only occasionally. *K. lanceolata* Torr., of the Southwestern United States and Northern Mexico, yields a good Krameria, but it is scarcely a commercial article.

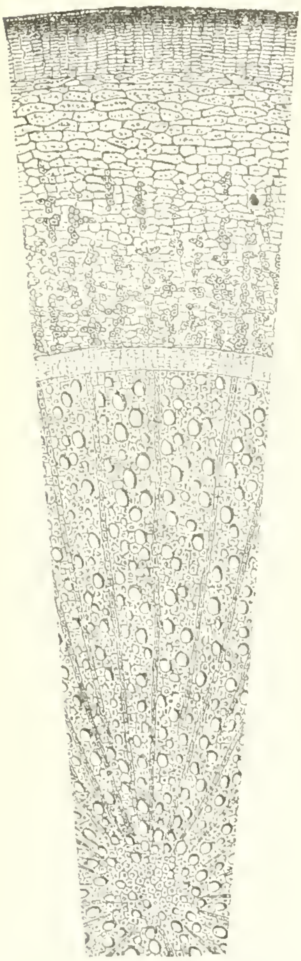

Fig. 4110.—Krameria Triandra; transverse section of root. (Baillon.)

Description.—*Peruvian Krameria*.—Root branches usually occurring with several or many attached to a short, hard, and woody tap root, which is 1.5–4 cm. (⅗–1⅗ in.) thick, roughly fissured and supports a knotty, several- to many-headed crown; of indefinite length, rarely exceeding 50 cm. (20 in.) and usually less than 1 cm. (⅖ in.) thick, cylindrical, flexuous or wavy, very flexible; externally light red brown, more or less marked with dark, scaly patches, especially upward, otherwise smoothish, devoid of transverse fissures; fracture tough and splintery, the pinkish-brown bark occupying less than one third of the radius, the wood yellowish or pinkish-white, finely radiate; inodorous and of a very astringent taste.

Brazilian Krameria.—Branches usually occurring detached from the tap root and crown, less flexuous than those last described, externally of a deep purple-brown or chocolate-brown and with numerous transverse cracks or fissures; fracture less tough than that of the last, the bark and wood both darker, the former occupying two-fifths, or even more, of the radius, the taste more astringent than that of the last.

The most important constituent is from eight to twenty per cent. of *krameria-tannic acid* or *rhatania-tannic acid*, a brilliant deep red amorphous mass, soluble in alcohol and, if pure, in water also. It is usually only partly water-soluble, owing to the change of a portion of it to phlobaphene by dehydration. Krameria-tannic acid gives a dull green color with diluted acids, and is flesh-colored with gelatin. It is decomposed by dilute mineral acids into sugar and rhatania red.

Published statements as to the relative percentages of tannin in the different varieties are not reliable, since it is the very commonest occurrence for the varieties to be confused in commerce and in experiments.

Rhatany is a reliable and useful astringent, owing to its tannin, and is applicable to all conditions in which gallic or tannic acid is useful. The crude drug may be given in powder, in doses of 1–2 gm. (gr. xv.–xxx.), though a liquid preparation is preferable. The pharmacopœia provides an extract, the dose of which is two to four grains, a fluid extract, dose fifteen to thirty minims, and a twenty-per-cent. tincture, the dose of which is from one to two fluidrachms. *Henry H. Rusby.*

RHEUMATIN is the salicylate of saloquinine, and represents a large percentage of the salicylic radical in combination with quinine. It occurs in tasteless white acicular crystals, which are but sparingly soluble in water. Overlach finds its action practically specific in acute rheumatism, without any digestive disturbances, and distinct from that of a mixture of quinine and salicylic acid. Pieper found it valuable in trigeminal neuralgia as well as in rheumatism. The dose is 1 gm. (gr. xv.) three or four times a day. *W. A. Bastedo.*

RHEUMATISM, ACUTE ARTICULAR.—Definition.—An infectious disease, caused by a germ or germs not yet identified, and characterized by (1) a general constitutional reaction; (2) an irregular febrile movement; and (3) non-suppurative inflammation of the connective-tissue structures of the joints, the muscles, and the heart.

History.—In former times articular rheumatism was confounded with gout. Sydenham, in the closing years of the eighteenth century, first made plain the difference between the two diseases.

Nature.—Rheumatism is now regarded almost universally as an infectious disease caused by germs from without. Two other theories were formerly held: first, that it is due to the presence of an excess of lactic acid in the blood; second, that it is of neurotrophic origin. These views are no longer held by the best men. With regard to the first, it need only be said that it offers no reasonable suggestion as to the cause of the excess of lactic acid. An excess of lactic acid is almost always present, but it is no more logical to say that the lactic acid causes the joint troubles than that the joint troubles cause the lactic acid, or that the fever causes both.

The second, or neurotrophic, theory is open to objection on the ground that it offers no cause for the neurotrophic disturbances. Furthermore, if so serious and acute a disease as rheumatism be neurotrophic in its origin, we ought to find in every case serious disturbance of the central nervous system, while as a matter of fact such disturbance is very uncommon. Again, all other diseases of proven neurotrophic origin are of slow progress and conspicuously slow recovery, which rheumatism, under proper treatment, is not. The neurotrophic theory is really founded upon a confusion between articular rheumatism and rheumatoid arthritis. The latter disease is now regarded as neurotrophic, but its morbid anatomy and clinical picture are so different from those of rheumatism that the two diseases may be said to have nothing in common except the fact that they both affect the joints.

In favor of the germ theory of rheumatism we may urge the following arguments: (1) All other acute diseases with fever and constitutional reaction are now believed to be infectious. Most of them have been proven so.

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(2) All other acute inflammations of joints—*e.g.*, pyæmic, gonorrhœal, tuberculous, and syphilitic arthritis—are known to be infectious. (3) Acute rheumatism has several times been found to occur in epidemics. (4) There are two cases on record in which parturient women, suffering from rheumatism, have borne children who shortly after birth developed fever and polyarthritis.

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The bacteriology of rheumatism is still in doubt. In 1891 Achalme, of Paris, claimed to have identified the germ. He isolated from the blood and pericardial fluid of, in all, eight rheumatic patients, a bacillus which he regarded as characteristic. It was found, however, that cultures of this bacillus, injected into animals, produced not the ordinary lesions of articular rheumatism, but local congestion, destruction of tissue, and gas bubbles. Westphal, Wasserman, and Malkoff, in 1899, found in a fatal case of post-rheumatic chorea a very few diplococci which produced in animals fever and non-suppurative polyarthritis. Poynton and Paine, of London, in 1900 found a diplococcus which may prove to be this same germ. They isolated it from eight cases of severe acute rheumatism, finding it in the blood, the pericardial fluid, the vegetations from diseased heart valves, the tonsils, and the urine. They also demonstrated its presence in the joint exudations of inoculated rabbits. These rabbits showed multiple, non-suppurative arthritis, valvular endocarditis, pericarditis, and moderate pyrexia. Passed along from one animal to another, the germ showed great constancy in its effects. These results are very striking, but up to the time of writing no confirmatory reports have been published.

A view which has gained some support during the past year is that rheumatism is due to the presence in the body, not of bacteria, but of toxins. F. W. Packard, of Philadelphia, has declared in favor of this view, and has also stated that in a large number of cases the intoxication results from an infected tonsil. It is certain that tonsillitis is of very common occurrence at the beginning of an attack of rheumatism, and it may be imagined that the lymphoid tissue of the tonsil, by its power of filtration (Manfredi) allows the toxins to pass through and stops the bacteria. The emigration of the inflammation from joint to joint, so often seen during an attack of rheumatism, seems to suggest a local intoxication rather than infection, and so also does the rapid and complete recovery under proper treatment. And salicylic acid, while a very weak germicide, is known to have a powerful chemical action upon toxins, *e.g.*, diphtheria antitoxin. There is need for further investigation along this line.

Etiology.—Rheumatism is seen everywhere. It is most common in temperate climates. In New York it occurs most frequently during the early months of the year. A series of 514 consecutive cases from the records of the New York Hospital gave the following results:

Season of year: July 1st to January 1st, 140 cases; January 1st to July 1st, 374 cases.

Sex: Of all ages, 337 males, 177 females.

Of cases under 20, 43 males, 44 females.

Age: Under 10 years, 6 cases, or 1.17 per cent.; 10–20 years, 81 cases, or 15.8 per cent.; 20–30 years, 200 cases, or 38.9 per cent.; 30–40 years, 130 cases, or 25.3 per cent.; 40–50 years, 66 cases, or 12.8 per cent.; 50–60 years, 23 cases, or 4.47 per cent.; over 60 years, 8 cases, or 1.55 per cent.

These figures are in general agreement with those for the Montreal General Hospital, quoted by Osler. It will be seen that rheumatism is pre-eminently a disease of early adult life, nearly sixty-five per cent. of the cases occurring during the period of greatest bodily and mental strain, or between the ages of twenty and forty. The difference in susceptibility between men and women is hardly explainable except upon the ground of difference in occupation and women's freedom from the alcoholic and tobacco habits.

Many observers claim a distinct hereditary predisposition (Osler, Church and Cheadle, Lyman). But, as many different conditions have in the past been grouped together under the common name of rheumatism, the importance of an hereditary predisposition may have been exaggerated.

Exposure to cold, especially *damp* cold (Lyman), is the exciting cause in a certain number of cases. Men who lead outdoor lives, exposed to all kinds of weather, and who are—as this class often is—somewhat alcoholic, are very liable. Second and third attacks are common. Of the 514 cases quoted above, 64 had had one previous attack, and 43 more than one; so that one attack of rheumatism confers no immunity as regards subsequent attacks.

Morbid Anatomy.—Typical rheumatism always attacks more than one joint. A case of monarthritis without history of previous attacks should be viewed with doubt. The inflammation is exudative in type, with congestion and a fibrino-serous exudate, containing a few leucocytes, in all the tissues of the joint proper, and also in the cellular tissue and tendon sheaths around the joint. There are rarely, if ever, in an uncomplicated case enough leucocytes to make the exudate purulent. The synovial fluid, with which the joint cavity is distended, is sometimes of acid reaction and may be blood-stained. The cartilage cells in the joint cartilages proliferate, and the intercellular substance splits up, assuming a velvety appearance. All these changes are susceptible of rapid repair.

The blood shows increase of fibrin, fats, cholesterin, and extractive matter. The serum remains alkaline. Urea and uric acid are not increased. Red blood cells are much diminished. No disease produces pronounced anæmia quicker than acute rheumatism.

The urine is acid, high-colored, and of high specific gravity. It deposits, upon standing, a sediment of amorphous urates and sometimes uric-acid crystals.

There is an excessive excretion of sweat. This is of neutral reaction, but quickly becomes acid if the patient's skin be not kept scrupulously clean.

Clinical History.—In the majority of cases the first symptom noticed is lameness of one or more joints. This may be preceded, during a few days, by the symptoms of an ordinary coryza or acute pharyngitis or tonsillitis. The slight lameness and soreness are usually overlooked, and the patient continues to follow his ordinary occupations. After a few days more the symptoms grow worse, swelling and redness appear in the affected joints, the pain increases until the least motion causes agony, there is a febrile movement, with or without distinct chills, anorexia, constipation, and profuse sweating, and we have the full clinical picture developed. In a few cases the disease is ushered in by a rigor, with an immediate development of all the symptoms; or the case may begin in a mild way, and later develop suddenly the graver and more acute type.

When the disease is once established, it shows very little tendency to spontaneous termination. Under the older systems of treatment it would run for many weeks. The inflammation may move entirely in a few hours from one part of the body to another—from knee to wrist, from wrist to ankle, or from one leg or arm to the other. Of the location of the disease it is a noteworthy fact that it shows a marked tendency to attack the same joint on both sides of the body. In the above-quoted series both knees were involved in 213 cases, the left knee alone in 79, the right knee alone in 59. All the joints of the body showed at least a plurality of cases of symmetrical involvement. The knee is the most frequent seat of inflammation, 351 cases showing affection of one or both. The ankle came second in my series with 256 cases; next the wrist, 125 cases; shoulder, 116; foot, 109; hand, 97; elbow, 78; hip, 44; and lastly the sternoclavicular joint, 1 case. The fever is irregular, rarely very high except in cases of hyperpyrexia, and yields more readily to the salicylates than do the joint troubles.

Complications.—Of these the most important are those which affect the heart. Indeed, were it not for the cardiac complications, an attack of rheumatism would be little more than a disagreeable incident in a man's life.

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Endocarditis ordinarily adds but little to the severity or immediate danger of the attack, but it leaves permanently damaged valves which, except in a very few cases, never regain their perfect function. As to the frequency of this complication www.libtool.com.cn the 514 cases quoted above, 152, or 29.57 per cent., showed murmurs distinctly valvular. Of these 104, or more than two-thirds, gave the signs of mitral insufficiency. Only two showed a pure mitral stenosis, while 24 showed a double mitral lesion. In 22 cases there were murmurs at the base of the heart, of which 8 were systolic, 6 diastolic, and 8 double.

Rheumatic endocarditis is usually an inflammation of the connective-tissue portion of the endocardium of the valves. The endothelial covering, according to MacLagan, is affected only secondarily as a result of friction caused by changes in the shape of the valve. By this means the endothelium is rubbed off, leaving a rough spot upon which the fibrinogenic elements of the blood coagulate, forming so-called "vegetations." Poynton and Paine report diplococci in the base of the valve, but not near the surface. Malignant ulcerative endocarditis is very rare in rheumatism. Where it occurs, it is probably always due to secondary infection.

Rheumatic endocarditis usually gives no symptoms. It is generally discovered by the attending physician, who must always be on the lookout for it. In bad cases there may be indefinite pain referred to the præcordium, or slight dyspnœa and palpitation. There may be embolic attacks, due to detachment of a vegetation.

Pericarditis, either dry or with effusion, often occurs. It shows the ordinary morbid anatomy of an exudative inflammation of a serous membrane. The symptoms vary according to the character of the exudate. In dry pericarditis there is great pain in the præcordium, with a violent and irregular pulse. The characteristic "see-saw" murmur may be present, or there may be only a systolic murmur, or a faint clicking sound, or even no murmur at all. With effusion we get muffling of the heart sounds, upward displacement or total disappearance of the apex beat, increase of the præcordial dulness, and the patient complains of great weakness and urgent dyspnœa on the slightest movement. Generally, but not always, there is increase in the fever, and there may be a distinct chill at the invasion of the pericarditis.

Myocarditis is rare in rheumatism. It is seen in middle-aged or older patients, whose aortæ and coronary arteries are not of the best. Fatal cases which come to autopsy show a slight degree of granular degeneration of the heart muscle, due to the systemic poisoning.

Respiratory Tract.—As stated above, coryza, pharyngitis, and tonsillitis are often seen early in the disease. Laryngitis and bronchitis occasionally occur. Pleurisy and pneumonia are sometimes found, usually in the cases with heart complications. Among the five hundred and fourteen cases mentioned there were fifteen pleurisies and five pneumonias. The pleurisy is generally accompanied by serous effusion. The pneumonia is patchy, and lobular in type. According to Osler, severe and fatal pulmonary congestion is sometimes seen.

Nervous System.—The peripheral nerves are sometimes affected by rheumatism. The sciatic nerve is the most common seat of trouble, but occasionally a part or the whole of the brachial plexus is involved. These complications are sometimes slow to yield to treatment. More severe are the *cerebral* complications. Rheumatic meningitis is certainly very rare, and probably in some cases salicylic acid poisoning has been mistaken for it. The cerebral symptoms most commonly seen are delirium, stupor and occasionally convulsions. These symptoms, in connection with excessively high temperature, constitute the condition known as *hyperpyrexia*, which is always grave and often fatal. The high temperature (sometimes reaching 110° F.) seems to be due to paralysis of the heat control centre in the medulla.

Chorea is sometimes, especially in children, seen in association with rheumatism, but more frequently combined with endocarditis than with polyarthritis. It is apt to occur late in the disease. The nature of the connection between the two diseases (rheumatism and chorea) is not known.

Eye.—Rheumatic iritis is certainly a genuine disease. It presents the ordinary appearance and symptoms of iritis, and yields to salicylates. It is usually mild. Iridocyclitis with destruction of the eyeball belongs rather to gonorrhœa than to rheumatism.

Skin.—Sudamina are common, as might be expected from the profuse perspiration. Erythema nodosum has been reported by Osler. Scarlatiniform erythema is seen from time to time. Purpuric spots occurred in three cases in my series.

Subcutaneous Tissues, Fascia, etc.—Occasionally, in severe cases, small lumps are noticed under the skin in the neighborhood of affected joints. These are called "rheumatic nodules." They consist of fibrous tissue with a number of small round cells. Poynton and Paine report having found diplococci in some of them.

Course and Prognosis.—As to whether or not rheumatism is a self-limited disease authorities differ. It is certain, however, that the disease without treatment runs a tedious and uncertain course, and is liable to relapse, and to develop a low form of chronic arthritis, the so-called chronic rheumatism. The prognosis is almost always good as to life. Only two deaths occurred in the five hundred and fourteen cases cited. This is a low ratio, less than 0.4 per cent. Probably the usual mortality is between 0.5 and 1 per cent. It would seem from the literature (and Lyman indorses this) that the disease runs a milder course in America than in England. The fatal cases are those with severe acute heart and lung complications, or hyperpyrexia. As regards complete recovery the prognosis must always be guarded on account of the heart complications. Most of these leave permanent damage, to give trouble perhaps many years later. Life insurance men say that second and third attacks are less likely to affect the heart than first attacks, perhaps because the second and third attacks come later in life. It is certain that the most serious rheumatic cardiac lesions are seen in young persons. The mitral valve, when not too extensively damaged, is able sometimes to adapt itself to new conditions, and regain perfect competency.

Diagnosis.—Articular rheumatism may be confounded with gouty, gonorrhœal, or septic arthritis, with tuberculosis and syphilis, with acute septic epiphysitis, and with arthritis deformans. *Gout* occurs late in life, in its acute form is monarticular, and the history of inherited tendency, of faulty hygiene, and possibly of previous attacks, helps to distinguish it. *Gonorrhœal arthritis* is also frequently monarticular, the joint has less of the appearance of an acute inflammation, is less painful, and an urethral discharge may be discovered on careful examination. *Tuberculosis* is also monarticular, and of subacute or chronic type. At the beginning of the second stage of *syphilis* there are sometimes joint pains with the slight febrile movement which precedes the roseola. Here the history usually serves, and the appearance of the rash dispels doubt. Septic arthritis and acute epiphysitis are always due to some septic focus elsewhere in the body, the course of the temperature is pyæmic, and the symptoms do not respond to salicylates. Some forms of rheumatoid arthritis are occasionally mistaken for rheumatism, but careful examination will almost always reveal the characteristic deformity of the affected joints. Rheumatism may, however, occur in a patient who is already the victim of rheumatoid arthritis. Here the diagnosis may be difficult, and one may have to rely upon the progress of the inflammation from joint to joint or upon the test of treatment. It may be repeated here that without the history of previous attacks, a certain diagnosis of rheumatism is impossible unless more than one joint is involved.

Treatment.—The patient must be put to bed and kept there. His pajamas or night gown should be of flannel, and he should lie between blankets whenever possible. The bowels must be opened freely at the out-

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set. The best purgative is one grain of calomel, given in quarter-grain doses every fifteen minutes, and followed, four hours later, by a Seidlitz powder, or a full dose of citrate of magnesia, or half an ounce of Rochelle salts. No more bed clothes should be allowed than just enough to give reasonable warmth. If their weight cause pain or discomfort, they must be supported upon some kind of a framework. The patient must be sponged off with warm water, often enough to keep his skin perfectly clean. The copious sweat rapidly undergoes acid fermentation, and if not removed causes itching and soreness. The diet should consist mainly of milk. This may be varied, from time to time, with small quantities of beef tea and clam broth. Plenty of water should be allowed, or vichy, or soda water, or lemonade. These drinks help to keep the urine bland, and ease the strain upon the kidneys. The drug of drugs to be used is salicylic acid in one of its forms. It may be given as the salicylate of soda, or as oil of wintergreen, or as salicin. Salicylate of soda is the cheapest, and most patients bear it well, but it sometimes upsets the stomach. Oil of wintergreen is said to be quicker in its action, but it has no advantage so far as the stomach is concerned, for patients quickly tire of its penetrating odor and taste. Salicin is less active than the other two, but delicate stomachs bear it better. Whichever of these drugs is chosen must be pushed to the limit of toleration. This, and only this, should be the limit of dosage. Salicylate of soda is usually given in watery solution, the other two usually in capsules. It is best to begin by giving twenty grains every two hours, and to continue this until deafness and tinnitus aurium begin to develop, when the dose should be lessened, or the intervals lengthened, or both. It is good practice to give ten or twenty grains of bromide of sodium when the tinnitus begins. Elderly people, whose arteries and kidneys are worn, do not bear salicylates well. Such patients must be carefully watched, and the dose regulated to suit them. Symptoms of poisoning sometimes develop quite rapidly. The writer has seen maniacal delirium, lasting two days, as the result of two and one-half drachms of oil of wintergreen, given in the course of twenty-four hours. Should poisoning occur the salicylates must be discontinued, bromides and chloral must be given, the heart being carefully watched, and in most cases no permanent harm results. As the pains subside, and the temperature comes down, the dose of salicylate may be reduced, but the medicine must be continued for several days after all pain has disappeared, otherwise the symptoms may return. Some authorities claim that relapses are more frequent under the salicylates than under the older systems of treatment. This does not seem to be the case, provided the medicine be continued long enough. The salicylates have no effect upon a cardiac lesion, once established, but by their action in shortening the disease and lessening its virulence and severity, they certainly protect the heart to some extent.

How the salicylates act is a question difficult to answer. They are not strongly antipyretic and analgesic, like acetanilid and phenacetin, and, according to Miquel, they are rather feebly antiseptic, salicylic acid being effective in preventing bacterial growth in a strength of 1 to 1,000, while salicylate of soda requires a strength of 1 to 100. Salicylate of soda has been found useful in relieving unpleasant symptoms due to diphtheria antitoxin, and if we suppose rheumatism to be due to intoxication rather than to infection, this may be the answer to the question. The efficacy of the salicylates is beyond question, but the reason for this efficacy needs further investigation.

There are some unfortunate patients who, on account of idiosyncrasy, cannot take salicylates at all. For these we must rely upon the old-fashioned alkaline treatment. Twenty grains each of citrate and bicarbonate of soda may be given every two or three hours. The results of this treatment are not brilliant.

Local treatment of the affected joints is advisable, with the idea rather of increasing the patient's comfort than of affecting the course of the disease. The joints must be kept at rest in the least uncomfortable position attainable. They should be protected by bandages of flannel, or lightly packed in cotton batting or wool. They may be dressed with a ten-per-cent. ointment of salicylic acid, or with pure oil of wintergreen, or with guaiacol, dissolved in olive oil, or incorporated with lanolin or lard. The joints must not be handled at all. The writer has seen most exquisite agony in a case under his care, caused by an ill advised friend of the patient, who insisted upon gently stroking her inflamed wrist. The manipulation gave momentary comfort, but within an hour the wrist swelled almost to twice its normal size, and throbbed until it was necessary to use iced cloths to relieve the pain. Ice has been commended as an application in rheumatism, also heat in various forms. In some cases hot or cold applications are of use, the choice lying with the one which gives the greater comfort, but in most cases protection and ointments will give all the comfort attainable. Occasionally after an obstinate case of rheumatism, one or more joints exhibit a low grade of chronic synovitis. These are best treated by blistering, followed by a tight bandage.

Of the complications of the disease, endocarditis calls for little or no direct treatment. The patient must be kept absolutely quiet, with the head low. If the heart be overacting, ice may be applied. Very rarely, if ever, does rheumatic endocarditis cause urgent cardiac weakness. Should this appear, the salicylates must be stopped, and a little strychnine may be very cautiously administered. No more than necessary should be given, for every extra heart beat may cause the endocarditis to spread. Pericarditis, on the other hand, calls for active treatment. An ice bag, or a cold coil, should be applied over the heart, aconite, in one-drop doses of the tincture, may be given under careful observation, and morphine or codeine may be needed to relieve the pain. If effusion appear, blisters and diuretics are required, and if these fail to cause absorption the pericardium may require tapping. Of the nervous complications, the neuralgic pains are best treated with local applications of pure oil of wintergreen, or of menthol, twenty-five per cent. in alcohol. Hyperpyrexia must be treated by cold baths. No other antipyretics are of the least use. Alcohol and strychnine are also needed. The treatment of this condition is quite similar to that of sunstroke, to which it is probably akin. The neurasthenic and melancholic conditions seen sometimes during convalescence require appropriate care, but these conditions have no peculiar features depending upon the rheumatism that caused them.

The skin complications require no treatment. The treatment of the respiratory complications is on general principles.

The after-treatment requires tonics, general hygienic regulation of the daily life, and avoidance of over-exertion. It is well to have the throat carefully examined and, if necessary, treated, for there is ample warrant for believing that future attacks may occur as the result of infection of a diseased tonsil. *Donald M. Barstow.*

RHEUMATISM, CHRONIC ARTICULAR.—DEFINITION.—A chronic affection, characterized by stiff and painful joints.

ETIOLOGY.—The impression is gaining ground that chronic, as well as acute, articular rheumatism is of bacterial origin, although the responsible micro-organisms have not as yet been identified. The disease, according to continental writers, is a frequent sequel of acute rheumatism, but in North America it is more commonly independent of antecedent acute or subacute attacks. It occurs most frequently after the middle period of life, especially among those who, in addition to contending with the hardships of poverty, must engage in occupations of a laborious character which involve exposure to cold and dampness, such as day laborers, farmers, hunters, washerwomen, and the like.

PATHOLOGY.—The cavity of the joint is not infrequently dry. The synovial membrane and its villi are

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thickened and injected, and adhesions may form between the opposing surfaces. The articular cartilages are distorted, perhaps eroded and partly absorbed in cases of long duration. The capsule and ligaments of the joint and the tendon sheaths adjacent to the affected articulation are thickened. Atrophy of the muscles in the vicinity of a chronically rheumatic joint is by no means uncommon, especially when single large articulations (knee, shoulder, hip) are involved. Atrophy from disuse is likely to occur if the joint becomes ankylosed. Peripheral neuritis and pressure from exudation on the muscles themselves or their nutrient vessels have also been designated as factors in the muscular wasting.

SYMPTOMS.—The conspicuous symptoms are pain and stiffness in the affected joint. Most commonly the onset is slow and insidious. The pain usually becomes more severe during rainy weather, particularly in the variable climatic conditions of spring and autumn. The stiffness is most marked in the morning and after rest, and lessens after exercise. The pain is apt to be increased by movement, and is often very troublesome at night. The affected joints may be tender upon palpation, but swelling, if present, is usually slight. The inflammation is rarely of sufficient intensity to cause redness of the joint. The course of the disease is as a rule afebrile, but if many joints participate in an exacerbation there may be a slight and transient rise of temperature. The disease may be monarticular, involving a single large joint, the knee, shoulder, or hip in particular, but generally a number of joints, both large and small, are implicated. The joints, if the disease is of some duration, are likely to creak or grate when moved, because of the dryness and roughness of the articular surfaces. In cases of long standing the joints are enlarged and distorted, the mobility is decreased in varying degrees, and they may become completely ankylosed. Muscular atrophy takes place, and the patient may, in the severest cases, become bedridden. The joint changes when established are usually persistent, and do not shift from one articulation to another as in rheumatic fever. In mild cases the general health may remain wellnigh unimpaired, but in the severer and more painful cases gastric disturbances, emaciation, anæmia, and neuralgias may be present with varying intensity. Other complications are not common, but chronic endocarditis, with resultant valvular defects, may be associated with the joint changes.

DIAGNOSIS.—Chronic articular rheumatism may require to be differentiated from chronic articular gout and arthritis deformans, although in the majority of cases the diagnosis is easily made.

Gout is more apt to affect the smaller joints. There is usually a history of acute attacks involving the great toe-joint, tophi if found are distinctive, and the evidences of arteriosclerosis and granular kidney are much more common in gout than in chronic rheumatism.

It is difficult, and readily may be impossible to distinguish between arthritis deformans and chronic rheumatism in the early stages. In more advanced cases the former presents greater deformity of the joints, while rheumatism tends rather to ankylosis with comparatively slight alteration in shape, and moreover is likely to attack a larger number of articulations than arthritis deformans. It is proper to state that by some writers arthritis deformans is regarded as an advanced stage of chronic rheumatism.

PROGNOSIS.—The presence of chronic rheumatism is, as a rule, not incompatible with a long life, but it is essentially a chronic ailment, and the majority of cases are obstinately resistant to all therapeutic measures. In exceptional cases great improvement or apparent cure may take place; in many the disability and pain may be much relieved; in some the disease may seriously affect many joints and render the patient helpless.

TREATMENT.—If circumstances permit, the patient should live or at least spend the winter months in a warm, equable, dry climate, such as that of Southern California or the South of Europe. Otherwise the utmost care should be taken to shield the subject from dampness, cold, and bad weather by good shelter and warm clothing. The digestive functions should be maintained in good order, enemata and laxatives being employed when they are required. The diet should be regulated so that it is digestible and ample in order to keep the nutrition of the body at its best. Moderate exercise should be taken when possible. A daily cold sponge followed by a good towelling is usually helpful, and those who find that the sponging disagrees with them should employ the dry friction alone.

Local treatment is of prime importance. Counter-irritation should always be used, by means of stimulating liniments or by painting with tincture of iodine; by the application of a series of small blisters; or by "striping" the painful joint with the Paquelin cautery, or, what answers as well, with a glass rod, the end of which has been heated in an alcohol flame. The application of ichthyol and iodine, salicylic acid (gr. xxx. to ℥ i.) or belladonna ointments, is at times of much service. Systematic massage and passive movements are useful, especially for the prevention of ankylosis and atrophy, and for the lessening of swelling and stiffness. Electrical treatment may or may not be of service, but is always worth a trial.

Hydriatic measures of various kinds should not be omitted. At home a hot bath at night often mitigates pain and secures a more restful sleep; so also do hot fomentations of the painful joints. Or, finally, the affected joint may be wrapped in three or four thicknesses of linen wrung out of cold water and covered with flannel and oiled silk or, in lieu of the latter, thick brown paper.

Complete and systematic hydriatic measures, including also the hot-air treatment (baking the affected joints) generally require a daily visit to, or, if practicable, a stay of some duration in, an establishment provided with the necessary apparatus and trained attendants, particularly in the sanatoria which avail themselves of natural medicinal and thermal waters. Among the latter are the Hot Springs of Arkansas and Virginia, Richfield Springs of New York State, Banff on the Canadian Pacific Railway in the Rocky Mountains, Mt. Clemens in Michigan, and Santa Rosalia * in Mexico. Here and in Europe a variety of baths—Turkish, Roman, sand, mud, and peat—have been employed. Thorough and persistent hydrotherapeutic treatment usually secures great relief, and even in obstinate cases a permanent cure is sometimes obtained.

Medicinal treatment is not very satisfactory. As a rule the administration of iron, quinine, strychnine, arsenic, and other reconstructives is helpful; so also is a course of cod-liver oil, mixed fats, or extra butter and cream in the dietary. Iodides, guaiacum, colchicum, alkalies, and bichloride of mercury, are occasionally useful. The salicylates are unquestionably beneficial during marked or subacute exacerbations.

Glentworth R. Butler.

RHEUMATISM, MUSCULAR.

—(Synonyms: Myalgia, rheumatic myositis.)

DEFINITION.—A disease characterized by (1) stiffness and soreness on motion of certain muscles; (2) tenderness on deep pressure over certain points in their substance; and occasionally (3) a general constitutional reaction.

CAUSE.—Muscular rheumatism is probably, like the articular variety, a local manifestation of a general toxæmia. Of the primary causes little is known. Some cases are probably of infectious origin. Others seem to belong to the group of auto-intoxications whereof gout is the classic type.

MORBID ANATOMY.—Adler (New York *Medical Record*, vol. lvii., p. 529) describes the process as follows: In one or more places hyperæmia, sometimes accompanied by

* "Santa Rosalia, a city of Southern Chihuahua, Mexico, on the Mexican Central Railway, 325 miles south of El Paso. It is celebrated for its hot sulphur springs, long known to be curative by the natives, and much resorted to by invalids. They are especially useful in inflammatory rheumatism. Population estimated at 8,000." From "The Universal Cyclopaedia and Atlas." Newly revised edition. Appleton & Co. 1901.

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small hemorrhages, takes place, followed by emigration of cells into the interstitial tissues, crowding between the bundles of muscle fibres and even between the single fibrils. Soon the interstitial tissue proliferates actively, bringing about an infiltration of the muscle, which varies in extent and density according to the intensity of the process. In the milder cases the process ends here, the infiltrating material is absorbed, and the muscle returns to practically the normal condition. In severe cases, however, there is more extensive formation of new connective tissue, which compresses the muscle fibres so that they degenerate and are absorbed. In cases of the severest type, there results a hard white mass of cicatricial tissue, in structure like a bit of tendon. Often the process is not confined to the muscles. The neighboring joints, fasciæ, tendons, and especially nerves, may be involved. The nodules are recognizable on palpation by a trained hand. They are not necessarily found in the spot where the pain is felt, for if a nerve be involved, the pain will usually be referred to the peripheral distribution of that nerve.

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Clinical History.—The disease most commonly affects one of four localities as follows: (1) The deltoid muscle; (2) the lumbar muscles (lumbago); (3) the intercostal muscles (pleurodynia); and (4) the sterno-mastoid muscle (torticollis, wry-neck). The relative frequency of these locations is hard to ascertain, for many patients are not sick enough to go to bed, and hence go to the dispensary rather than to the hospital. Less frequently we find the trouble located in the muscles of the head, especially the suboccipital region, and occasionally in the muscles of the jaw. Adler (*loc. cit.*) reports three cases of rheumatism in the abdominal muscles, one case simulating biliary colic, the other two suggesting appendicitis. No one of the voluntary muscles is altogether exempt.

The disease may be ushered in by a chill, a febrile movement, and all the signs of an acute infectious disease. This is uncommon. Most patients develop their symptoms gradually, and the disease runs a subacute course, although it is rarely without some fever. The pain is not usually excessive. It is increased by attempts to use the affected muscles, and also by lying upon the affected side. It is dull and aching in character, and very tiresome and wearing. In some cases, where nerves are involved, the pain is paroxysmal and radiates over a wide surface. Such cases are often puzzling.

Diagnosis.—In typical cases this is very easy. Lumbago and wry-neck are common enough, and not easily confused with anything else, although in the former case pyelitis, and in the latter, deep cervical cellulitis, must be thought of. Deltoid rheumatism has been confused with necrosis at the upper end of the humerus. Intercostal rheumatism may be mistaken for pleurisy. Suboccipital rheumatism may be confused with neuralgia, neurasthenic headache, or migraine. Abdominal rheumatism may simulate disease of the liver and gall bladder, the appendix, or the uterine adnexa. In doubtful cases the diagnosis must be made by palpation of all the muscles in the region where pain is felt. "The infiltration varies in size, shape, and consistency. After subsidence of the acute stage the infiltrations may be recognized by careful palpation. . . . They may be round, fusiform, or flat, hard and firm or soft and doughy, with surface smooth or uneven. . . . While normal muscles react upon a certain vigorous grip with contraction of the part touched, the diseased tissue will react with diminished vigor or not at all; it also shows diminution of the normal elasticity. After the acute stage is past, although the muscle resumes its function without pain, yet the diseased areas remain tender upon pressure. . . . When examining, it is necessary to compare the two sides of the body. Aside from other changes, the diseased side will always be found abnormally sensitive" (Adler, *loc. cit.*).

Course and Prognosis.—The course is uncertain. Some cases clear up rapidly, others are very obstinate. In a general way it may be said that muscular rheumatism runs a slower course than the articular variety, and also has a greater tendency to relapse, as slight lesions usually remain in the muscle substance after the subsidence of the attack. It also has a strong tendency to become chronic. Therefore the prognosis as to complete recovery should be guarded.

Treatment.—In all but very mild cases the patient should be put to bed whenever possible, in order that the affected muscles may be at rest. A brisk purge is essential, if it be our aim to promote elimination of the toxins. Further treatment depends upon the cause of the attack, in so far as the cause can be made out. If the affection be a true rheumatism, the salicylates must be given in full doses for two or three days; if it be an auto-intoxication, the salicylates are generally useless, and an eliminative treatment, as for gout and allied conditions, must be adopted. An exclusive milk diet, with the bowels freely opened every day, is useful, and this may be given to the walking cases, provided they will take enough—at least four quarts a day, and six if possible. Milk is diuretic, and comparatively free from toxalbumins. Local treatment, in the shape of counter-irritation in various forms, is usually necessary. It may take the form of a blister, or a few quick strokes with the actual cautery at white heat, or acupuncture, or painting the skin over the affected muscle, with guaiacol, or the oil of wintergreen, or a twenty-five-per-cent. alcoholic solution of menthol crystals. W. G. Thompson recommends injections of sterilized water into the deeper parts of the substance of the muscle. Adler commends massage very highly, but declares that the masseur must be specially trained to the work. Of course massage cannot be used until after the acute stage is passed.

The after-treatment of these cases is highly important. The patient must keep his skin in healthy activity by daily bathing. Overclothing must be avoided. The test of this is, that there shall be sufficient for comfort, but it must be so regulated that in any ordinary weather the skin shall not be moist except after brisk exercise. Moderate and regular daily exercise, in open air and daylight, promotes complete oxidation of the food, and thus protects the system against auto-intoxication. Regarding diet, it may be said that the albumins should be somewhat restricted. Alcoholic liquors should be taken only in small quantities. A good whiskey, well diluted, is probably the least harmful stimulant. Large quantities of water—four pints a day—should be taken to keep all the urinary salts in complete solution. Over-fatigue and sudden violent exertion are to be avoided.

Donald M. Barstow.

RHEUMATOID ARTHRITIS.—(Synonyms: Rheumatic gout; deforming arthritis; chronic rheumatic arthritis; rheumatic joint; osteo-arthritis.)

Definition.—A chronic and progressive disease of the joints characterized by deforming changes in the synovial membranes, cartilages, and bone, with peri-articular bony outgrowths which interfere to a greater or less extent with the mobility of the affected articulations.

Etiology.—As a rule the disease develops between thirty and fifty years of age, although it may occur in children under twelve. It exists with preponderating frequency in women, from one-half to four-fifths of the cases occurring in this sex, especially at the time of the menopause. Sterility and uterine or ovarian disease apparently predispose. There is in some cases a family history of a tendency to gouty or other disease of the joints, or to tuberculosis of the lungs; and two or more cases may occur in the same family. Worry, grief, mental shock or overwork, exposure to cold and dampness, insufficient diet, and local traumatisms appear at times to be exciting causes. There are two theories as to the essential cause of the disease; one, that it is of nervous origin; the other, that it is a chronic infection. According to the former theory the disease is akin to the arthropathies of nervous origin. Thus the joint changes in arthritis deformans are very similar to those which may occur as a result of locomotor ataxia, syringomyelia,

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hemiplegia, and injuries of nerve trunks. The not infrequent presence of neurotrophic phenomena, such as marked muscular atrophy, glossy skin, and alterations in the nails and bones, is of some significance, so also is the occurrence of numbness, tingling, and severe pain, involving special nerve distributions. Moreover, the joint lesions are usually symmetrical.

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On the other hand, the idea that the disease will prove to be a chronic infection is gaining adherents, although a specific microbic agent has not as yet been identified. In favor of this view is the fact that, in a considerable proportion of cases, arthritis deformans follows an acute infection, especially gonorrhœa and epidemic influenza. In some instances the onset is acute and the joints are red, swollen, and painful; and in children there may be splenic enlargement and swelling of the lymphatic glands.

Pathology (or Morbid Anatomy).—The morbid changes begin in the cartilages of the affected joints, which after proliferating become softened and, especially in the centre and at the points of greatest pressure, are absorbed or worn away. The exposed articular bone surfaces become smooth and ivory-like (eburnated). The proliferating cartilages and synovial membranes at the border of the joint form an irregular fringe of nodules and polypoid bodies which ossify (osteophytes) and interfere more or less seriously with the mobility of the joint. The ends of the bones may become enlarged, and the ligaments are greatly thickened. Complete ankylosis is not infrequent, due principally to the locking of the joints by the osteophytic growths (Haygarth's nodosities) and the thickened ligaments. In elderly persons and in cases of long duration the articular ends of the bones may undergo wasting, so that the head of the humerus, or of the femur (morbus coxæ senilis), may practically disappear, causing partial dislocations and false joints. The affected articulations are more or less misshapen and the deformity may reach an extreme grade. When the hand is affected the fingers frequently bend laterally toward the ulnar side. The great toe is deflected toward the outer border of the foot. The vertebræ when diseased may be completely ankylosed by bony outgrowths, and the spinal column thus consolidated. Atrophy of the muscles about the joint, sometimes of extreme degree, is of common occurrence.

Symptoms.—Five varieties of the disease are recognized—the general progressive form, the monarticular form, the vertebral form, the form affecting children, and Heberden's nodes.

The *general progressive* form may be acute or chronic. The *acute* outbreak occurs especially in young women in connection with parturition and lactation, or in older women at the menopause; it is occasionally observed in children. The symptoms resemble those of rheumatic fever. A number of joints become swollen, seldom reddened, and there is a moderate rise of temperature. The subjects become anæmic, low-spirited, and lose flesh and strength. In some instances the disease may greatly improve, only to renew its onset under the influence of further child-bearing or nursing.

The *chronic* variety is that which is observed in the majority of the cases. As a rule one or two joints, usually of the hands, are first involved; then those of the knees and feet and other articulations; finally, in the severest cases, all the articulations may be implicated. The involvement is usually symmetrical. The earliest symptoms are slight swelling in or about the joints, and pain on movement with impaired mobility. There may or may not be effusion into the joint. The pain may be extremely severe and continuous, or slight and variable. It is usually worse at night and during the exacerbations. The disease progresses irregularly, days or weeks of improvement alternating with renewals of pain, swelling, and stiffness. Slowly the joints become deformed by ligamentous thickening and the formation of bony outgrowths. The mobility of the joint decreases and creaking or grating is felt or heard upon motion. In the end the joint may be completely immobile, owing to the checking action of the osteophytes and the fibrous thickening of the capsular ligaments. The disused muscles waste away, and when contractured may give rise to persistent flexion of the affected members. In the worst cases the patient is bedridden and almost if not quite helpless. In one case under observation practically every joint in the body was ankylosed; even the lower jaw was wellnigh immovable. Tingling, numbness, glossy or pigmented skin, onychia, rapid muscular atrophy, and increased reflexes have been observed. Anæmia and gastro-intestinal disturbances are not uncommon, especially during the exacerbations of the disease. The heart is not often involved, but in one personal case, that of a young woman, there were advanced arteriosclerosis and an aneurismal dilatation of the aorta.

The *monarticular* form affects especially the hip, knee, or shoulder, occurs mainly in old people, and not infrequently is an apparent sequel to an injury. The pathological changes are similar to those of the chronic general form, and the muscles early undergo atrophy. When affecting the hip the disease constitutes the morbus coxæ senilis, the anatomical alterations of which have been described.

The *vertebral* form, spondylitis deformans, is a progressive rigidity of the spine, due to ankylosis of the vertebræ. Two types are described. The first is the so-called spondylitis rhizomelia (Strümpell-Marie), which attacks men only at or beyond middle age. It begins usually in the hip-joints, which become ankylosed, the process subsequently extending to the spine and shoulder-joints, very rarely to the knee-joints. The spine becomes rigid, the ribs flexed, and there is some kyphosis. The dorsal and gluteal muscles are atrophied and exostoses are found upon the vertebræ and sacral bones. There is but little pain attending the process. In the second (Bechterew-Marie) type the disease begins in the spine, which becomes ankylosed and kyphotic, the shoulders stoop, the head is lowered and carried forward, and there is much intercostal pain, with anæsthesia, muscular atrophy, and other signs of involvement of the roots of the spinal nerves. The hip- and shoulder-joints are slightly if at all affected. The disease is often hereditary. There is little doubt that both types are forms of arthritis deformans, and are not, as formerly supposed, independent diseases.

Heberden's nodes, knobby enlargements of the proximal ends of the terminal phalanges of the fingers, are much more common in women than in men; they begin, as a rule, between thirty and forty years of age. They are regarded as indicative of a long life, but it has been stated that cancer occurs with undue frequency in women who have such nodosities. While the nodes are forming the affected joints may be tender and swollen, perhaps slightly reddened. Exacerbations may be excited by dietary errors, or slight accidental traumatisms; but in most instances the attacks alternate with periods of quiescence without apparent cause. Fortunately, those who develop Heberden's nodes seldom have the larger joints affected.

The *juvenile form* occurs more frequently in girls than in boys and, as a rule, before the second dentition. While the disease may be a replica of that affecting grown persons, the most important class of cases differ in many respects from the adult affection. The onset may be acute, with fever, possibly with chills, but generally the first symptom is a slight stiffness in one or two joints, others slowly becoming affected. There is no crepitus in the affected joints, and the main anatomical change is a general thickening of the periarticular tissues and enlargement of the joint with little or no alterations in the bones. The mobility of the joint is impaired, perhaps totally destroyed. There may be marked atrophy of the muscles. The most interesting feature of the malady is a general and marked swelling of the lymph glands, occurring especially in the cases attended by fever and increasing with the latter. The spleen also is enlarged and palpable. Profuse perspirations are rather common. The heart is rarely affected. The subjects are anæmic, weak, and ill-developed.

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DIAGNOSIS.—In the early stages it is always difficult and frequently impossible to distinguish arthritis deformans from chronic rheumatism. When the disease is well developed the diagnosis is seldom in doubt. The peculiar joint deformities in advanced cases are quite characteristic. The more acute cases may be mistaken for rheumatic fever, but the slighter fever, the lesser pain, redness, and swelling, and the usual absence of cardiac complications separate it from the latter. From gout arthritis deformans is distinguished by the absence of chalky deposits and, usually, of cardio-renal disease, as well as by the fact that gout usually attacks the metatarso-phalangeal joint of the great toe.

PROGNOSIS.—In a majority of cases the progress of the disease is arrested, leaving several joints more or less crippled. In other cases the disease advances irregularly, with periods of quiescence, and persists throughout the life of the patient. A few become helpless and bedridden. As a rule the milder forms of the disease are not incompatible with fair health and a long life, but the disability may be very great.

TREATMENT.—It is of prime importance to maintain the general health at its highest point. Plenty of fresh air, daily cool or cold sponging followed by vigorous toweling, well-ventilated sleeping-rooms, ample hours for sleep, daily exercise according to ability, laxatives and digestive tonics when needed, and a liberal dietary of meat, eggs, milk, butter, wine and malt liquors, should be considered essentials.

Local treatment embraces cold or hot compresses covered with oiled silk, and left on for two or three hours at a time, massage carefully given and long continued, persistent hot-air treatment (baking), small and repeated blisters, "striping" from time to time with the thermo-cautery, friction with ointments containing iodine and ichthyol, systematic passive movements, and even the forcible breaking of adhesions in selected cases.

Hydriatic treatment should be begun early and is of great value. At home a nightly plain hot bath, hot Nauheim bath, or hot-air bath may be employed. If the patient is able he should go to a hydriatic establishment in connection with a natural thermal or medicinal water, such as the Hot Springs of Virginia or Arkansas, Mt. Clemens in Michigan, Richfield Springs of New York, Green Sulphur of Florida, or Sharon Springs; Bath in England; Baden, Wiesbaden, Aix-les-bains, Carlsbad, Gastein, Homburg, or Wildbad on the continent of Europe, or the sand baths, mud baths, and peat baths of various localities.

Electricity may be employed, but its effects are uncertain.

Medicinal treatment is at times very helpful. Iron, arsenic, and cod-liver oil in full doses are the remedies that are especially indicated. Iodide of potassium (five to ten grains), or the syrup of the iodide of iron (ten to twenty minims) three times daily are especially useful if there is much periarticular thickening. In the acute polyarticular attacks the salicylates are unquestionably of great value. *Glentworth R. Butler.*

RHIGOLENE.—Of the products of the fractional distillation of petroleum the lightest is obtainable as a fluid by condensation, and consists mainly of the paraffin *butane*, a body gaseous under ordinary conditions. This condensed distillate is termed *cymogene*. The distillate of next higher boiling-point boils at about 18° C. (64.4° F.). Such distillate consists largely of the fluid paraffin *pentane* ("amylic hydride"), C_5H_{12}, and is the substance commonly known as *rhigolene*. Rhigolene is a colorless, mobile fluid of slight and not unpleasant odor and taste; very light, very inflammable, and, as its boiling point predicates, very volatile. It mixes in all proportions with common (ethylic) ether. Rhigolene was proposed by B. W. Richardson as a substitute for ether for the production of local anæsthesia by freezing, after his method. Because of the low boiling-point of rhigolene—lower than that of ether—the cold produced by the evaporation of a spray of rhigolene is very intense and very rapidly attained. Dr. Richardson observed an area of skin become hard, white, and insensible at the expiration of *two seconds* after beginning the driving upon it of a rhigolene spray. But such very rapid freezing Dr. Richardson found to be undesirable, because the intense cooling of the superficial frozen area prevents the abstraction of heat from below, and so limits unduly the depth to which the anæsthesia can be carried. Hence Dr. Richardson proposed a mixture of rhigolene and anhydrous ether in equal parts. Rhigolene dissolves camphor, spermaceti, and iodine, and has been used by Richardson, again, as a solvent of those bodies for use for local applications. A rhigolene solution of camphor and spermaceti together Richardson found to make an excellent conjoint cooling anodyne and healing application to burns. The vapor of rhigolene, inhaled after the manner of vapor of chloroform, is readily taken, and produces general anæsthesia with great rapidity. But in this application rhigolene has shown itself dangerous, and has never come into practical use.

Edward Curtis.

RHINOSCLEROMA.—A chronic infectious disease affecting chiefly the nose, the mucous membrane of the mouth, pharynx, and larynx. It is due to a bacillus resembling in some respects the bacillus of Friedländer, and is characterized by the formation of diffuse and nodular swellings of extreme hardness, often followed by dense cicatrices. It is a disease of extreme chronicity, and has not been found to be amenable to any form of treatment.

The disease was first described by Hebra in 1870 as a tumor formation situated in the nose or its vicinity. The growth is constant, but exceedingly slow; it is hard and indurated and sharply circumscribed, the surrounding tissue showing no inflammatory or other change. The growth appears in the form of smooth nodes of various size or as a diffuse induration. The surface is smooth and shiny, and either of a brownish-red or normal color. It is painless in itself, but painful on contact. It produces no danger to the organism save by mechanical interference with respiration.

Kaposi gave a more detailed description of the process in 1873. In this he calls attention to the frequent involvement of the soft palate, due to the extension of the process from the nose. It begins in the mucous membrane of the side of the nose or in the cartilaginous septum. It may produce narrowing and even complete closure of the nares, and from the nose it extends to the pharynx, to the upper lip, to the hard palate, and to the alveolar processes of the upper jaw.

We owe our chief knowledge of the disease to two monographs, one by Mikulicz (*Arch. f. Chirurgie*, 1876, vol. xxvii.), and the other by Wolkowitsch (*Arch. f. Chirurgie*, 1889, vol. xxxviii.). There have been in addition a series of publications of single cases often giving detailed histological reports, and the discovery of the bacillus by Fritsch in 1882 has been followed by a long series of articles on the presence of the bacillus, its relation to the lesions, its cultural characteristics, morphology, etc.

The investigations of Mikulicz were made on two cases. One of these had lasted for sixteen years, and the growth had so interfered with function that operative removal of a considerable part of it became necessary. The growth began on the inner surface of the left nostril as a small nodule, which gradually increased in size. Nodules accompanied by diffuse induration almost completely closed the nose and extended to the septum and the upper lip. The affected parts were dark red and extremely indurated. The nose, which was at first greatly enlarged, gradually sank and its form was lost. The infiltrated upper lip was drawn upward and backward, and the entire area affected became a flattened indurated mass. There was gradual narrowing of the mouth, which became so hard and stiff as to interfere with eating. The opening finally became so narrow that only the point of the small finger could be passed into it. An operation was performed consisting in enlargement of the

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mouth by extensive removal of the indurated tissue about it. The entire upper lip and a part of the cheek were adherent to the alveolar processes. The middle of the hard palate was covered with irregular cicatrices, which extended to the soft palate and were joined with similar cicatrices in this. The diseased tissue, although so hard to the touch, gave little resistance to the knife and the hemorrhage was slight. In the second case the disease appeared as an enlargement and induration of the nose, which after five years became double in size. The tissue removed was similar in character to that removed in the first case, and was so hard that fair microscopic sections could be made of it in the fresh state.

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At the time of the publication of Wolkowitsch the disease had become much better known. Quite a number of cases had been published, and on account of the extent of the lesions in the pharynx, which had been largely neglected by the first authors, the name pharyngoscleroma had been proposed as a substitute for rhinoscleroma. It had been further found that the disease often extended into the lower part of the larynx, and especially on the lower surface of the vocal cords and sometimes into the trachea. The laryngeal and tracheal lesions have been specially studied by O. Chiari and Bendler. In 1873 Gerhardt described under the name of "chorditis vocalis inferior hypertrophica" a form of disease of the larynx which he characterized as a chronic inflammatory hypertrophy of the vocal cords leading to stenosis. From a review of the literature he concluded that the condition had been known before, but not recognized as an independent disease.

Langhofer in 1880 studied the condition histologically, and found the lesions characteristic of rhinoscleroma. He held the two conditions to be the same, and that scleroma could appear in the larynx and trachea independently of any affection of the nose. This was shortly confirmed by O. Chiari, and in 1885 Chiari and Rhiel collected thirty cases of rhinoscleroma, in nine of which the disease had extended into the larynx. In Bandler's case, which was studied from autopsy, the larynx was stenosed in high degree by a thick, hard mass of tissue extensively ulcerated. The trachea was stenosed; its wall was 0.75 cm. thick. This thickening came chiefly from the mucosa and submucosa, which was converted into a hard mass of tissue, partly covered with thickened epithelium and partly ulcerated. On the inner surface of the trachea there were radiate cicatrices. The infiltration extended down to the bifurcation, and for a distance of from 1 to 1.5 cm. into the primary bronchi. The lesion extended up to the pharynx and nares, but without altering the external appearance of the nose.

Wolkowitsch gave a complete clinical and anatomical description of eleven cases, together with short descriptions of all of the cases which he could collect from the literature. In his first case ulceration was prominent. The disease often begins with the appearance of a nodule or as an induration, either at the sides or in the median line of the nose. In certain cases the induration extends over the whole nose and down to the lip, or the chief extension may be backward, or it may extend in both directions. Ulceration is rarely a prominent feature, but in certain cases large crater-like ulcerations, with elevated indurated edges, are formed; they present some similarity to carcinoma.

In other cases the growth seems gradually to fill up the nose. It grows more rapidly from the interior than from the exterior. The nose becomes enormously enlarged and flattened laterally.

The disease is usually found in the lower classes, and it is difficult to get information as to the manner of onset. Sometimes catarrh was noticed as the first symptom. When ulceration is present, the ulcers discharge a thin fluid which is often offensive. There may be external nodules which represent an extension from the interior and give but little idea of the extent of the process. The upper part of the nose is not affected, so that the sense of smell is not lost as long as the external opening is left. In rare cases the disease begins in the pharynx and larynx, and the disease of the nose is secondary and may not appear. The lachrymal sac has been secondarily affected in a few cases, and the disease has also extended into the Eustachian tube. The deeper parts are rarely affected, but in some instances both thickening and ulceration of the cartilage and of the bones has been found. When the disease appears in the nostrils there is a great tendency for it to extend to the upper lip, especially upon the external surface. The nodules are often covered by a network of veins. The gums are thickened; irregular, hard, dark or bluish-red nodules, which sometimes extend to the mucous membrane of the palate, are formed on them. The teeth lose their direction, become pressed forward or backward, and often thrown out. The disease is almost invariably symmetrical, affecting chiefly the middle line and extending equal distances laterally. The growth extends very slowly but continuously. In one of Mikulicz's patients there was more rapid growth at each pregnancy. Like so many affections of the skin there is a continuous peripheral extension with central cicatrization and contraction. There seems to be but little tendency for the lesions to become the seat of pyogenic infections or other secondary processes.

In one case a carcinoma developed in the lesion after the disease had existed for twenty-five years.

The first histological examination was made by Kaposi, who regarded the process as a sarcoma. He found the papillary body and superficial corium thickly infiltrated by small cells, while the deeper layers showed a thick connective-tissue network with slight cellular infiltration. The next investigation was that of Geber, who disagreed with Kaposi, and considered the disease a chronic inflammatory process and not a tumor. Mikulicz also regarded it as a chronic inflammation. Microscopically, he found areas of round-cell infiltration, and, among these, cells which were much larger and paler, with a pale vesicular nucleus. The growth was sharply separated from the normal tissue. Proceeding from the normal tissue to the growth the first change seen was atrophy of the sebaceous glands and the hair follicles. The infiltration was chiefly in the deeper layers of the corium, the papillary body showing little change other than atrophy. Mikulicz considers that the lesions in the epithelium are due to the deep cellular infiltration; the vessels passing through this are in part compressed, and they serve rather the nutrition of the growth than that of the normal tissues. The sweat glands also become atrophied. The connective tissue at first is unaltered, its fibres being simply pressed apart. In places it loses its fibrillar character and the intercellular substance becomes homogeneous. Nerve bundles may be found running through the infiltration, but they seem to be especially resistant. The muscles are destroyed much earlier than the nerves. They are atrophied, often show the degenerative proliferation of nuclei, and in places where the infiltration is more rapid they become hyaline. Fat cells are often present to a considerable extent. Mikulicz thinks that the large cells arise from the connective tissue.

Cornil and Alvares in 1883 called attention to the appearance of hyaline masses in the large cells first described by Mikulicz. They found that the bacteria were in relation to the hyaline masses, which, as they supposed, in part represent the bacterial capsules, and in part are due to a hyaline degeneration of the cells brought about by the bacteria. Wolkowitsch believed that the large cells represented a special form of degeneration of the granulation cells. The hyalin has the general characteristics of hyalin as described by von Recklinghausen. The cells occasionally break down and leave the hyalin free. The peculiar refraction of the fresh tissue and its peculiar induration are due to the hyalin.

The rhinoscleroma bacillus was first described by Fritsch in 1882 in all of the twelve cases which he investigated. The bacilli have been found constantly by every investigator. They are present in large numbers, and are chiefly in the large cells, though they may be found between them; they vary somewhat in size; they are short,

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often appearing in double form, and they present some resemblance to the pneumococci, but they are usually much larger. The capsule formation is a permanent characteristic and may be demonstrated even in the tissues. The best way of showing them is to harden the tissue in one-per-cent. osmic acid and then to stain it with some aniline color. The capsules by this means become very prominent, and have a grayish-brown color.

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From the appearance of the organism and from its cultural characteristics it was considered by many to be identical with the bacillus pneumoniæ of Friedländer, and a great deal of the bacteriological literature has been on this subject, but the general opinion now is that it is distinctly different. The organism in culture has the following characteristics: It forms a mucoid cap-like colony on gelatin plates; no gas in sugar-agar; no acid in milk-sugar bouillon. The best description of the differential diagnosis between the scleroma bacillus and Friedländer's bacillus is that of Paltauf, who investigated fifteen cases. The principal points of difference between the two are these: first, the superficial whitish extension of the scleroma bacillus on gelatin is drier and more consistent than the corresponding growth of Friedländer's bacillus; second, there is an entire absence of gas formation in sugar-agar; and, third, the organism develops very imperfectly on acid media.

The geographical distribution of the disease is narrow. The first cases were seen in Austria, and the disease has always been more frequent there than elsewhere. The disease is also not uncommon in Russia, where Wolkowitsch studied his cases, but Central America and chiefly the republic of San Salvador seem to be the principal seat of the disease after Austria. Cases have also been observed in France, Germany, Belgium, and Cairo. Only five cases have been reported in the United States, and only one of these was a native American.

The disease belongs to the general class of granulation tumors. The large cells are of the epithelioid character, and resemble the epithelioid cells formed in tuberculosis, and the masses of them may suggest some similarity to tuberculous granulation tissue. They do not undergo caseation, nor is there any necrosis in mass. They are particularly prone to hyaline degeneration, which appears to be due to the action of the bacilli, which they often contain in large numbers. With their complete hyaline degeneration they disappear, and their place is taken by dense masses of connective tissue, to the contraction of which the cicatrization is due. The formation of these masses of large cells appears to be the primary and essential process; the other lesions are those common to all similar processes. It is probable that we must regard the disease as due to the bacillus which is always associated with it. The disease is a peculiar one, and the bacillus is in relation with the cell formation, which constitutes its histological specificity. It is an organism which is easily cultivated, but no characteristic lesions can be produced by inoculation of animals. It is pathogenic only in large doses. In spite of its similarity to Friedländer's bacillus and to the group of the bacillus mucosus capsulatus, both in morphology and in some cultural characteristics, it should be considered to be an independent organism. None of these organisms lead to a proliferation of tissue, and their general action is to produce exudations. The narrow geographical distribution of the disease also points to a distinct etiology. In view of the wide distribution of the bacillus mucosus capsulatus, it is unlikely that a variety of this would have so restricted a field. *W. T. Councilman.*

RHINOSCOPY. See *Nasal Cavities, Diseases of: General Diagnosis.*

RHODANIDES. See *Sulphocyanides.*

RHUBARB.—*Chinese Rhubarb; Rheum*, U. S. P.; *Rhei Radix*, B. P.; *Radix Rhei*, P. G.; *Rhubarbe de Chine, Rhubarbe de Muscovie, Rhubarbe de Perse*, Codex Med., etc.

The dried rhizome and larger roots of *Rheum officinale* Baill., *Rheum palmatum* L., and probably of other species of *Rheum* (fam. *Polygonaceæ*), deprived of the outer corky layers.

The general features of the rhubarb plant are well illustrated by the common garden pie-plants, *R. rhaponticum*, etc. There are twenty or more species, all from Southern and Central Asia, the drug being collected in Northwestern China, Thibet, and the adjacent regions. Both of the above-named species have been introduced to cultivation in Europe, and have produced a drug identical in its essential features with Chinese rhubarb. The second named has not been cultivated upon a commercial scale, but *R. officinale* is quite extensively so cultivated in England. The product is smaller, retains more of its bark, is more spongy, and less esteemed than the Chinese product.

The underground portion consists of a short, thick, erect rhizome, which gives off several thick roots. These are dug in the autumn and the rhizomes and roots preserved separately, the former constituting the most and the more highly esteemed portions of the drug. They are two or three times as large as the roots. The outer corky bark layer is removed and the pieces are dried, mostly by being suspended upon strings passed through perforations made for the purpose.

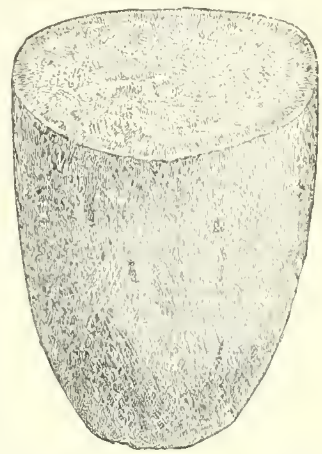

FIG. 4111.—Piece of Round Chinese Rhubarb, showing the white lozenge-shaped reticulation on its surface and the irregular medullary rays on the section. (Baillon.)

DESCRIPTION.—Rhubarb occurs mostly either in unevenly barrel-shaped pieces—from two to five inches in length and one-third to two-thirds as thick, the ends truncated, the surface showing the angular markings left by peeling, though these are more or less rounded off—or in longitudinal halves or slices of such barrel-shaped pieces. Usually the pieces are perforated by a rather large hole. The surface is of a bright light yellow and covered with a fine powder, which should consist of the rhubarb substance, but is sometimes powdered curcuma. That which has been kiln-dried or "high dried" possesses a surface roughened with broad ridges, separated by broad grooves, the latter frequently discolored to appear smudgy or blackish. The surface is less powdery. Underneath this superficial powder the surface of rhubarb is found reticulated, the oblong or lozenge-shaped ends of the reddish-brown or deep yellow-brown medullary rays being separated by intersecting bands of a grayish-white parenchymatic tissue. The fracture is irregular but not at all fibrous, and of a grayish-red color. Upon transverse section the larger (rhizome) pieces show, near the periphery, a nearly continuous circle of pretty stellate fibro-vascular bundles, these being wanting in the root pieces. Upon this transverse view the direction of the medullary rays is seen to be very irregular, less so toward the periphery. Rhubarb possesses a peculiar fine aroma, which, however, becomes coarse, heavy, and a little empyreumatic in the high-dried form. When chewed it produces a very gritty effect between the teeth, is mucilaginous, colors the saliva yellow, and imparts a bitter, astringent, and somewhat aromatic taste.

Powdered rhubarb is frequently adulterated, more especially with turmeric or curcuma. This may be recognized under the microscope by its large, solitary, oval

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starch grains, and by the fact that the particles quickly impart a deep yellow color to a colorless volatile oil close to their margins, when placed in contact with it.

CONSTITUENTS.—From a therapeutic point of view most of the constituents which have been isolated from rhubarb are unimportant. An active substance which has been extracted (usually to the extent of from three to five per cent.) is "cathartic acid," common to a number of important purgative drugs. In doses of from three to five grains it produces the general purgative effects of rhubarb. It is, however, not a simple substance. The resinous constituents remaining after the extraction of the crystalline bodies named below appear also to be quite active. This resinous body has been separated into portions respectively called phæoretin, aporetin, and erythroretin. No one, however, has seriously proposed the substitution of the use of any one constituent of rhubarb for the entire substance or its preparations.

The three constituents which have attracted the most attention from a chemical standpoint, though the second only appears to have any activity, are chrysophanic acid (not an acid however), emodin, and rhein. They are successively, in the order named, oxidation products from some original body which has not been determined, thus: Chrysophanic acid, $C_{15}H_8O_2.(OH)_2$; emodin, $C_{15}H_7O_2.(OH)_3$; rhein, $C_{15}H_6O_2.(OH)_4$. Rheotannic acid is a glucoside yielding rheumic acid. There exist also an unstudied bitter principle, an odorous oil, also a derivative product, about two-thirds of one per cent. of fat, starch, and calcium oxalate, the last reaching to a fourth, or possibly more, of the weight of the drug.

HISTORY AND VARIETIES.—Rhubarb has been used in China from the remotest ages (2700 B.C., Flückiger), and possible references to it are found in the earliest European books on medicine. As early as the seventh century of our era, there can be no doubt of its occurrence in Europe, and by the tenth or eleventh it was well known and highly valued.

For about a hundred years previous to 1860 the Russian Government monopolized the rhubarb trade between Siberia and the Chinese provinces, and established an exceedingly strict inspection of all the roots exported that way, condemning and destroying all but those which were absolutely perfect. In this way an exceptionally fine quality was obtained, and exported, after its long hard journey, from Moscow. Curiously, in England and this country the old and entirely inappropriate name "Turkey rhubarb" was given to this variety. Since 1860 this inspection has been discontinued, and this grade of rhubarb has entirely disappeared from English and American commerce.

The great bulk of the present commercial product is known as Canton rhubarb, though this name also has ceased to be descriptive. Shensi rhubarb is preferred to Canton, and a specially fine variety is that known as Tze-chuen. The round pieces are in general preferred to the flat and the natural to the high-dried. For household use rhubarb is frequently cut into pretty little forms, fingers, crescents, stars, etc.

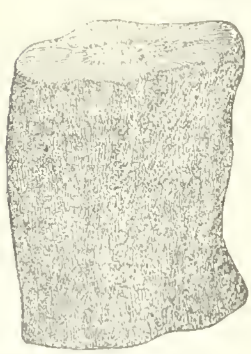
FIG. 4112.—European Rhubarb. (Flückiger.)

ACTION AND USE.—When chewed rhubarb stimulates the saliva. In small doses, in the stomach, it seems to act as a digestive stimulant; in larger ones it appears to be a simple purgative, hastening along the contents of the bowels by increased peristalsis carrying the liquid contents of the small intestine rapidly down, to soften and force along the more solid mass in the colon and rectum. Intestinal secretion is supposed to be less stimulated by it than by salines or the cathartic resins. Its coloring matters are absorbed, and may tinge the milk and urine.

Rhubarb is mild and fairly certain in its action; it produces comparatively little pain, no depression in moderate doses, and its action is not prolonged. The tannin in it is credited with producing some constipation after its use, but the simple emptying of the bowels without irritation of the mucous membrane would be enough to explain this result. Rhubarb is given in almost all conditions in which simply emptying the bowels is desired.

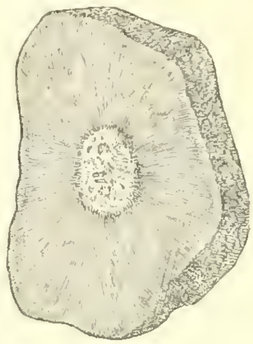
FIG. 4113.—European Rhubarb; surface of a transverse section. (Flückiger.)

ADMINISTRATION.—Rhubarb is offered by the Pharmacopœia in a great variety of forms; it is also found in a good many of the popular proprietary laxative mixtures. It makes a fine, deep yellow powder which is sometimes given, but not often, on account of its very nauseous taste. Two or three decigrams (gr. iij. to v.), once or twice a day, would be a very mild tonic-laxative dose; a single dose of 1 gm. (gr. xv.) is mildly, while one of 2 gm. (gr. xxx.) would be severely, cathartic. Rhubarb in substance is frequently taken by chewing and swallowing a piece of the root as large as a pea or a bean, once a day or so, preferably after eating; the taste, when the drug is used in this way, being less nauseous than that of the powder. The tonic, almost carminative, action of rhubarb upon digestion, has led to its being widely used in this way. The following are the preparations of the United States Pharmacopœia:

Extract, of about 300 per cent. strength; fluid extract; tincture, containing 10 per cent. each of rhubarb and glycerin and 2 per cent. of cardamom; aromatic tincture, twice as much rhubarb, 10 per cent. glycerin, 4 per cent. each of cassia-cinnamon and cloves, and 2 per cent. of nutmeg; sweet tincture, 10 per cent. each of rhubarb and glycerin, 4 per cent. each of liquorice and anise, and 1 per cent. of cardamom; compound powder, 25 per cent. of rhubarb, 65 per cent. of magnesia, and 10 per cent. of ginger; pills, each containing 0.2 gm. of powdered rhubarb and 0.06 gm. of soap; compound pills, each containing 0.13 gm. powdered rhubarb, 0.1 gm. purified aloes, 0.06 gm. powdered myrrh, and 0.005 c.c. oil of peppermint. From the fluid extract is prepared the syrup, of 10 per cent. strength, with 1 per cent. potassium carbonate, 5 per cent. each of glycerin and water, and a little spirit of cinnamon; also the mixture of rhubarb and soda, containing 3.5 per cent. each of sodium bicarbonate and spirit of peppermint, 1.5 per cent. fluid extract of rhubarb, 35 per cent. glycerin, and a little fluid extract of ipecac. The aromatic syrup is made of 15 per cent. of the aromatic tincture, with 85 per cent. of syrup.

ALLIED PLANTS.—The genus contains about twenty species, most of whose roots have qualities similar to the above. Several of these, *R. rhaponticum*, and others, are cultivated in Austria and elsewhere in Europe for this purpose, and the European product is trimmed and prepared so as closely to imitate the Chinese. It can generally be told by its duller color, more spongy texture, absence of gritty crystals when chewed, and the more regular arrangement of its medullary rays; the stellate spots are absent. It is very inferior to genuine rhubarb.

Henry H. Rusby.

RICE. See *Starch*.

RICE BODIES.—(Synonyms: *Corpuscula Oryzoidea*; *melon-seed bodies*.) In chronic tuberculous affections of the tendon sheaths, bursæ, and synovial membranes,

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there are frequently formed small hyaline bodies resembling grains of rice or boiled sago. On section they are either homogeneous or granular, or concentrically laminated. In the central portion there is usually a small cleft. Many of these bodies possess a definite capsule, which is narrow, and is made up of concentric layers containing a varying number of nuclei. In the main mass nuclei are either not present at all or are found in very small numbers. Others consist of a hyaline fibrous tissue which in certain parts may show few nuclei. Some are made up wholly of fibrin, while in others the fibrin consists of bands scattered throughout the connective tissue. Giant cells are often present. As shown by the staining reactions these bodies for the greater part represent organized masses of fibrin which have undergone a hyaline change. All stages of the process may be seen. Some of the bodies stain throughout as fibrin with the Weigert fibrin stain; in other cases the hyaline substance stains red with Van Gieson's method. Double staining shows in others the presence of fibrin threads in the midst of the hyaline fibrous tissue. Van Gieson's method causes some of the bodies to take a yellow or brownish stain, the material of which these are composed not giving a fibrin reaction. A deep diffuse blue staining with hæmatoxylin shows the presence of lime salts in others. There has been much dispute over the origin of the fibrin in these bodies, some writers holding that it is the result of a "fibrinoid degeneration" of granulation tissue. The actual facts, however, tend to support the view that the majority of these bodies are formed from masses of exudative fibrin, which becoming organized undergoes a hyaline change.

As shown by the staining the genesis and nature of these bodies must vary. They may consist of fibrinous masses loosened from a fibrinous exudate covering the inner surface of the tendon sheath or bursa; or of partly organized masses of fibrin which have become loosened. The most common mode of formation is from loosened masses of tuberculous or syphilitic granulation tissue. The inner surface of the tendon sheath or bursa in such cases presents a polypoid or villous appearance due to organizing masses of fibrin. The connective tissue grows into the fibrin, organizing it, and after organization becomes changed into a hyaline substance possessing no nuclei. At the end of the villi there are thus formed more or less firmly attached hyaline bodies, which when loosened from their attachments become rice bodies. Around the detached body fresh deposits of fibrin take place, through the organization of which the body acquires a concentric laminated appearance. The hyaline change may begin at the periphery or centre of the body, or in any portion of its substance. It is also probable that portions of necrotic tissue loosened from the inner surface of a tuberculous hygroma may give rise to rice bodies.

By the majority of writers the presence of rice bodies in the joints, in the sheaths of tendons, or in the bursæ, is regarded as positive evidence of the tuberculous nature of the affection. In the great majority of cases the process is undoubtedly tuberculous; tubercle bacilli may be found in numbers upon the surface of the rice bodies, and occasionally within their substance. The formation of these bodies is, however, characteristic of a fibrinous exudate within the structures named, whether due to tuberculosis, syphilis, or other infection. The number of the bodies bears a certain relation to the chronicity of the process.

In many cases great numbers of the bodies may be present within the distended sheath or hygroma. In some cases they may be distinctly felt, and give a marked crepitation when moved upon each other. On cutting into the sac the little hyaline bodies may roll out in great numbers. *Aldred Scott Warthin.*

RICHFIELD SPRINGS.—Otsego County, New York.

Post-Office.—Richfield Springs. Hotel and cottages.

Access.—From New York viâ New York Central and Hudson River Railroad; also viâ Delaware, Lackawanna, and Western Railroad. From Philadelphia viâ Delaware, Lackawanna, and Western Railroad. From Washington and Philadelphia viâ Pennsylvania Railroad.

This charming summer resort is picturesquely located on Lake Canandarago, at an altitude of 1,750 feet above the sea-level. Richfield may be classed among the most attractive of our summer resorts. In writing of his visit here Charles Dudley Warner well and truly said, "The charm of Richfield is in the character of its landscapes." It is scenery "that one grows to love, and that responds to one's every mood in variety and beauty. In a whole summer the pedestrian will not exhaust the inspiring views, and the drives over the hills, round the lakes, by woods and farms, increase in interest as one knows them better. The artist is here year after year, one season being too short to satisfy the demands which the charms of the region make upon his love of the beautiful." The art of man has added much to the natural attractiveness of the location. The greatest attraction of Richfield, however, is found in the fine White Sulphur Springs. There are sixteen springs at this resort, and some of them have become widely celebrated. The bathhouse in connection with the springs is one of the most complete in the world, and provides for the therapeutic use of water combined with massage and electricity in a thoroughly scientific manner. It contains sixty-seven rooms for sulphur baths, Turkish and Russian baths, a large swimming pool, a pulverization room, inhalation rooms for the treatment of bronchitis and catarrh, electrical rooms, douche rooms, and a sun bath. The bathhouse is situated on the grounds directly in front of the Hotel Earlington. The following analysis of the principal spring, known as the White Sulphur Spring, was made by Professor Chandler, of New York:

One United States gallon contains (solids): Sodium hydrosulphate, gr. 1.72; calcium hydrosulphate, gr. 0.09; potassium sulphate, gr. 1.67; calcium sulphate, gr. 112.34; strontium sulphate, gr. 0.01; magnesium sulphate, gr. 5.15; sodium hyposulphite, gr. 0.38; magnesium bicarbonate, gr. 31.74; sodium chloride, gr. 0.52; lithium chloride, gr. 0.02; silica, gr. 0.64; and traces of alumina, barium sulphate, iron bicarbonate, and calcium phosphate. Total, 154.28 grains.

Sulphureted hydrogen gas is present to the extent of 14.20 cubic inches in each gallon. This spring, it will be observed, is very heavily charged with sulphureted hydrogen gas. Other important springs at Richfield are the Iron and Magnesia Springs, besides additional sulphur springs. The drinking-waters are obtained from springs west of the village, and are pure and abundant. A course of baths at Richfield has been found of value in cases of insomnia from overwork, in nervousness, in stomach disorders resulting from abused digestion, in chronic malarial infections, in gout and rheumatism, and in some of the disorders of the liver and kidneys. The visitor will find in the Hotels Earlington, St. James, and smaller places accommodations to please any taste or exchequer. *James K. Crook.*

RICKETS.—(Synonyms: Rhachitis or Rachitis; Fr., *Nouure, Rachitisme;* Ger., *Rhachitis, Englische Krankheit.*)

Definition.—A general disease of infancy and early childhood, chiefly characterized by alterations in the bony skeleton and by impaired nutrition. In severe cases there may also be changes in the viscera.

History.—The disease was known to the writers of antiquity, but was often confused with other maladies causing deformities of the skeleton, especially with tuberculous spondylitis. We owe the first accurate description of the condition to the English physician Glisson, who published a work upon the subject in 1650. The disease seems to have been especially prevalent in England at that time and later, and has always been the subject of study by English physicians; hence its name of the Englische Krankheit.

During the eighteenth century the French physicians made many contributions to our knowledge of the rachi-

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tic process, while more recently the Germans have been most active. Among the names which will always be connected with the history of the study of this important disease of infancy may be mentioned Trousseau, Guérin, Elsasser, Virchow, Kölliker, Rokitansky, and Kassowitz.

Etiology.—The nature of the agent which underlies the pathological changes www.libtool.com.cn rachitic children is still unknown. It has been assumed to be caused by an insufficient amount of calcium salts in the blood, and color has been given to this theory by the oft-quoted experiments of Sutton and others, in which rachitic changes were thought to be produced in animals by nourishing them on food practically free from lime salts. It has been recently shown, however, that the changes which were produced in animals by this means are rather those of osteomalacia than a true form of rickets. The similar belief that an imperfect absorption of the lime salts from the intestine was responsible for the rachitic condition has been shown to be untenable, for the urine of rachitic children contains an amount of calcium quite sufficient to supply the needs of the skeleton; and if larger amounts of calcium salts are administered to either rachitic or healthy children the excess is rapidly excreted in the urine.

The chemical theory that the lime salts either could not be deposited because of the diminished alkalinity of the blood or that they were dissolved out by the action of an acid circulating in the fluids of the body, has been shown to be without foundation. The blood of rachitic children contains neither an excess of acid nor an excess of alkali.

The view brought forward by Kassowitz that the bone changes are purely inflammatory in nature is not in entire accord with the anatomical findings. The most recent suggestions are that the disease is an infection or that it is an auto-intoxication. Neither view has been supported by sufficient experimental evidence to warrant its acceptance, however attractive the assumption may be. Although, therefore, we do not know the actual cause of the disease, there are many predisposing conditions which are known. Among these are chiefly imperfect food and unsuitable hygienic surroundings.

The disease is most frequently seen among the children of the poor, especially those who have been reared upon an artificial diet containing large quantities of carbohydrate and small amounts of fat. It is rare in children who have been breast-fed, the exceptions being principally the children of the laboring classes, where the mother begins to work soon after the delivery of the child, or in children who have been nursed for a long period until the milk becomes insufficient for the needs of the infant.

Children fed upon sweetened condensed milk are frequently rachitic, while those obtaining the unsweetened form are not likely to suffer. Boiling the milk is also thought to set up obscure changes in the composition of that fluid which affect the nutrition and may cause rickets and especially scurvy. The exact form in which the hygienic factors exert their influence is not so clear as it is with food. Some observers, notably Mey, are inclined to consider lack of light and fresh air as very potent forces in the production of the rachitic process; others, for example Lange, regard the hygienic factor as comparatively unimportant and, though acknowledging that the disease is more prevalent in cities where the hygienic surroundings are bad, they lay the most stress upon the food factor. It is certain, however, that rickets is very infrequent in the country, in high altitudes, and in the tropics. It is also true that the children born in these conditions are much more likely to be breast-fed than those in the tenement districts of large cities. The influence of race in the susceptibility to rickets is seen in the negro and in the Italians. The children of both of these races, when confined to the tenement districts in cities, offer our most marked examples of advanced and severe rickets. Congenital influences play some part in the causation of rachitis, though at present the trend of opinion is against a true congenital form of the disease. Cases so described are regarded as distinct from rickets, though showing bone lesions closely resembling those seen in rachitic children. Parental syphilis is a strong predisposing factor in the production of rickets, though it does not seem to be the cause of the disease, as Parrot attempted to show. Tuberculosis and alcoholism in the parents also predispose to rickets, chiefly by reducing the child's power of resistance. Both sexes are equally subject to the disease, though in hospital statistics a larger number of males will be noted. This apparent anomaly is due to the fact that a larger number of male children are received for hospital treatment than female, and large statistics, including private cases, will show about equal numbers affected. The clinical development of the disease is most noticeable in the second year of life, though a large proportion of children show signs of the disease during the first year. After the third year the disease is infrequent. Late cases have been described in children even up to the twelfth year, but such observations are extremely rare. The disease is one which concerns the period of the most active growth and formation of the bones, progressively diminishing as the skeleton assumes its definitive condition.

Pathology.—The constant and characteristic lesions of rickets are to be found in the bones; the visceral changes are comparatively slight and secondary. A rachitic bone, when examined in a fresh condition, is softer than normal, and the actively growing portions—that is, those parts near the epiphyseal junction in the long bones and the ossification centres of the cranial bones—are larger and much more vascular than in normal bones from a child of the same age. The periosteum is thickened and strips with some difficulty from the surface, leaving irregular areas of soft, newly formed bony tissue adherent to the inner layers of the periosteum. The bone from which the periosteum has been removed is soft and very vascular, and has a spongy appearance. The same changes may be noted if one of the long bones is split open and the internal layer of the periosteum is examined. The calcification zone at the epiphyseal junction, which in normal bone is well defined and narrow, is broad and not sharply defined in rachitic bone, and may be quite unrecognizable. In the later stages of the disease, when the acute process has ceased, the rachitic bone is usually harder than normal bone, especially where an active production of new bony tissue has taken place. This new-formed bone may resemble ivory in its density and texture. Frequently, however, when the restoration of the bone has been incomplete, it is soft and porous, and contains a considerable quantity of fat scattered through the substance. Such bones are very light and fragile, and green-stick fractures are frequent. The microscopical changes correspond to the gross lesions. The centres of the flat bones of the skull are vascular and the bony layers are replaced by osteoid tissue. This may be very abundant in amount, in which case the bone is so soft that it can be easily indented by the finger, and gives a soft crepitus when palpated, a condition known as craniotabes; or the osteoid tissue may be located in small areas, a few millimetres in diameter, and give the bone an appearance of a coarse sponge. The osteoid tissue may not ossify, and the aperture thus left in the bone may be closed simply by the pericranium. Such marked changes in the regular course of ossification of the cranial bones are as a rule rare, and confined chiefly to the posterior portion of the cranium.

The more frequent course is for the osteoid tissue to be gradually replaced by bone, either by direct ossification or by the replacement of the abnormal tissue by normal bone. When the osteoid tissue ossifies directly the structure produced is as a rule more dense than normal and resembles ivory. In the long bones the most marked lesions are at the epiphyseal junction. It should be remembered, in order to understand the pathology of the subject, that the bones grow in length at this point, while they increase in diameter by the production of new bone from the inner layers of the periosteum. At the same time the medullary cavity is enlarged by absorption of the inner layers of bone. In rickets the pathological

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changes consist in the distortion of these normal conditions. The inner layers of the periosteum produce an excessive amount of very vascular osteoid tissue, which undergoes either ossification or absorption. The ossification which takes place is of a very imperfect sort, so that the new bone is soft, spongy, and very much more vascular than normal. In the medullary cavity the process of absorption is very irregular and often excessive in amount. The cavity may extend into the epiphysis, or it may be filled with osteoid tissue, which replaces the normal bone marrow and thus may contribute to the anæmia from which rachitic children suffer by directly diminishing the production of the blood cells. The course of the bone growth, which takes place at the epiphyseal junction, is also disturbed by a combination of the same processes which contribute to the irregular bone production by the periosteum. The cartilaginous area of the epiphyseal portion of the bone is broken up and penetrated by a vascular osteoid tissue, which may be prematurely ossified or may form marrow cavities. The cartilage cells also proliferate and become dislocated from their normal positions. Absorption of these masses may occur or they may become ossified. The normal calcification zone becomes irregular and is broken up by the advance of the osteoid tissue into the epiphysis. After a variable period of from three to eighteen months the active process ceases and the formation of bone begins in a normal manner. The swelling of the epiphyses diminishes, the extreme vascularity is reduced, and the areas of osteoid tissue become calcified. The structural reparation is never quite complete, though a large amount of the distortion of the bone may disappear.

The effect of these changes in the structure of the bones is first to delay their growth, and second to cause deformities. The results of the first condition may be seen in the small bodies and shortened limbs of children that have suffered from rachitis of a severe type. The softness of the bones permits their easy distortion under pressure, as is so well seen in the chest, while the deformity which results from growth alone is best noted in the square form of the cranium or in the curvatures of the upper extremities.

The lesions of the viscera are not an essential portion of the rachitic condition, but they are quite frequently met with in severe cases. The lungs frequently show acute or chronic bronchitis or a bronchopneumonia. When the deformity of the chest wall is considerable, the lungs may be the seat of a marked emphysema in the areas upon which there is no pressure, while those portions which are compressed by the incurving of the thorax may be in a condition of atelectasis. The spleen is frequently increased in size owing to an interstitial splenitis of a chronic form; the liver occasionally shows similar changes. The lymph nodes are often swollen and hyperplastic. Hydrocephalus is no more frequent in rachitic children than in others, the enlargement of the head being due to the increase in thickness of the cranial bones. The muscles of the body are flabby and atrophied.

Symptoms.—The symptoms of the disease vary with the stage of the malady. The earliest symptoms are restlessness during the night, sweating of the head, craniotabes, and the beading of the ribs. The beading of the ribs is an especially early and valuable symptom, and consists of a row of nodules formed at the costo-chondral junction. The beading is often more marked internally, especially in cases with extreme incurving of the chest wall. The craniotabes is often an early symptom, and may best be demonstrated by gently palpating the posterior surface of the head with the tips of the fingers. Small areas, softer than the remainder of the skull, will be felt, and the tissue may crackle under the pressure. In rachitic children the skull appears relatively large and the frontal prominences are well marked; alterations which, when associated with the prominent posterior part of the head, give to the latter the characteristic square appearance, the *tête carrée* of the French. The anterior fontanel is larger than normal, and its closure may be delayed even to the third or fourth year. The two lateral openings are often late in closing, as are also the sutures. The superior and inferior maxillæ are slightly distorted in severe cases, chiefly by muscular action. The teeth are delayed, not appearing until the end of the first year, or even later, and there are often irregularities in the time and order of appearance and arrangement of the different groups of teeth. Some observers consider the teeth of rachitic children to be especially prone to decay. The thorax, as has been mentioned above, is frequently deformed. In mild cases the only change noted is the swelling of the costo chondral junction, forming the so-called rachitic rosary. The flexibility of the bones of the chest permits the pressure of the atmosphere to exert a considerable influence in the production of deformities, so that a distinct depression frequently exists along the line of the ends of the ribs, or there may be a transverse groove parallel to the line of the insertion of the diaphragm. The deformities known as funnel breast and pigeon breast are largely dependent upon an antecedent rachitic process. Any obstruction to the free admission of air to the chest, such as is associated with chronic bronchitis, enlarged tonsils, or adenoid growths of the pharynx, is likely to exaggerate any chest deformity. The lessened capacity of the thorax causes the liver and spleen to be much more prominent than their increase in bulk from hyperplasia would warrant. The abdomen is usually distended, the enlargement being chiefly due to the distention of the intestines with gas, aided by the weak condition of the muscles of the gut wall and of the abdomen.

In rachitic children the spinal column is much more flexible than normal, owing to the imperfect ossification of the vertebræ and the relaxation of the spinal ligaments. When such children assume an erect position a marked kyphosis can usually be noted, which disappears when the child assumes a recumbent posture. The curve of the rachitic kyphosis is rounded in form, and involves the bodies of a number of vertebræ, in contrast with the sharp projection of the kyphotic curve in spinal tuberculosis. There is usually a compensatory lordosis in the lumbar region and rarely a left-sided scoliosis.

The clavicle and the scapula may be curved slightly. The pelvis is often the site of serious deformities. It is flattened laterally and the promontory approaches the arch of the pubis, which is also narrowed. The approximation of the promontory to the pubis is in part due to the rotation of the sacrum on a horizontal axis, in part to the inward displacement of the ischia. These pelvic deformities are often permanent, and render the bearing of children difficult or impossible. The extremities very early show the characteristic enlargement of the epiphyses, especially of the lower end of the radius, ulna, and tibia. Such epiphyseal swellings may also appear at the upper and lower ends of the humerus and femur, but are much less marked.

If the disease is of a severe type the diaphyses of the bones may become curved. The convexity of the femur is forward and outward; that of the tibia and fibula is often lateral, but may also be forward; that of the radius and ulna is toward the extensor surface, while the humerus is bent forward. The irregular growth of the epiphyseal ends of the bones, combined with the curvature, gives rise to deformities which are especially serious in the lower extremities. The axis of rotation of the knee-joint may remain horizontal, or, as is seen in advanced cases, the axis may be rotated either inward or outward, so that a simple osteotomy of one bone will not suffice to correct the deformity, but both the femur and the tibia will have to be severed and the axis of the joint restored to its normal rotation plane.

The cause of these deformities is not, as is usually assumed, the result of allowing the child to walk before the bones are sufficiently hard, but is due to the rachitic curvature of the shafts of the bones and to the uneven enlargement of the condyles of the femur. A moderate amount of deformity may be increased, however, by allowing the child to walk while the rachitic bone is still

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soft. The other symptoms of the disease not connected with the skeleton are chiefly those relating to the digestive, respiratory, and nervous systems. The frequency of respiration of rachitic children is increased in those cases in which there exists a considerable diminution of the respiratory capacity, owing to the deformity of the chest wall and the pressure of the gas-distended intestines against the diaphragm. Bronchitis and atelectasis very frequently complicate the respiratory and circulatory changes produced by the narrowing of the thorax.

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Laryngismus stridulus is a not uncommon complication of rickets, and is responsible for a considerable proportion of the fatal terminations of the affection. General convulsions are a frequent complication of the disease, and tetany is also occasionally seen.

A chronic gastro-intestinal catarrh is usually present in rachitic children, and is easily increased in severity by slight indiscretions in diet. The stools are either constipated or thin and fluid. They are as a rule paler than normal and may be very foul-smelling. They contain an excess of calcium salts derived in part from the food and partly from the softening bone. The blood shows an anæmia of the chlorotic type with a moderate reduction of the red cells and a considerably lessened hæmoglobin content. A moderate leucocytosis may also exist, which is in all probability not characteristic of the disease, but is dependent upon the respiratory and intestinal complications. The urine shows no striking alterations. Occasionally there may be a trace of albumin present and a diminution in the excretion of the phosphates and the chlorides. There is no alteration in the amount of lime salts excreted in the urine.

Fever is not a regular accompaniment of the disease. When present it is due to one of the complications. The skin of the rachitic child is pale. Eczema is not infrequent, and occasionally multiple skin abscesses are seen. Severe sweating is the rule in all cases of rickets. The subcutaneous fat is well preserved, though the patients are soft and flabby.

Course and Prognosis.—Cases considered to be congenital rickets have been described by competent observers, but as a rule the symptoms of the disease begin in the latter half of the first year of life; and in a majority of the cases the disease runs its course inside of eighteen months or two years. Very chronic cases, lasting for years, are exceedingly infrequent. The condition which has been classed by some clinicians as acute rickets is probably a form of scurvy. The prognosis of an uncomplicated case of rickets is good so far as life is concerned. The disease is self-limited and often disappears without treatment when the child is old enough to begin a mixed diet. The prognosis of the bone deformities is not so good, and many of the severe cases are permanently deformed, though surgical interference will often allow the complete correction of the deformities of the lower limbs. Death results in all cases from some intercurrent disease and not from the bone lesions alone. Marasmus and laryngismus stridulus are responsible for a considerable proportion of the fatal cases, while the others are carried off either by bronchopneumonia, or by tuberculosis, or by some intestinal condition. Whooping-cough is an especially dangerous complication in rachitic children with marked deformity of the chest.

Diagnosis.—A well-developed case of rickets is easy of recognition, especially at a time when the bone lesions are most prominent; but in children in the early stages of the disease the diagnosis is more difficult, and must be made from the general symptoms. The most important of these are the restlessness at night, the sweating of the head, the general tenderness of the body, and the malnutrition. The craniotabes and the persistent and wide-open fontanel are valuable symptoms, as is also the late eruption of the teeth. The bone lesions of syphilis are in the nature of thickenings under the periosteum rather than of an increase in the size of the bone, and the necroses seen in syphilis are not present in rickets. The other evidences of congenital lues will aid in the differential diagnosis. Confusion between the kyphosis due to tuberculous spondylitis and that due to rachitic softening of the vertebræ and intervertebral cartilages will be avoided if it be remembered that the curve in tuberculous disease is sharp and affects the bodies of only one or two bones, while that due to rachitic disease is more gradual and less limited. The rachitic bones are not very tender to pressure, and the kyphosis can be overcome by placing the patient on a flat mattress. Pott's disease is rarely seen in children under two years of age, a time when rickets is most likely to be well developed.

Rickets is differentiated from scurvy by the absence of the ecchymoses and the changes in the gums.

Prophylaxis.—The prevention of the disease depends naturally upon the avoidance of the conditions determined as the immediate factors in the causation of the malady. This is perfectly possible among people of good circumstances, but becomes a matter of great difficulty when we must cope with the conditions of tenement life among the very poor.

Every care must be taken with the children of parents who have previously borne rachitic children, as the predisposition increases with each child. The mother should be allowed to nurse the child if it is possible for her to avoid hard, manual labor during the course of lactation. But if she is not able to do this, the better plan will be to feed the child on Pasteurized cow's milk. A convenient form of apparatus for this purpose, and one requiring a minimum of intelligence on the part of the user, is that devised by Dr. R. G. Freeman. During the hot season of the year the child should be sent to one of the seaside hospitals or to the country for a time; or if this is impossible, it should be given every opportunity to obtain fresh air that is possible.

Treatment.—The care of rachitic children should be begun as early as the diagnosis can be made, in order to prevent severe bone lesions and also to obtain the maximum result from the treatment, as the best results are secured in cases in which the disease has been recognized in the first stages. The diet should be altered from that under which the child has developed the disease to one which is more nearly normal. If the child is breast-fed the quality of the mother's milk should be determined, and if necessary it may be supplemented by cow's milk in the proper modification. If the mother cannot nurse the child, it must be fed upon properly prepared cow's milk. The diet should be rich in fats and proteids, and contain but a small amount of carbohydrates. This will eliminate all of the proprietary infant foods. Cod-liver oil should be administered in small doses as soon as the stomach will tolerate it. Arsenic and iron are useful to combat the anæmia. The excessive sweating may be relieved by cool sponging, and by atropine in doses of about gr. $\frac{1}{200}$ per day. Opinions vary as to the value of the phosphorus treatment of rickets. Originally recommended by Trousseau, it has been rendered popular through the efforts of Kassowitz, who regards it as a specific. It may be administered in the form of a solution in oil, made by diluting the official oil of phosphorus with olive oil, in doses of gr. $\frac{1}{200}$ three times a day after meals. The use of extracts of the thyroid, thymus, and adrenal glands has not given satisfactory results.

The hygienic treatment of the child is nearly as important as the correction of the food. The child should spend a large portion of the day in the open air and in the sun if possible. Such open-air treatment is best carried out in the country; but if this is impossible, the child should be taken on excursions on the water or to the country, and during the rest of the time be kept in the parks and open squares of the city. The roof of one of the tenement houses is better than the street for such a child, and if the weather is not too hot such a place is often the best possible. The child will be strengthened, and is much less likely to catch cold, if it is sponged off with cold water every day. The addition of some sea salt to the bath is of use if the child is strong enough to stand the stimulus, while massage or even gentle rubbing of the body and limbs before or after the bath is of the greatest value in keeping up the general nutrition.

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The correction of the deformities of the extremities is a matter of surgical interference; but much can be done to prevent the curvature from becoming severe by not allowing the child to assume a posture which will increase the deformity, and also by keeping up the muscular tone. The kyphosis may be relieved by allowing the child to sleep on a flat, hard mattress without a pillow. If the deformity of the occiput is marked, the pressure may be prevented by the use of a firm horse-hair pillow with a concavity to receive the flattened portion. If the kyphosis is extreme in a child which is old enough to be about, and in which the bones of the legs are firm enough to permit walking, it may be advisable to fit the thorax with a jacket or a steel brace, which should be worn only when the child is in an erect posture. The use of braces in order to prevent or to cure deformities of the lower extremities is of but very slight benefit. It is better to wait in these cases until firm ossification of the bones has taken place and then to correct the deformity by a proper osteotomy. *Francis Carter Wood.*

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RIGOR MORTIS. See *Cadaver, Legal Status of.*

RIO DE JANEIRO, BRAZIL.—Rio de Janeiro, the largest city in South America, with a population of about 779,000, is situated upon the western side of one of the most magnificent harbors in the world. It is in no sense a health resort,—indeed, quite the contrary,—but it is mentioned as an illustration of a tropical or equatorial climate, and also to convey some knowledge of its climate to those who for any reason, either temporarily or permanently, are obliged to reside there.

The city itself occupies flat land with hills in the outskirts, and beyond rise precipitously mountains of from fifteen hundred to three thousand feet high. Foreigners are advised to make some of the high-lying suburbs or towns in the vicinity their place of residence, at least during the warmer months, in order to escape the continuous heat and great atmospheric humidity which combine to make the climate of the city itself so debilitating.

The population of the city is a heterogeneous one, composed of Portuguese, Italians, Germans, French, English, and negroes. There are parks, a national library, museum, colleges, various schools, hospitals, and an observatory. An immense amount of coffee—said to be more than one-half of the world's product—is exported from here.

The water supply is good but somewhat inadequate, and the drainage is said to be satisfactory. Modern sanitary conditions exist. In the outskirts, among the hills and mountains, the scenery is most beautiful and the vegetation luxuriant.

The climate can be summarized as a moist, warm, tropical one; warmest in what is our winter and spring, and coldest in our summer and autumn, but at all times warm or hot. The rainfall is high, the largest amount occurring in our autumn and winter. The air is often sultry and very debilitating. There is generally a daily sea breeze from the south and southeast—part of the trade winds come from the southeast;—it begins about 1 P.M. and lasts until about four or five o'clock. The nights are usually calm. The climatic chart has been arranged from the very elaborate series of observations published by L. Cruls, director of the Observatory at Rio de Janeiro, and the reader who desires to make a more exhaustive study of this climate is referred to this work.

The temperature arrives at its maximum at the beginning of February, and at its minimum the beginning of July. The mean annual variation does not exceed 10.8° F., and the mean diurnal variation does not reach 5.4° F.

The humidity is really greater than would appear from the average relative humidity as shown in the table, on account of the high temperature, for a humidity of over seventy per cent. at a temperature of over 70° F. is very moist. The excessive moisture is one of the striking characteristics of this climate, and renders the heat so unbearable. The daily occurrence of the sea breeze, however, mitigates this condition. There is a large amount of cloudiness and there are but few clear days. The average yearly rainfall is 42.5 inches, and there are one hundred and twenty-seven days of rain. March and December are the rainiest months and July is the driest month. The most prevalent wind is from the south and southeast—the sea breeze,—and next in frequency is that from the northwest—the land breeze.

Yellow fever is generally prevalent during the warm months, and there are severe epidemics at intervals. In the lowlands intermittent fever prevails. The negro population suffers from smallpox. There is, at St. Sebastian, a large hospital which was founded in 1888, and which is devoted to the treatment of epidemic diseases. One would naturally infer that the mortality in such a climate and with so many epidemic diseases would be high, but from the official statistics the average mortality from 1897 to 1901 is found to be 19.4 per 1,000. Tuberculosis causes much the largest number of deaths of any one disease, and bronchitis and bronchopneumonia come next in frequency, while infantile diseases rank third. It would appear, then, that any one individual resident of Rio de Janeiro had many more chances of dying of tuberculosis than from yellow fever, and that this dread disease (tuberculosis) may be quite as prevalent in warm countries as in cold. *Edward O. Otis.*

RITTER'S DISEASE. See *Dermatitis Exfoliativa Neonatorum*, and *Pemphigus.*

RIVIERA, THE.—As the various especial resorts upon this coast have been, and will be, quite thoroughly discussed, only a very brief and general reference will be

CLIMATE OF RIO DE JANEIRO. LATITUDE, 22° 54′ 23″ S.; LONGITUDE, 43° 8′ 34″ W. FROM OBSERVATIONS MADE AT THE OBSERVATORY OF RIO DE JANEIRO, PERIOD OF OBSERVATION, NINE TO FORTY YEARS.*

	Jan.	Feb.	March.	May.	July.	August.	Sept.	Nov.	Year.
Temperature (degrees Fahrenheit)—									
Average or normal	79.45°	79.6°	78.6°	72.4°	69.1°	70.1°	70.8	74.4°	74.2°
Mean maximum	94.4	94.7	91.6	84.6	78.2	83.9	86.1	93.3	88.7
Mean minimum	66.7	68	66.3	59.7	57.4	57.8	58.1	61.3	55.8
Highest or maximum, 102° Dec. 8th, 1889.									
Lowest or minimum, 50.3° Sept. 1st, 1882.									
Humidity—									
Average relative	78%	80%	79%	79%	78%	77%	80%	77%	78%
Precipitation—									
Average in inches	4.6	4.3	5.3	3.5	1.4	1.7	2.2	4.2	42.5
Wind—									
Prevailing direction	S. S. E.	S. S. E.	S. S. E.	N. W.	N. W.	N. W.	S. S. E.	S. S. E.	S. S. E.
Weather—									
Average number clear days	11.2	9	12.8	10.9	16.8	12.5	5.7	9.1	131
Cloudiness†	61	62	59	60	50	77	71	64	64
Average number days of rain	12.6	12	11.5	10.6	5.9	6.5	11.1	11.8	127
Average number days of storm	6.3	5.3	3.8	9.6	.4	.6	1.4	2.7	30

* "Le Climat de Rio de Janeiro," par L. Cruls, Director of the Observatory of Rio de Janeiro, from observations taken during the period of 1851 to 1890, Rio de Janeiro, 1892.

† 100 is taken to represent a completely covered sky, and 0 a completely clear sky.

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made here to this region as a whole, and the reader is referred for more detail to the articles upon *Alassio, Bordighera, Cannes, Hyères, Nervi, Nice, Mentone, Monte Carlo*, and *San Remo*.

The Riviera is a strip of coast extending 323 miles along the shore of the Mediterranean, at the foot of the maritime Alps and their offshoots. The portion from Hyères to Genoa, 203 miles, is called the Western Riviera; and that extending from Genoa to Leghorn, 112 miles, the Eastern Riviera. It is the former portion that is the more frequented, and is what is generally meant when one speaks of the Riviera. The topography of this region is that of "a long shelf, or rather a series of shelves, on the south side of a very high mountain wall, which wall, up to the level of these shelves, is submerged in the waters of the sea" (Richards).

The general climatic features of all this region are the same, varying at one resort or another in certain minor aspects according to the local peculiarities of situation, principally with regard to shelter from the winds. These climatic features—and here the colder months of the year are only considered—are comparative warmth, moderate dryness, a large amount of sunshine, and great heat of the sun's rays; the small number of rainy days, and relative immunity from cold winds. No station is entirely exempt from these cold winds, but some are more exposed than others, as has been shown in treating of the various resorts. Moreover, the seasons differ from one year to another. The latitude of the Riviera has not so much to do in the production of its mild winter climate, but this is rather due to the protection afforded by the maritime Alps from the cold northerly winds, and also partly to the southern exposure and partly to the warm water of the Mediterranean Sea.

The mean temperature for the three cold months (December to February) according to Weber ("A System of Physiological Therapeutics," vol. iii., Book I., "Health Resorts," F. Parkes Weber, 1901), is from 47° F. to 49.8° F.; for the six cold months (November to April), about 51° F.

According to the same authority the mean relative humidity is from sixty-five to seventy per cent., and the annual rainfall from twenty-eight to thirty-one inches, the greater part falling during October and November.

The principal winds are the northwest—the "mistral," a cold dry wind prevailing in March; the northeast, or "bise," a cold wind; and the southeast, or "sirocco" a "warm, wet, enervating wind."

Quoting Weber again, "during the six winter months one hundred days or more may be expected to be fine enough for most invalids to be in the open air for several hours."

Besides the danger from the high winds, especially the dreaded "mistral," there is also to be mentioned the great difference between the sun and the shade temperatures, and the rapid fall of the temperature after sunset, with the increased humidity at that time. The dust is also an objectionable feature of this region. The Riviera season extends from about the end of October to the end of April. Abundant and good accommodations, all more or less expensive, are to be found in all the Riviera resorts.

As to the natural attractions of the Riviera, they are too well known to require any extended description. "Nothing," says Lindsay, "can exceed the loveliness of this strip of flowery coast land, with its jutting crags and circling bays, bounded on one side by spurs of the Alps, and on the other by the Mediterranean, now glittering in brilliant azure, again rippled into sapphire by the breeze." In comparing this region with the littoral of Southern California, the latter is undoubtedly superior in climate, but in beauty of scenery supplemented by art, the former is by far the more attractive.

The Riviera is visited in the winter by great numbers from Northern Europe, who desire to escape the cold and more or less cheerless winters of their own region. This climate affords a blessed relief for those who desire to spend the winter in a warm, sunny climate amidst most attractive surroundings. The aged, the feeble, the convalescents; those with diminished powers of resistance, and those suffering from various chronic affections with deficient powers of reaction, all find more or less comfort, relief, and healing here. The diseased conditions for which this climate is recommended are chronic bronchitis and emphysema, bronchial asthma, certain varieties of pulmonary tuberculosis, scrofula, chronic pneumonia, and anæmia.*

The Riviera is now easily and comfortably reached by steamers sailing from New York or Boston direct to Genoa, and from Genoa the railroad runs along the shore of the Mediterranean parallel with the celebrated Corniche road for a good part of the way. Express trains also run from Paris direct to the Riviera. *Edward O. Otis.*

ROANOKE RED SULPHUR SPRINGS.—Roanoke County, Virginia.

Post-Office.—Roanoke Red Sulphur Springs. Hotel and cottages.

Access.—Viâ Norfolk and Western Railroad to Salem, thence nine miles north to springs.

This resort is located under the shadow of the outlying ranges of the Alleghanies, twelve miles from Roanoke City. The manifold attractions of the Virginia mountain region find here a faithful exemplification. The high and dry location, the pure, fresh air, and the unsurpassable mountain scenery unite to form a most delightful summer health resort. In the hotel will be found all the comforts and attractions which go to render a stay at a watering place enjoyable. The Roanoke Red Sulphur waters have been examined by Prof. M. B. Hardin with results as follows: One United States gallon contains (solids): Calcium carbonate, gr. 6.54; magnesium carbonate, gr. 5.83; lithium carbonate, gr. 0.02; manganese carbonate, gr. 0.02; iron carbonate, gr. 0.06; sodium chloride, gr. 0.24; ammonium chloride, gr. 0.02; calcium chloride, gr. 0.03; strontium sulphate, gr. 1.71; calcium sulphate, gr. 2.19; sodium sulphate, gr. 3.04; potassium sulphate, gr. 0.33; sodium hyposulphite, gr. 0.03; ammonium nitrate, gr. 0.05; silica, gr. 0.83; organic matter, gr. 0.76; bicarbonates, gr. 5.96; and traces of copper carbonate, lead sulphite, barium sulphate, alumina, and arsenic. Total, 27.66 grains. The gases present in one gallon of the water are: Carbonic acid, 12.4 cubic inches; sulphuretted hydrogen, 2.44 cubic inches.

These waters are useful in those classes of cases which require a fairly concentrated sulphur water. They possess alterative, diuretic, and tonic properties. It will be observed that they contain an unusually large proportion of strontium, an element whose therapeutic properties are not as yet fully understood.

The following analysis of the chalybeate spring at this resort was made by Dr. H. Froehling: One United States gallon contains (solids): Calcium carbonate, gr. 0.45; magnesium carbonate, gr. 0.95; iron carbonate, gr. 2.09; manganese carbonate, gr. 0.09; sodium carbonate, gr. 0.44; bicarbonates, gr. 2; and very small quantities of sodium chloride, potassium sulphate, sodium sulphate, aluminum sulphate, aluminum phosphate, silica, ammonium carbonate, and organic matter. Total, 7.20 grains. Free carbonic-acid gas, 12.30 cubic inches. This water is very useful in anæmia and debilitated states of the system. The Roanoke Sulphur Springs are much resorted to in the treatment of chronic bronchial, pulmonary, and throat affections. The waters of the spring, combined with the wholesome atmospheric conditions of the neighborhood, are believed to be almost a specific for hay fever. *James K. Crook.*

ROCHESTER, NEW YORK.—Rochester, N. Y., a city of 162,608 inhabitants, is situated on both sides of the Genesee River, seven miles from Lake Ontario. It lies in the so-called "Lake Region" of the United States, which region has the climatic peculiarity of great winter cloudiness in comparison with that of the Oregon winter, and

* Vide: "A Joint Inquiry as to what kind of Patients should be Sent to the French Riviera," by Stanley M. Rendall, M.D., of Mentone, and Thomas Linn, M.D., of Nice.—The Climatologist, November 15th, 1891.

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of the St. Lawrence Valley district. As will be seen by the climatic chart, the number of clear and fair days are least in winter, and the relative humidity is highest. The rainfall is least in autumn.

"During the six months, April to September inclusive, the relative humidity of the atmosphere is markedly lower at Rochester than at New York, and the cloudiness is nearly the same at the two places; during the midsummer months it is actually less at the former than at the latter. Thus, during the winter season, Rochester is decidedly damper and more cloudy than New York; during the summer season, and especially the midsummer season, New York is markedly damper and a trifle more cloudy than Rochester" (Richards, previous edition of the Handbook).

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Climate of Rochester, N. Y. Latitude, 43° 8′; Longitude, 77° 42′. Period of Observation, Thirteen Years.

	January.	February.	March.	May.	July.	August.	November.	Year.
Temperature (degrees Fahr.)—								
Average or normal	24.4°	25.1°	30.1°	56.8°	70.9°	69.4°	36.2°	46.8°
Average daily range	11.0	15.6	14.5	18.8	17.9	18.0	13.5	
Mean of warmest	30.9	34.1	39.5	65.7	80.0	78.6	45.0	
Mean of coldest	16.9	18.5	24.9	46.9	62.1	60.6	31.5	
Highest or maximum	69.0	63.0	69.0	90.0	96.0	96.0	71.0	
Lowest or minimum	−12.0	−12.0	7.0	23.0	48.0	47.0	1.0	
Humidity—								
Average relative	80.1%	76.9%	75.7%	62.3%	66.7%	67.3%	75.5%	71.4%
Precipitation—								
Average in inches	3.31	2.68	3.41	3.31	3.52	3.05	2.91	36.78
Wind—								
Prevailing direction	W.	W.	W.	W.	W.	S. W.	W.	W.
Average velocity in miles	11.1	11.3	11.6	9.6	7.5	6.9	10.3	9 6
Weather—								
Average number of clear days	1.5	3.3	3.9	9.2	9.2	10.4	2.9	71.5
Average number of fair days	8.2	10.8	11.0	12.5	14.7	13.7	9.3	133.3
Average number of clear and fair days	9.7	14.1	14.0	21.7	23.9	24.1	12.2	204.8

It will further be noted from the chart that the temperature range is great, a characteristic of the climate in the temperate zone; and that the prevailing wind the year through is from the west or southwest. If this chart is compared with that of Portland, Me., given in the present volume, it will be seen that there is a close resemblance in many of the data. The temperatures are very nearly the same. At Rochester the average mean annual temperature is 46.8°, and at Portland, 46.5°; for the winter, in the former place, the average is 25.7°, and in the latter, 25.6° F.; and so of the other seasons. The rainfall for the year in Portland is 39.04 inches, and in Rochester, 36.78 inches. The average relative humidity is 71.4 per cent. at Rochester, and 69.7 per cent. at Portland. We notice, however, that there is more wind at Rochester, and the direction is more constant. When we come to the number of clear and fair days, there is a decided difference. While the number of clear days at Rochester is only 71.5 per annum, it is 107.7 at Portland; and the number of clear and fair days at the latter place exceeds by forty-seven the number at Rochester. More sun and less wind, then, are to the advantage of Portland.

Where an outdoor life under clear skies and in sunshine is desirable for a patient, it is evident that he must seek some other locality than that of this "Lake Region" as represented by Rochester.

Forty-four miles south of Rochester is situated the Jackson Sanatorium, for the treatment of certain chronic cases, such as neurasthenia, etc. It is said to be well equipped with apparatus for the various forms of treatment by hydrotherapy, electricity, etc.

Edward O. Otis.

ROCKBRIDGE ALUM SPRINGS.—Rockbridge County, Virginia.

Post-Office.—Rockbridge Alum Springs. Hotel and cottages.

Access.—Viâ Chesapeake and Ohio Railroad to Goshen, thence by stage to springs.

These springs are located in a glen-like nook formed by the spurs of the North and Mill Mountains, and they break forth from a mass of slate rock at the base of the ridge. This slate contains large quantities of alumina and the salts of iron, and the springs are formed by the percolation of water through this mass. Four different reservoirs, numbered respectively No. 1, No. 2, No. 3, and No. 4, have been formed. The immediate surroundings of this resort are very attractive. The hotel and cottages afford comfortable accommodations. The numerous springs here vary somewhat in their analyses, the proportion of alum ranging from 6.88 gm. per gallon in Spring No. 6, to 81.05 gm. in Spring No. 7. Different chemists have also arrived at different results in analyses of the same spring. The following analysis, by Prof. M. B. Hardin, of Spring No. 2, is fairly representative of the group:

One United States gallon contains: Sodium sulphate, gr. 0.03; calcium sulphate, gr. 3.23; lithium sulphate, gr. 0.02; magnesium sulphate, gr. 5.61; potassium sulphate, gr. 0.41; aluminum sulphate, gr. 42.61; manganesium sulphate, gr. 0.09; iron persulphate, gr. 1.95; nickel sulphate, gr. 0.14; calcium phosphate, gr. 0.17; sodium chloride, gr. 0.11; silica, gr. 3.70; sulphuric acid, gr. 3.83; and traces of cobalt sulphate, zinc sulphate, lead sulphate, ammonium nitrate, calcium fluoride, antimony, copper, arsenic, and organic matter. Total, 62.35 grains. The following gases were also found in one United States gallon: Oxygen, 1.49 cub. in.; nitrogen, 3.98 cub. in.; and carbonic acid, 10.89 cub. in. These have long been regarded as among the best alum waters known. They are clear and odorless, but possess a strongly astringent and styptic taste. Their temperature ranges from 50° to 56° F. They are of undoubted efficacy in cases requiring an astringent chalybeate. They have proved valuable in atonic and catarrhal states of the different mucous membranes—for example, in chronic diarrhœa, in leucorrhœa, in pharyngitis, in rhinitis, etc. They are very useful locally in scrofulous ulcers and in other slow-healing similar conditions. The waters sometimes prove purgative in large doses and are always diuretic in doses of one-quarter to one-half of a small tumblerful taken six, eight, ten, or twelve times a day. The effects of the water often last far beyond the period during which they are taken.

James K. Crook.

ROCK CASTLE SPRINGS.—Pulaski County, Kentucky.

Post-Office.—Rock Castle. Springs Hotel.

These springs are located in the Rock Castle River, and are accessible by the Louisville and Nashville and Queen and Crescent Railroad lines. There is daily connection by stage with morning and afternoon trains at London. The situation is one of great natural charm

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and beauty, being in the heart of the Cumberland Mountains, at an elevation of over two thousand feet above the sea-level, and surrounded by a vast natural park of pine trees. The pure air and equable temperature, as well as the isolation from the thoroughfares of travel, combine to render the location one of exceptional freedom from the ills of hot weather. A comfortable hotel, with ample arrangements for the comfort of guests, is at hand. The surrounding forests, hills, and fields offer many attractions for the botanist, the naturalist, and the sportsman. The following analysis was made by Dr. Robert Peter: One United States gallon contains: Iron carbonate, gr. 0.84; calcium carbonate, gr. 2.58; magnesium carbonate, gr. 0.86; calcium sulphate, gr. 0.17; magnesium sulphate, gr. 0.12; sodium sulphate, gr. 3.09; sodium chloride, gr. 0.15; silica, gr. 0.74. Total, 8.55 grains. A considerable quantity of free carbonic acid gas is also present.

The waters of the springs have been in use since 1843. They are said to possess excellent tonic and diuretic properties. It is also maintained that the location is very beneficial for cases of hay asthma, nasal catarrh, laryngitis, etc.

James K. Crook.

ROCK ENON SPRINGS.—Frederick County, Virginia.

POST-OFFICE.—Rock Enon Springs. Hotel.

ACCESS.—Viâ Valley Branch of the Baltimore and Ohio Railroad to Winchester, thence by coach over picturesque mountain road sixteen and one-half miles to springs. Time from Washington, six and one-half hours.

This resort is located in the great North Mountains. It is surrounded by the primeval forest, and nestles under the shadow of a majestic peak in a romantic gorge, through which flows Laurel Brook, a beautiful stream which is supplied by the mountain springs, and which winds about the hotel and its attractive lawn. The locality is free from swamp lands and malaria. The hotel has a location of twelve hundred feet above tide water. This is a model caravansary, and the visitor may feel assured that every device for his comfort, health, and amusement has been arranged for by the thoughtful proprietor. The scenery in the neighborhood is exceptionally fine. Close to the hotel are three mineral springs, which have been found to possess well-marked medicinal properties.

The *Chalybeate Spring* was analyzed by Professors Gale and New, of the Smithsonian Institute, Washington, who found it to contain, in one United States gallon, the following solid constituents: Sodium carbonate, gr. 1.21; calcium carbonate, gr. 5.13; calcium sulphate, gr. 3.56; magnesium sulphate, gr. 12.89; magnesium chloride, gr. 1.12; iron oxide, gr. 14.25; manganesium oxide, gr. 1.05; alumina, gr. 0.80; silica, gr. 0.42. Total, 40.43 grains.

The water resembles that of the Pyrmont Spring in Waldeck, Germany. It is a strong chalybeate, and possesses aperient and diuretic properties.

A qualitative analysis of the *Alkaline Spring* by Professor Lupton, late of the University of Virginia, showed the presence of potassium and magnesium carbonate, sodium chloride, calcium sulphate and carbonate, silica, and carbonic, sulphuric, and hydrochloric acids. The water is antacid, diuretic, and aperient, and is used in affections of the kidneys and urinary passages, in dyspepsia, in gout, and in catarrhal affections.

The *Old Capper Spring* once gave its name to the resort, and it is styled Capper's Springs in the older books. It has been in use for more than a century. The water is described as being efficacious in rheumatism and in diseases of the skin, and as a cure for certain of the intestinal worms.

White and blue sulphur springs of excellent quality are also found in the neighborhood. The following data show the mean temperature at Rock Enon for July and August during the past ten years: July, 7 A.M., 66° F.; 12 M., 77°; 3 P.M., 78°; 6 P.M., 75°; and 10 P.M., 66.25°. For August, at the same hours, the record was 64.5°, 74.5°, 76°, 73°, and 66° F.

James K. Crook.

RODENT ULCER. See *Carcinoma of the Skin.*

ROENTGEN RAYS, USE OF, IN MEDICINE AND SURGERY.—The discovery by Wilhelm Conrad Roentgen, in 1895, of the kind of radiant energy now known as the Roentgen or *x*-rays, was at once recognized as giving a most important addition to the armamentarium of the diagnostician in surgery. With improved apparatus and technique, and with more extended experience, the application of the Roentgen rays has gradually extended until their use is now universally regarded not only as indispensable in surgery, but as most valuable for diagnosis and therapy in many diseases not classed as surgical.

Nature and Action of the Roentgen Rays.—The Roentgen rays are produced by the passage of an electrical current of *small volume* and *high tension* through a specially constructed vacuum tube of high exhaustion. If an electrical current is passed through a glass tube from which the air has been but partly exhausted, an arc of light will be projected from the cathode (negative pole) to the anode (positive pole). If a similar tube of high exhaustion is used, no arc of light will form, but a peculiar fluorescence will appear at the anode. This fluorescence appears to emanate from any body exposed to the cathode of a vacuum tube. In the ordinary Roentgen-ray tube, the anode is a platinum plate placed in a line with the cathode, and the electrical energy passing from the cathode falls upon the anode, and from thence both fluorescent and Roentgen rays are projected. If the cathode is concave and directed toward the side of the tube, fluorescence will appear to emanate from the side of the tube at the point toward which the cathode is directed. Not only does the body fluoresce upon which the cathode rays are directed, but it will glow with heat if the electrical current is strong. In consequence, if the cathode rays are directed toward the side of the vacuum tube, the tube will become heated at the point of impingement, will soon soften and be destroyed by the giving way of the melted glass. For this reason the cathode rays are in practice directed toward a platinum plate which forms the anode, and which is set at an angle of about 45°, so that the Roentgen rays are directed from it outward at about a right angle to the long axis of the tube (Fig. 4114).

The visible fluorescence which appears in the tube must not be mistaken for the Roentgen rays.

The Roentgen rays are themselves *invisible*, and are appreciable to the senses only by their effect upon cer-

FIG. 4114.—Diagram of Roentgen-Ray Tube with Lines of Roentgen Radiation. The lines diverging from the anode show by their relative proximity to each other those parts of the hemisphere in front of the anode which are more or less acted on by the Roentgen rays.

tain substances. This effect is manifested in three ways: (*a*) by the fluorescence of certain chemical substances when the rays fall on them; (*b*) by the reduction, when exposed to the rays, of certain silver salts ordinarily used for photography; and (*c*) by changes produced in living tissues when the rays act upon them for a sufficient length of time.

The first of these effects, *i.e.*, the fluorescence of cer-

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tain chemical substances, is the means used for producing visual effects directly from the vacuum tube. When the Roentgen rays fall upon certain substances, notably calcium tungstate, the double cyanide of platinum and ba-

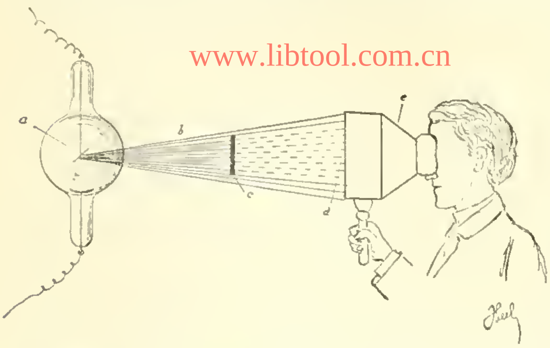

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FIG. 4115.—Diagram showing the Fluoroscopic Method of Obtaining Visual Images by Roentgen Radiation. *a*, Anode; *b*, Roentgen rays passing to light-excluding chamber with fluorescent screen *d*, on which appears the fluorescing image formed by rays passing by or through the object *c*.

rium, platinum and magnesium, platinum and potassium, zinc oxide, etc., these substances glow with visible fluorescent light, the fluorescence in a degree depending upon the number and strength of the impinging rays.

This property of producing visible fluorescence is utilized to give visual effects from the rays. A chemical substance which will fluoresce, usually the double cyanide of potassium and barium, is spread and fixed on some plane surface which is opaque to light. Upon excluding light and allowing the Roentgen rays to pass through the support and fall upon the coated surface, this is seen to glow to a degree depending upon the amount of radiant energy which falls upon it. The amount of energy affecting the fluorescent surface depends upon the energy given out by the tube, the distance of the tube from the plate (the effect varying inversely as the square of the distance), and the extent to which the passage of the Roentgen rays to the fluorescent surface is obstructed by objects placed between the sensitive surface and the tube (Fig. 4115).

The visible images produced by the Roentgen rays are in every sense shadow pictures. The objects outlined by the rays are not themselves seen, but only their shadows cast upon a fluorescent screen or impressed on a photographic plate. It is of the greatest importance in interpreting these shadow images to recognize the fact that they are shadows and not real images of the objects observed.

Roentgen rays are always projected in straight lines from the fluorescing anode, and unlike light rays they are incapable of refraction, dispersion, or regular reflection. Consequently the shadow images formed are similar to shadow images made by ordinary light when projected from a point, and therefore depend for shape and size not only upon the shape and size of the object projecting the shadow, but upon the position in which the object is placed, its relative distance from the source of the rays, and the plane upon which the shadow is cast. These facts are of the utmost importance in judging the radiographic image, and a competent observer in reaching a conclusion always considers all these factors and their relation to each other. Correct estimation of the relative value of these factors is of especial importance in ascertaining the size and position of foreign bodies lodged in the tissues, and is to be particularly considered in medico-legal cases where deformity may be inferred from malposition of tube or plate, or from erroneous reading of the shadow picture.

In addition to their non-deviation from the direct lines in which they are projected, Roentgen rays differ from light in that they are capable of passing through or penetrating all substances. This transparency (to use the term) to Roentgen radiation is not, however, the same with all substances, but appears to be in large measure in inverse ratio to the density of the substances. The property of obstructing the passage of the rays differs markedly with different tissues, both normal and abnormal, of the human body; and as the rays which pass through the least resistant tissues are thus able to exert their greatest effect upon the fluorescent screen or photographic plate, the shadow image gives the outlines of certain tissues, and by difference in density it may furnish evidence of normal and abnormal conditions. Thus, for instance, not only are the outlines of a long bone clearly marked out by the rays, but the medullary cavity is shown as well; and, while in radiographs of the normal lung the denser bronchi only are shown, in pulmonary tuberculosis the tuberculous thickenings from their greater resistance to the rays appear as clearly defined shadows.

As to the real nature of the Roentgen rays many hypotheses have been advanced, some physicists holding that they are longitudinal vibrations of the luminiferous ether, others that they are minute particles of matter driven out from the cathode, and others that they differ from ordinary light rays only in the number of vibrations. While consideration of these hypotheses is of interest to the physicist, to the physician and surgeon the practical facts are: (*a*) that *Roentgen radiation is a form of energy projected in straight lines from its source*; (*b*) *that the ease of its passage through the human body depends upon the structure and density of the tissues*; (*c*) *that it is capable of producing molecular and chemical changes in certain substances used for making its action visible, such as the fluorescent screen and photographic plate*; *and* (*d*) *that it can produce tissue changes by affecting the metabolic action of living cells.*

Practically, the selection of apparatus which will best produce these visual, chemical, and physiological effects is a matter of much importance, and as there are many variations in type of apparatus for producing Roentgen radiation, a careful study of the apparatus and the principles upon which they are constructed is necessary before they can be properly understood and judicious selection made.

ROENTGEN-RAY APPARATUS.—There are two types of apparatus commonly employed for producing the electrical current of small volume and high tension necessary to excite the vacuum tube to Roentgen radiation—the static machine and the induction coil.

The Static Machine.—The static machine is the only apparatus in which an electrical current of required strength and tension is directly produced. In this apparatus the electrical current is produced by the machine and carried direct to the tube, the electrical energy given out being derived from the mechanical energy used in driving the machine. Two forms of static machine are most used—the Wimshurst and the Holtz. Of these the Holtz form is most used in America, while the Wimshurst is almost exclusively used in England. The use of static machines for Roentgen-ray work is much more common in the United States than in any other country. In this country much attention has been paid to this form of apparatus, and a type of apparatus considerably modified from the original Holtz has been developed, which is, with certain limitations, quite satisfactory. The machines now most used (Fig. 4116) have from eight to sixteen circular glass plates mounted on an axle. These plates rotate in one direction, and between them are fixed inductor plates of glass.

The special *advantages* of the static machine are that it is easy to operate, that with ordinary care it is not liable to get out of order, and that it is capable of producing a steady and fairly powerful output, which is not injurious to vacuum tubes. For good work it is necessary to have a static machine of large size, twelve to sixteen plates, thirty-two inches in diameter, or even larger, and it should be driven not by hand but by power, a one-half horse-power motor with speed regulation being required to give good results. The *disadvantages* of the machine

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are that it occupies much space, that it is liable (unless carefully managed) to fail in damp weather, and that as powerful effects cannot be obtained with it as with the larger coil apparatus. Under proper management a

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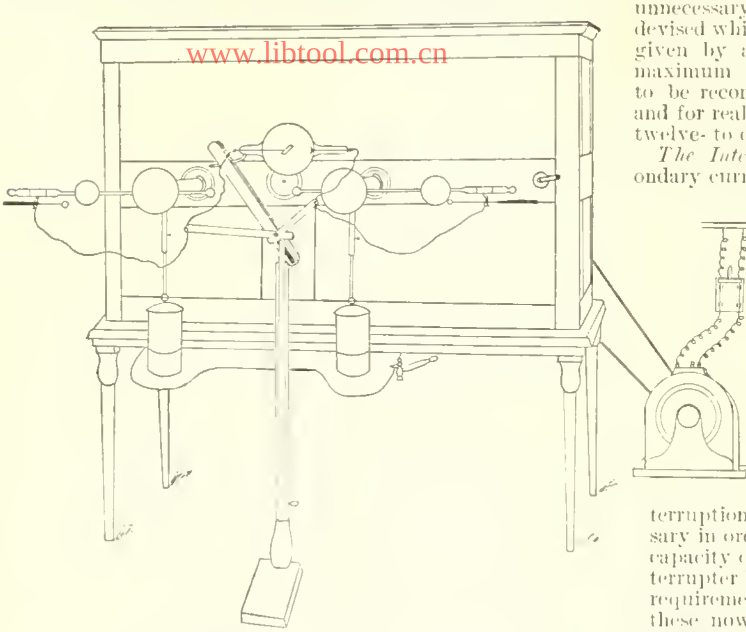

FIG. 4116.—Static Machine Arranged for *x*-Ray Work.

large static machine will do satisfactory fluoroscopic and photographic work, but where therapeutic work has to be done the majority of operators consider a coil apparatus indispensable. With a static machine great care must be taken to keep its interior free from moisture; a tight case and the occasional use of calcium chloride for drying being necessary. In operating it, steady and sufficiently rapid revolution of the plates and careful attention to the use of the "spark gaps" and Leyden jars is indispensable to success. The static machine is to be particularly recommended where commercial electrical currents for running a coil cannot be had, as under these conditions a large static machine run by a water, steam, or gasoline engine will give much better satisfaction than a coil apparatus energized by a primary battery.

Coil Apparatus.—The principal parts of a coil apparatus are the induction (Ruhmkorff) coil, the interrupter, the vacuum tube, and a suitable electrical source. In the coil apparatus, the secondary current of small volume and high tension necessary to excite the vacuum tube is obtained by induction from a primary current of large volume and relatively low tension. The primary current is obtained from primary batteries, storage batteries, or dynamos—when from the latter, the dynamo current for electric lighting is usually employed—and is carried to the coil by insulated wires. In the coil (Fig. 4117) the primary current traverses that part of the coil which is called the primary and, being interrupted with high frequency by the interruptor, by induction produces a current of high potential in the secondary part of the coil, from which it is carried by insulated wires to the vacuum tube.

The Induction Coil.—Induction coils are made of various sizes and are wound to correspond to the primary current by which they are supplied, whether from battery or from dynamo. They should be used only with the current for which they are designed. Their size is given in inches, this indicating the length of spark they give when supplied with a proper current. The longer the spark length, the greater the care which must be employed in manufacturing the coil (to prevent its being destroyed by the powerful currents which are necessary to energize it) and the more the resulting work which the coil is capable of doing. For practical Roentgen-ray work, coils exceeding eighteen inches in spark length are unnecessary, as the vacuum tube has not yet been devised which can dispose of all the electrical energy given by an eighteen-inch coil when giving its maximum output. Coils below six inches are not to be recommended except for very light work, and for really satisfactory work coils giving a large twelve- to eighteen-inch spark are to be preferred.

The Interrupter.—To produce the required secondary current it is necessary more or less rapidly to interrupt or break the primary current. The interrupter is a most important part of the coil apparatus. The essentials of a good interrupter are suddenness of break, good contact at the make, and adjustment for regulating the frequency of the interruptions. The greater the abruptness with which the current is cut and the more instantaneous and perfect the contact when the current is made, the greater will be the effect on the secondary coil; also adjustment for regulating the frequency of the interruptions and the length of the make is necessary in order to adjust the induced current to the capacity of the tube in use. Many forms of interrupter have been devised in order to meet these requirements. There are three main types of these now used—the vibrating spring type, the mercury type, and the electrolytic type. Of these different types the vibrating spring interrupter (Neff's hammer) is the original and simplest form (Fig. 4117).

An upright spring, carrying a heavy piece of iron at its upper end, is fixed on the baseboard so that the iron head is opposite one end of the core of the coil. On the face of the hammer furthest from the core is fixed a piece of platinum, and opposite this is another piece of platinum fixed in the end of a screw held in a brass pillar. The electrical current is carried from one pole of the battery through the coils of the primary to the vibrating hammer, thence, when the platinum points are in contact, to the screw and from it to other pole of the battery. The current magnetizes the soft-iron core, which attracts and pulls the hammer toward it and away from the

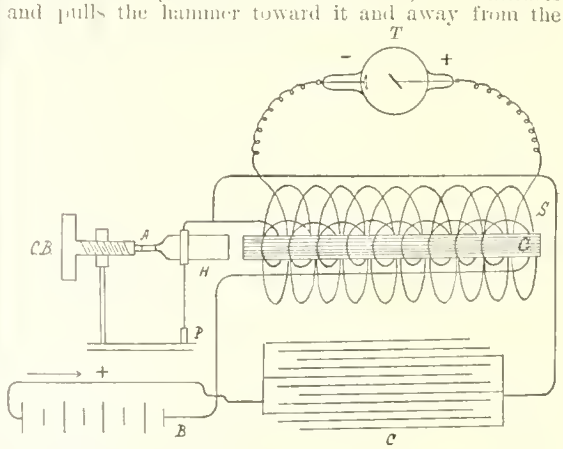

FIG. 4117. Diagram of Induction-Coil Apparatus with Vibrating Hammer Interrupter. *A*, Contact; *B*, battery; *S*, secondary; *C*, soft-iron core; *H*, hammer; *c*, condenser; *T*, tube.

screw. This breaks the current, the core is demagnetized, and the spring carries the hammer back against the screw, which again completes the circuit, and the process is repeated. By adjusting the screw and the

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tension of the spring, the rate of the vibrations and the relative length of break and contact can be regulated to a certain degree to correspond with the tube used.

The advantage of this interrupter is its simplicity, but it is not adapted to coils giving a spark over six inches

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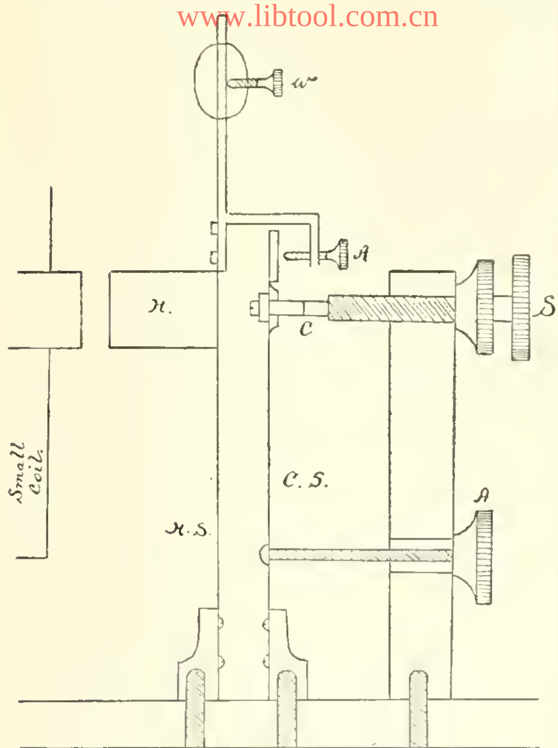

FIG. 4118. Diagram of Independent Vibrator. h, Hammer; w, movable weight; h. s., hammer spring; c, contact points; c. s., contact spring; A, S, A, adjusting screws.

in length. The break made by it from its occurring when the hammer starts to move, is not abrupt, and the contact from the wearing of the platinum is apt to be imperfect. Also the intense heat developed at the point of contact sometimes welds the platinum points together and stops the working of the apparatus. Large coils, requiring heavy currents, cannot be used with the interrupter, both from the liability of welding the platinum and from the jumping of the current across the gap at the break.

The *independent vibrating interrupter* (Fig. 4118) is a modification of, and a great improvement on, the Neff hammer. With it coils up to fifteen inches, energized by commercial currents up to one hundred and ten volts, can be quite satisfactorily worked. In this form the interrupter is operated by a secondary battery connected by a shunt from the main circuit, and is entirely independent of the main coil.

In this interrupter the current passes from the battery to the coil and returns (Fig. 4118) through *c.s.*, *c.* and *S*, unless broken at *c*. The current is broken at *c*, by the screw *a* striking the contact spring, when the hammer is attracted by the core of the small coil. This interrupter gives a relatively long contact, and the break is very sudden as the contact spring is struck when the hammer is moving at high speed. The rapidity of the interruptions can be varied in wide range by raising or lowering the movable weight (*w*) on the hammer spring. The advantages of this form of interrupter are that it is easy to manipulate, that it does not readily get out of order, and that it gives good results on all but the largest coils.

Mercury Interrupters.—The mercury interrupters are of two types—the dip interrupters and the turbine. The dip interrupter (Fig. 4119) consists of a small electric motor which, when in motion, rapidly dips one or two silver needles, hung on an eccentric of the shaft, into mercury, overlaid with petroleum, contained in glass receptacles.

The needles being connected with one pole of the battery and the mercury with the other, the current is made and broken by the entrance and exit of the needles from the mercury, while the number of interruptions is regulated by the speed of the motor, and the relation of make to break is determined by the time the needles remain in or out of the mercury.

The *turbine interrupters* (Fig. 4120) consist essentially of a hollow metal cylinder in which openings are cut, and within which a rapidly revolving turbine wheel, by centrifugal force, throws outward a stream of mercury. The cylinder being connected with one pole of the current and the wheel and mercury with the other, the current is made when the stream of mercury impinges against the wall of the cylinder and is broken when it passes through the openings. The rapidity of the interruptions can be regulated by the speed of the motor which runs the turbine wheel, and the length of the make and break, by the size of the openings in the cylinder and the distance between them. In practice, the openings are triangular sectors, and the relation of make to break can be varied by raising or lowering the cylinder. The break, from the force with which the mercury is thrown, is extremely sudden. The mercury is used dry, and requires only occasional cleaning.

The dip and turbine interrupters give the highest attainable results. They can be used on the largest coils and with direct currents up to two hundred and fifty volts. The turbine are in many respects better than the dip interrupters, as they are easier to manage and, in the best forms, are capable of more varied adjustment. They are expensive, compared with other interrupters, but for critical and professional Roentgen-ray work are unexcelled.

Electrolytic Interrupters.—These interrupters are entirely different in principle from those above described. Their action

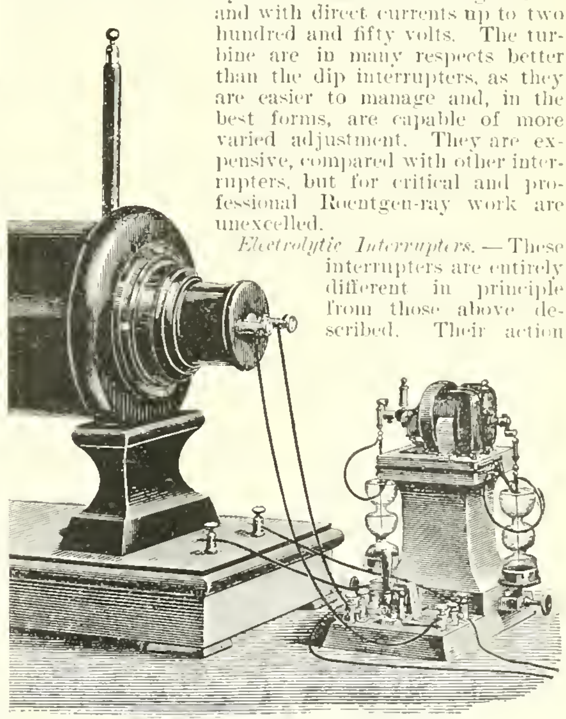

FIG. 4119. Coil with Mercury Dip Interrupter.

depends upon the electrolytic action of an electrical current. These interrupters consist essentially of a large sheet of lead connected with the negative pole of an electrical current and a small surface of platinum connected to the positive pole, both being immersed in dilute sulphuric acid (Fig. 4121). When a current is passed, electrolytic action occurs in the fluid and the sudden formation and disappearance of a non-conducting

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Roentgen Rays.

envelope of gas about the exposed platinum alternately breaks and makes the currents. In practice, at least forty volts at the terminals of the interrupter must be used to give good results.

These interrupters, from the rapidity of the interruptions, give a steady and intense light for fluoroscopic purposes, but for photographic work the radiation is not so energetic as that given by the mercury interrupters. The advantages of this interrupter are its cheapness and simplicity. Its disadvantages are that it is not fully controllable, that it is liable to explode, and that it is not possible to work it long at a time, as the fluid soon becomes overheated.

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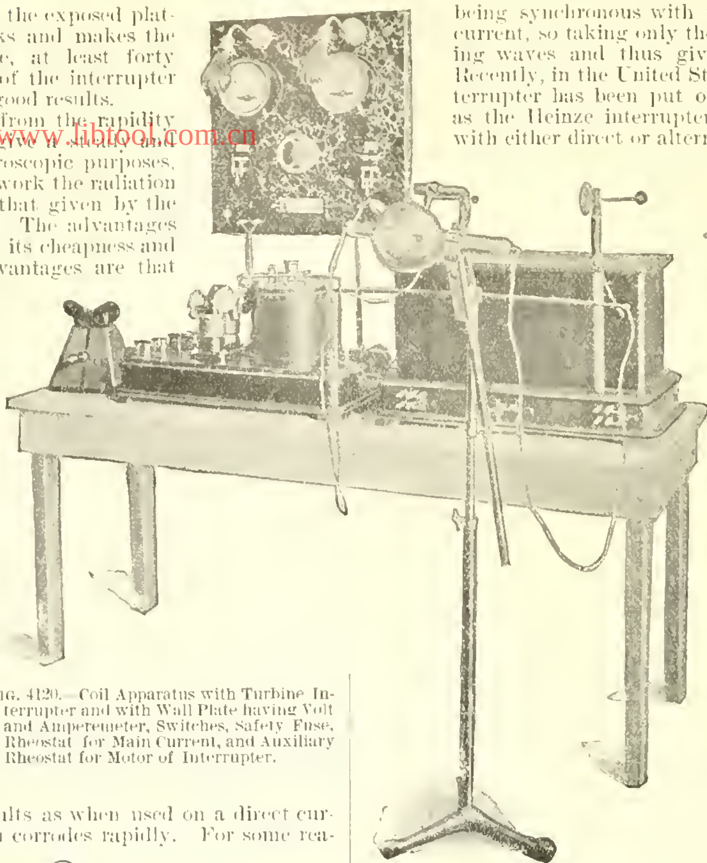

FIG. 4120.—Coil Apparatus with Turbine Interrupter and with Wall Plate having Volt and Amperemeter, Switches, Safety Fuse, Rheostat for Main Current, and Auxiliary Rheostat for Motor of Interrupter.

Interrupters for Use with Alternating Currents.—All the interrupters so far discussed, with the exception of the electrolytic type, can be used only on *direct* currents. The electrolytic interrupter can be used on an alternating current, and is the cheapest method of using such a current; but it does not give as good results as when used on a direct current and the platinum corrodes rapidly. For some rea-

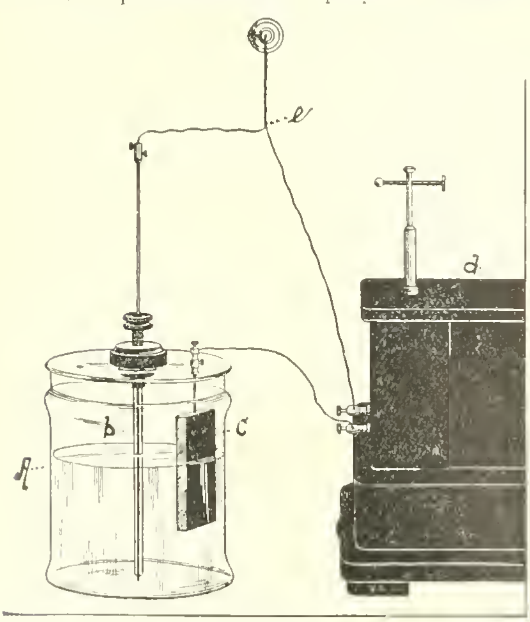

FIG. 4121.—Electrolytic (Wehnelt) Interrupter. *A*, Interrupter; *b*, platinum wire in porcelain cylinder; *c*, lead plate; *d*, coil; *e*, wires connecting interrupter and coil with an electrical source.

son the electrolytic interrupter does not explode or "choke" (cease working) on alternating currents.

Synchronous interrupters of the turbine mercury type are considerably used abroad for utilizing alternating currents. They depend in principle upon the make being synchronous with the alternation of the current, so taking only the crest of the alternating waves and thus giving a direct current. Recently, in the United States, a form of dip interrupter has been put on the market, known as the Heinze interrupter, which can be used with either direct or alternating currents.

This interrupter consists essentially of a small motor whose crank eccentric rapidly carries a platinum needle into and out of dilute sulphuric acid. The principle is a combination of the mercury dip and the electrolytic. The interrupter is completely under control when working with a continuous current, and by means of the control lever the make and break of the interrupter can be made synchronous with the alternations of an alternating current, and so send a unidirectional current through the coil.

The Condenser.—This part of a coil apparatus (Fig. 4117, *e*) consists of a number of sheets of tinfoil, insulated from each other, and connected with the wires by which the coil is connected with the electrical source. The function of the condenser is to act as a sponge and, when the interrupter breaks the current, instantly to absorb the electricity in the primary and so completely and immediately to demagnetize the core, thus greatly increasing the energy in the secondary. So energetic is this action that a twelve-inch coil without a condenser will barely give a two-inch spark. The condenser is usually placed in the base of the coil, but may be mounted separately. With the electrolytic interrupter no condenser is used.

Vacuum Tubes.—Tubes are graded from low (soft) to high (hard). A high or hard tube is one of high vacuum. These tubes require powerful currents to excite them, and they produce rays of great intensity. With such tubes the shadows of the bones viewed with a fluoroscope appear gray, and metallic objects are readily seen through them. Tubes of this character are very energetic in action on the photographic plate, and are useful for work through thick parts, as the hip, pelvis, or head.

A low or soft tube is one of low vacuum. Low tubes are readily illuminated by currents of low power, and therefore give rays of low intensity and penetration. Between the low and high tubes there are all gradations. Low tubes have too little penetration for work with any but extremely thin parts of the body, while very high tubes give such powerful rays that sufficient contrast between the bones and surrounding tissues is lost and critical differentiation of structure is impossible. Moderately high tubes are best for general work both in radiography and in therapy.

In using a vacuum tube it is necessary to adapt the current to the tube or the tube to the current, or both to each other. The current is regulated in the static machine by the rapidity of revolution of the plates and by adjustment of the spark gaps. In the coil apparatus the

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Roentgen Rays.

strength of the primary current is regulated by a rheostat, and the quality of the secondary current is conformed to the tube by adjustment of the interrupter. With respect to conforming the tube to the current, tubes are divided into non-regulating and regulating tubes.

Regulating tubes consist of the usual vacuum tube with a small attachment containing a chemical which when heated gives off vapor and reabsorbs it when cooled. When the vacuum of the tube becomes too high it can be lowered by heating the bulb by the passage of an electrical current, so forcing vapor into the tube. A very ingenious and useful self-regulating tube has been devised by Queen (Fig. 4122). In this the chemical is heated by the current passing to an adjustable spark point, and by adjusting the distance of this point from the cathode connection any desired degree of vacuum may be maintained.

In tubes to be used with the powerful currents given by the larger coils and rapid interrupters, special provision has to be made to prevent rapid destruction of the anode by the powerful cathode stream which impinges upon it.

Where the current is moderately powerful, tubes with extra thick anti-cathodes will resist the cathode stream. With powerful apparatus the water-cooled tube (Fig. 4123) must be used. In this tube the anti-cathode is placed at the base of an inwardly projecting cylinder, so that it can be kept cool by running water and thus withstand the great energy developed.

Success in the use of the Roentgen ray-apparatus depends largely upon proper manipulation of the tube and the current supplied to it. When a tube is used, care should be taken not to allow the platinum anode to become overheated. As a rule, radiation is at its best when the anode is just short of white heat at its centre, where the greatest energy of the cathode stream is exerted. For this radiation, tubes with thick or water-cooled anodes are required, as thin anodes are soon perforated and destroyed. When in operation the tube should be constantly watched, for on account of the heat developed the vacuum in the tube becomes gradually lower, and as the current passes more readily the anode may become overheated unless the operator reduces the current. Tubes become higher with use. When a tube refuses to illuminate, careful application of heat will overcome its resistance for a time; but, with use, it will finally become so hard that no current can pass through it. When this occurs, re-exhaustion is the only remedy.

Electrical Sources.—Three sources of electrical current are used for Roentgen-ray purposes—dynamos, storage batteries, and primary batteries.

The *dynamo currents* generally used are from commercial electric-light circuits, and this kind of current is best

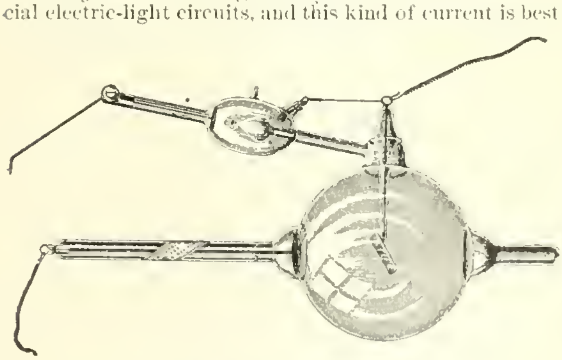

Fig 4122.—Queen Self-Regulating *x*-Ray Tube.

for Roentgen-ray work, where it can be had, as it affords sufficient energy to operate the coil and the discharge may be made as heavy as desired. Commercial currents are either continuous or alternating. The *continuous current*, unless of very high voltage, can be carried direct to the coil, requiring only a rheostat for regulating it and a safety fuse to prevent accidents. These currents are usually one hundred and ten volts, and all forms of interrupter can be used with them. Currents of higher voltage may be used, but with two hundred and twenty volts, or higher, the "reactive kick" of the primary becomes so great as to be a source of danger to the oper-

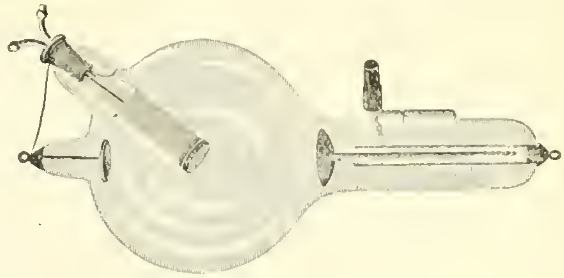

Fig. 4123. Water-Cooled Tube.

ator in case of accidental contact with certain parts of the apparatus. With these high-volt currents it is best to use a current transformer which reduces the current to a point of safety.

The *alternating current* can be used only with an electrolytic interrupter, a Heinze interrupter, or a synchronous mercury interrupter.

Storage Batteries.—Next to a dynamo current that from a storage battery gives best satisfaction. Storage batteries, like batteries generally, have the disadvantage of being more or less difficult to keep in order. The "chloride accumulator" is probably the best type and, in its more compact form, is useful for making part of portable apparatus. These batteries can be charged from dynamo currents or from primary batteries. To charge from an alternating current, a current rectifier which takes only the crests of the alternating waves, must be used. To give a good output, a little more than one cell of a battery is required for each two inches of spark length given by the coil.

Primary Batteries.—This form of electrical source is the least desirable of any used for energizing coils for Roentgen-ray work. Primary batteries are bulky, require a great deal of attention to keep them in order, and are expensive to maintain. They can be recommended for use only where commercial circuits or storage batteries cannot be employed. Any of the more energetic forms of battery will run a coil, but, from the trouble incident to working them, only one form—the Edison-LeLande battery—can be satisfactorily used for this purpose. This battery requires comparatively little attention, and gives a very constant electromotive force. About four battery cells are required for every two inches of spark length given by the coil.

Installation of Apparatus.—The method of assembling a coil apparatus depends upon the current supplied, the form of interrupter used, and the size of the coil. With a small apparatus having a hammer interrupter and energized by a primary or storage battery, it is only necessary to connect the coil direct to the battery. When a continuous commercial current is used a safety fuse and rheostat should be placed in the main circuit to protect the coil from injury and to regulate the current. When a mechanical interrupter is used it is run by a shunt from the main circuit, and should have a separate rheostat and safety fuse (Fig. 4124).

In installation of the larger coils the addition of a volt and ampere meter is useful to show the quantity and quality of the current, and wall plates are made having safety fuse, rheostats, and volt and amperemeters conveniently assembled on them (Fig. 4120). With an electrolytic interrupter the installation is somewhat simplified, as the interrupter is placed directly in the circuit which supplies the coil (rheostat and safety fuse being used) and a condenser is not required (Fig. 4125).

Surgical Uses of the Roentgen Rays.—The principal surgical uses to which Roentgen radiation is put

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are: (*a*) to diagnose fractures and determine the form and extent of the bone lesions; (*b*) to diagnose dislocations; (*c*) to determine the existence and extent of acute, chronic, and neoplastic pathologic changes in the bones;

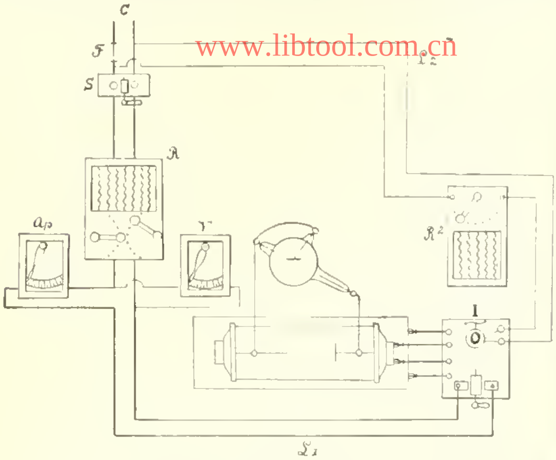

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FIG. 4124.—Diagram of Installation of an Apparatus with Mechanical Interrupter. *C*, Wires to maintain circuit; *F*, safety fuse; *S*, switch for connecting current; *R*, rheostat for current to coil; *Ap*, *V*, ampere and volt meters; *Li*, wires to coil; L_2, wires to interrupter; R^2, rheostat for interrupter; *I*, interrupter.

(*d*) to determine bone malformations and deformities; (*e*) to determine the presence and location of foreign bodies.

The peculiar resistance of osseous tissues to the Roentgen rays makes traumatisms of these particularly easy to determine. By the proper use of the rays the presence or absence of fracture, and, if present, the form and extent of the bone trauma can be accurately determined. Cases of difficult diagnosis are made plain, and since the rays have come into use it has been demonstrated that fracture is present in many obscure cases thought to be severe strain or sprain. The attention of the writer has been particularly called to this fact in connection with injuries of the knee-joint. Recently two cases of persistent lameness were referred to him, which were supposedly due to severe strain. In one of these cases the external condyle of the femur was split off to the intercondyloid notch (Fig. 4126) with no displacement, and in the other the internal tuberosity of the tibia was similarly fractured. In both these cases no crepitus could be elicited; the only prominent symptoms were persistent swelling and pain at the joint and the patients walked about with the aid of a cane.

Not only has the use of the rays given the surgeon a sure method of determining the presence of fracture, but it has greatly increased his knowledge of fractures resulting from indirect and direct violence, particularly those forms which are due to gunshot injury. The facts disclosed have been extremely valuable from the standpoint of treatment, for it has been conclusively proven that conservatism is indicated even in cases of most extensive bone lesion, provided the wound is not infected. In fact, as a result of Roentgen-ray observations combined with clinical experience, the rule may now be formulated that whatever the extent or form of a fracture, if no infection is present, operation is contraindicated, unless the bone fragments are so displaced that they produce deformity, may interfere with the function of the part, or are pressing upon vital or important structures.

When the diagnosis lies between a suspected fracture and a dislocation, as in obscure injuries of the elbow-joint, the rays at once determine the matter accurately. They are equally effective in showing the result of treatment, and at once enable the surgeon to determine whether or not a dislocation or fracture has been properly reduced (Figs. 4127 and 4128).

In determining the presence and extent of bone lesions it is most important that the rays be properly used. As before stated, visual effects from the rays are from observed shadows, and these shadows depend for shape and size not only upon the shape and size of the objects casting the shadows, but upon the relative position of the light and object and their distance from each other. For these reasons, to reduce distortion to the minimum, radiographs should always be made with the tube so placed that the anode will be as nearly as possible on a line perpendicular to the long axis of the bone above the place of fracture, and at least eighteen inches distant from it. Also, when the part injured admits, radiographs should always be taken from two directions, preferably at right angles to each other. Unless this precaution is taken, a fracture may be overlooked from the fragments overlying each other in a direct line and so throwing a straight continuous shadow, when a radiograph taken at another angle will at once show a displacement.

In this connection the *medico-legal* aspects of radiography may be considered, and here again the fact must be emphasized that radiographs are shadow pictures, not actual pictures of the objects themselves, that consequently the images are *never* accurate representations of the objects, that distortion is always present to greater or less extent, and that proper reading of radiographs can, in difficult cases, be arrived at only after much experience on the part of the expert; and then information must be at his disposal, giving the relative position and distance from each other of the tube, the plate, and the object radiographed. It is also primarily essential to expert opinion that this opinion be based upon full knowledge of radiographic pictures of normal structures, particularly of the shadow images given by the bones at the articulations.

For medico-legal as well as for diagnostic purposes, it is to be noted that *bone callus* is at first quite transparent to Roentgen rays, so much so that a fracture which is quite firmly united may show on the photographic plate as though no callus existed, and so give the appearance of an ununited fracture. For this reason the Roentgen rays cannot in all cases be relied on to give the actual condition of union or non-union of fracture.

The Localization of Foreign Bodies in the Tissues and in the Body Cavities.—The advantages of the Roentgen rays over all other means of locating foreign bodies are now so well understood that their use has practically entirely superseded all other methods.

The difficulties of using the probe for locating lodged missiles is well known. The contractility of tissues

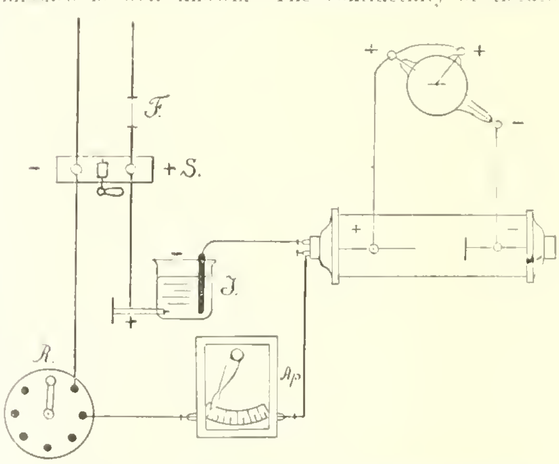

FIG. 4125.—Diagram of Installation of Apparatus with Electrolytic Interrupter. *S*, Switch; *F*, safety fuse; *R*, rheostat; *Ap*, amperemeter; *I*, electrolytic interrupter.

and the shifting of muscular and fascial structures by change of position may completely obstruct the wound track; and after the wound is healed, unless the foreign

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Roentgen Rays.

body can be felt beneath the skin, its localization by other than the Roentgen rays is usually impossible. With these all parts of the body may be painlessly and safely explored, and the presence or absence of foreign bodies determined, and if found, they may be accurately located. In a great majority of cases the localization of a foreign body in the tissues is a comparatively simple process.

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Direct observation with a fluoroscope or a radiographic picture will give all necessary information. In such cases the position of the foreign body relative to surface markings and points on the bones will materially aid in determining its position.

The depth at which a foreign body lies and its position may be determined with absolute accuracy by views taken at different angles. The principle involved is that as the anode, the object, and the shadow of the object are always in line, when two observations are made with the position of the anode changed, it must follow that the object must lie at a point where the lines drawn from the shadow to the anode at each observation cross each other. In other words, if two observations are made with the anode in different positions for each, and these positions and the places where the shadows of the object fall at the surface of the body are marked, the object can be located at the point where lines cross each other, which are drawn from the positions occupied by the anode to the places on the surface of the body where the shadows of the object were cast. Various means have been devised for determining the positions of the anode and the shadows of foreign bodies relatively to the surface of the body. Of these the MacKenzie-Davidson apparatus, or one of its modifications, is most convenient and accurate, and with such apparatus foreign bodies can be located with mathematical exactness.

FIG. 4126.—Radiograph showing Fracture of the External Condyle of the Femur.

For locating foreign bodies in the eyeball, Dr. Sweet has invented a very ingenious and satisfactory apparatus.

Calculi.—Recently great advances have been made in determining the presence of pathologic foreign bodies in the urinary and gall bladders and in the kidney.

The pathologic concretions formed in these organs, from their difference in composition and consequent resistance to the Roentgen rays, differ materially in the case with which they may be detected. Those calculi which contain inorganic material, such as the mineral salts, may be most easily made out. For this reason gall stones are difficult to radiograph, as they are generally composed of organic matter. Uric-acid calculi are quite transparent to the rays and consequently difficult to determine. For these reasons while a radiograph showing a shadow cast by a calculus is proof positive of the presence of a calculus, the absence of a shadow is no indication that a calculus may not be present, as the calculus may be so transparent as to cast no shadow. However, with proper technique, the presence of calculi may be demonstrated, when present, in a large percentage of cases.

FIG. 4127.

FIG. 4128.

FIGS. 4127 AND 4128.—Radiographs of a Fracture of the Radius and Ulna before Reduction (Fig. 4127), and after Reduction and Wiring (Fig. 4128).

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FIG. 4129.—Calculi in the Pelvis of the Kidney. Radiograph made with intensifying screens—exposed one second. (Ziemssen-Rieder.)

For the detection of calculi the character of the tube is of the greatest importance, a "critical tube," giving the maximum of differentiation, being necessary. The difficulties incident to this work are well known to all practical workers, but advances are constantly being made, and here it is well to mention the work recently done with the aid of *intensifying screens*. In this method a photographic film is placed in a light-tight envelope, between two screens coated with fluorescent salts. When exposed to the Roentgen rays the intensifying screens fluoresce and so greatly shorten the time of exposure. In this way almost instantaneous exposures may be made through the thickest part of the body (Fig. 4129).

With improved technique much has been done in determining the pathological conditions of the organs within the thorax. The value of the rays in determining *tuberculous* changes in the lungs is now fully recognized, and must rank with, if not higher than, auscultation and percussion. In fact, by the rays tuberculous changes may be determined fully as early in most cases as by physical signs, while the location and extent of the pathological changes can be definitely shown (Fig. 4130).

Similarly, empyema and pleurisy with effusion can be shown by the shadows given by the fluids in the pleural cavity.

In diseases of the *heart* and *aorta* the alterations in form of these organs are plainly and accurately shown, thereby enabling the observer to determine definitely the condition present. In valvular disease the shape and size of the heart are more accurately determined than is possible by most careful percussion. Likewise in aneurism of the arch of the aorta, the abnormality in form of the aorta is shown, so giving invaluable aid to the diagnostician (Figs. 4131 and 4132).

RADIOTHERAPY.—The therapeutic uses of the Roentgen rays depend upon their ability to affect the metabolic action of the body cells. When living tissue is exposed for a sufficient length of time to rays having considerable power, peculiar changes are effected in the cells, these changes being expressed first by increased cellular activity, and afterward by cell death. These cell changes are not produced at once, as when ordinary heat is applied to a part, but appear only after a considerable time has elapsed. Thus in the *x-ray burn*, due to exposure of the skin to too powerful or too prolonged exposure to the Roentgen rays, the first signs appear usually about the third day after the exposure. The first evidence of the effect of the rays is a slight redness of the skin. This deepens and extends, and in a day or two small blebs appear, which break, and from these tissue destruction extends by cell necrosis until finally large denuded areas may form, which are very painful and slow to heal. The action of the rays upon the body cells has been ascribed to the true light rays given off from the vacuum tube, but it is really due to the Roentgen rays, as the skin is affected when covered by a sheet of hard rubber, which shuts off all light rays, but allows the Roentgen rays to pass readily.

So far, the therapeutic use of the rays has been mainly confined to diseased conditions of the skin, the mucous membrane, and the tissues lying directly beneath them.

The effect of the rays upon the deeper tissues, both

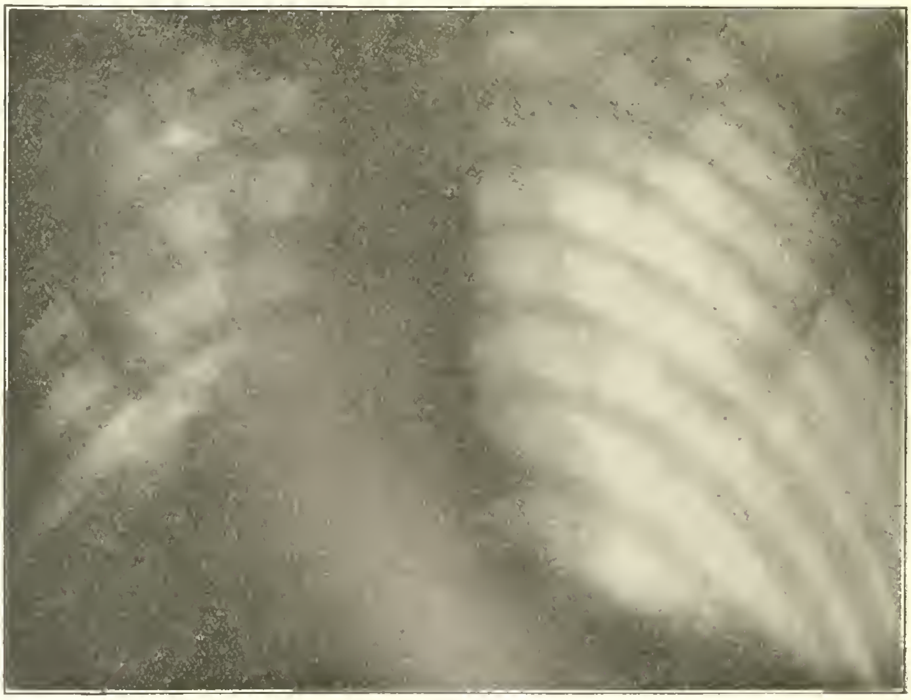

FIG. 4130.—A Radiograph of the Chest showing Tuberculosis of the Left Lung; the Right Lung Normal. (Ziemssen-Rieder.)

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normal and abnormal, is a field having many possibilities, but one in which no definite results have yet been recorded.

In certain pathological conditions of the skin and subcutaneous tissues many brilliant cures have been made, and radiotherapy is now acknowledged to be a most valuable aid to the practitioner. Thus, cases of lupus,

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3. The "normal exposure" in a single sitting, and await reaction.

Treatment by any of these methods is appropriate under proper conditions. The second is the method to be preferred, inasmuch as the first is tedious for both patient and physician, and the third demands a certain experience on the part of the operator. After the first

FIG. 4131.

FIG. 4132.

FIGS. 4131 AND 4132.—Radiographs showing Normal Heart and Aorta (Fig. 4131), and an Aneurism of the Arch of the Aorta (Fig. 4132).

eczema, sycosis, favus, epithelioma, rodent ulcer, and carcinoma have been relieved or cured without producing any inflammatory reaction or inconvenience to the patient.

Practical Application of Radiotherapy.—Radiotherapy requires a complete armamentarium consisting of an induction coil of at least twelve-inch spark length, an interrupter capable of adjustment, and a suitable vacuum tube, preferably of the regulating kind. In treatment much depends upon the tube used. With a low tube the radiant energy is not powerful, penetrates but little, and in consequence its action is largely confined to the superficial tissues. With an extremely high tube the radiation is very penetrating, and appears to pass too deeply, or through the part exposed. A *medium* tube is, therefore, best in that its radiation penetrates sufficiently and yet is largely absorbed by the tissues.

The tube used should be capable of producing a good picture of the thorax of a medium-sized man, when viewed through the fluoroscope at a distance of 60 cm. from the focus. With a tube of this kind the time required for each sitting will be between five and twenty minutes. Although a five-minute exposure will produce a slight effect, a radiance lasting twenty minutes may be regarded as the "normal exposure." Such an exposure will have the following results: On normal skin, after a period of latency of fourteen days, the hair will fall out, accompanied by an erythema lasting a few days; on skin affected with sycosis the loss of hair will occur as early as the eighth day, accompanied by the formation of numerous pustules; lupus tissue will become exfoliated after a lapse of a week. On the other hand, the effect of a normal exposure of twenty minutes can be produced by dividing the action of the radiance over several sittings of shorter duration.

Taking into consideration the intensity of the radiance, the number of séances, and the length of intermissions, we may formulate the following three methods of radiotherapy:

1. Daily sittings, with a radiance of slight intensity, lasting five minutes, continued until the first symptoms of reaction appear.

2. (*a*) Sittings, with a radiance of medium intensity, twice a week until reaction begins to be manifest (about two weeks); or (*b*) three or four sittings, with a radiance of medium intensity, given on alternate days.

sign of reaction appears it is advisable to await the termination of the characteristic inflammatory process, and then, if necessary, repeat the exposure. If, in using the second and third methods, absolutely no reaction occurs at the end of three weeks, we may feel justified in repeating the "normal exposure"; if, however, a mild reaction, non-progressive in character, has taken place, an additional exposure, less than normal, can be applied. As stated above, the second "normal exposure" is made after the subsidence of the inflammatory reaction excited by the first; thus this treatment may involve, in accordance with the nature of the case, repetition of *x*-ray applications extending over months or even years. Often in cases of hypertrichosis, in some cases of sycosis, and in nearly all cases of herpes tonsurans and favus, a single "normal exposure" usually suffices, *i.e.*, by using method No. 3, a perfect cure results after a single sitting.

Finally, it may be stated that radiotherapy is as beneficial in the hands of an expert as it may be harmful if improperly used. Over-exposure or too frequent exposure to powerful radiation may induce a severe ulcerative process, which is very painful, slow to heal, which may even endanger life, and require surgical intervention before a cure can be effected.

The physician can no longer shield himself behind a supposed idiosyncrasy of his patient. It appears that patients in poor health, whose vital resistance is lowered, are more easily affected by the rays than are persons in full health, and this should be taken into account; but, in general, the tissue changes induced are directly in proportion to the amount of radiant energy which falls upon the part.

THE THERAPEUTIC ACTION OF LIGHT.—Actinotherapy, like radiotherapy, is based upon the effect which light produces upon living cells. This effect is mainly manifested in two ways: (*a*) the effect of light upon the organism generally; and (*b*) the local effect of light.

The Effect of Light upon the Organism as a Whole.—The effect of light upon living organisms is shown in nature in a multitude of ways, and is illustrated by the difference in appearance presented by plants grown in the shade and the same species grown in sunlight; also, it is well known that persons who live in dark or ill-lighted habitations lack the ruddy, healthful appearance of those who habitually live out of doors. It is true that while this difference in vitality is due not alone to the dimin-

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ished amount of light, but is largely owing to other unfavorable conditions, such as lack of fresh air, exercise, etc.; still, light is a decided factor in favoring health, and is one of the agents which, combined with fresh air, exercise, sanitary habitation, and suitable climatic conditions, is of the greatest benefit in the treatment of debilitating diseases.

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The efficacy of a combination of the above-named factors in the treatment of *tuberculosis* is too well known to require discussion, and the accentuation of the light factor by the use of "light baths" is an important addition to the therapy of this disease. It is true that the use of sun baths dates back to remote antiquity, but the fact that the skin and soft parts are more or less permeable to rays of ordinary light has not until recently been conclusively demonstrated. The bactericidal effect of the actinic rays has now been conclusively shown, and the beneficial effect of sun baths in pulmonary tuberculosis has been ascribed by some to the bactericidal action of light; but it is more probable that the good effect of sunlight is due to a general favorable stimulation of the body cells, whereby their metabolic activity is increased and the tissue resistance to bacterial action is raised.

The Local Applications of Actinotherapy.—The local use of light for the cure of disease is in many ways analogous to the use of Roentgen radiation.

Both light rays and Roentgen rays appear to act by altering the metabolic action of the cells upon which their energy is exerted, but the resulting cell changes caused by these agents appear to be materially different. The effect of Roentgen radiation upon living tissue has been discussed under radiotherapy, to which the reader is referred for an account of the tissue changes produced by that agent. The effect of light in the treatment of pathologic conditions appears to be largely, if not entirely, due to the chemical or actinic effect of certain of the light rays. Relative to the biologic and therapeutic effects of light, it is important to note that light is not a simple entity, but that every ray consists of a series of distinct parts, each of which has its particular properties. The effects of solar radiation may be arranged in three different groups—heat, light, and chemical action. The heat rays are mainly found in the infra red, red, and orange of the spectrum; the yellow and green rays make the strongest impression upon the human retina, while chemical action is chiefly found in the blue, violet, and ultra-violet rays. While all solar wave lengths, even the infra red rays, induce chemical change under favorable conditions, the ultra-violet, violet, and blue are the most powerful in the order mentioned. This chemical action of certain light rays is particularly shown in the action of light in reducing silver salts in photographic processes. The same rays of solar light which produce chemical changes in inorganic compounds produce vital chemical or metabolic action in living cells. The action of light upon the skin has been noted by mountain climbers, who suffer from "sunburn," due to the intense action of sunlight in high altitudes, where the cold is so great as to negative the supposition that the sun's heat could produce the condition. This inflammation of the skin, *erythema solare*, was formerly called erythema caloricum, as it was thought to be due to overheating of the integument. This heat theory of erythema was first combated by Charcot in 1859, and has since been entirely refuted by the fact that severe erythema occurred in persons travelling among ice fields and in the polar regions with the temperature much below zero, and in persons exposed to an electric arc light, where the light is intense and the heat faint.

Widmark, of Stockholm, by the use of glass and rock-crystal plates, demonstrated experimentally that the power of light to affect living tissue rested mainly in the violet end of the spectrum. Glass absorbs most of the ultra violet rays from an electric light, but rock crystal allows them to pass through. With a rock-crystal lens Widmark caused the rays from a twelve hundred candle power arc light to become parallel. When the rays were directed upon the skin and a glass plate interposed, so obstructing the ultra-violet rays, no inflammation was produced, but when a rock crystal plate was used which allowed the ultra-violet rays to pass, a severe inflammation was set up.

The experiments of Widmark were corroborated by those of Finsen; and the latter's application of the principles adduced to the treatment of certain pathological conditions of the skin, notably lupus vulgaris, gave rise to the so-called Finsen treatment of skin diseases and the red-light treatment of smallpox.

The treatment of *smallpox* by red light has given remarkable results. By the exclusion of all except the red rays of light the course of the eruption and of the disease itself in many cases is markedly changed. The unfavorable action of light upon the course of smallpox was noted by Picton in 1832, by Black in 1867, and by Barlow and Waters in 1871, but it was reserved for Finsen (1893) to define a treatment based upon the deleterious effect of the actinic rays. Arguing from the fact that the actinic rays are able to produce inflammation in the healthy tissues, he arrived at the conclusion that their exclusion in inflammation of the skin might be beneficial. This view is supported by the fact that in smallpox the deepest eruptions are found on the hands and face, which are the parts of the body most exposed to light. Total exclusion of light or the exposure of the skin to those rays only which are not harmful (non-actinic rays) is therefore indicated. As total darkness is not conducive to the patients' well-being, it is preferable to let them lie in a room lighted by red light only, the red rays being non-actinic and therefore harmless. The arrangement of the red room is very simple, being similar to that of the dark room used in photography. The window panes should be of red glass, or, where a room has to be extemporized, the room may be darkened by thick curtains at the windows and illuminated only by the light from red lanterns, such as are used for photographic purposes. Upward of two hundred cases of smallpox treated by this method have been reported, and all physicians who have given their experience with the method state that the results are remarkably good. If the patients were brought into the red light before the beginning of the suppurative stage, as a rule no suppuration occurred. The vesicles continued clear and after a few days dried to crusts, which fell off without leaving a scar. By the non-appearance of suppuration all the symptoms dependent upon that condition were absent. When the primary fever disappeared, the temperature remained about normal and the secondary fever of suppuration did not occur. In consequence the duration of the disease was shortened and the mortality lessened.

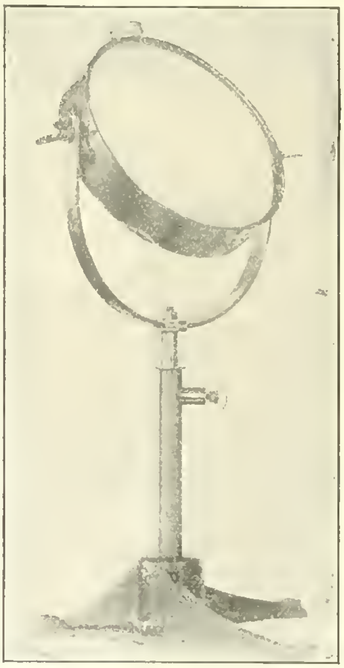

FIG. 4133.—Finsen Apparatus for Use with Sunlight.

Recently Finsen's red-light treatment has been tried in other infectious exanthemata, and Backmann and Chati-

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nière have obtained especially satisfactory results with it in the treatment of measles.

Actinotherapy after Finsen's Method.—The Finsen method of the local treatment of skin diseases has for its practical basis the experiments made by himself and Widmark in producing local inflammation of the skin by the ultra-violet rays. In theory this treatment rests upon the many experiments showing that the chemical rays affect the metabolic action of living cells and cause the death or inhibit the growth of bacteria. The investigations of Bie and others have shown that the bactericidal power of light resides almost exclusively in the blue, violet and ultra-violet rays, and that only a small percentage of such potency exists in the red, yellow, and green. The rays of light which have strong bactericidal action are, therefore, the same as those which will produce inflammatory action in the skin. That light can pass through the skin was demonstrated by Godneff. He placed small glass tubes containing silver chloride under the skin of dogs and cats and then kept some of the animals in the dark and others in direct sunlight. After an hour he removed the tubes and found the silver chloride blackened in those animals kept in the light, but not in those kept in the dark.

Finsen then demonstrated that actinic light better penetrated those tissues which are deprived of blood. His treatment, therefore, consists of concentrating actinic light through rock crystal lenses upon living tissue made ischaemic by pressure. Sunlight or artificial light may be used, but the latter is most generally useful, as it is always available and controllable. When sunlight is used it is concentrated on the part by a large hollow lens composed of a flat and a convex glass enclosed in a brass ring (Fig. 4133). The lens is filled with a watery ammoniacal solution of copper sulphate. The water absorbs the infra-red (dark heat) rays and the blue solution absorbs a part of the red, yellow, and green rays.

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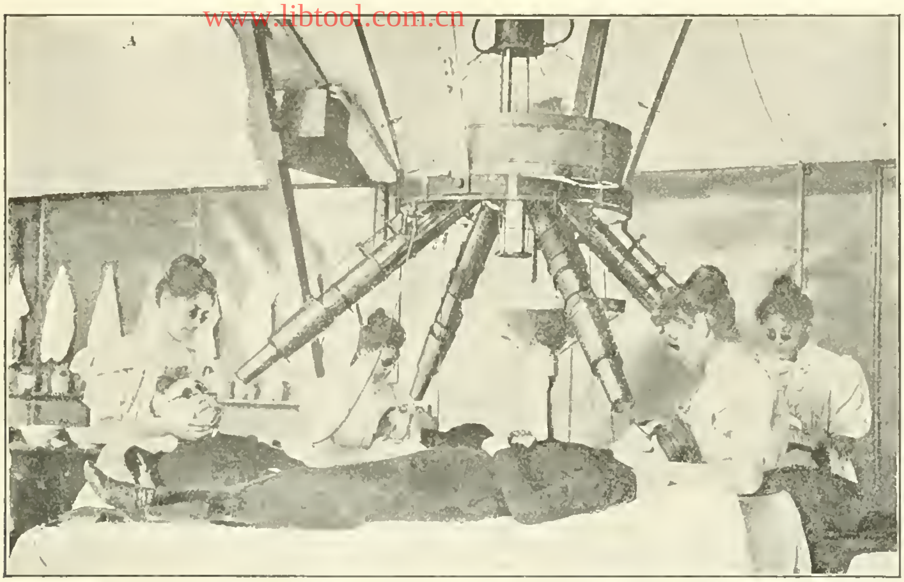

Fig. 4134.—Finsen Apparatus for Treatment with Electric Light. (Bie.)

In treatment by electric light an arc lamp, taking sixty to eighty ampères of current, is used. Current from an electric-light circuit is used, the amperage being raised and the voltage reduced by a converter constructed for the purpose. The apparatus consists of three parts: (1) the light; (2) the cooling apparatus; (3) the light-concentrating apparatus (Fig. 4134). The arc light is surrounded by a shade to prevent the eyes of those present from being dazzled. From this light there radiate four or more telescopes, each telescope conveying the light to a patient. The telescope lenses are of rock crystal, as this obstructs the active rays less than any other material. The space between two of the lenses is filled with water

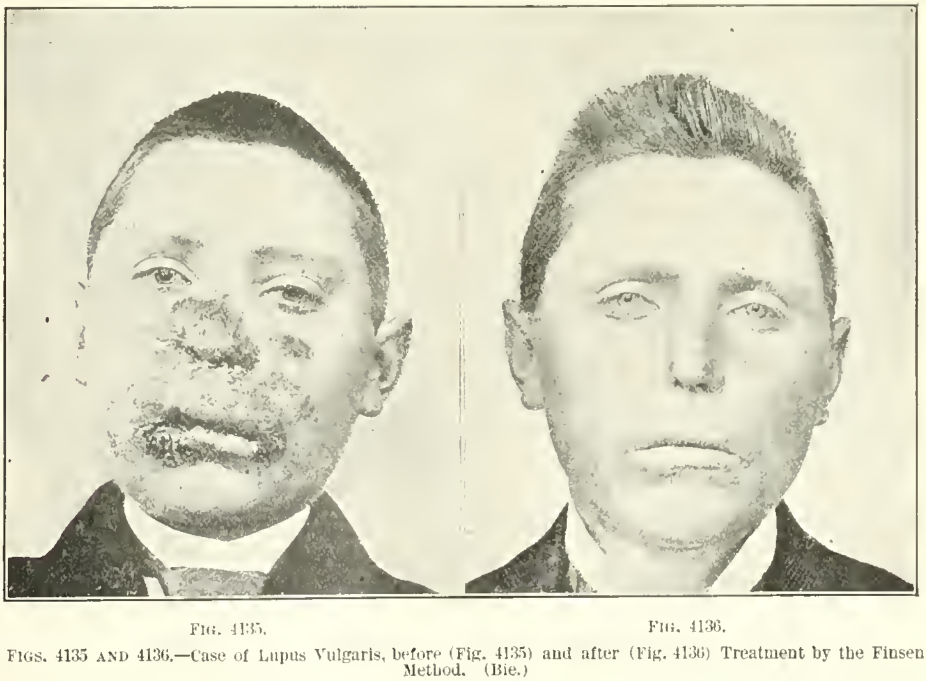

Fig. 4135. Fig. 4136.

Figs. 4135 and 4136.—Case of Lupus Vulgaris, before (Fig. 4135) and after (Fig. 4136) Treatment by the Finsen Method. (Bie.)

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to moderate the temperature, and an enclosing water-jacket still further reduces the heat. The lenses are so arranged as to render convergent the divergent rays from the arc light; these rays then being brought to a focus by a lens cooled by water and held by a nurse and pressed by her firmly on the part treated. The patient lies on a table or is seated in an adjustable chair, the position of which can be varied so that the light will fall perpendicularly on the surface to be treated. Each application lasts about an hour and is repeated daily. Although the light is cooled in its passage through the concentrating apparatus, it is yet too hot to be directed on the skin without detriment; hence the water-cooled lens, applied to the skin, is used in all cases whether sunlight or electric light is used. The effect of the treatment on the patient is in no way painful. A few hours after the first application there is a certain amount of "reaction"; the part swells, becomes reddened and tender, but there is little pain. The reaction varies in degree in different cases, being always seen in lupus vulgaris, but does not occur in lupus erythematosus. The beneficial effects of the treatment are often manifested in a few days, and recovery sometimes follows a very few applications. Generally fifteen to twenty-five applications must be made before a cure is effected. The results are very satisfactory; the skin becomes soft, smooth, and pliable, and scarring is hardly noticeable, other than to the extent dependent upon the tissue destruction caused by the disease (Figs. 4135 and 4136).

The Finsen method has been most successfully used in the treatment of lupus vulgaris, but recently encouraging reports have been made of the treatment of alopecia areata, epithelioma of the skin, and nævus vasculosus.

William Cline Borden.

ROETHELN.—Definition and History.—Roetheln is an exanthematous disease of mild character, attended with a slight elevation of temperature, propagated by contagion, and bearing a close resemblance to measles and scarlatina. It is widely known in this country under the above appellation, and also, in common parlance, by the term "German measles." The latter name, being English, is generally used. Thus in its nomenclature Roetheln resembles the other exanthemata, which have each a technical and a common name. The Germans, however, use the names Roetheln and rubeola as synonyms; and this tends to confusion, since we signify by rubeola the different disease, true measles or morbilli. Various other names have been given to the disease by different writers, prominent among them being epidemic roseola, rubeola scarlatinosa, rubeola morbillosa, rubeola notha, and rubella. The last-mentioned name has been suggested as most appropriate, since it is a diminutive of rubeola, and thus the two words express the analogy existing between the two diseases, just as do the terms variola and varicella. For the reason, however, that Roetheln is more widely recognized, the writer retains it in this article.

Roetheln is, so far as definite knowledge is concerned, a new disease. As late as 1886 the "Index Medicus" gives it no separate place, and the articles on the subject are grouped under the heading of measles; yet the number of communications, treating of this affection, which have been written during the past ten years or so (1877–1887), will aggregate more than one hundred. Before that time, however, the disease had been from time to time spoken of, as far back as a century and over; though until the time of the present generation the greater number of observers did not consider it a distinct disease, but believed it to be a modification of measles, generally, and, in some instances, of scarlatina. Mention was made of epidemics in 1845 and 1853, and in 1873–74 the disease was carefully described, though under the name of epidemic roseola. In Germany attention was given to the subject many years before any English or American writings appeared. Now almost all physicians grant its individuality, and the arguments supporting this view will be presented hereafter.

Age of Patients.—Roetheln is generally classed as one of the diseases of childhood; and, since there are no clearly proved instances of its second appearance in the same individual, it follows that those affected are usually young in years; the general rule being that any one of the contagious exanthemata is experienced but once in the lifetime of an individual. Still, it is much less prominently an affection of infants and children under five years of age than are the other eruptive fevers. Adults are frequently attacked, but the majority of those who suffer from this disease contract it some time before the age of puberty. In other words, the time of life when susceptibility is greatest is between the ages of two and fifteen years. Young infants do not seem to contract it, and it is believed that sucklings are not susceptible. As, however, it is a disease of less frequent occurrence than measles or scarlatina, and as it seems to be less actively contagious than those diseases, many growing children escape it; and these facts constitute a possible explanation of the circumstance that adults are not infrequently attacked during the prevalence of an epidemic.

The season of the year does not seem to exert any influence on its prevalence. Epidemics occur indifferently in hot and in cold weather.

Etiology.—Roetheln is propagated by contagion, and by this means alone. The materies morbi is believed to be portable, but the cases in which the source can be traced point toward the necessity of close contact for the transmission of the disease from the sick to the well. In a single epidemic the total number of cases among those unprotected by having previously experienced the disease is found to be small in comparison with the other contagious exanthemata. Especially is this noticeable with reference to measles, which will attack, simultaneously or successively, all the susceptible children in a household almost with certainty; while we generally meet with a single, or perhaps two, cases of Roetheln, and the greater number of those exposed, in greater or less degree, escape. J. Lewis Smith, in one epidemic, saw forty-eight cases in twenty-one families—an average of a little more than two to each family. In an institution, such as an orphan asylum, the number of cases would be comparatively larger, since the exposure would be of necessity greater at first. Isolation, therefore, can be expected to accomplish more in the direction of prevention than it does with measles or scarlatina.

Roetheln is encountered almost exclusively in epidemics, and sporadic cases are very rare. This is probably more decidedly the case with this disease than it is with scarlatina, and possibly also with measles.

Considerable difficulty is experienced in tracing cases of Roetheln to their sources—largely, no doubt, because affected persons are frequently unconfined, owing to the general mildness of the disease, and the absence of alarm concerning it. Undoubtedly, however, if its origin could always be traced, an exposure to contagion would be discovered. In other words, it is practically certain that the disease does not originate *de novo*; nor is it produced by general causes, such as improper hygienic surroundings in the matter of poor ventilation, overcrowding, or insufficient or improper dietary conditions. On the contrary, it is not found to be a disease of greater proportionate prevalence in tenement-house districts, where the conditions referred to are in prominent existence. A large proportion of the cases are encountered in the families of the better classes, and, most of all, in institutions, such as orphan asylums.

We may reasonably conclude that Roetheln is less actively contagious than measles or scarlatina, since so many of those exposed escape. Under the same conditions of exposure the number of cases arising of either of those two diseases would probably considerably exceed those of Roetheln.

The age at which susceptibility is greatest has been mentioned, being considerably more advanced than that which obtains with the other exanthemata; but as yet there is little definite knowledge as to the stage of the

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disease itself in which propagation by contagion is most likely to occur. We can only say that the probability is in favor of contagiousness during the whole course of the disease—from the time when prodromal symptoms, if present, appear, until the eruption has entirely disappeared.

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Clinical History.—*Stage of Incubation.*—Much attention has been given to the duration of the stage of incubation—the time elapsing between a traceable exposure and the onset of the disease. This is frequently made difficult of accurate investigation for the reason before mentioned, that isolation is not observed because of the mild character of the affection, and sometimes even confinement within doors is not enforced. The general experience is that this stage occupies from fourteen to twenty-one days; though in some epidemics the duration has been considerably less. Shuttleworth had the opportunity of ascertaining, in an asylum, that twenty-one days lapsed after the first case appeared before the second occurred, isolation being enforced, and two days later two fresh cases developed. Goodhart says that the incubation, in twenty-three out of twenty-five cases, was from fourteen to twenty-two days. Edwards gives six days as the shortest and twenty-one days as the longest. Cheadle ascertained it to be eight days in one instance, nine in another, and (approximately) twelve days in five more. Griffith's experience was that in twenty-six cases the eruption appeared between the fifth and twelfth days after the first case was discovered. Therefore it must be granted that considerable variation exists in the length of this stage, although we may consider that a period of fourteen days represents the average. The incubative stage of measles is much more constant—standing, as it does, at thirteen and fourteen days.

Stage of Invasion.—In very many instances the eruption is the first thing which calls attention to the existence of sickness. Since many of the patients are old enough to describe any subjective symptoms which may be present, it follows that the stage of invasion is frequently attended with little or no disturbance of general health. With children too young to describe their own sensations, the attention of parents is often attracted by no manifestation whatever—such as restlessness, or crying, or digestive disturbance—until the eruption becomes visible. It is, however, probable that there is always present a slight rise of temperature, not sufficient to cause discomfort; and close questioning might elicit an admission of a feeling of malaise. But, as stated, the breaking out of the rash is what causes uneasiness, and leads patients or parents to consult a physician for the purpose of ascertaining the nature of the sickness.

There are, on the other hand, cases in which there is more or less decided disturbance of health prior to the appearance of the eruption. Epidemics undoubtedly vary greatly in severity, as do individual cases in a single epidemic; and from the average of descriptions it would appear that the disease is more severe, as well as of more frequent occurrence, in Europe than in the United States. These more severe cases present certain indications of sickness, before the rash appears, which, taken in connection with known exposure, point toward Roetheln as the oncoming disease; but in themselves they have little value as regards the differential diagnosis, especially, from scarlatina and measles. The symptoms, when present, have special reference to the mucous membranes of the air passages, and to the digestive system. They are: mild inflammation of the throat and tonsils, shown by swelling and redness on examination, and by pain and slight cough; a slight degree of coryza; conjunctival irritation, lachrymation, and a little tendency to œdematous swelling of the eyelids. Nausea and anorexia have been frequently observed, and in rare instances vomiting. Frontal headache in a few instances is the source of much discomfort. The digestive disturbances appear to have been prominent in some and absent in other epidemics. With these symptoms—and, it is not improbable, in their absence—there is a rise of temperature to 99° or 100° F. in mild, and as high as 103° F. in severe, cases. In addition to these indications there is one symptom highly characteristic of the fully developed disease, as will hereafter be seen,—a symptom which has been observed in the prodromal stage. This is enlargement of the post-cervical lymphatic glands—not those at the angle of the jaw, as obtains in scarlatina and diphtheria, but those in the back of the neck. This enlargement should always be looked for, since it is the only feature of diagnostic value in the stage of invasion. Jaccoud found it, in five out of thirty-two cases, four or five days before the efflorescence. Associated with this, stiffness of the neck with pain on movement of the head, in slight degree, should be sought for.

Any throat inflammation present might easily be accounted for in expecting scarlatina to develop; and coryza, cough, and conjunctival irritation belong to the clinical history of measles. Rise of temperature also, of course, accompanies the onset of both these diseases; and consequently, excepting only the glandular enlargement, so far as these general symptoms are concerned, it is only in their lesser degree of severity that they are characteristic of Roetheln rather than of the other two affections.

These indications, when present, precede the eruption by a period, in the great majority of cases, of less than twenty-four hours; although in some instances malaise is present for three or four days before this stage is ended. Cheadle, in describing a severe epidemic, observed that the prodromal symptoms persisted longer in severe than in mild cases. Edwards gives the average duration as three days.

It is therefore observable that the stage of invasion, when present, is subject to considerable variation—both as to length and severity—and is, in fine, a much more uncertain quantity than is that of scarlatina or measles.

Stage of Eruption.—The prominent feature of the disease is the eruption, often, as before stated, being the only phenomenon perceptible, and generally being by far the most prominent manifestation of a condition of sickness. Very great differences, in different epidemics and in individual cases, are to be found; and, considering the eruption alone, a diagnosis might well be difficult, if not impossible. As the symptoms other than the eruption, such as those found in the prodromal stage, present considerable variation, and as this fact holds with the eruption itself, we may conclude that the disease, as a whole, is far less *stable* than scarlatina and measles. These are more than variations of degree—they affect the essential characters of the symptoms and of the eruption.

Scarlatina, for instance, may be very mild or very severe as regards the throat inflammation and fever; and its eruption may be difficult of detection, or as marked as a pronounced rash of erysipelas; but these are differences of degree, and the sore throat and eruption are uniformly present, and are *sui generis*. The same rule holds with measles. The essentials of the disease—the catarrh of the respiratory tract, and the characteristic eruption—may, one or both, be very mild or very severe; but they must both be present in any case in which the diagnosis is undoubted. Roetheln, on the other hand, may consist, from beginning to end, of the eruption only, or may present some of quite a variety of symptoms affecting the mucous membranes of the air passages or of the digestive apparatus.

Regarding the eruption itself, its characteristic points are as follows: Its color is generally a pale rose, less distinctly rose-hued than that of measles. It is very frequently brownish, brownish-red, and sometimes quite distinctly brown, with no tinge of rose or pink to be detected, and giving the general effect of duskiness.

As to location, no part of the surface is entirely exempt. The palms of the hands, the soles of the feet, and the scalp have been observed to present it; although usually it is not to be found in those regions. As a general rule, the face, trunk, arms, and legs break out successively before the final disappearance of the rash; although cases are often described in which the affected area is much less extensive.

Either the face or the upper part of the body may be

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first affected, and the spread of the eruption is rapid—one day or less sufficing for its appearance on the remoter parts after its initial appearance. The maximum of intensity is very quickly attained. Beginning on the face, for example, in very faintly marked spots, after a period of a few hours, and certainly within one day, it will be at its height, and the spots will be plainly visible. Then a fading process sets in, gradually progressing, accompanied with, or followed by, some desquamation, and continuing for about two days; so that, in any selected locality, from the first appearance to the final disappearance, an average period of three days is occupied. This, however, is not a definitely fixed time; sometimes it embraces but two days, and at other times it is protracted to six or seven.

The duration of the eruption as a whole, without reference to any special part of the surface, is consequently a little longer than that of its presence in a given locality—by the time occupied in the spreading from the region first to that last attacked. As this generally requires one day, or somewhat less, the eruptive stage of the disease can be expected to continue about three days on the average, though subject to the variation spoken of, having as extremes two and seven days. It will be observed, from the rapidity of development in a selected locality as compared with the rapidity of the spreading to other regions, that different parts will present the eruption in greatly varying conditions; and that at no given time will it be at its maximum uniformly over the entire surface of the body. In other words, it may even reach its height in one part before appearing in another. This is a point of value in diagnosis, and of contrast to scarlatina and measles, in both of which there is generally a stationary period as regards the spread and intensity of the eruption after the maximum has been attained.

The eruption is papular. If the hand is passed gently over it, a sense of roughness, at least, is perceptible, showing a certain degree of elevation above the surrounding skin. From this very slight condition of elevation differences are to be found up to a state in which the elevation is distinctly and at once visible—as much so as in a fully developed rash of measles. But, in some degree, elevation of the spots is always present, and therefore it is a mistake to describe the eruption as macular.

The size of the papules is one of the points in which there is considerable variation. In general they are smaller than the papules of measles, varying from the diameter of a pin's head to that of a pea. In a certain proportion of cases the spots are so small as to constitute mere punctation, and the skin presents the appearance of being covered with innumerable fine dots. They are of irregular shape, but with a more decided tendency to assume the circular form than is observed in the spots of measles. In a given case there is generally some uniformity in the matter of size—either the papules are for the most part of the larger size, or they are nearly all small. Still greater differences of size have been described, however, papules of one-third of an inch in diameter having not infrequently been encountered.

Generally the skin between the papules presents a perfectly healthy appearance, although careful investigation will occasionally reveal the existence of minute fine lines or processes connecting adjoining papules. A general erythematous redness of the skin has also been noticed. Confluence of the papules is very rare, though not uniformly absent.

Vesicles have been observed, but this has clearly been a coincidence, and not at all a part of the ordinary course of the eruption. They are probably found quite as often with measles, and in either case must be regarded as anomalous. The eruption has been observed to disappear suddenly, and after a short time to reappear; and unusual warmth, as from heavy clothing, renders it more distinctly visible. A certain amount of itching is often present, though not severe, and the heat and burning, which are a source of discomfort in scarlatina and measles, are not at all pronounced in Roetheln.

To sum up the characteristics of the eruption, we may make a division of the cases into two classes, which correspond with the descriptions formerly given of rubeoloid Roetheln on the one hand, and scarlatinoid on the other. In each variety the resemblance to the other disease, as far as the eruption is concerned, may be very close—often sufficiently so to render the diagnosis extremely uncertain, if the other points of history and symptomatology be not carefully considered.

In the first class of cases, comprising the greater number, the papules are of larger size, perhaps abundant enough to be considered confluent, of somewhat irregular shape, pale rose color, and raised considerably above the skin. It will be seen that this state of affairs can obtain with measles quite as well as with Roetheln.

In the second class the papules are smaller, more circular in shape, less elevated above the skin, of darker hue, much more numerous, and sometimes very closely aggregated, so as to give the punctated appearance alluded to. If this be the appearance, there may easily be nothing in the eruption by which to discriminate it from a scarlatinal rash at the onset or during the first day of the disease. A fully developed rash of scarlatina is continuous, leaving no skin normal in appearance between the eruptive spots; and in Roetheln the papules are distinctly separated from each other.

If, therefore, an extreme case of either variety be taken, it will be found that other points in symptomatology and history are requisite, and possibly a delay for one or two days may be necessary, in order definitely to eliminate doubt in the diagnosis.

Desquamation.—Desquamation is the mode, or perhaps a better term would be the accompaniment, of the termination of the eruption, beginning on the second or third day. It is furfuraceous in character, never occurring in large scales or pieces of skin as in scarlatina. It is fine, and in this resembles more the desquamation of measles. It is much less decided than in scarlatina, and is often so slight in amount as to be perceived only on very careful inspection, and frequently passes unnoticed by either the patient or the physician. Many writers on the subject do not make mention of the process, and frequently the statement is made that it is not a part of the clinical history of the disease. The writer cannot contradict this, though holding the view that it is present in some degree in all cases. As fading of the color of the eruption very quickly sets in, and is progressive until its final disappearance, the desquamation is the accompaniment of this.

The desquamation is not to be found affecting at one time the entire surface which has presented the eruption. It follows the appearance of the rash, and, consequently, is visible on one part of the surface before it is on another. Furthermore, it does not take place over the entire affected surface—much of the eruption fades away without desquamation, and the latter is to be searched for about the trunk, legs, and arms especially. The face and extremities usually escape. In this there is another point of resemblance to measles.

Following the customary division of the eruptive fevers into stages, we may consider the stage of desquamation, fading, or decline, to occupy the time from the second day of the eruption to the end of the disease. But it must be borne in mind that the line of division between these two stages, *i.e.*, of eruption and of desquamation, is much less distinctly marked than in scarlatina or measles.

Occasionally a faint staining or pigmentation has remained for several days after the disappearance of the rash proper.

Symptoms Other than the Eruption.—These have been in part considered under the head of premonitory symptoms, or those presenting themselves in the stage of invasion, and are, in great part, simple continuations of them. They are found, like those of scarlatina and measles, to have special reference to the mucous membranes of the nose, throat, and conjunctiva, together with more or less disturbance of the digestive functions. The inflammatory condition of the throat and tonsils, which is

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the most frequent of these symptoms, varies greatly in degree, and, beginning in the stage of invasion, persists up to the time when the rash has reached its height, and then subsides with the disappearance of the rash. Slight cough sometimes persists for a few days longer. The conjunctival irritation and the œdematous swelling of the eyelids are not often wanting, and follow much the same course as the throat symptoms.

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The nausea, which presents itself often enough to call for special mention, is generally noticeable only until the rash has developed.

The tongue is commonly coated, but does not at all present the appearance of the strawberry tongue of scarlatina. All these symptoms, when present at all, are of decidedly milder character than they are in scarlatina and measles.

The temperature range has been referred to as being liable to differences in epidemics and in individual cases. As a general rule, the rise is much less than that of the two other diseases. An elevation of from one to two degrees—to 99.5° or 100.5° F.—is what we may look for; it persists for about three days, and in the given case does not present the fluctuations characteristic of measles, but remains at the same level until its final subsidence.

The pulse and respirations are accelerated in proportion to the rise of temperature.

In general a severe case presents a greater variety of these symptoms, as well as a greater severity, and a mild case, absence, or nearly such, of them.

The single phenomenon, over and above the eruption, which is characteristic, and one might almost say pathognomonic, of Roetheln, is the enlargement of the post-cervical and suboccipital lymphatic glands. Probably in no case is it found wanting. This occurs at the onset of the disease, and therefore, as stated, may not infrequently be discovered before the appearance of the eruption. The number of glands affected varies from one or two up to seven or eight. Search should be made for them from the occiput down to the level of the shoulders, and toward the middle of the neck rather than at the sides or near the angle of the jaw. In scarlatina, diphtheria, and other throat affections, the glands which present enlargement are those at the angle of, as well as beneath, the lower jaw. In such instances the swelling seems to be proportionate to the severity of the throat inflammation, and to be associated with it, as in adenitis in the neighborhood of inflammation elsewhere in the body. But the adenitis of Roetheln cannot be so explained, as it is found equally in the cases with considerable sore throat, and in those with none. Therefore it should be regarded as a distinct phenomenon of the disease, and not as an accessory.

Associated with the enlargement is stiffness of the neck, and pain on moving the head, in some degree, though never very severe. The enlargement itself varies, the glands being of about the size of a split pea or bean; suppuration does not occur, and the swelling and pain subside with the disappearance of the eruption. Occasionally a single gland will remain perceptibly enlarged, though painless, for an indefinite length of time.

Valuable as this point is, there are yet sources of error, and glandular enlargement from other causes must be excluded.

The condition which we recognize as struma, indicating the general condition of ill health due to bad hygienic surroundings and malnutrition, has, as a prominent feature, general glandular enlargement, perceptible in the groins, axillæ, etc., as well as in the neck; and syphilis may present the same condition. Accordingly, search should be made in those other localities before assigning a cervical adenitis to an oncoming, or present, attack of Roetheln. Enlargement of the glands at the angle of the jaw is to be attributed to other causes. Children with eczema capitis have, almost always, large lymphatic glands in the neck.

During an epidemic of measles in 1886, the writer made investigation with special reference to this point, and found that in twenty-four out of twenty-nine cases an enlargement of glands exactly similar to that of Roetheln was present, and constituted a prominent feature of the cases. This was evidently a peculiarity of that epidemic, as the writer has neither before nor since found it to be the case, except in isolated instances. Griffith states that he has not infrequently found it. Care was taken to render the diagnosis of measles certain, and mention is made of this point here to show that the adenitis characteristic of Roetheln is not absolutely pathognomonic, and will not in itself suffice for differential diagnosis from measles.

Non-identity with Measles and Scarlatina.—The writer has, of necessity, made frequent mention of Roetheln as contrasted with scarlatina and measles, and the reasons for considering it to be an independent disease must now be considered. There are still some who consider it a hybrid, consisting of elements drawn from both those diseases, and being intermediate in character between them. This position is scarcely tenable, and is not supported by clinical facts; since the greater number of cases, though having points in common with both, present, each one, strong points of resemblance to one or the other of the two affections, and not to both at the same time. That is, any single case is either decidedly scarlatinoid or decidedly rubeoloid; and the differential diagnosis lies between two and not three diseases. Furthermore, hybrids are not at all common, and analogy is opposed to this view. Generally, what is called a hybrid can be resolved into its elements, and may be pronounced a conjunction of two or more diseased conditions. Undoubtedly scarlatina and measles may be found coexisting in the same individual, or following each other so closely as to overlap, the inmates of a household being exposed to and contracting both diseases at the same time, or in rapid succession. These cases, however, present the phenomena of both diseases in such a manner and degree as to exclude uncertainty in the diagnosis, and they bear no closer resemblance to Roetheln than does any single well-pronounced case of either disease.

The question of its identity with one or the other of these diseases calls for more careful consideration.

There are but few who believe Roetheln to be identical with scarlatina, but many consider it of the same nature as measles. In a scarlatinoid case the principal points in common are: the short period of invasion, the existence of some sore throat, and the fine punctate appearance of the rash at first. Roetheln is liable to be confounded only with a very mild case of scarlatina; for the vomiting, high fever, pronounced sore throat, and characteristic tongue of average scarlatina are not encountered in the former disease. The points of difference are most prominent in the longer duration of the eruption in scarlatina, its greater uniformity, its macular character, the nature of the desquamation, and the presence of sequelæ which do not occur in Roetheln. In addition to which the adenitis of Roetheln is not to be found in the other disease.

As to measles, the similarity also exists in a certain proportion of cases of mild character. The symptoms which may be common to both are the rose color and papular character of the rash, the shorter duration of the period of eruption, the fine desquamation, and possibly the adenitis. The main point of difference is the presence, in measles, of two or three days of fever, with catarrhal inflammation of the respiratory mucous membranes, uniformly preceding the eruption. The sequelæ of measles, also, are not to be expected in Roetheln.

As stated, these resemblances are encountered only in extreme cases. Average cases of each disease have special characteristics sufficient to clear away doubt; and the differences just enumerated go far toward proving non-identity in either direction. But the strongest reason for believing in the individual nature of Roetheln—constituting, indeed, a conclusive proof—is that no mutual protection is afforded. That both scarlatina and measles are, if the expression be allowed, autoprophylactic has been proven by thousands of observations. Second attacks of scarlatina are so rare as to be curiosities in the history of medicine; and with measles, although the

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rule is not so free from exception, yet a second attack is a very infrequent occurrence. This rule applies to Roetheln. As yet there are few, if any, authentic records of second attacks. But when the question of mutual protection, which would be a *sine qua non* to the supposition of identity, is considered, the most conclusive evidence of its absence is www.libtool.com.cn

Of J. Lewis Smith's 48 cases, 19 had had measles, and 1 contracted the disease subsequently. Of Shuttleworth's 30 cases, more than half had had measles, and 4 scarlatina. In one case the patient had measles five months, and scarlatina one month, before. In 13 of the cases, in which subsequent observation was possible, 7 contracted measles and 6 scarlatina after the lapse of a few years. Goodhart observed that 39 out of 63 cases had had measles.

Instances might be multiplied to a very large number, but it is unnecessary; for the non-existence of mutual protection is too well established to admit of doubt. There is, however, another aspect of this question, or, rather, another explanation of the facts, which has been presented with considerable appearance of probability. It is that Roetheln is simply the modification of measles presented in second attacks, bearing the same relative position that varioloid does to smallpox. There are two reasons for regarding this position as untenable. The first is, that pronounced attacks of true measles have, in a large number of instances, followed, and not preceded, Roetheln, and these cases have presented no modification in kind or severity of the symptoms which go to make up the clinical history of measles. This applies with equal force to scarlatina. The second reason is, that in the individuals who have been the subjects of second attacks of measles, the symptoms have been as uniform and pronounced as in the first.

On the contrary, a much closer analogy can be traced between smallpox and varicella on the one hand, and measles and Roetheln on the other. The ratio is much the same in regard to corresponding severity, and in similarity of appearance of the eruption.

The final separation, in the minds of medical men, of the former pair from each other was beset by the same uncertainties as that of the latter.

Another fact of significance is that Roetheln occurs in epidemics, when neither scarlatina nor measles is prevailing; and, in the same epidemic, most of the cases will be rubeoloid, and a smaller number scarlatinoid.

Text book descriptions of measles commonly refer to a variety of the disease under the designation of "rubeola sine catarrho," this name indicating a condition in which there is fever, with an eruption similar to that of ordinary measles, and at the same time absence of the inflammation of the respiratory apparatus. Perhaps it is fair to regard these as cases of Roetheln; and a significant observation made by Watson, in his "Practice of Medicine," gives support to this view. He says: "It is observed that rubeola sine catarrho confers no protection against recurrence—is commonly succeeded by an attack of measles in its true form." Meigs and Pepper make the same observation as to their experience.

To summarize, the points demonstrating the non-identity of Roetheln with measles or scarlatina are:

1. The difference in clinical history.
2. Absence of mutual protection.
3. Absence of modification in second attacks of those two diseases.
4. Occurrence of epidemics while the other two are not prevailing.
5. In any epidemic, resemblance of some of the cases to one, and of some to the other, of the two diseases.

A further differentiation of the two varieties into two distinct diseases is possible; but it would be a refinement almost beyond our present powers of observation.

DIAGNOSIS.—The diagnosis is principally made by process of exclusion, because, at the outset, the presence of scarlatina or measles is generally suspected. From scarlatina at the outset, or in the first day or two of sickness, in certain mild cases, the points of difference are: In Roetheln, the absence of, or presence in a milder degree, of sore throat; the absence of the strawberry tongue, and the existence of a whitish coating if any change be present; the absence of continuity of the eruption; and the presence of post-cervical adenitis, the glands at the angle of the jaw being unaffected. After the lapse of two or three days the course of the eruption in Roetheln is to reach its maximum and begin to disappear quickly, and the desquamation, when perceptible, is fine, and not in flakes or patches of some size.

Pronounced cases of scarlatina do not resemble Roetheln sufficiently to render the diagnosis uncertain.

From measles the discrimination is to be based mainly on the absence of the stage of fever with catarrh preceding the eruption, or its very mild character and shorter duration. The cervical adenitis has much weight, though it is not absolutely conclusive. Though the rash may very closely resemble that of measles, yet the papules are less elevated, smaller, less aggregated, less decidedly rose-colored, and run their course more quickly—desquamation setting in two or three days before it would be likely to occur in measles.

Subjoined is a comparative table of these three diseases in their different stages, giving also the average duration of each stage:

ROETHELN.	SCARLATINA.	MEASLES.
	Stage I.—Incubation.	
Duration, six to twenty-one days.	Two to fourteen days.	Twelve to fifteen days.
Inconstant.	....	Constant.
	Stage II.—Invasion.	
One day or less.	Less than one day.	Two to four days.
Often absent.	Never absent.	Never absent.
Malaise, slight.	Vomiting.	
Sore throat and lachrymation.	Decided sore throat.	Drowsiness, cough, coryza, conjunctivitis, photophobia.
Cervical adenitis.		
Temperature, 99°-100°	Temperature, 103° +.	Temperature, 102° +.
	Stage III.—Eruption.	
Three days.	Six to eight days.	Four to five days.
Begins on face or chest.	Begins on chest.	Begins on face.
Papular, slightly.	Macular.	Papular, decidedly.
Pale rose, or darker and brownish.	Deep-red scarlet.	Rose.
Not continuous.	Continuous.	Not continuous.
Ceases spreading in one or two days.	Ceases spreading in three or four days.	Ceases spreading in two or three days.
No stationary period.	Stationary period of two to three days.	Stationary period of two to three days.
Burning or itching, slight.	Burning, often great.	Burning and itching, decided.
	Stage IV. Desquamation.	
Very slight and fine.	In scales of quite large size.	Furfuraceous, and often not pronounced.
Overlaps stage of eruption.	Preceded by stationary period.	Preceded by stationary period.
Last two or three days.	Lasts ten days, and sometimes longer.	Lasts about four days.
		Leaves dull-colored stains.
	Complications.	
	Acute form of Bright's disease.	Bronchitis.
None characteristic.	Rheumatism.	Pneumonia.
	Otorrhœa, and necrosis of temporal bone.	Tuberculosis.
		Inflammation of the intestines.

In addition to these other exanthemata, certain simple skin diseases must be considered in the diagnosis. Sometimes the eruption of miliaria papulosa (prickly heat) resembles that of Roetheln; but it occurs in well-defined patches of several inches in diameter, is associated with unusual sweating, and lasts many days longer. Also, there are no febrile and constitutional symptoms accompanying miliaria, and the itching is usually great.

The most careful investigation possible into the origin or sources of contagion should be made; and in cases of

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doubt a positive diagnosis should be withheld for one or two days. It may be advisable to explain the uncertainties, and to adopt the precautions as to isolation, etc., necessary in scarlatina.

Complications.—Complications or sequelæ characteristic of the disease do not exist. A condition of transient albuminuria is spoken of, but it is not indicative of renal disease. After the rash disappears we may expect to find the usual condition of health present. The prognosis is therefore good.

Treatment.—Because of the mildness of the disease there is generally nothing called for in the matter of medication—simple restriction of diet and avoidance of exposure during the continuance of the elevated temperature being all that is necessary. Practically the interest and importance attaching to Roetheln lie in recognizing it as a separate disease, and in the exclusion of the more serious affections, scarlatina and measles.

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Thomas D. Swift.

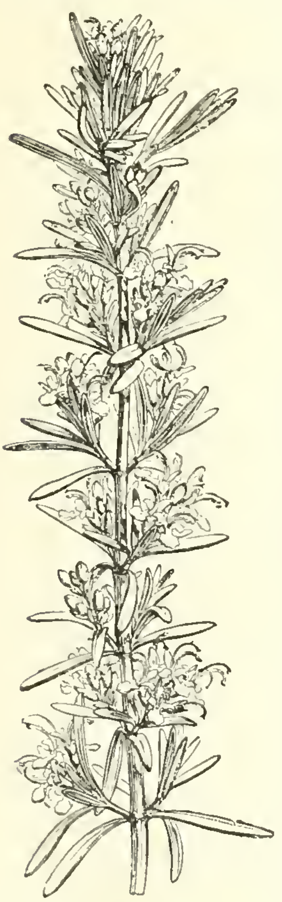

Fig. 4137.—Rosmarinus Officinalis: flowering branch. (Baillon.)

ROSEMARY.—*Roris marini.* (*Rosmarinus*, U. S. P. 1880.) The dried leaves of *Rosmarinus officinalis* L. Fam. *Labiatæ.*

These leaves are obtained from a small, slender, evergreen, blue-flowered shrub, native of the Mediterranean region, and somewhat cultivated for medicinal purposes and as a decorative shrub. The flowering twigs are also sometimes employed. The leaves are about 2.5 cm. (1 in.) long, oblong, but so strongly recurved at the edges as to appear linear in the dried condition, obtuse at both ends, destitute of a petiole, entire, coriaceous, dark-green with a slight bluish cast above, and grayish-green and densely woolly and glandular underneath. The odor is characteristic and somewhat camphoraceous, the taste aromatic, pungent, and somewhat terebinthinate. Although the use of the drug has now largely been superseded by that of its one or two per cent. of volatile oil, the action is not quite the same in both of them, since the drug itself also contains considerable tannin and resin and a little bitter substance. The latter, therefore, is a useful aromatic bitter and tonic. The fresh decoction, or the fluid extract, applied to unhealthy wounds, is a good vulnerary, though somewhat irritating unless carefully employed. The dose of rosemary is 0.5–1 gm. (gr. vij.–xv.)

Oil of Rosemary (*Oleum Rosmarini*, U. S. P.) presents the appearance of a colorless or at most a pale yellow fluid, has a specific gravity of from 0.895 to 0.915, is freely soluble in alcohol, and possesses the characteristic odor of the drug and a similar and somewhat camphoraceous taste. It contains cineol, borneol, and camphor, with other less important substances. It possesses all the activity of the drug, but in an intensified degree. It is often given internally as a carminative and general intestinal stimulant, though its use has greatly declined. The dose is from one to five minims. It enters into the compound tincture of lavender. Owing to its actively local stimulant or irritant properties, it is considerably used as a local application for promoting the nutrition of the skin and also as a vulnerary. *Henry H. Rusby.*

ROSEOLA.—Roseola is often incorrectly used as synonymous with rubella or Roetheln. Unquestionably many efflorescences which have been called roseola are in fact the efflorescences of rubella, and the reverse is quite true, that many of the reported cases of rubella are nothing more nor less than roseola. When properly used, the word roseola should simply indicate a rose-colored rash, a form of erythema, and should not be spoken of as a specific disease.

A roseolous efflorescence may often precede the appearance of the exanthemata of rubella, scarlet fever, measles, variola, and vaccinia, but should not be confounded with the specific efflorescences which are characteristic of these affections, and which usually occur later in the course of the disease. A roseolous rash may also occur in other conditions such as cholera, typhoid, diphtheria, and malaria—in fact, in almost any condition which gives rise to fever. If the word is to be used at all, one should designate the disease accompanying it, as, for instance, "roseola syphilitica," "roseola vaccinia," "roseola febrilis," "roseola typhosa," etc., but the tendency is to drop the term entirely from medical nomenclature.

Whereas the roseolous erythema may closely resemble the efflorescence of rubella, measles, or scarlet fever, it has the following points of distinction: It is neither contagious nor epidemic; there are no characteristic prodromal symptoms; it is not confined to any special portion of the body; there is either no fever at all, or, if the fever be present, it does not run a characteristic course; it may last a few hours, or it may disappear after a few days without desquamation; the erythematous areas are not so crescentic as in measles nor so punctiform as in scarlet fever.

A roseolous rash is very common in infants and in children as a result of dentition, gastric or intestinal disturbances, or in connection with the many febriculæ seen in early life, for which no sufficient cause can be found. Again, it may occur in infants who are in perfect health, and in whom nothing else abnormal may be detected. It is in these special cases that the term "roseola infantilis" has been used. *Maynard Ladd.*

ROSES.—The genus *Rosa* L. (fam. *Rosaceæ*) comprises upward of a hundred species of prickly shrubs. Although of little medicinal value, strictly speaking, these species contribute several articles possessing important uses in flavoring, perfuming, and coloring and exerting a mild stimulant, antispasmodic or tonic action. Three of these articles are official, as follows:

Rosa Gallica or *Red Rose*, "the petals of *Rosa Gallica* L., collected before expanding."

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Rosa Centifolia, White Rose, Pale Rose, or *Hundred-leaved Rose*, "the petals of *Rosa centifolia* L."

Oleum Rosæ, Oil of Rose, Otto or *Attar of Rose*, "a volatile oil distilled from the fresh flowers of *Rosa Damascena* Miller."

Although the red rose plant is native in Europe and adjacent Asia, the official product is obtained wholly from cultivated plants, chiefly in Southern and Central Europe, especially in France. The peculiar structure of the flower renders it quite an easy matter to collect the cones of unexpanded petals. The calyx lobes, having spread backward before the opening of this cone, a sharp knife is drawn about the base of the latter, which is then lifted off, leaving the stamens still attached to the rim of the calyx tube. The cones are then very carefully dried in the shade, or they may be packed in salt. In the finest grades they mostly cohere in the cone, though loose petals may also be of fine quality. They should preserve a deep purple-red color and a fine velvety surface, as well as a strong and fine rose odor. The taste is bitterish, astringent, and very slightly acrid. The individual petals have a roundish outline, a notched summit, and a very short, broad, yellowish-white basal claw. Fragrant as they are, the amount of volatile oil in them is minute. The important constituent is a beautiful bright red, readily soluble coloring matter. Mildly astringent properties are imparted by a small amount of gallic acid. Small amounts of fat and quercitrin also exist. Red rose is practically inactive, though a sentimental effect is often gained by administering it in mild cases of hysteria. The Pharmacopœia provides a fluid extract, made with diluted alcohol and 10 per cent. of glycerin, and a confection consisting of 8 per cent. of the No. 60 powder, 64 per cent. of sugar, 12 per cent. of clarified honey, and 16 per cent. of stronger rose water. There is an official 12.5 per cent. syrup of the fluid extract. Red rose also enters into the pills of aloes and mastiche. There is, of course, no particular dose.

White rose is native of Western Asia, and is believed by some to be a mere variety of the red. Its constituents are identical with those of red rose except that the amount of coloring matter is extremely small. The use of this drug is therefore restricted almost wholly to flavoring. It is likely to be dropped from the next edition of the Pharmacopœia.

Rosa Damascena, the Damascus rose, is cultivated for the production of rose oil, chiefly in Bulgaria. This oil, being then exported and repacked in other countries, becomes the chief source of the various commercial brands bearing other geographical names, although a moderate amount of this product is actually distilled from roses grown in other countries. The oil is simply distilled with water. The following is the official description:

"A pale yellowish, transparent liquid, having the strong, fragrant odor of rose, and a mild, slightly sweetish taste.

"Specific gravity: 0.865 to 0.880 at 20° C. (68° F.).

"It is but slightly soluble in alcohol, and neutral to litmus paper moistened with alcohol.

"The congealing and melting points of the oil are subject to some variation, depending upon the amount of stearopten, but, when slowly cooled to a temperature usually between 16° and 21° C. (60.8° and 69.8° F.), it becomes a transparent solid, interspersed with numerous slender, shining, iridescent, scale-like crystals. Upon the application of the heat of the hand, the crystals should float in the upper portion of the liquefied oil.

"If to five drops of the oil, contained in a test tube, five drops of concentrated sulphuric acid be added, a reddish-brown, thick mixture will be produced, but no white fumes or tarry odor should be developed, and the fragrant odor of the oil should not be destroyed. If this mixture be then shaken with 2 c.c. of alcohol, the resulting liquid may be turbid, but should be nearly colorless, and should not at once assume a red or reddish-brown color (absence of *oil of ginger-grass* or *Turkish oil of geranium*, from *Andropogon Schœnanthus* L. [Fam. *Gramineæ*], and of oil of *rose geranium*, from *Pelargonium Radula* [Cavanilles] Aiton, *Pelargonium capitatum* Aiton, and *Pelargonium odoratissimum* [L.] Aiton; Fam. *Geraniaceæ*)."

The important odorous constituent of rose oil is geraniol, long regarded as a distinct substance under the name "rhodinol." There is also a small quantity of citronellol. Various derivatives of these also occur.

Although rose oil undoubtedly has antispasmodic and stimulant properties, practically its entire use is for perfuming and flavoring.

Official *rose water* may be regarded as indirectly a preparation of rose oil, although not prepared from that substance. It is recognized under two titles, namely, *Aqua Rosæ*, or *Rose Water*, and *Aqua Rosæ Fortior*, or *Stronger Rose Water*. The latter is the water, saturated with the oil, obtained as a by-product in the distillation of rose oil. The former is made by mixing, immediately when required for use, equal volumes of the stronger rose water and distilled water. From stronger rose water is prepared the *Ointment of Rose Water* or *Cold Cream* (*Unguentum Aquæ Rosæ*, U. S. P.), made with 12.5 per cent. of spermaceti, 12 per cent. of white wax, 60 per cent. of expressed oil of almond, 19 per cent. of stronger rose water, and 0.5 of 1 per cent. of sodium borate, these figures being approximate, since part of them respond to weights, part to measures.

In addition to the above official products, there is used in Europe, and there to only a very slight extent, a confection made from the fruits of *Rosa canina* L., the *dog rose*. This fruit contains only sugar, malic and tannic acids, and their compounds, and is a very inferior preparation.

Rosaceæ.—This great family includes several subfamilies regarded by many botanists as themselves entitled to family rank (*Pomaceæ*, the apple family; *Drupaceæ*, the prune family, etc.). Thus considered, it is doubtless the most important fruit-producing family, yielding raspberries, blackberries, strawberries, plums, peaches, cherries, and similar stone fruits, the apple, pear, quince, medlar, etc. From a medicinal point of view, the family is of considerable importance, yielding the almonds, wild cherry, North American ipecac, koosso, prune, quillaja, blackberry bark and the roses, all elsewhere considered, besides a number of minor drugs, several of which are considered below.

Raspberry, or *Rubus Idæus*, U. S. P., is the fruit of *Rubus Idæus* L., the cultivated red raspberry of European nativity. The Pharmacopœia provides that the American wild red raspberry (*R. strigosus* Mx.) or the black cap (*R. occidentalis* L.) may be employed in the absence of *R. Idæus*. This fruit contains only sugar, fruit acids, and their salts, like others of its class, and its medicinal properties are merely those of a mild laxative, refrigerant, and antiscorbutic. Its fine flavor and beautiful red color make it a very useful adjuvant or vehicle, and an official syrup of the fresh fruit is provided for this purpose. Although not official, a similar syrup made of strawberries is in common use.

Astringent Drugs.—Probably the most common and important property of the drugs of the rose family is their astringency, due to the presence in them of considerable quantities of tannin. In such products as the leaves of the blackberry, raspberry, and strawberry, this tannin is accompanied by appreciable quantities of gum, thus favorably modifying the action, and these are very largely employed as domestic astringents. *Tormentilla*, the rhizome of *Potentilla Tormentilla* L., as well as the rhizomes of other species of *Potentilla*, contains about the same amount of tannin as geranium, and is similarly employed. The same is true of *Sanguisorba* and of various species of *Acæna*, and of the root and bark of several species of *Spiræa*, *Hardhack*, or *Steeple Bush*, the leaves being also employed like those of the strawberry and raspberry. Under the names *Meadow Sweet*, *Queen of the Meadow*, and *Ulmaria*, the leaves of *Spiræa Ulmaria* L. are also employed in the same way.

Henry H. Rusby.

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ROSSCOMMON SPRING.—Monroe County, Pennsylvania.

Post-Office.—Wind Gap. Hotel.

Access.—From Philadelphia viâ Reading Railroad; from New York viâ Central Railroad of New Jersey. The Rosscommon depot is only a few hundred feet from the hotel.

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The summer resort known as Rosscommon is situated in the Wind Gap of the Blue Ridge Mountains, on the north incline of the range, one thousand feet above tide water. The location is fifteen miles west of the Delaware Water Gap, twelve miles from Stroudsburg, and fifteen miles from Easton. The hotel, known as the Rosscommon Inn, is situated on a handsome plateau, half a mile square, and surrounded by forests. The neighborhood is entirely free from malaria and mosquitoes, and a fine breeze prevails almost constantly; hence the name Wind Gap. The accommodations at the inn are plain and unpretentious, but very comfortable and home-like. The spring, discovered a few years ago, adds considerably to the attractions of the place. The water flows from a fissure in the rock at the bottom of the spring, and constantly discharges a large volume of carbonic acid gas. It was analyzed in 1887 by Prof. William H. Chandler, of the Lehigh University, with the following result:

Neutral (lightly carbonated). One United States gallon contains: Sodium chloride, gr. 0.08; sodium sulphate, gr. 0.09; potassium sulphate, gr. 0.05; magnesium sulphate, gr. 0.02; calcium carbonate, gr. 0.39; magnesium carbonate, gr. 0.10; silica, gr. 0.47; iron carbonate, a trace. Total solids, gr. 1.20. Carbonic-acid gas (free and partially free), 1.42 cubic inches.

This analysis does not present a mineral water in the strict acceptation of the term. It is probable that very few common potable waters would show so light a mineralization: yet it is entirely free from organic matter, and has sufficient gas to give it a bright sparkle and to render it very palatable. The water is bottled and sold.

James K. Crook.

ROYAL GORGE HOT SPRINGS.—Fremont County, Colorado.

Post-Office.—Canyon City. Hotel.

Access.—From Denver viâ Denver and Rio Grande Railroad. Canyon City is also the western terminus of the Arkansas Valley branch of the Atchison, Topeka, and Santa Fé Railroad.

The town of Canyon City, with a population of thirty-five hundred inhabitants, is rapidly becoming a charming city of healthful and comfortable homes. It is the county seat of Fremont County, and is situated on the north and south banks of the Arkansas River, one hundred and sixty miles south by west of Denver, and one hundred miles below Leadville. The scenery about the place is grand and romantic to a high degree. A walk of a few minutes takes the tourist to the famous Royal Gorge, where the granite cliffs tower 2,000 feet above the head. The altitude of the springs is 5,200 feet above the sea-level. The location is protected by the mountains on three sides, and the report of the United State Meteorological Bureau shows that for any given month in winter the temperature on an average is six degrees warmer than at any other point in the State. The rainfall is only fourteen inches per annum, and it is said that there are over three hundred sunny days in every year. The capacity of the hot springs is difficult to estimate, as they break out into the Arkansas River in several places. One of them, which issues from the earth a little above low water, yields fifteen gallons per minute, but the combined flow of the springs would be many times greater. Within half a mile of the hot springs are cold soda and iron springs. Excellent bathing facilities have recently been provided at the hot springs. The following analyses are by Prof. Oscar Loew, of the United States Geological Survey. That of the Royal Gorge Hot Springs shows that one United States gallon contains: Sodium carbonate, gr. 73.20; magnesium carbonate, gr. 12.80; calcium carbonate, gr. 33.50; sodium sulphate, gr. 79.30; sodium chloride, gr. 18.20; lithium chloride, a trace. Total, 217 grains. Temperature of water, 102° F.

The analyses of the Royal Gorge Cold Soda and Iron Springs show that one United States gallon contains:

Solids.	Iron Duke. Grains.	Little Ute. Grains.
Sodium chloride	83.00	118.00
Sodium sulphate	12.20	12.10
Sodium carbonate	76.80	76.40
Calcium carbonate	33.00	22.50
Magnesium carbonate	14.60	14.00
Iron	Traces.	Traces.
Lithia	Traces.	Traces.
Total	219.60	243.00

The waters of both cold and hot springs are highly charged with carbonic acid gas. The hot baths here are strongly recommended for rheumatism and skin diseases. Dr. Prentiss, of Canyon City, informs us that persons suffering from pulmonary trouble are usually much improved by a sojourn in the sunny, even climate of this region.

James K. Crook.

ROYAT-LES-BAINS, FRANCE.—This well-known French spa is situated in the centre of France, being one of a group of mineral-spring resorts in this region of the Auvergne Mountains. Not far distant are Mont Dore, La Bourboule, Chatel Guyon, Vichy, and others.

Royat, a small town of 1,528 inhabitants, is beautifully situated in a narrow valley watered by the Tiretaine, and surrounded by the lower Auvergne Mountains. All the surrounding country is charming, and there are many most attractive excursions, particularly to the Puy de Dôme, where an extensive and grand view is obtained. This resort has been called the "Ems" of France, but in climate, picturesqueness, and charm of situation it is far superior to the German spa.

The climate exhibits the characteristics of a mountain climate of moderate elevation, the altitude being 1,475 feet. There are sudden transitions of temperature; sudden storms of wind and rain with thunder; a dry atmosphere; and brilliant sunshine. The soil is volcanic, and the dust from such a soil is abundant and blown about in clouds by the wind. The peculiar situation of Royat itself, as Yeo says ("Health Resorts," J. Burney Yeo), also modifies the climate. "Lying as it does in the floor of a somewhat narrow valley, surrounded on all sides by mountains, and open only to the east, running, moreover, in a direction east and west, and facing the east, it is particularly exposed to the direct heat of the sun." "It is therefore," continues Yeo, exceedingly difficult to find any kind of shady walks in the immediate vicinity of Royat when the sun is up and the sky is cloudless." Therapeutically the climate is invigorating and refreshing.

The waters are what are known as "warm muriated alkaline," containing bicarbonates of soda, potash, lime, and magnesia, together with chloride of sodium and a small amount of lithia. Arsenic in very minute quantity is also found in these waters, as are also the salts of iron and manganese. All the springs are rich in free carbonic acid gas. The natural temperature of the water is from 68° to 95° F. In this country the Healing Springs of Virginia and the Hot Springs of North Carolina are somewhat similar in their composition and uses. There are four principal sources: the Eugénie, St. Mart, Cæsar, and St. Victor. The Eugénie is the warmest (95.9° F.), and is the most highly mineralized. The St. Victor contains the most iron and arsenic. These springs together furnish 1,522,000 litres of water a day. The water is clear and transparent, and has no odor.

The waters of Royat are employed for drinking, bathing, gargling, and inhalation. The bathing establishment is complete, and said to be one of the finest in France. A specialty of this spa is the running water bath, where the water is led directly from its source and at its natural temperature into the bathtub, and con-

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stantly flows in and out. There are arrangements for douches with massage attached to each bath, and also independent apparatus for douches of various forms. There are inhalation rooms; facilities for gargling, irrigation, and pulverization; baths and douches of water charged with carbonic acid gas; hydro-electric baths; a large public swimming bath; and a gymnasium.

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The chief drinking fountain is from the Eugénie Spring, and is situated in a pleasant park. The water is very agreeable to drink. There are two casinos with music, concerts, balls, and theatrical performances. "The excursions," says Yeo (*loc. cit.*), "are numerous, varied, and interesting; for no more remarkable country to the geologist, the naturalist, and the archæologist can be found than this great mountainous district of extinct volcanoes, old mediæval towns, historic churches, and Roman and even earlier remains."

The accommodations are abundant, good, and of reasonable price. Although open throughout the year, the season is from the 15th of May to the 15th of October.

Royat is about nine hours distant from Paris viâ Clermont-Ferrand, which is fifteen minutes distant from Royat.

The disorders for which these waters are of value are chiefly arthritic and anæmic affections. Rheumatism; gout associated with anæmia; skin diseases, such as eczema, acne, and pityriasis; chronic laryngitis and bronchitis; bronchial asthma; neuralgia; sciatica; atonic dyspepsia; various uterine affections; gouty glycosuria; biliary and renal lithiasis; neurasthenia; and various forms of anæmia are all treated here. The contraindications are organic cardiac affections, a tendency to hemorrhage, organic affections of the central nervous system, scrofula, and other tuberculous affections.

For the after-treatment the seaside for a short time is recommended, except in joint and bronchial affections, for which a winter in the south of France is preferred.

Not far from Royat is Durtol, 1,705 feet high, where is a sanatorium, opened in 1898.

For a further consideration of this resort, as well as others in France, the reader is referred to "Stations Hydro-Minérales, Climatériques, et Maritimes de la France," Paris, 1900. *Edward O. Otis.*

RUBBER.—*Elastica*, U. S. P. *Caoutchouc*, Fr. Cod.; *India rubber*, *Gum elastic*, etc. The concrete milk juice of several species of *Hevea*, Aubl. (fam. *Euphorbiaceæ*), known in commerce as *Para rubber*.

From a commercial standpoint, the substance bearing the above names is derived from a large number of milky-juiced plants, growing in the tropics of both the Old and the New World, these plants belonging to many and distantly related families, but more especially, in the order named, to the *Euphorbiaceæ*, *Urticaceæ*, *Apocynaceæ*, and *Asclepiadaceæ*. Besides these, which yield rubber on a commercial scale, the substance caoutchouc occurs in small amounts in a very large number of milk juices.

The rubbers from these different botanical sources naturally differ widely in appearance and quality. Some of them—perhaps more because of the manner in which the milk juices are treated than because of natural differences in the latter, they being often mixed with ashes, soap, and other substances, and allowed to ferment in holes in the ground—are quite unfit for official use. Others, though clean, and not, strictly speaking, objectionable, are inferior from the standpoint of deficiency in their useful properties. Para rubber has been selected for official purposes because of its cleanliness, purity as caoutchouc, high elasticity, durability, and ready solubility in appropriate liquids.

Origin.—The plants yielding Para rubber are large trees, frequently exceeding a hundred feet in height and five or six feet in diameter, growing in the valleys of the Amazon and its tributaries. The basin of the Madeira and its tributaries produces the largest amount. Though mostly exported viâ Para, whence the name, much of the same grade comes out through the west coast of South America. The milk juice is obtained by gently tapping the outer and middle bark layers with a sharp pick and catching the exudation in small cups attached to the trees. The milk is then gathered and carried to the smoking stations, where it is coagulated in successive layers upon a flat wooden paddle, by being held in the smoke of smothered fires, special articles being preferred for this fuel. When a suitable quantity has been gathered upon the paddle, an incision is made at the upper end of the mass, called a *bolacho* or "bottle," to permit of its being slipped off from the end of the paddle. It then possesses a flat form, a whitish color, and smooth surface, and may weigh from a few up to seventy-five pounds, or even more. The product of the upper tributaries is usually in bolachos of about twenty-five pounds, the larger bolachos coming mostly from the lower Madeira. The rubber soon begins to turn yellow, then brown, and ultimately black, first upon the surface and then gradually toward the interior, the complete process of darkening requiring several years. At the same time it loses water, and of course weight. It may be exported in the original bolachos, but owing to the danger of adulterants in the form of sand, stones, etc., it is now mostly cut into small pieces in Para.

Description.—The following is the official description of elastica:

In cakes, balls, or hollow, bottle-shaped pieces, externally brown to brownish-black, internally brownish or of lighter tint; very elastic; insoluble in water, diluted acids, or diluted solutions of alkalies; soluble in chloroform, carbon disulphide, oil of turpentine, benzin, and benzol. When heated to about 125° C. (257° F.) it melts, remaining soft and adhesive after cooling. Odor faint, peculiar; nearly tasteless.

Composition.—The percentage of caoutchouc in india rubber varies with the amount of water which the substance has lost. In its original liquid condition there is said to be about thirty-two per cent. of this hydrocarbon ($C_{20}H_{32}$). With caoutchouc exist a little wax, a free acid, and some proteid matter. There is a little free carbon, which results from the smoking process.

Properties and Uses.—On continued exposure to the atmosphere, rubber undergoes changes which render it brittle and weak, and this may be prevented by keeping it under water, which preserves it by inducing superficial fatty changes. *Vulcanized rubber* is produced by combining the original rubber with sulphur, under the influence of heat, by various processes. It still retains its elasticity, but becomes harder and is no longer soluble in the same liquids as before. *Hard rubber* or *ebonite* may be obtained by combining rubber with various other substances than sulphur.

Strictly speaking, rubber has no medicinal properties, since it is insoluble in all the fluids of the body. The original milk, being drunk by mistake, has invariably coagulated into an insoluble mass in the stomach, the result being fatal in the absence of surgical treatment. Its uses are wholly mechanical. The most important is as a mass for plasters. Such a mass possesses very good qualities, although experiments seem to indicate that the effect of the incorporated medicinal substance is somewhat less than when combined with the official plaster mass. Rubber mass adhesive plasters for surgical dressings, Esmarch's and other elastic bandages and wrappings, orthopedic appliances, nipples, syringes (hard and soft), pessaries, artificial teeth, specula, catheters, etc., represent important uses of rubber, which require only enumeration. Articles of rubber, either hard or soft, should be kept in a closed box or drawer, and occasionally used or washed to prevent their becoming too dry and brittle. Silver instruments should never be kept in the same enclosure with them. Soft rubber is spoiled after a short time by oils and fats, and eventually hardens in spite of precautions.

By dissolving rubber in appropriate liquids, with or without the addition of other adhesives, various forms of cement or glue can be obtained, and impervious coverings can be produced by applying such substances and permitting evaporation. *Henry H. Rusby.*

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RUBELLA. See *Roetheln.*

RUBIDIUM AND AMMONIUM BROMIDE.—A double salt having the chemical formula $RbBr.3NH_4Br$. It is a white or yellowish-white crystalline powder, soluble in water, and possessed of a cooling and saline taste.

This salt has been proposed as a more suitable means of administering bromine than the ordinary ammonium, potassium, or sodium salts. Laufenauer (*Therap. Monatsch.*, August, 1889), reasoning from the fact that lithium bromide is more powerful than ammonium bromide, the sodium salt more so than the lithium, and the potassium salt still more powerful, was led to believe that the more strongly electro-positive the salt, and the higher its atomic weight, the greater its power in disease. As rubidium is powerfully electro-positive and has a high atomic weight, the bromide of rubidium and ammonium was prepared, and in a series of experiments was found to prove more satisfactory than the other bromides in epilepsy and other conditions in which bromides are indicated.

Further use of the drug has proved its efficacy, but has not shown any decided advantage over other bromides. It, however, has not the depressing effects of the potassium salts, and may be given where the more common compound has to be discontinued. As an anti-epileptic remedy, it is given in doses of sixty to ninety grains in divided portions. As a hypnotic and sedative, sixty grains may be given in a single dose.

Rubidium bromide and *rubidium iodide* have also been prepared, but their therapeutic value has not been established. *Beaumont Small.*

RUBINAT MINERAL SPRINGS.—Province of Lerida, Spain. These springs, which supply the well-known waters of the Rubinat group, are located at a high elevation in the Pyrenees, near the village of Rubinat. We are informed that some of the springs have been known from time immemorial, and were resorted to in the Middle Ages by pilgrims from all over the kingdom. In recent years the waters have come into commercial use, and those of some of the springs are exported in large quantities to the American markets. Among the better known waters of the group are the Rubinat-Condal, Rubinat-Serre, and Rubinat-Llorach, all of which are extensively sold in the United States. Following are analyses of the first two:

Rubinat Condal.—One United States gallon contains:* Sodium sulphate, gr. 5,407.34; potassium sulphate, gr. 13.22; magnesium sulphate, gr. 183.97; calcium sulphate, gr. 109.44; sodium chloride, gr. 115.94; silica, alumina, ferric oxide, gr. 2.08; loss, gr. 0.98. Total, 5,832.97 grains.

Rubinat Serre.—One United States gallon contains:* Sodium sulphate, gr. 4,695.97; magnesium sulphate, gr. 135.54; calcium sulphate, gr. 79.57; calcium bicarbonate, gr. 29.40; sodium chloride, gr. 262.23; potassium silicate, gr. 36.83. Total, 5,239.54 grains.

These analyses show very potent waters of the sulphated saline group. They owe their purgative properties chiefly to the presence of the sulphate of sodium in large quantities, although both contain considerable sulphate of magnesia. They act as very efficient saline cathartics and are indicated in conditions where such remedies are useful. The dose varies from one to eight or nine ounces, according to the indications, and the water is best taken in the morning, on rising. According to the author's observation these waters are not so likely to cause griping as are some of the stronger bitter waters. *James K. Crook.*

RUE.—*Ruta.*—The leaves of *Ruta graveolens* L. (fam. *Rutaceæ*).

This is a perennial herbaceous or partly woody plant, two or three feet in height. It has pale green, cylindrical, branching stems, alternate, smooth, light green, glandular dotted leaves, which usually dry yellowish; the lower twice or three times pinnate and long petioled, the intermediate once or twice pinnate, the uppermost simple and sessile; divisions wedge-shaped, rounded, or blunt at the extremity. Flowers yellowish, in a terminal corymb, with the parts in fours or fives; stamens twice as many; sepals small, pointed; petals large (one-half inch long), rounded and hooded at the ends, narrow below. Fruit a dry, dehiscent capsule, containing numerous angular, blackish seeds. Rue is a native of Southern Europe, the Levant, etc., and is also cultivated. It has a strong disagreeable odor, and a bitter, sharp taste.

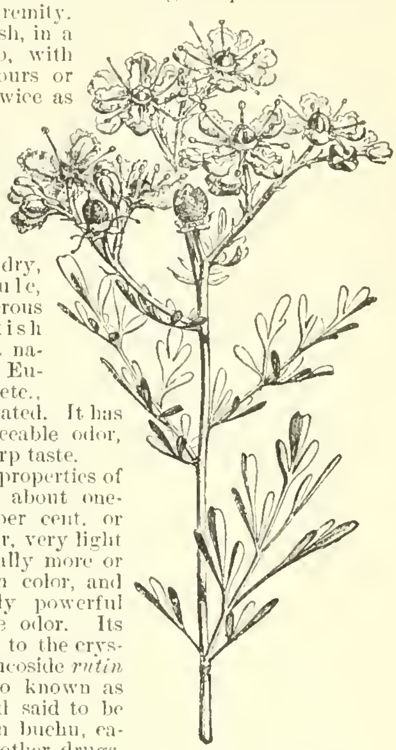
FIG. 4138.—Flowering Branch of Rue. (Baillon.)

The aromatic properties of rue are due to about one-fourth of one per cent. or less of a peculiar, very light volatile oil, usually more or less yellowish in color, and of an extremely powerful and disagreeable odor. Its bitterness is due to the crystalline yellow glucoside *rutin* ($C_{42}H_{50}O_{25}$), also known as *rutinic acid*, and said to be contained also in buchu, capers, and some other drugs. Considerable quercitin and sugar also occur.

ACTION AND USES.—Rue is one of the most ancient of drugs. Its action appears to be that of the volatile oil, differing chiefly in its lesser intensity. Taken internally, in small doses, it is stomachic, laxative, and stimulant to the secretions, especially to those of the intestine and kidneys. In somewhat larger doses it is a powerful anti-spasmodic. It also acts as an emmenagogue, and is in overdoses an irritant intestinal and renal poison and an abortifacient. Among the ancients it was used for its aphrodisiac properties. The dose of the drug ranges from ten to twenty grains, and it is best given in the form of a twenty-per-cent. tincture, made with diluted alcohol, dose fifteen to sixty minims.

Oil of rue was official in the United States Pharmacopœia of 1870 and 1880. It possesses all the above-named properties of rue in a greatly intensified degree. It is a powerful counter-irritant, capable of producing vesication similar to that from croton oil. It is a well-known and dangerous abortifacient, and is capable of acting as a fatal irritant-narcotic intestinal poison. It is not often given internally at the present time. The dose is from two to five minims. *Henry H. Rusby.*

RUMINATION IN MAN. See *Stomach, Diseases of the.*

RUPIA. See *Syphilis.*

RUSSEL'S BODIES. See *Carcinoma.*

RUTLAND, MASSACHUSETTS. — Rutland, Mass., situated in almost the geographical centre of Massachusetts, fifty-four miles from Boston, is the seat of the "Massachusetts State Sanatorium" for pulmonary tuberculosis, the first institution of the kind established in the United States, having been opened for patients October 1st, 1898.

* Converted from grams per litre.

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The site occupied by the sanatorium and its grounds consists of about two hundred and fifty acres of land, at an elevation of 1,160 feet, protected on the northwest by a wooded hill rising 100 feet higher. The climate is that of inland New England modified by the elevation. The winters are cold and long, with much snow, and the temperature is very variable. The average annual rainfall is high, and although, taking the year through, there is a good deal of sunshine, there are usually not many successive sunny days. The atmosphere, however, is pure and free from dust, and there is a clear sweep of country round about.

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The sanatorium buildings consist of a series of one-story wards radiating toward the south, connected by a long convex corridor. In the rear toward the north are the kitchen, dining-room, assembly hall, heating, electric and laundry departments. At the centre of the curved corridor and connected with it by an open passageway is the administration building, looking toward the south. The patients sleep, for the most part, in open wards, there being only a few isolated rooms. At the southern termini of the wards are sun rooms and piazzas. In the neighboring woods are various picturesque camps made of boughs and other material where much of the daytime is spent both in summer and winter. There are accommodations for two hundred and fifty patients and still further additions are contemplated. (Plate LI.)

The whole establishment is under the charge of a resident physician and superintendent, with two visiting and several house physicians. Only the incipient cases are received, or those whose condition offers a reasonable hope of radical improvement. Both male and female patients are received.

The treatment is the hygienic-dietetic, essentially the same as that which is pursued in all modern sanatoria for pulmonary tuberculosis: "Constant life in the open air: judicious exercise, varying with individual cases, in conjunction with the 'rest cure'; and a properly regulated diet of nutritious food" (Bowditch, Sixth Annual Report, 1902). It is a part of the regulations that patients must spend at least *eight hours* out of doors daily, unless excused by the physician; and that all windows are to be opened and closed by the nurse or attendant only. When there is a driving storm, and in winter when the patients are getting up or going to bed, the windows of the wards are closed, but at other times they are constantly kept open. "Medicines are used as little as possible."

Male patients, whose condition will permit it without injury, are utilized in light work upon the farm connected with the institution. Most patients are obliged to furnish $4 a week toward their board, which is somewhat less than half of the actual expense.

As to the results obtained, the last report, up to September 30th, 1902, shows 72 per cent. of the incipient cases for the previous year apparently cured or arrested, and 19 per cent. of the moderately advanced cases. Taking all stages of the disease, there were 48.33 per cent. apparently cured or arrested, and 43.49 per cent. improved. This for the previous year.

For a more extended consideration of the yearly results and of the subsequent histories of former patients, the reader is referred to the yearly reports of the trustees published by the State. For a more detailed description of the sanatorium and the treatment, one is referred to the article of Dr. V. Y. Bowditch, one of the visiting physicians, in the *Boston Medical and Surgical Journal* for February 8th, 1900; also to the yearly reports of the sanatorium.

Numerous boarding-houses and small sanatoria have sprung up in the vicinity, most of them conducted by former patients; they receive consumptives at a moderate rate, and carry out the "treatment" as learned in the sanatorium. *Edward O. Otis.*

RYE. See *Starch.*

END OF VOLUME VI.

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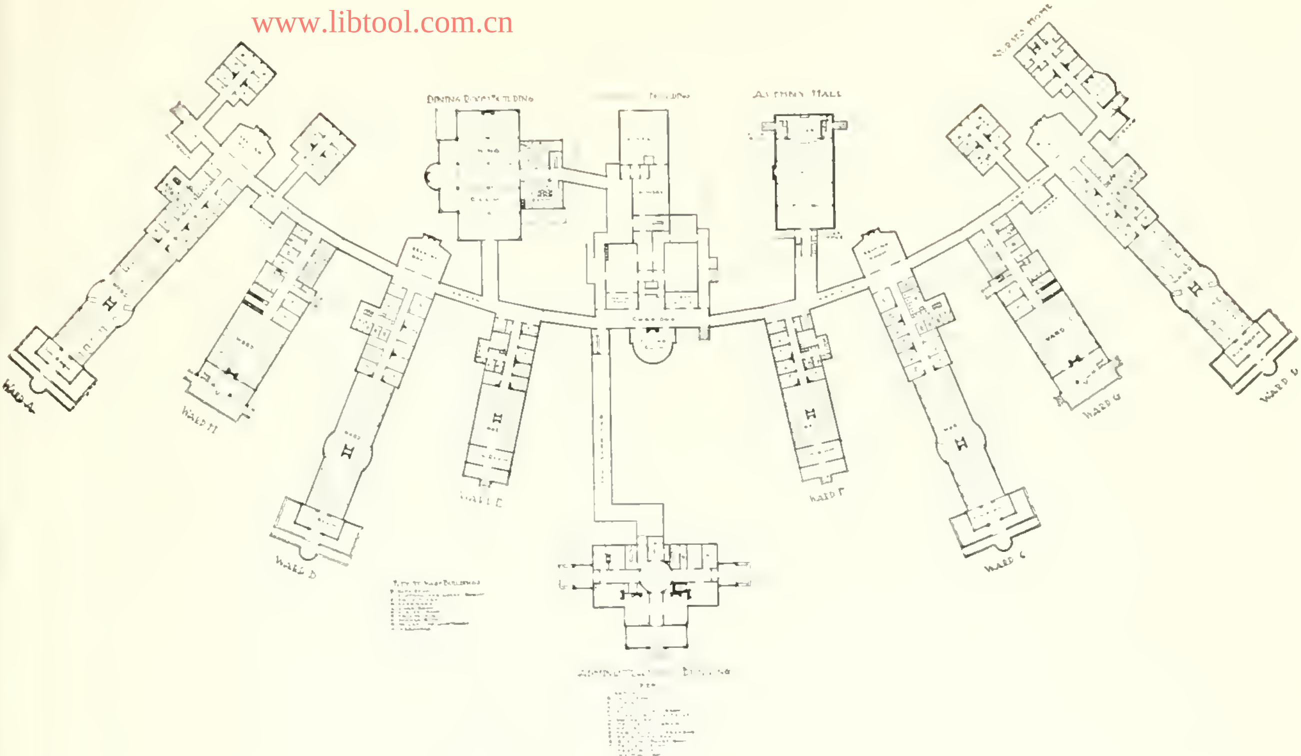

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THE STATE SANATORIUM AT RUTLAND, MASSACHUSETTS

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