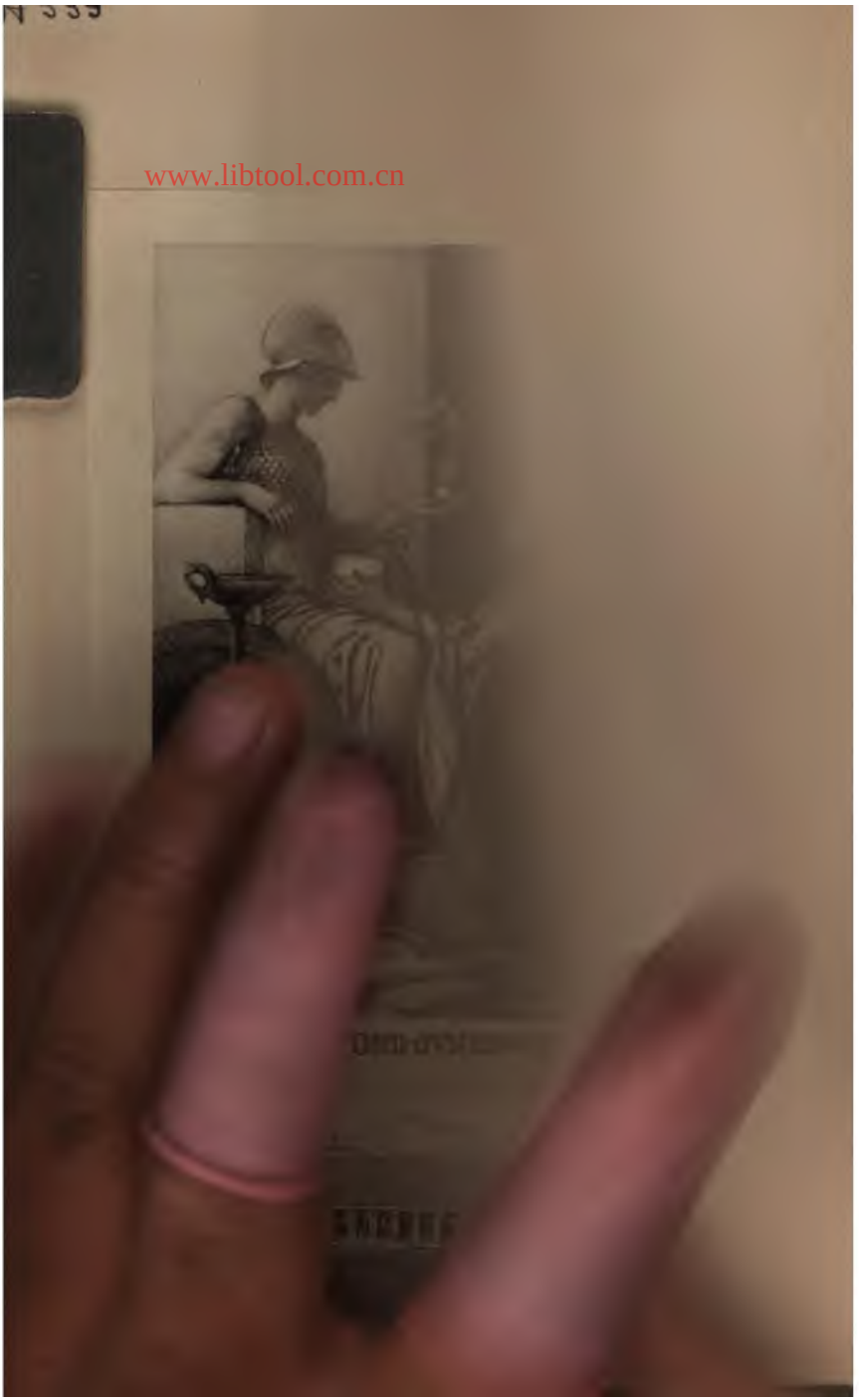

THE DOCTRINE OF FORMAL DISCIPLINE IN THE LIGHT OF EXPERIMENTAL INVESTIGATION

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The Doctrine of Formal Discipline in the Light of Experimental Investigation

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EDITOR'S PREFACE

The chief problems of educational psychology evidently include the nature of mental endowment, or the original nature of man, the nature of the learning process and the nature of training. The last-named issue has occasioned within the last decade a quite unusual amount of debate, for, on the one hand, its outcome is of the first importance for educational theory, while, on the other hand, its solution, on account of the complexity of the questions involved, is far from being obvious or simple. Not long ago, as a result of the earlier experimental studies, it was felt by many that transfer of training was present either not at all or at least in such slight amounts as to be negligible. More recently, the pendulum has certainly swung in the other direction. Experimentation has been directed less toward searching for the existence of transfer than to searching for the kind of transfer present and the conditions under which it appeared. One factor in this shift of attack upon the problem as a whole has been the conviction that experimentation conducted upon children still in their formative years and under the more natural conditions of their everyday life might very well reveal the presence of formal training that could not be demonstrated with adults in the psychological laboratory.

The work presented by Dr. Hewins in the present monograph will be found closely similar in general conception to that presented by Dr. Rugg in his recent monograph. In conjunction with the laboratory testing of children reported in our series by Dr. Wang,

these monographs are bound to exert a considerable influence upon current thinking as to the nature and extent of the transfer of training.

Dr. Hewins' summary of previous work upon the problem will prove most helpful to students. Her own experiments have the particular merit of being readily repeated by classroom teachers in the same field.

G. M. W.

CONTENTS

The Doctrine of Formal Discipline in the Light of Experimental Investigation

INTRODUCTION

It would seem to be entirely superfluous to explain what is meant by the doctrine of formal discipline, for since the epoch-making experiments of James (25, 54)[1] a little more than a decade ago, this theory has occupied the center of the controversial stage of pedagogical problems. Since the Middle Ages, when the doctrine flourished in justification of the classical learning, or even from earlier times as claimed by Locke (31) in his statement "Formal discipline has been invoked from Plato's time to the present as a defense of the courses in mathematics," the theory of formal discipline has been held as almost axiomatic, but with the abandonment of the old "faculty" psychology, it has lost its main prop and its subsequent subjection to experimental investigation has left the theory on a somewhat unstable foundation. We cannot establish the truth or the falsity of the doctrine on *a priori* grounds in this scientific age, but must subject it to many careful, scientifically conducted and controlled experiments covering a wide range of school subjects and performed with school children of various ages, grades, mental attainments, and environments; for its reliability cannot be based longer upon

[1] Reference numbers in parentheses refer to the bibliography at the end of the book.

psychological experiments, pure and simple, performed upon a few adults in college laboratories with complex apparatus.

The experimental investigations until within the last few years have been mainly psychological, conducted by professors of colleges with college or university students or instructors as subjects, necessarily few in number; and only recently have tests been made with school children. Of these, a small number have been tried in this country, and they have been for the most part confined to the elementary schools. Judd (28) describes formal discipline as the "great problem of High-School education." The subjects of the elementary school are studied mainly for their content value and their practical relationship to the future normal life of the child fitted for the demands of his environment. Grammar may be a possible exception, although this should be taught from the standpoint of improving the child's English, rather than as a mental discipline. In the high school, however, nearly every study claims as one of the best reasons for its introduction into, or continuance in, the course of study, some definite mental training which will carry over into other walks of life, however remotely related. Mathematics is said to train the reasoning powers, science the observational abilities, literature and history the imagination, etc. Thus we can agree with Judd (28) that the "final answer of the question will relate to the work of the High School." We must not argue or speculate about the matter, but we must investigate these claims for the various studies and support them by definite tests or refute them by similar carefully conducted and controlled experiments. Many experiments will be required

upon all the subjects and under varying conditions, before we can generalize scientifically as to the validity of the doctrine. But with the question of the value of the disciplinary view of the studies in the balance, it would be well to look to the content side until such time as the theory has been definitely proved or disproved. Burt's (10) advice is to "emphasize and extend the elements shared by the curriculum and the conditions of school in common with the conditions and requirements of life."

The experiments performed and described by the author have been undertaken with the object of contributing a mite to the countless ones necessary to determine the validity or falsity of the disciplinary conception, especially as applied to high-school subjects.

PART I. HISTORICAL.

I. Aims of Investigators.

Reviewing the experimental researches on this topic, we find that while the aims of the investigators have been manifold, they may be grouped under several main divisions. First, we may classify them as primarily psychological or primarily pedagogical.

Psychological.

1. Experiments on the effect of training of one kind of sensitiveness on other kinds of sensitiveness. These include those of Bennett (6) to test the effect on discrimination of length by the eye as a result of practice in discriminating length by arm-mov ements; those of Wallin (58, 60) to attempt to control the reversions in a number of reversible perspective outlines; those of Seashore and Jenner (42) on the training of the voice by the aid of the eye in singing; those of Coover and Angell (12) to test the general practice effect of special exercise, including experiments on the transfer of practice effects in sound to light discriminations, and the transference of practice in sorting cards to "typewriter reactions"; those of Thorndike and Woodworth (53) on the effects of practice in estimating length of lines on estimating length of lines, areas, and weights; on the effects of practice in picking out and marking words of some one special sort on the observation of words containing certain combinations of letters and picking out and marking certain letters; and those of Urbantshitsch (56) on the effects of

practice with sound stimuli on tactual, gustatory, olfactory, and visual stimuli.

2. Experiments on the accuracy of voluntary effort and the effect of special training on the general rapidity and accuracy of motor adjustments. These experiments include those of Davis (14) to test the accuracy of voluntary effort in lunging at a target, those of Jastrow (27) to test quickness of response to touch and visual stimuli; those of Gilbert and Fracker (reviewed by Thorndike, 54) to test quickness in moving the finger at a given signal; those of Swift (52) to test the acquisition of skill in the complex muscular act of keeping three balls in the air, and in typewriting; those of Judd (2) to test the influence of training in the judgment of direction of lines, and the transfer of practice in the Müller-Lyer illusion; those of Foster (18) to test the effect of practice upon visualizing and upon the reproduction of visual impressions; those of Whipple (62) to test the effect of practice upon the range of visual attention and visual apprehension; those of Bergström (7) on sorting cards, wherein was tested the interference of habits formed with ability to perform opposite acts; those of Bair (21, 54) to test effects of special training on general power to meet new situations; those of Münsterberg (21, 35) to test whether a habit associated with a given sensory stimulus can continue automatically, while some effect of a previous and different habit associated with the same stimulus remains; those of Ruger (41) to test the transfer of specific motor habits.

3. Experiments on the effect of special training on the general rapidity and accuracy of memorizing. Here are included those of James (21, 25, 54) to test improvement in memory after special training in memorizing

poetry; those of Ebert and Meumann (2, 21) to test the effect of practice in memorizing meaningless syllables on the power of immediate recall and retention of numbers, letters, monosyllabic nouns, words of Italian prose and poetry, visual signs, etc.; those of Fracker (19, 21) to test the effect of practice in memorizing four tones on memorizing poetry, four shades of gray, nine geometrical figures, nine numbers, extent of arm movements, etc.; those of Jansen (26) to test similar points to those of Prof. Meumann; those of Bennett (6) to test the effect of practice in memorizing poetry on memorizing rows of figures and names of places; those of Thorndike and Woodworth (21, 53) to test the influence of special training in memorizing on the general ability to memorize.

4. Experiments on cross-education or the transference of practice from one member to a symmetrical one. These comprise those of Davis (14, 54) to test transference of motor ability from the practised right hand to the unpractised left in lunging at a target; those of Scripture (44) to test transference of ability from the right hand practised on a mercury dynamometer to the unpractised left hand; those of Scripture, Smith, and Brown (45, 54) to show transfer from the right hand, practised on inserting a needle into a hole without touching the sides, to the unpractised left hand; those of Raif (37, 44), who performed similar experiments in piano playing; those of Wallin (58, 60) to attempt to control the reversions in a number of reversible perspective outlines, in which he found that practice with one eye afforded practice for the other unused eye; those of Volkmann (21, 54), reviewed by Henderson and Thorndike, showing the effect of practice in training the sensitiveness of the skin of the left arm,

upon the right arm; those of Swift (52) to test the acquisition of skill in the complex muscular act of tossing three balls, in which he found that practice transferred from the right to the left hand; those of Starch (50), who found in the experiment of tracing the outline of a six-pointed star as seen in a mirror that improvement was transferred from the left to the right hand; those of Davis (14, 54) to show the transfer of tapping ability with the toe of one foot to the unpractised toe and to show the increase in girth of the right arm and the left arm through lifting a weight with the right arm; and those of Woodworth (54) showing a transfer of practice in hitting a dot with the right hand to the unpractised left.

Pedagogical.

In the pedagogical field, the aims of the experimental investigations have been more limited. The experiments with school children have been confined to few school subjects and few mental abilities. Miss Aiken's (1) pioneer experiments, described in 1896, and her astounding results argue well for the validity of the doctrine of formal discipline. Recently, Dallenbach (13) has made Aiken's experiments, together with the laboratory studies of Whipple (62) and of Foster (18) on visualization, the basis of an exhaustive scientific test on elementary school-children. His results tend to support those of Miss Aiken and lead to the conclusion that experiments with adults are not reliable tests of what occurs with school-children.

Pedagogical experiments relating to this topic may be grouped under those concerned with college students and those concerned with school children. The school subjects utilized for investigatory purposes

have been arithmetic, spelling, and grammar and the mental abilities, memory, habits, and ideals. Arithmetical experiments with college students include those of Starch (49) to test the transfer of training in arithmetical operations; those of Lewis (30) and Collins (11) to ascertain the relation between mathematics and general reasoning; and those of Rietz and Shade (38) to discover the correlation of efficiency in mathematics and in other studies, while with elementary or high-school pupils Winch (67, 68) has experimented to discover if improvement in numerical accuracy transfers, Lewis (30) has found interesting data in regard to the relation between mathematical and practical reasoning, and Stone (51) has tested the relation between distinctive procedures in arithmetic work and the resulting abilities. Wallin (59) has tested elementary pupils to ascertain if spelling efficiency acquired in column drill transfers to dictated compositions, and Briggs (9) has investigated the disciplinary effects of formal English grammar.

With reference to mental abilities, memory has received most attention, although reason has been given some attention, as in the experiments of Lewis and Collins, cited above. College students have been used by Sleight for experimentation in regard to the transfer of memory, while elementary pupils have been made subjects of investigation by Winch to test immediate memory, both visual and auditory, and to test the transfer of improvement in memory; and by Sleight (46, 47) to ascertain if memory training is general or specific.

The effect of special habits on the general conduct or habits of school children has been tested by Squire (3) and by Ruediger (40). Squire's aim was to test the transfer of neatness and accuracy in arithmetic

papers to other school subjects, while that of Ruediger was to test the influence of ideals of neatness in improving the written work of the 7th-grade school children. Judd (2) in his target experiment has demonstrated the value of a recognized method.

There is urgent need for investigation in regard to other school subjects and other mental powers if the problem is to be solved satisfactorily, and it is to be hoped that the experiments may be undertaken by the classroom teacher, drilled in the methods of experimental pedagogy, for only then will there be sufficient trained investigators and optimal conditions for work that may produce unassailable conclusions.

II. Means, Methods, Results and Conclusions of Experimental Investigations.

The means employed by the various investigators have been almost as numerous as their aims. Under this heading are included apparatus and materials used and the subjects of the investigation. In many cases, especially in the psychological experiments, the apparatus has been quite complicated, while the subjects have been generally few in number and usually those possessing psychologically trained minds. The same is true of several of the pedagogical experiments, while, as has been previously stated, few school children, especially in this country, have been used as reagents.

As widely different as are the aims and materials of the many investigators of the doctrine of formal discipline, just as widely divergent are the methods pursued.

The results and conclusions obtained will warrant a separation of the investigators into two groups—those in favor of the doctrine and those opposed.

Psychological Experiments.

1. Effect of training of one kind of sensitiveness on other kinds. The apparatus used by Bennett (6) in discrimination of length by the eye as a result of practice in discriminating length by the knowledge gained from arm-movements, consisted of 2 parallel, horizontal, steel rods, 2 feet long and 1½ inches apart. On the lower rod were two spools fixed immovably 25 cm. apart, and on the upper rod were two spools which were freely movable. In the training the two subjects were required to move the two movable spools on the upper rod to equate their distance to that of the immovable spools on the lower rod, through the sensation derived by arm-movement. The final tests were visual estimates of length. The result of the experiment was negative; one subject showed improvement, but the other an equal degree of lack of improvement.

In the experiments of Wallin (58) to attempt to control the reversions in a number of reversible perspective outlines, the apparatus consisted of drawings of a parallelopiped, a book, a table, and a pyramid. Two subjects practiced in attempting to envisage uniformly the infrequent or non-predominant perspective, in all cases monocularly. Wallin found that perspectivity was subject to a high degree of practice control. In 9,246 trials, the per cent. of successful control in three groups amounted to 40, 62, and 82. There was an average gain of 42 per cent. between the first and last 20 days of the series. He also found that the practice effects were transferred to the unpractised eye. "In a given series of experiments in which the figures were reversed in the direct and indirect visual fields, it appeared that the reversions

occurred about 2½ times faster when the figures were directly regarded instead of being seen by the peripheral retina. But after practice with certain figures, it sometimes happened that the figures reversed most readily when a point outside the figures was fixated." This furnishes an instance of the transference to the peripheral retina of fixation motives attaching to the fovea. Here an acquired foveal disposition spread to the adjacent retinal elements, or the foveal tendency was transmuted into a "generalized retinal habit."

Seashore and Jenner's (42) experiments on the training of the voice by the aid of the eye in singing, made use of the voice tonoscope. Each of the six observers sang before the speaking tube. The tests were divided into: (1) accuracy in striking a required pitch, (2) the least producible change in pitch (minimal change). The preliminary practice was given with six observers. Each period of practice consisted of 160 trials, which took about 45 minutes. Tests were given for 12 days; the first 5 days "without aid," the singer depended entirely on the ear; and the next 5 days with aid, that is, the record was read from the tonoscope in each trial; the eleventh day the record was taken without aid again; and the record of the twelfth day was taken with the aid. Their conclusions pertinent to the topic in hand are: (1) "The aid enhances the ability to strike a tone which has been heard." There was 42 per cent. superiority of the aided series over the unaided. (2) "The aid enhances the ability to sing an interval." The aided series was superior to the unaided 50 per cent. in singing a major third, 50 per cent. in singing a fifth, and 60 per cent. in singing an octave. (3) The voluntary control of the pitch of the voice is improved 26 per cent. by the aid.

(4) "There is probably some transfer of gain from the aided training to the following unaided singing." (5) "There is no evidence of the transfer of gain in the accuracy of the memory image." (6) "The gain in the discriminative control of the pitch of the voice is fully transferred. (7) "Improvements in the ability to strike a tone, or an interval, and the ability to produce a minimal change are very much more pronounced and more rapid in the aided than in the unaided series." These seven points show that "by the use of the tonoscope we facilitate in a decided manner the ability to sing in true pitch and the improvement is almost immediate." (8) It seems probable "that a higher degree of accuracy of pitch in singing may be attained by aiding the ear in the training than would be possible to attain without such aid."

Coover's and Angell's (12) investigations to test the general practice effect of special exercise included experiments on the transfer of practice effects in sound to light discriminations and the transfer of practice in card-sorting to "typewriter reactions." In the former experiment, four reagents were trained by means of a sound pendulum in discrimination of intensities of sound for 17 days during a period of 57 days, and each reagent made 40 judgments in each day's training. Before and after training, the reagents were tested in the discrimination of shades of gray. Each test consisted of three series, of 35 judgments each, delivered on three separate days. Control reagents were given the tests. It was found that there was an improvement in three of the trained subjects of 7, 5, and 15 per cent. respectively, but a failure in one of them; the control reagents showed a

loss in discriminative ability in the final tests. Coover and Angell concluded that the "improvement seems to consist of divesting the essential process of the unessential factors," that "efficiency of sensible discrimination acquired by training with sound stimuli has been transferred to the efficiency of discriminating brightness stimuli and that the factors in the transfer are due in great part to habituation and to a more economic adaptation of attention, *i. e.*, are general rather than specific in character." In their second experiment just referred to, in which reaction with discrimination (choice) was tested, four reagents were trained through four days in card-sorting, during which 4000 cards were distributed by each reagent. They were tested for five days on "typewriter reactions"—about 3000 reactions in each case; and after training in card-sorting, an after test was given for three days which included about 1800 reactions. The results warranted the conclusion that "training in card-sorting is the cause of the increased ease and facility experienced by the regular reagents in the second trial in 'typewriter reactions'"; but this improvement is not considered due to "identical elements." "The general condition that is common to both is the habit of stripping the essential process of unnecessary and complicating accessories." The cause of transference of facility is the formation of a habit of reacting directly to a stimulus, which results in an equitable distribution of attention and the consequent power of concentrating the attention.

Thorndike and Woodworth (53) in their tests of improvement in mental functions used magnitudes, such as lines of various lengths, areas of different sizes, and weights of several magnitudes; the practice

work was on estimating magnitudes of the same general sort. They also tested the "influence of training in observing words containing certain combinations of letters or some other characteristic, on the general ability to observe words." The subject practised picking out and marking words of some one special sort until a high degree of proficiency was attained. From four to six subjects were used in the various experiments, all of which tested the "influence of improvement in a function on other functions closely allied to it."

Their conclusions were as follows: "It is misleading to speak of sense discrimination, attention, memory, observation, accuracy, quickness, etc., as multitudinous separate individual functions are referred to by any one of these words." "There is no reason to suppose that any general change occurs corresponding to the words 'improvement of the attention,' or 'of the power of observation,' or 'of accuracy.'" "Improvement in any single mental function rarely brings about equal improvement in any other function, no matter how similar, for the working of every mental function-group is conditioned by the nature of the data in each particular case." "The general consideration of the cases of retention or of loss of practice effect seems to make it likely that spread of practice occurs only where identical elements are concerned in the influencing and influenced functions."

Urbantschitsch (56) studied pathological cases with diseases of the eye and ear and found that stimulation also affects parts seemingly not immediately concerned. An hour's operation on the right eye showed on the left a relative enhancement of the capacity to see. In many patients with chronic catarrh of the middle

ear, the observer was surprised to find that an important pathological influence was transferred from the ear to vision. In a later investigation he demonstrated that the sensitivity for tactual, gustatory, olfactory, and visual stimulation can be increased by practice with auditory stimulation.

To summarize the conclusions of the investigators upon the topic of the effect on other kinds of sensitivity of training one kind of sensitivity, we find that Wallin, Seashore and Jenner, Coover and Angell, and Urbantschitsch subscribe to the doctrine of transfer, but Thorndike and Woodworth are opposed. Bennett's tests must be disregarded, as the two reagents obtained results diametrically opposed. The results of Wallin and Bennett could be set aside on the ground of having too few subjects, unless their results were subsequently verified by other observers. In all of the tests, the subjects were too few in number, but the results of Seashore and Jenner, of Coover and Angell, and of Urbantschitsch, seem to place the preponderance of scientific conclusion on the affirmative side.

2. Experiments on the accuracy of voluntary effort and the effect of special training on the general rapidity and accuracy of motor adjustments. Here, many diverse methods have been used, with resultant dissimilarity of results and inferences.

Davis (14) used a target and a fencer's foil, and worked with six subjects. He had 10 thrusts made with the right hand and recorded on a paper target. After five minutes, the record of 10 thrusts with the left hand was made on another paper target. The initial tests were repeated after 10 days' practice of 10 thrusts daily with the right hand. It was found that the subjects could be educated in accuracy and

co-ordination of voluntary movement. The left hand improved from 57.2 per cent. to 36.5 per cent. nearer the center of the target; while the right hand improved from 50.5 per cent. to 24.3 per cent. Increase in accuracy is due to practice in lunging. His experiments did not test the transfer of this special training to other motor adjustments, but only to the bilaterally symmetrical organ.

Jastrow (27), in testing quickness of response to tactile and visual stimuli, experimented with two "Sleight-of-Hand Experts," Kellar and Hermann, and with miscellaneous individuals for the control. The tests included measurements with the aesthesiometer, judgments of weights of different magnitudes, and tests of sensitiveness to texture, for which coils of different sized wire were utilized. The results showed that Hermann's and Kellar's tactual and muscular perception were below normal. With the Weber compass, Hermann could distinguish the points at 3.5 mm. distance, Kellar at 2.5 mm., and the average for miscellaneous individuals at 2 mm. Herman was unsuccessful, Kellar successful, in arranging in correct order five weights, each of which weighed $\frac{1}{15}$ more than the previous weight. In a general series of tests, 92 per cent. of those tested arranged the series correctly. In the tests with the different sized wires, "both Mr. Hermann and Mr. Kellar succeeded in arranging both series correctly, but this was also done by nine out of ten persons who were tested in the same way." Quite a number of tests of the quickness of movement and of mental processes, and of visual perception, were made. Some of the ordinary forms of reaction experiments were also tried. Tests to find out the comprehensiveness of perception were likewise

given. Selecting those tests in which the records of Hermann and of Kellar differ markedly from the normal, Jastrow finds: "In the quickness of response to a touch and a visual stimulus both the special subjects, and Mr. Kellar as well in response to an auditory stimulus, excelled to a considerable extent the average individual." But in the "most complicated reaction they both fall considerably below the normal." There are decided indications of unusual quickness for both; but no very decided excellence appears in the scope and accuracy of visual perception. "In tests involving mainly tactual and muscular perception, the indication is rather that they are below than above the normal." Thus Jastrow concludes that "the positive results of the investigation are thus small, but as far as they go they are consistent with the forms of dexterity that are utilized in sleight-of-hand performances." "They also indicate that it may well be that special skill in one very specialized form of training may be only slightly influential upon other forms of capacity."

In Gilbert's and Fracker's (54) experiments, reviewed by Thorndike, two subjects were tested for their quickness in moving the finger, (1) when they heard a certain sound, (2) when they felt a certain electric shock, (3) when they felt a certain blow, and (4) when they saw a blue surface. They were also tested for their quickness in moving the finger at these same stimuli when either the given sound or one less loud, either the given shock or one less intense, either the given blow or one less hard, and either a blue or a red might appear. They were trained for a number of days in quickness in reacting to the sound, (*a*) when only it was given, (*b*) when either it or the weaker

sound might be given. Then they were tested as before. It was found that there was an improvement in all cases, except one case with one observer. One observer was trained only in (*a*) quickness in reacting to sound. He improved markedly in the corresponding tests, but not so much as the others in the second set of tests. Thorndike explains this improvement on the ground of "identical elements." Elements common to all these tests are concentrated attention, alertness, effort, co-ordination of sensory and motor areas, and rapidity of discrimination.

Swift's (52) experiments on the testing of the acquisition of skill in keeping two balls going with one hand, were made with solid rubber balls. There were six subjects—five university students and one professor. Ten series were given; each of which consisted in throwing until failure to catch one or both balls. Practice was with the right hand, but there was a preliminary test with the left. He discovered that progress was at first slow and then more rapid. There was great irregularity of advance. Progress was by "jumps." A "warming up" is necessary but "steady and calm intensity makes for progress." He also found transference of practice effects from the right hand to the left. Swift, himself, performed an experiment which combined physical and mental tests, in the acquisition of skill in typewriting. He wrote one hour each day from copy. Here, he also found that the rise of the practice curve is rapid, but that there is irregularity from day to day. In both of Swift's experiments, there is no test of the transfer to other abilities of special ability gained by practice. It was discovered that training of the right hand was effective upon the left, but he does not believe that

this gives any support to the doctrine of "formal education." "There is no evidence to show that training has general value."

Judd's (2) method in testing the influence of training in the judgment of direction of lines, was to place his one subject with his right hand hidden from his own view by a screen. On the left of the screen, nine different lines were shown in succession and the observer was required to place a pencil held in the unseen right hand in the direction indicated by the several lines seen by him. The subject was trained to the more accurate localization of one line, No. 5. After improvement, the original conditions were restored and the tests again made. Every line was affected in the final test. "This means that there had been a transfer of effects under the conditions of the training described." A new practice series was begun with Line No. 2, and the amount of practice given was much greater in quantity and more radical in type, but the subject remained relatively unaffected. Judd's conclusions are that "joint improvement is only one of the possible forms of transfer; reciprocal interference is just as significant a type of relation and just as certainly a type of transfer as is joint improvement," and "the closing up of the possibilities of future practice is much more important a consequence of any practice series than the direct transfer of effects to other functions." In the experiments on the transfer of practice in the Müller-Lyer illusion, two observers were tested in the comparison of two complex geometrical figures. Judd found that both learned to apprehend the lines correctly in about the same number of comparisons. When the figures were reversed and a second series of tests begun, the

observer who knew about the effect of practice adjusted himself to the new demands and rapidly overcame the illusion. The other showed greater error and no disposition to improve. Judd concluded that "the practice gained in the first series was transferred in both cases; in one case, it worked improvement; in the other, it increased the illusion, and rendered the observer incapable of rapid readjustment."

In Foster's (18) experiments on the effect of practice upon visualizing and upon the reproduction of visual impressions, real objects, pictures, and nonsense-drawings were exposed to three observers for 10–60 seconds. They were required to reproduce by drawing and description. He found ability to reproduce increased with practice, it was rapid at first and slow later.

Whipple (62), in testing the effect of practice upon the range of visual attention used a disc-tachistoscope and 5-, 6-, and 7-place nonsense combinations of letters. The subjects were six college students, each of whom observed 124–250 exposures of .08 second's duration. His results show that the average number of letters that can be grasped in a single exposure lies between 4 and 5 (4.82). "Attention and effortful observation through a series of from one to two hundred or more exposures has a curiously small effect upon the range of attention." "Adult observers very quickly reach a physiological limit of visual observation when the exposure is so restricted as to prohibit eye-movements and roving of attention." In studying the range of visual apprehension, the form of material to be used—dots, pictures, nonsense-syllables, drawings, or stanzas of poetry—was stated and the exposure with the tachistoscope for 3 seconds was made when

the observers were thoroughly prepared by fixation and attention to receive it. Again, groups of ten objects upon a table were exposed for 6 seconds. Three observers performed these experiments. "The most striking quantitative results of these tests is the very small increase for certain kinds of material in the number of items observed with the exposures of 3 and 6 seconds as compared with the exposure of .08 seconds (range of attention tests)." "With an exposure of 6 seconds, the average number of objects named was 6.05, while with an exposure only $\frac{1}{75}$ as long, between 4 and 5 objects could be named." The tables show facts that "negative the idea of general ability in apprehension or even of general ability in visual apprehension: we may state only that a given individual excels in the attentive observation of pictures, of drawings, of words, or of certain kinds of objects, etc., not that he excels in all-round observation." The table also "seems to show the improbability of a series of classroom exercises training and developing general capacity to attend."

Bergström (7), in his study of the relation of the interference effect to the practice effect of an association, sorted 80 cards into 10 different piles, each containing 8 cards with the same picture. In sorting the same pack a second time, a given card could be placed in the same position as the first time or in one of nine other positions. If put in the same, it is a simple practice effect, and if in a different one it is an interference effect. The cards were sorted with the greatest possible speed. He found that the "interference effect of an association bears a constant relation to the practice effect and is in fact equivalent to it." The variations are due to memory.

Bair's (54) method in his studies of the influence of special training on general power to meet new situations was to label 6 keys of a typewriter with 6 symbols (letters or figures). Fifty-five of these letters or figures (in chance order) were now shown one by one, and the subject on seeing one taps the corresponding key. Record was kept of the time taken to tap out the series. Six different symbols were then used in a new series and the subjects' time-record taken as before. In a similar manner, twenty different sets of symbols were used. There were four subjects. A steady improvement was found in the time taken to tap out a series. In another experiment, he took daily records for twenty days of the time required to repeat the alphabet from memory, repeating it forwards and backwards and inserting the letter *n* between each letter in two other repetitions. The test exercises consisted of repeating the alphabet forwards and backwards and inserting *x* and *r*. He again found improvement in the tested series.

Münsterberg (35) studied the interesting theoretical problem whether a habit associated with a given sensory stimulus can continue automatically, while some effect of a previous and different habit associated with the same stimulus remains. The experiments were made with his inkstand, his watch, and the doors of his laboratory. For instance he exercised the habit of taking his watch out of his pocket on the left side until it became automatic. Then he practised taking it out on the right side until the new habit was automatic. He then returned to the old habit and found that it took less time to relearn this than it did to learn the second. He concluded that some effect of the first habit remained, although the

second had become automatic. When this process was repeated several times, the time required for relearning each of the two habits decreased, following the laws of the practice curve. He maintains that apparently contradictory habits do not destroy each other; at first, it is hard to create the new habit, but once formed, it is easy to shift back and forth from one to the other.

Ruger (41) in testing the transfer of specific motor habits in his study of the Psychology of Efficiency, had his subjects from the psychological laboratory, use "animal" and "human" methods in taking apart or putting together various puzzles. The preliminary and final tests consisted in testing a subject with a puzzle thrown in chance positions. The training consisted in handling four special but important positions. The training of another subject consisted entirely of chance positions in a series about half the length of the first subject's series. The second tests of the first subject showed no improvement over the initial results and were inferior to those of the second subject. "This failure to profit by the highly specialized training seems to have been due to the lack of a generalized rule of procedure." Ruger therefore concluded that "in general, the value of specific habits under a change of conditions depended directly on the presence of a general idea which would serve for their control." In regard to concrete imagery he found that "the value of the image as well as of the motor habit depended on the precision of the analysis." As regards attitude and attention, he concluded that "no evidence was secured in favor of an automatic change in level of attention but there were indications of its indirect control by means of ideals of what

constituted an efficient state of attention." Among the most important of the ideals of method were the "idea of efficiency as a goal to be reached, ideals of scientific method, and the ideal of an optimum personal attitude."

Summarizing the results and conclusions of the eleven authors whose experiments have just been briefly described, it will be readily seen that not a great deal of evidence has been produced either for or against the doctrine of transference. The inference that improvement results from practice is supported almost unanimously. Some interesting evidence is deduced in regard to the interference of practice effects. Some of the experiments give data in regard to "cross-education." Where it was desired to secure information upon the subject of the transfer of practice, the practice was in all cases so similar to the tests that improvement in the practice series naturally resulted in improvement in the final tests. Obviously, some of the tests in both the preliminary and final series should be as dissimilar to the practice series as possible. This similarity warrants the explanation of transference as due to "identical elements" or "similarity of method or ideas." In some cases, the limited number of the subjects precludes generalization, as does also the securing of results diametrically opposed by independent investigators. Davis, Swift, Judd, Foster, Bair, Münsterberg, and Ruger all found that improvement results from practice. Judd and Bergström emphasized the importance of interference as well as of practice effects, but in their experiments only one or two subjects were used, while Bair and Münsterberg claim that apparently contradictory habits do not destroy one another. Davis and Swift in their tests

obtained evidence with regard to the transference of practice from the right to the left hand. Of those who entered upon the investigation of transfer, Gilbert and Fracker, Judd, and Ruger admitted that some transfer occurred while Jastrow and Whipple found no evidence of its existence. In most of the cases the subjects were too few in number and the practice too similar to the tests to warrant trustworthy conclusions.

3. Experiments on the effect of special training on the general rapidity and accuracy of memorizing were tried by James, Bennett, Ebert and Meumann, and Fracker with contradictory results on the question of improvement with practice and transfer.

James (25) took account of the time necessary for each of five observers to learn a given amount of poetry. Then all practised; James learned the first book of Paradise Lost and the others varying amounts of poetry. Then the time required to learn an amount similar to that of the first test was taken for each of the observers. James found that two subjects required more time for memorizing (one considerably more) after training, and the other three subjects a little less time; but he concluded that the tests were long enough to give training on the test-verse, so the experiment may be regarded as giving no evidence in favor of transfer.

Bennett's (6) method was to have one observer commit to memory 5 rows of figures, 30 figures in each row, at the rate of one row per day. The training was carried on for 4 weeks, 16 lines from *In Memoriam* being memorized each day. The second observer wrote out five lines of names of places, 15 names in each line, and committed one line each day.

The practice was on two stanzas of the *Faerie Queen* committed daily for 5 weeks. In each case the final test was similar to the preliminary. Bennett found that the final test in memorizing numbers required 58 per cent. of the time of the first test; while that in memorizing names of places required 22 per cent. of the time of the first test. He concluded that "the possible increase in the ability to remember figures, could readily come from the special training in doing that very thing in so many subjects of the curriculum." "There is some sort of transfer from memorizing one class of facts to memorizing another class of facts, and from memorizing prose to memorizing poetry. Memorizing poetry gives increased ability to memorize figures or names of places."

Ebert and Meumann (2, 6, 21) in their investigation to determine the effects of training in learning material of one kind upon the capacity to learn material of the same and different kinds, used eight subjects whose memories were tested for ease of learning different sorts of material, such as series of letters, numbers, nonsense syllables, words, Italian words, strophes of poetry, and selections of prose. They learned 32 series of nonsense syllables, 12 in a row; two series of syllables on one day and tested the retention of two more. Thus, they learned four series of 12 syllables each on each of 16 days. At the end of this time the first test material was relearned and the facility of relearning was compared with the original. Then there was another period of learning; four men trained on 16 series of the same material as before; and four had 32 series. Then the final test was given. Tests were also made after 75–156 days of vacation. Their results favor a belief in a general effect from special

training. There was a gain in the average performance of the 8 observers for each kind of material used. There is a tendency for the gain to be greater in material that is most closely related to that on which practice was obtained, 59 per cent. of gain in memorizing numbers, 58.2 per cent. in letters, 42 per cent. in nonsense syllables, while Italian words, poetry and prose showed gains of 30 per cent., 27 per cent., and 29 per cent. respectively. They found that retentiveness was increased as well as quickness. Tests made after the lapse of from 75–156 days of vacation showed no loss of training; in some, an increase in memory capacity.

Fracker (19) in his study of the transference of training in memory, tested memory for poetry, the order of four shades of gray, the order of nine tones, the order of nine shades of gray, the order of four tones, the order of nine geometrical figures, the order of nine numbers, and the extent of arm-movement; the training series was memory for four tones. The subjects were eight college students and professors. The instruments employed were the psychergograph and the telephone. The four tones consisted of a major chord and the nine numbers were of two figures each. The following results were obtained: The gain in the tests for poetry was not very great in the case of any observer. The gain in the four shades of gray was often greater than the gain in the training; it was usually as great, seldom less. Four observers gained more in the nine tones than in the training series; two made the greatest gain in the nine tones of any of the test experiments. He judged that the "influence of training seems to be very strong." Three observers made a greater gain in the nine grays

than in the training. One gained more in the four tones (major chord) than in the training series, but no observer made the greatest gain in this test. This test was most like the training series and should have shown the greatest gain, according to many investigators' results as to the effects of practice. Fracker thinks that the failure to gain was due to a different method of response. One made the greatest gain in the nine numbers' test. Fracker draws the general conclusion that the "central or most essential element in improvement is individual imagery" and the "improvement is more rapid if the imagery is consciously developed." He also concluded that transference is due to "identical elements" or a "spread of training"; and he is in favor of the former, or in favor of a "limited spread of training."

Reviewing these investigations, it is evident that James reached conclusions leading him to discredit the belief in transference effects when applied to memory tests, whereas Bennett, Ebert and Meumann, and Fracker all obtained results which appear to be overwhelmingly in favor of a "spread of training." Bennett had only two reagents, but both showed a decided amount of improvement, while the experiments of Ebert and Meumann and of Fracker because of the increased number of observers, the variety of material used in the tests, and the number of the tests, point almost conclusively to the reliability of the belief in the spread of practice effects, at least in memory work, even to material not closely related to that used in the practice series.

4. Data derived from experimentation in regard to the effect of the training of one organ upon the bilaterally symmetrical one, or closely related member, have

been advanced in favor of the doctrine of formal discipline. Investigations upon this subject have been made by Davis, Scripture, Raif, Wallin, Volkmann, Swift, Starch, and Woodworth, among others. The experiments of Davis (14), Swift (52), and Wallin (58), in which they found a decided transference from a practised to an unpractised member, have already been referred to in other connections.

Scripture (44) had his subject take 10 records of the right hand with a mercury dynamometer and 10 records of the left hand. Only the right hand was practised and final tests taken with the left hand. He found that the left hand had gained 50 per cent. in strength. In another experiment, he had 20 trials of each hand in inserting a needle into a hole without touching the sides. The right hand was practised 200 times and the left hand again tested. The unpractised left hand increased from 50 per cent. to 76 per cent. of successful trials.

Raif (37) tested the average speed of the finger movements of each hand in 18 pupils. The exercises to develop rapidity began with the right hand only. The right hand increased from an average speed of 116 to 176 strokes per minute after 2 months' practice, whereas the left hand, entirely without practice, increased from 112 to 152.

Volkmann (6, 14, 21, 54), in his experiments on the influence of practice on the power of perceiving small distances, tested the sensitiveness of both arms of one subject for the two points of a Weber's compass. The left arm was then practised for several weeks. It was found that in the right arm, the distance of the perception of the two points was reduced from 26.4 to 15.7 mm., while in the practised left, the reduction

was from 23.6 to 11.2 mm. He also found that practice on one finger of the left hand gave increase in ability in all the fingers, but none in the arm.

Starch (50) had two subjects trace the outline of a six-pointed star as seen in a mirror. The subjects traced one-half of one outline with the left hand. Then one subject made ten complete outlines with the right hand while the other made fifty. Both then traced another half with the left hand. He found that the average improvement in the right hand after practice was 88 per cent. while the unpractised left hand had improved 83 per cent. The subject who had made 50 tracings with the right hand showed an improvement of 82 per cent. and 68 per cent. with the unpractised left hand. "Altogether the left hand profits to the extent of 90 per cent. of the gain made by the right hand." Ten laboratory students made ten records with the right hand and improved on the average 53 per cent.

Davis (14, 54) had six subjects tap on a telegraph key with the right and left index fingers and right and left great toes. The right great toe was practised from 10–20 days. He found that improvement with the right toe was accompanied by 151 per cent. as much improvement in the left foot, 100 per cent. as much in the right hand, and 83 per cent. as much in the left hand. In another experiment, he took the girth measurements of both arms of six subjects and the number of times that each arm could raise five pounds. The subjects were practised from two to four weeks on the flexion of the right arm with weight. The result showed that practice had effected an increase in the girth measurements. The right arm increased twice as much as the left, but the left made marked gains.

Woodworth (54) practised the left hand of one subject in hitting a dot at speeds of 40, 120, and 200 strokes a minute and tested the right hand before and after practice. He found improvement in both hands.

Although in some instances the number of the subjects of the investigations was quite limited, still, because of the unanimity of results of the eight investigators, there can be no question of the effects of practice of one member upon its fellow. With one exception, all of the paired external organs were subjected to experimentation. Experiments were performed with the hands, fingers, arms, toes, and eyes. I do not recall any one's testing the effect of the practice of one ear upon the other, nor is it certain that this would prove feasible because of the practical impossibility of effectively closing up either avenue of auditory stimuli. Practice was given to left-hand members as well as to right-hand and with the same results. While all the results are consistent, differences appear in the explanation of the results, in the conclusions reached. Some are not in favor of permitting results of experiments in cross-education to contribute to the support of the doctrine of formal discipline, while others consider them due to the presence of "identical elements," a "transfer of training" or a "co-ordination of movements."

Pedagogical Experiments.

1. Mathematics—A. College students. Starch (49), in investigating the transfer of training in arithmetical operations, used eight observers each having fourteen days' practice in mental multiplication. Seven others were also given the preliminary and final tests which consisted of six tests in arithmetical

operations and two tests in immediate auditory memory span. He found that the practised observers showed from 20–40 per cent. more improvement in the arithmetical tests than the unpractised; but that there was little change in memory span for either group. He concludes that the "improvement in the end test was due therefore to the 'identical elements' acquired in the training series."

Lewis (30) examined the records of ten different classes of Dartmouth students who had taken law and mathematics, to discover the relation of reasoning in these two subjects. Fifty per cent. of the best students in law were conspicuous for their poor showing in mathematics, while 42 per cent. of those poorest in law stood at the head of the series in mathematics.

Collins (11), in order to verify Lewis' results in the above experiment and in a high-school experiment to be described later, had eight instructors rank certain students in percentages as to their reasoning power. These students were ranked in their ability to carry on miscellaneous kinds of reasoning. By means of marks from the school records, mathematics grades were contrasted with the averages in United States history and commercial geography. His results are almost exactly opposite to those of Lewis and lead to the conclusion that "with the exception of from 20–25 per cent. of erratic people, those good in mathematics are good in other subjects, those of average ability in mathematics are of average ability in other subjects and those poor in mathematics are poor in other subjects."

Rietz and Shade (38) used college records and found high correlation between efficiency in mathematics and natural science and also between efficiency in mathematics and in foreign languages.

B. Elementary and High-School Pupils. Winch (67, 68) was most painstaking in his elaborate investigations with school children. In his efforts to determine if improvement in numerical accuracy transfers, he tried five series of experiments, using different schools, standards or grades, and neighborhoods. In the first four series he divided the class into two groups on the basis of record in arithmetical process. After one-half had been trained on exercises in "rule" sums, a final test in arithmetical reasoning was given to both groups. There was an improvement in accuracy of numerical computation during practice. The first series of experiments was performed with girls from a poor neighborhood, Standards VI and VII, and ages 13 years. He found that, while an improvement was shown by the practised group in numerical accuracy, it was insufficient to transfer. In his second series of experiments, he used girls from a poor neighborhood, Standard II, age 10 years. He found considerable improvement in the practice series and this was transferred to the final problem work. "Whereas the numerical accuracy of the non-practised group was decidedly superior to that of the practised group in the preliminary tests, yet after the practice period, the position of the two groups, section by section, is reversed." But from one of his tables, he decided that it would be unsafe to conclude that any transfer of accuracy had taken place. The third series of experiments was given to girls of a good neighborhood but of poor ability in arithmetic, Standard III, age 10 years. He found a positive correlation between reasoning and accuracy and improvement in numerical accuracy within the practice series. He states that "there certainly appears to be an advan-

tage on the side of the practised group in the second, third, and lowest sections, but the highest is worse in comparison of the preliminary and final tests." In the fourth series of experiments, boys were employed; they were from a poor neighborhood, did good work in arithmetic, were from Standard III, and aged 10 years. There was found to be a high correlation between reasoning and accuracy and very considerable improvement in the practice series. Every section in both groups showed improvement in arithmetical reasoning. He thinks that the improvement may possibly be due to natural growth and to other branches of school instruction. From these four series of experiments, he concludes that it seems possible to improve the accuracy of numerical computation without any certainty of thereby improving the accuracy of arithmetical reasoning. "Therefore, pending more conclusive experiments, numerical accuracy should be sought for because it is valuable in actual life and not because of improvement." In a later investigation, he utilized a class of 72 boys, of Standard III, with an average age of 10 years. He gave six tests in arithmetical reasoning, which enabled him to divide the class into two equal groups, one of which was practised in arithmetical computation while the other was occupied in drawing. After 10 practice exercises, six final tests were given to all. There was marked improvement in the computation, but he found no evidence of the transfer of this improvement to arithmetical reasoning.

Stone (51) investigated the arithmetical abilities of 6A pupils, the time expended, and the materials of the course of study used in securing these abilities. Twenty-six school systems from various parts of the country were examined. Tests in fundamentals and

reasoning were used, requiring the marking of 6000 papers. He reached the conclusion that there is a lack of correspondence among the systems in fundamentals and reasoning; likewise in the four fundamental operations; and in rapidity and accuracy. "On the whole, ability in reasoning implies ability in fundamentals no more than ability in such a subject as English implies ability in mathematics in general, and not so much as ability in English implies ability in such subjects as geography and history." In answer to one of his problems, he stated that the nature of the product of the first six years of arithmetic is complex and that the "net result is several products, rather than a product." He also discovered that there was a lack of relationship between time-cost and abilities produced, likewise a lack of relation between abilities and a good course of study.

Lewis (30) in his high-school tests, asked the question: "Is there a reasoning faculty, which, by exercise in mathematics, can be made stronger for other kinds of reasoning, as in law or business?" Two tests, one containing originals in geometry and the other questions in practical reasoning, were given to 24 different groups of pupils. He found that 63 per cent. of the good mathematicians were at the foot of the practical reasoning series, and of those at the foot of mathematical reasoning, 47 per cent. were at the head of practical reasoning. From this and from his investigation with the Dartmouth students, he concluded that the "reasoning faculty is a myth," for "students able in mathematical reasoning are not even generally able in practical reasoning and law."[1]

[1] I am informed by Professor Rietz, of the University of Illinois, that the original data obtained by Lewis do not, in fact, warrant the conclusions drawn from them.—*Editor.*

2. Spelling. Wallin (59) investigated the question whether spelling efficiency acquired in column drills transfers to dictated compositions. He dictated work in which lists of words occurred which had been previously learned by drill. He also dictated a column of words. Only words on the list in both cases were counted. He concluded that the "data obtained furnished conclusive evidence in favor of an affirmative answer." The average loss of efficiency through transfer from dictated column to composition was 1.44 per cent. while there were five instances in which there was an actual transfer gain. He concluded therefore "that column drills in spelling may produce a positive increment of spelling efficiency in dictated compositions or connected writing."

3. English Grammar. Briggs (9), in order to ascertain the disciplinary effects of formal English grammar, gave 54 tests to from 25–30 children of the 2d–7th grades in the Horace Mann School. Among the tests were those to discover the ability to see likenesses and differences; the ability to judge, amend when faulty, and to apply a definition thoroughly; the ability to make a rule, to judge reasons, to select facts, to reason in arithmetic; the ability to reason syllogistically, to detect catches, to make prompt and accurate associations, to follow directions, to correct errors and point off sentences, and tests of the knowledge of formal grammar after the training period. Three 30-minute periods per week during six months were devoted to the investigation. The first set of tests was given to all the children. Then for three months, the children of one room were drilled in formal grammar, wherein emphasis was laid on grammar as a strict science and an attempt to secure a

general ideal of method (like Ruediger's) was made. During this time, the second room of children did work in composition and language. There were then given the second set of tests, after which the conditions were reversed for three months in the two rooms. Finally, the first set of tests was given again to all the children. From his results Briggs concludes that "these particular children after the amount of formal grammar that they had, do not, as measured by the means employed, show in any of the abilities tested improvement that may be attributed to their training in formal grammar." "The burden of proof now rests with those who believe in a strengthening mental discipline from formal grammar."

4. Mental Traits. A. Memory. Sleight (46), in order to discover if memory training is general or specific, experimented with two classes of women students in a Training College, the average age being 18–19. The tests were of immediate memory and made use of letters, nonsense syllables, dates, poetry, and prose substance.

Sleight also investigated the same question with three classes of pupils aged 11–12 years in three different schools. Each class was tested with 10 different kinds of memory material and then sorted into four groups of equal average ability. One group was practised on poetry, the second on tables, the third on reproducing the gist of prose, while the fourth received no training. After three weeks of practice, a second series of tests was followed by three more weeks of practice, in turn followed by a third series of tests. The tests made use of letters, dictation, names, geographical places, nonsense syllables, dates, poetry, prose, substance of prose, and points in a

circle. A new feature was a cyclic arrangement by means of which all three test series could be considered equal in difficulty. Finally, some time after the third series, a fourth series was given.

The results with both the college and elementary pupils showed no general improvement of the practised over the unpractised. In nonsense syllables there was considerable improvement of the trained over the untrained, but only with those who practised on poetry or tables. This was ascribed to the presence of rhythm as a common element and the deduction is made that the effects of practice are transferable when common elements exist. Practice in prose substance effected an improvement in that form of memory, and in no other; it had, in fact, a disastrous effect on the power to memorize mechanically. The conclusion is reached that "we must therefore face the fact that some practice has the effect of diminishing the power to memorize some other material."

Winch (63–66) has conducted four elaborate series of memory experiments with school children, two to ascertain if memory is improvable with practice and two to discover if improvement in memory is transferable. In studying immediate memory, he exposed sets of consonants to view for a short time. The subjects were 25 girls of Standard VII, ages 12–15, and 33 boys of Standards VI and VII, ages 11–14. His conclusion from these two sets of experiments was that a wider range of age and standard would be necessary to answer questions as to the improvability of memory by practice, improvement with age, and relation to general intellectual proficiency. A second series of experiments was then given to 39 girls, Standards II–VIII, and ages 8–14, chosen on an age

basis. Results were compared with the school marks over the space of one year. He concluded that memory improved with practice, that general mental ability is accompanied by "good memory," that "good memory" is usually accompanied by general proficiency, and that there is a general improvement rising with age and standard. Another series of experiments was given to girls from two divisions of Standard VI, six from the upper and six from the lower division, and with the same results. In a later series of experiments on auditory memory, conducted along similar lines to those just described, he verified his conclusions with visual memory. He attempted to answer the question: "Is the improvement in memory gained through practice in one subject of instruction, transferred to another subject which has not been practised?" He divided each class into two groups of equal ability, determined partly by test and partly by the opinion of the teacher. He gave three series of experiments to girls from Standards VI and VII, average age of 12–13, and from three schools of different neighborhoods. In all cases, the practice was on poetry, while in two cases the tests were historical and in the other geographical. While the practised half was studying poetry, the other group was occupied in writing or working sums. In the three series, he found that the practised group was superior to the unpractised and therefore concluded that "improvement, gained by practice in memorizing one subject of instruction, is transferred to memory work in other subjects whose nature is certainly diverse from that in which the improvement was gained." This conclusion, he goes on to say, is true for this age and the attainments of these children. In another

article on the transfer of improvement in memory in school children, he reported his results in answer to the problems: "Whether there is any transfer of improvement in rote memory for meaningless things to substance memory for stories (1) by an auditory method, (2) by a visual method," and "whether there is any transfer of improvement in rote memory for things with meaning—for example, poetry—to substance memory for stories." He conducted three series of experiments. The first series was given to boys and girls of Standard III, of an average age of 10 years. Three preliminary tests in substance memory consisting of stories read aloud, also some tests in rote memory for meaningless things consisting of consonants read aloud, were given, and the class was divided into two equal groups on the basis of the tests in substance memory. One group received three practice exercises in rote memory, while the other group drew difficult geometrical designs. Then a further test in substance memory was given to both groups. The results showed an improvement within the practice medium itself from 11.9, the first practice test's average mark per child per test to 15.8 average mark per child for the third test, out of a maximum of 24. The comparison of the final and preliminary tests shows that there is a steady improvement, which is greatest in the practised group; and "about as much or more improvement, reckoned in percentages, as has been made in the practice medium itself—rote memory for meaningless things—has been transferred to the substance memory." The second series of experiments was with girls of Standard IV, age 10 years. Four tests in substance memory, consisting of written stories, were given, and as a result,

the class was divided into two equal groups. Through several weeks one of the groups did 13 practice periods of 9 exercises each in rote memory, consisting of the learning of consonants exposed visually, and the other group worked exercises in arithmetic. Then both groups worked four more tests in substance memory. There was an improvement within the practice medium itself; also "both groups show improvement in the final tests and it seems fair to suppose that the excess of improvement in the practised over the unpractised group may be a measure of improvement due to the special practice in rote memory." In the unpractised group there was an improvement of 16 per cent., while in the practised group there was an improvement of 21 per cent., probably due to special practice. In the third series of experiments, the girls were from Standard V, 12 years of age and backward in scholarship. There were four tests on substance memory for stories, followed by division of the class into two equal groups. One group practised rote exercises on poetry. Then four final tests were given to both groups. All the work was done visually. The results showed an improvement in rote memory for every individual in the practised group; and "the excess improvement of the practised, about 6 per cent. in the final test, may perhaps be attributed to the effect of the practice exercises in rote memory." His conclusions from these experiments in regard to the transfer of improvement in memory are: "Improvement through practice in rote memory is followed by improvement in substance memories for stories." "Improvement by practice in one mental function may produce an improvement in the other."

B. Habits. Squire (3) insisted on neatness and accuracy in the preparation of the arithmetic papers by the 13 pupils in the second half of a third grade. It was found that there was an improvement in the arithmetic papers, but that this did not transfer to the language and spelling papers, in which there was a decrease in both accuracy and neatness.

C. Concentration of attention. Miss Aiken's (1) experiments on the concentration of attention by the use of daily exercises to quicken the perceptive faculties, to cultivate the habit of accuracy in seeing and hearing, and to cultivate quickness of discrimination, and their amazing results have already been referred to.

Dallenbach's (13) problem was to find out the effect of a daily drill for 15 minutes conducted during a period of 17 weeks. The subjects were 11 girls and 18 boys, of ages 7–10. The materials consisted of charts, of numbers, letters, words, geometrical figures, etc. The experiment lasted for 17 weeks, and comprised a week of fore-practice followed by a week of tests with 4 weeks of drill; the two latter alternated until 4 weeks of tests and 12 weeks of drill series had been given. Ten months later, another test series was given to 31 children, 19 of whom had had the training. His conclusions are that the effect of drill is persistent, and that boys surpass girls in visual apprehension. During the following school term, there was a striking general rise in the school grades of these pupils, seemingly due to his formal drill exercises, also a special test by the *Aussage* method, showed that the practised children were superior in recall and description to their unpractised schoolmates when tested some 50 weeks after the termina-

tion of the special drill. "Original work of drilling the children has produced a training that has not only persisted, but also 'spread' to some extent to other functions." He concluded that he has "evidence in favor of a restricted belief in formal discipline."

D. Observation. Bennett (6) investigated to find the result of special practice in discriminating different saturations of blue upon other sense powers in the case of 16 children, 11 years old, from the Speyer School of Teachers College. A Milton-Bradley color wheel was used with a set of the larger and smaller disks. The children recorded their judgments with an *I* or *O* according as the saturation of the inner disk or outer disk was greater or with an *S* if it was the same for both. Preliminary and final tests were in discriminating different mixtures of red and white, of yellow and green, of orange and black, and different pitches. They practised with the blue and white disks for half an hour, twice a week, from October to March. Bennett found that ability to discriminate different saturations of blue increased with practice in the training series. Ability to discriminate different mixtures of red and white, of yellow and green, and of orange and black was greatly improved in the final tests. In most cases, there was an improvement in the test series, both before and after training. There was an improvement of 20 per cent. for the boys and 23 per cent. for the girls in discrimination of pitch, but it was "not at all commensurate with that in the color field." He concludes that "training in the discrimination of some colors is highly effective in the discrimination of others, much less so with tones."

E. Quickness, accuracy, attention, etc. Norsworthy (36) sought to find individuals with differences in one

trait, then to measure those individuals in other traits and to compare the results. Tests were given in multiplication, in observing misspelled words, in marking words containing *e* and *r*, in observing the word *boy* wherever it occurred, and in marking semicircles scattered amongst all sorts of geometrical forms. Results led to the conclusion that it is "probable that certain functions which are of importance in school-work, such as quickness in arithmetic, accuracy in spelling, attention to forms, etc., are highly specialized and not secondary results of some general function." In other words, there is no such thing as *general* memory, quickness, accuracy, or observation.

F. Ideas of Method. Judd (2) required two groups of pupils in the 5th and 6th grades to hit with a small dart a target which was placed under twelve inches of water. The difficulty involved was due to deflection of light through refraction. One group was given a full theoretical explanation of refraction while the other was kept in ignorance. The results of the first test were the same for both groups. Then the twelve inches of water were reduced to four. The boys ignorant of the theory were very much confused, while the others were not. "Theory was not of value until it was backed by practice." The conclusion is therefore drawn that "every experience has in it the possibilities of a generalization." Here there was a transference of method.

G. Ideals. Ruediger (40) tested the point: "Does the ideal of neatness brought out in connection with, and applied in, one school subject function in the other school subjects?" He experimented with 83 pupils from the 7th grade of three schools, each in a different city. In the written work of one school

subject, he paid all the attention possible to the habit and ideal of neatness. He talked with the class about neatness, though not referring specifically to the other school subjects. He collected at least three papers in each subject before he brought up the matter of neatness and then one or more papers a week in three or more subjects. The experiment covered eight weeks. The marks for all school subjects were raised although the gain was greater in the subject in which neatness had been emphasized. "Evidently neatness made conscious as an ideal or aim in connection with one school subject does function in other school subjects." He would ascribe transference to "identity of aim."

Reviewing the pedagogical experiments, as in the psychological, we find two camps with reference to the question of transfer. Starch, Collins, Rietz and Shade, Wallin, Winch, Ruediger, Dallenbach, Aiken, Bennett, and Judd found evidences of a spread of training or of correlation of abilities. Lewis, Stone, Briggs, Sleight, and Squire, because of their results, would not subscribe to the doctrine, at least in the aspects that they studied. Of these investigators, certainly the most elaborate experiments were performed by Winch and Sleight; and unfortunately for the solution of the problem, they disagree. Starch ascribes the evident transfer to the "identical elements" in the practice and test series, while there was no transfer from arithmetical computation to auditory memory span. In Wallin's experiments, transfer of spelling efficiency from column drills to dictated composition may likewise be ascribed to "identical elements." Winch's conclusion that "improvement gained by practice in memorizing one

subject is transferred to memory work in other subjects whose nature is certainly diverse from that in which the improvement was gained" is criticised by Bagley (3) on the ground that "the nature of the subject-matter is not so diverse as to exclude altogether the operation of identical elements, nor is the difference between the two groups in memory capacity at the close of the test so great that one needs to assume a 'general' function of memory has been trained." Ruediger ascribes transference to "identity of aim," and Judd's target experiment illustrates the transference of "identity of procedure or method." Lewis, while finding no evidence of the correlation of reasoning ability in mathematics and law, believes like Ruediger, and Bagley in the transference of ideals. Sleight, like Judd and Bergström, found evidence of interference effects. From such a varied mass of results and explanations, it is impossible to do more than speculate as to the validity or falsity of the doctrine in connection with pedagogical investigations.

Summary of the Historical Review.

After this necessarily brief review of some thirty psychological experiments and twenty-odd pedagogical ones, it is important to discover the consensus of belief arrived at by scientific investigation. Ebert and Meumann, Coover and Angell, Judd, Winch, Wallin, Fracker, Urbantschitsch, Münsterberg, Dallenbach, and Spearman may be considered among the more prominent proponents of the doctrine of formal discipline. On the other hand Thorndike and Woodworth, Stone, Sleight, Burt, Heck, Whipple, Swift, Bolton, DeGarmo, Henderson, Jastrow, Norsworthy, and Squire, either as a result of personal in-

of experimental work in this
the main with the opposi-
improvability with practice
material, similar or closely
orm. Prominent among the
of training" where "identical
Thorndike and Woodworth,
Sleight. (The term "Identical
; it includes identity of sub-
ntity of form or procedure,
.) All psychologists seem to be
there is identity of substance,
according to the general laws
il a physiological limit has been
se who emphasize identity of
as an explanation of transfer-
s on the importance of concen-
are Thorndike and Woodworth,
Coover, Bagley, Ruger, Judd
and Tracker. ger, Ruger, Lewis, and Bagley
are impressed with the necessity for an aim or ideal.

Probably Spearman (48), in his able article on Qualified and Unqualified "Formal Training," has expressed the idea that will bring reconciliation between the two opposing factions when he states that the "attack is not against formalism utterly, but against unqualified formalism." He advances four qualifications: (1) Transference is not peculiar to form. "As far as economy is concerned, all sorts of training, formal, material, or a mixture, would appear to be about on an equal footing." (2) Transfer must always be regarded quantitatively. After a review of Sleight's experiments, the conclusion is drawn that "it is evident that the training is indeed

transferred from one material to another, but only in proportion to the similarity between them." (3) Transference is not always improvement. He cites conclusions of Judd, Fracker, and Sleight in support. (4) There is a need of separation for transfer. For example, procedure may be developed into a clearly conceived method; this thenceforth becomes an independent, and sometimes exceedingly useful tool of thought. An instance is Judd's experiment with the target under water. "An even more important instance of separating an element from the complex in which it occurs is the evolution of particular impulses into a general maxim or ideal." Compare Squire's negative results with Ruediger's positive ones. He concludes by saying that the "two chief opposing schools are at cross purposes; the one is defending what may be called qualified formalism, while the other is attacking unqualified formalism." The great problem is "how these facts are to be utilized in the re-ordering of our educational system."

PART II. ORIGINAL INVESTIGATION.

I. Introduction.

The original investigation was undertaken to secure experimental data in regard to one of the aspects of the doctrine of formal discipline, expressed in familiar language of "training observation." Little has been done upon this problem experimentally. Several persons, as has been noted in the historical part of this essay, have investigated the transfer of improvement of rote memory to substance memory, the transfer of arithmetical abilities, and the transfer of reasoning abilities. This particular "faculty" or habit of observation was selected because the writer, a teacher of biology, could give the tests in the ordinary routine of the classroom without seriously disturbing the required work and also without the subjects suffering the disadvantages incurred when the tests are foreign to the immediate school program and conducted by a stranger. No explanations were made to the pupils as to the object of the experiments. In connection with a previous experiment, they had had a few tests somewhat similar to several of the non-biological tests. The results of these tests had been reported to the pupils individually at the conclusion of the entire set of tests and had been tabulated on the board by recording the name and percentage of the pupil receiving the highest rating in each test. This previous experience may have acted as an incentive in the present work, as they were told that they would again be informed of the results. When all three series of experiments had been completed, pupils were given their individual

ratings in the various tests, with tabulation of the names and percentages of the leaders for each test of the three series of all three classes.

II. Subjects.

The subjects were all pupils in the first term of the freshman class of a New York City High School. When the third series of tests was given they had entered upon the second term. These pupils were distributed in three classes.

Class 1 had 12 boys and 20 girls; *Class 2* had 10 boys and 18 girls; *Class 3* had 12 boys and 12 girls whose results are tabulated in the following pages. Several others in each class took the tests, but because of irregular attendance, absence from one whole series of tests or more, or because there was an odd number of boys or girls after division into two equal groups, their results had to be discarded.

The ages of the pupils varied from 12 to 17.

Class 1, average age, boys 13.7; girls 14 years.
Class 2, " " " 14.1; " 13.8 "
Class 3, " " " 13.8; " 14.1 "

III. Time Schedule of Tests.

The tests in the first and second series were given in the afternoon. Class 1 recited from 12:50–1:30; Class 2 recited from 1:35–2:15; Class 3 recited from 2:15–2:55. The tests were given immediately after the class had assembled.

The first series of tests was given on April 22, 23, 24, 25, 26, 29, 30. The practice series occurred on the 10 school days from May 15 to 28. The second series of tests was given on June 3, 4, 5, 6, 7, 10, 11. The third series of tests was given on November 4, 6, 8, 11,

12, 13, 14. Between the second and third series, the classes were promoted and were not kept intact. The classes during the third series recited during the three periods from 9:30 to 11:45.

IV. Practice Series.

On the basis of averages obtained from the tests of the first series, each class was divided as nearly possible into two groups. In each class effort was made to place the pupil receiving the higher average of the two highest pupils on the side which was to receive no practice, while the second highest was placed in the division to be practised. This method was continued until the list was exhausted. Thus among successive pairs, there was usually a slight advantage on the non-practised side, and the totals of the two groups in all three classes showed the non-practised side to have the advantage at the end of the preliminary tests.

On May 15, the practice series was begun and continued for ten minutes daily until the expiration of two weeks. While the one half of the class was observing and describing the biological material of the practice series, the other half was writing answers to questions on topics previously assigned for home-study from the text-book. The text-book work was required of all for outside study, but only the non-practised half wrote answers to questions. In order to prevent failure to do the assignment, the pupils were not informed in regard to the procedure until the class assembled each day of the practice tests. All the other biological work was the same for all classes. The classes were kept in ignorance of the reason for division into two groups during the practice weeks, and although they were quite interested as to the cause and

speculated somewhat about it, no reference to the previous tests was made as an explanation. It appeared, however, that the non-practised half considered that the practised half must be superior as they were chosen to do the extra tests. The reverse, however, was true for successive pairs as far as the preliminary tests were concerned. None of the pupils knew that a second or a third series was to be undertaken until each was actually begun. They were then reminded of the previous tests, informed that they would learn their results later, and that comparisons would be made between their work in the first and second series of the tests. Absolutely no reference was made to the practised or unpractised half, and it was not apparent that the pupils thought that there was any connection between the practice and the series of tests.

During the practice series, while actually engaged in the ten minutes' daily practice, the practised were separated from the unpractised. During both the first and second series and throughout the term, the pupils occupied the seats which had been individually assigned to them at the beginning of the term.

V. Method of Conducting the Tests.

The directions were given orally. Before each test, paper was distributed to each pupil, who ruled it, if the nature of the test so required, inscribed his name thereupon, and was informed of the content or material of the test. From previous experiments, the pupils had learned to obey directions, and collect papers with almost military precision. The signals used were: Start! Stop! Look! Write! Draw! Collect!

Time was kept by the second-hand of a watch.

VI. Details of the Tests.

Series I, April 22 to 30.

Test 1. April 22. Each pupil received a twig of horse chestnut with an unopened bud and one with developing leaves. The direction given was to write a complete description of these stems. Time 10 minutes.

Test 2. April 23. A picture was suddenly exposed for 30 seconds, and the pupils were permitted 5 minutes to write down their descriptions.

The picture represented a girl clad in an old fashioned, gaily colored dress. Standing up on its hind legs beside the girl, was a large dog, while several puppies were frolicking on the ground. The background indicated a country scene with rocks, trees, and hills in the distance and a water-fall near-by.

Test 3. April 23. Each pupil received a forsythia flower and was directed to write a complete description. Time 5 minutes.

Test 4. April 24. Ten nonsense syllables of two letters each, printed in two rows on oak tag, were exposed for 30 seconds. (See Fig. 1.) Pupils were directed to place the right syllable in the right place. One minute was allowed to write them.

Test 5. Branches of lilac leaves were distributed to each pupil, and directions given to write a complete description of the lilac leaves. Time 8 minutes.

Test 6. April 25. A nonsense figure (Fig. 2) consisting of 10 lines, drawn with black pencil on oak tag, was exposed for 30 seconds and one minute was allowed for drawing it.

Test 7. April 25. A chart (Fig. 3) having 10 geometrical figures in two rows, drawn with black pencil on oak tag, was exposed for 30 seconds, following the direction to draw the right figure in the right space of their paper, which had been ruled beforehand by the

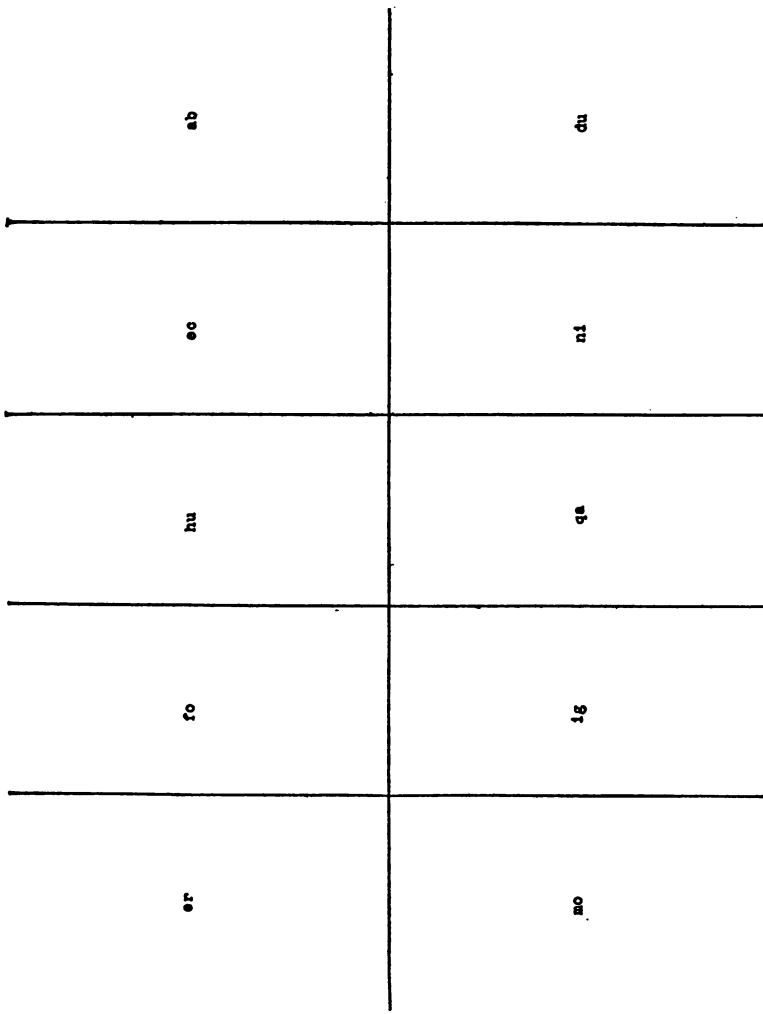

FIG. 1.

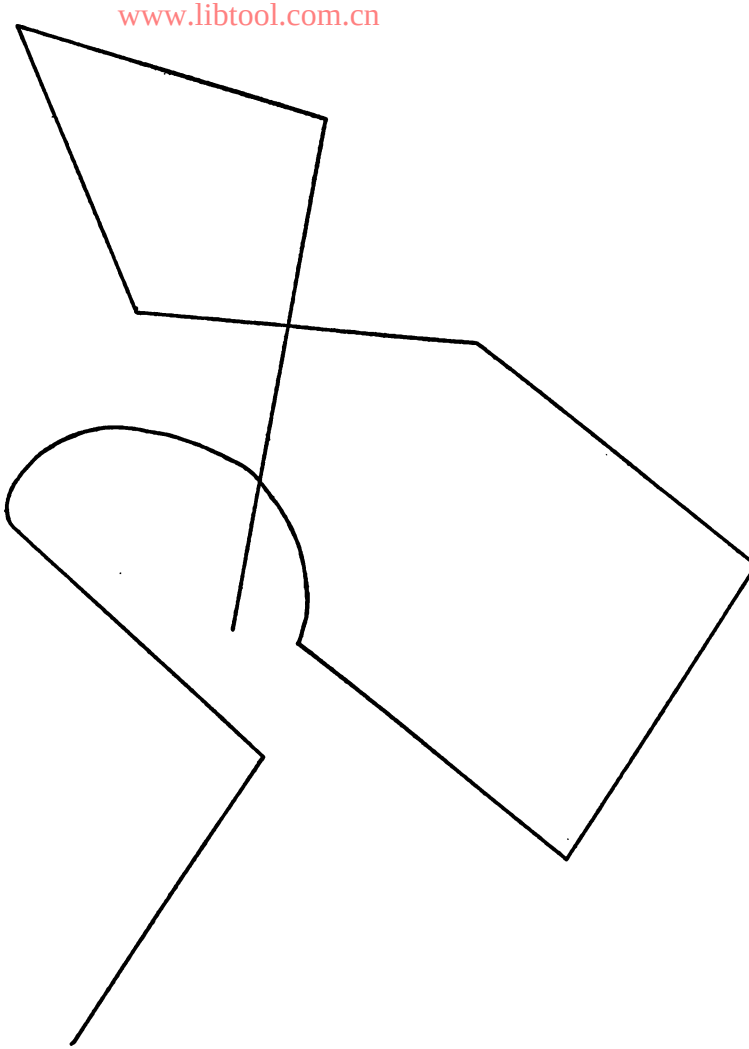

FIG. 2.

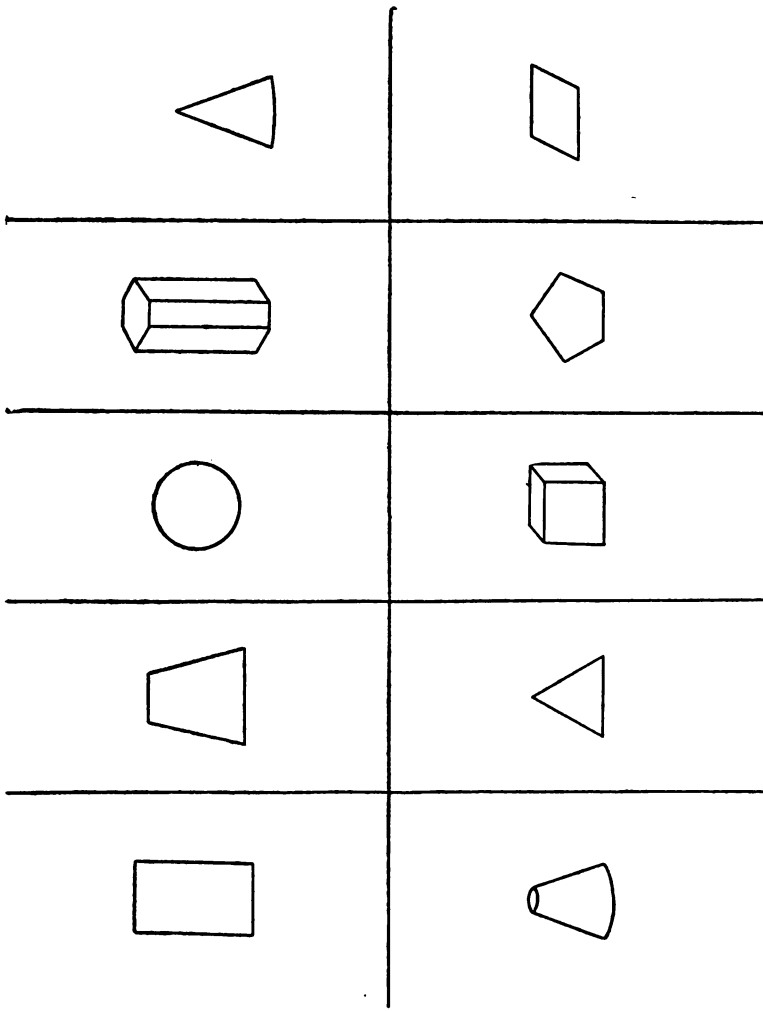

Fig. 3.

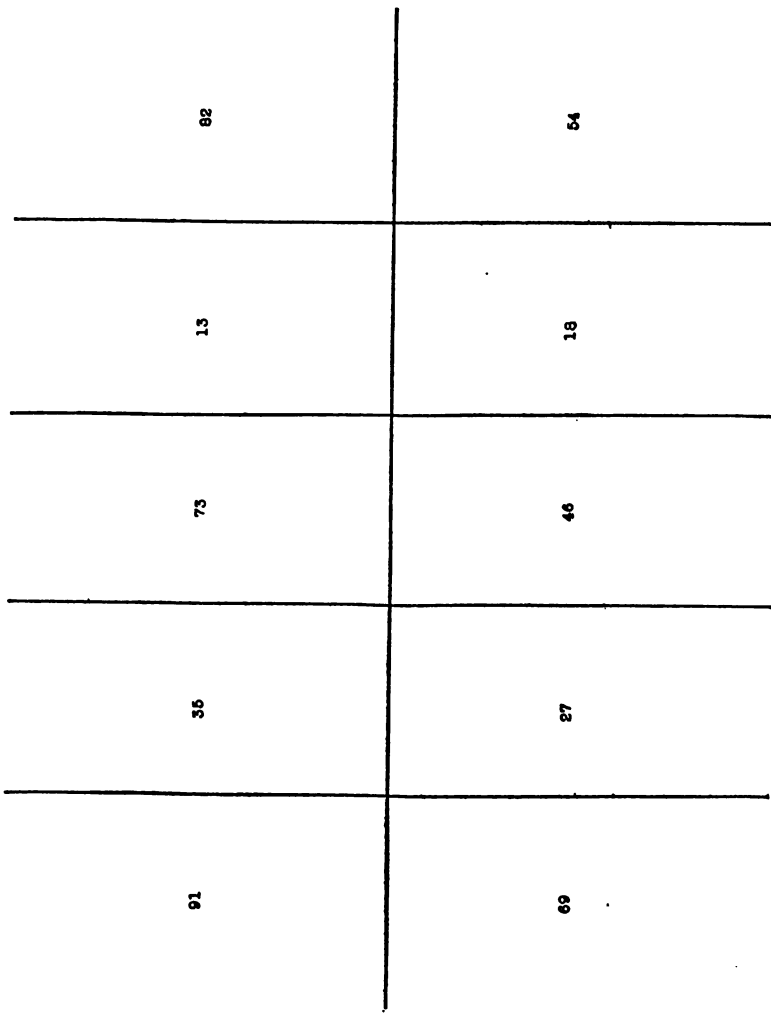

FIG. 4.

pupils. Three minutes were allowed for reproduction of the figures.

Test 8. April 26. A chart having ten two-place numbers in two rows printed on it (Fig. 4) was exposed for 30 seconds with the direction to place the right combination in the right space on their ruled paper. One minute was allowed for recording.

Test 9. April 29. Pupils were permitted to examine specimens of scouring rush or horsetail for one minute and then, with the specimens hidden from view, were given five minutes to describe their observations.

Test 10. April 29. In a similar manner, they were allowed one minute to examine a maple seedling and 5 minutes to describe it from memory.

Test 11. April 30. A colored chart with various anatomical features of the pea flower was exposed for 30 seconds, an allowance of 5 minutes was made for description. This test was not used in the comparison of the three series, because it was found that, as the pupils had not yet studied flowers, they were unable through lack of technical terms to describe much that they had seen.

Test 12. April 30. A figure was outlined in the air with a pencil point. (See Fig. 5). Pupils were informed that 10 lines would be drawn and that at the end they were to reproduce them on paper.

Test 13. May 1. A colored chart of the potato plant, similar to Test 11, was exposed, but was not used in the series, for the same reason as in Test 11.

For the nature of the practice series which was carried on May 15 to 19 and May 22 to 26, consult the tabular statement, page 69.

Series II. June 3 to 11.

Test 1. June 3. Each pupil received a twig of sassafras and was allowed 10 minutes to write as com-

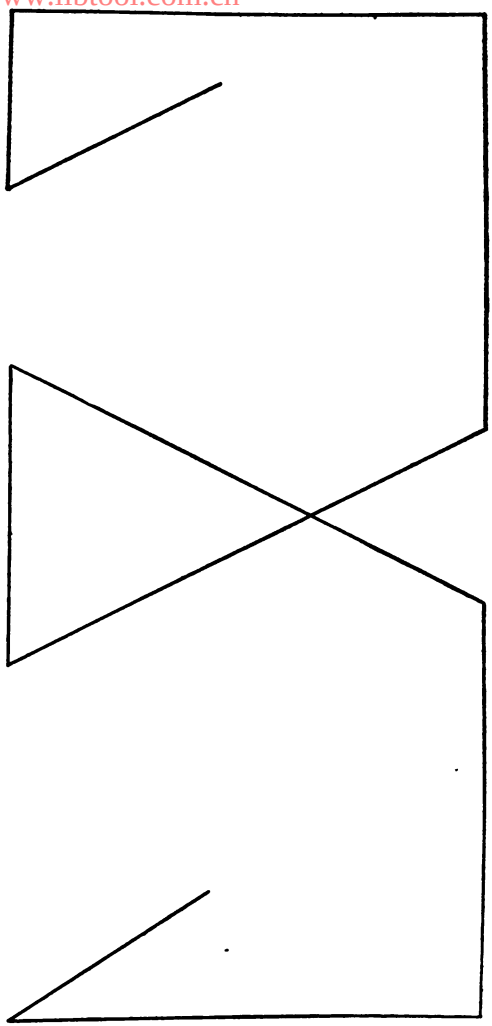

FIG. 5.

plete a description as possible. Because of a change in the program, Class 3 did not recite on this day and was unable to take the test.

Test 2. June 4. Another picture was exposed for 30 seconds and five minutes were permitted for a description of the picture.

A little girl in a pink dress was standing near a brass table in a richly furnished room. Rugs covered the hard-wood floor and an easy chair and pillow were in the foreground. A large vase of cattails and palms was on the floor and another containing pampas grass was on the table.

Test 3. June 4. Syringa flowers were distributed to each pupil and five minutes' allowance was made for a description.

Test 4. June 5. Another chart with ten nonsense syllables of two letters each was exposed for 30 seconds. The arrangement was like Fig. 1, but the syllables were: ro, fe, cu, eh, ad, in, og, na, qi, ub. One minute was given for recording the syllables in the right place.

Test 5. June 5. A branch of forsythia leaves was distributed to each pupil, and eight minutes' time was given in which to write as complete a description as possible.

Test 6. June 6. Another nonsense figure of ten lines (Fig. 6) was exposed for 30 seconds. Allowance for reproduction was one minute.

Test 7. June 6. Ten geometrical figures (Fig. 7) were exposed on a chart for 30 seconds after the admonition to place the figure in the correct place. Three minutes were allowed to draw the figures.

Test 8. June 7. Ten two-place figures (similar to Fig. 4) were exposed on a chart for 30 seconds. One minute was allowed for recording in the proper places.

Test 9. June 10. A fruiting moss plant was distributed to each pupil. After one minute's observa-

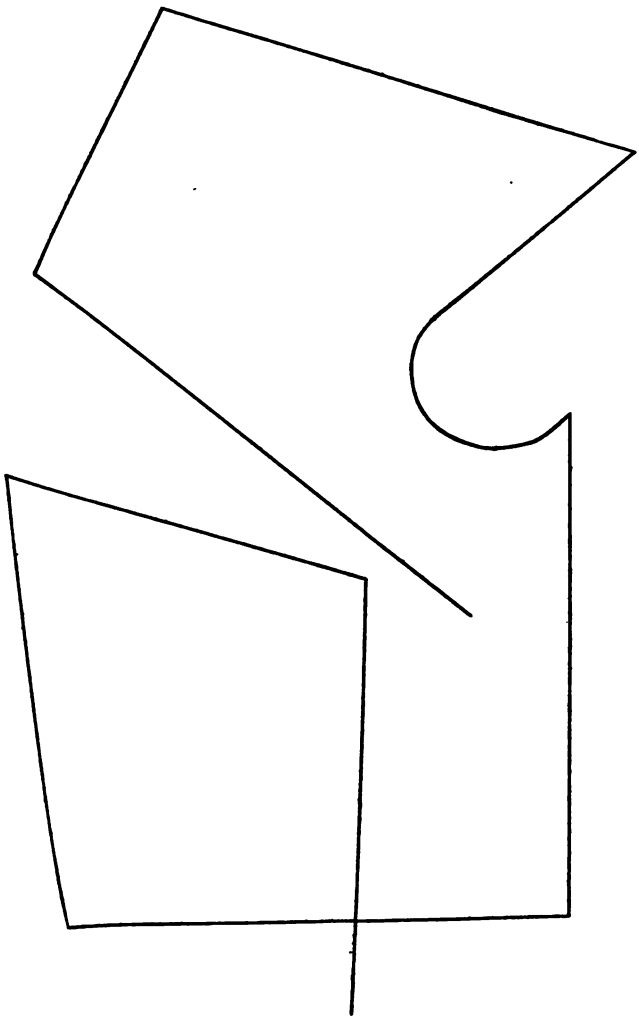

FIG. 6.

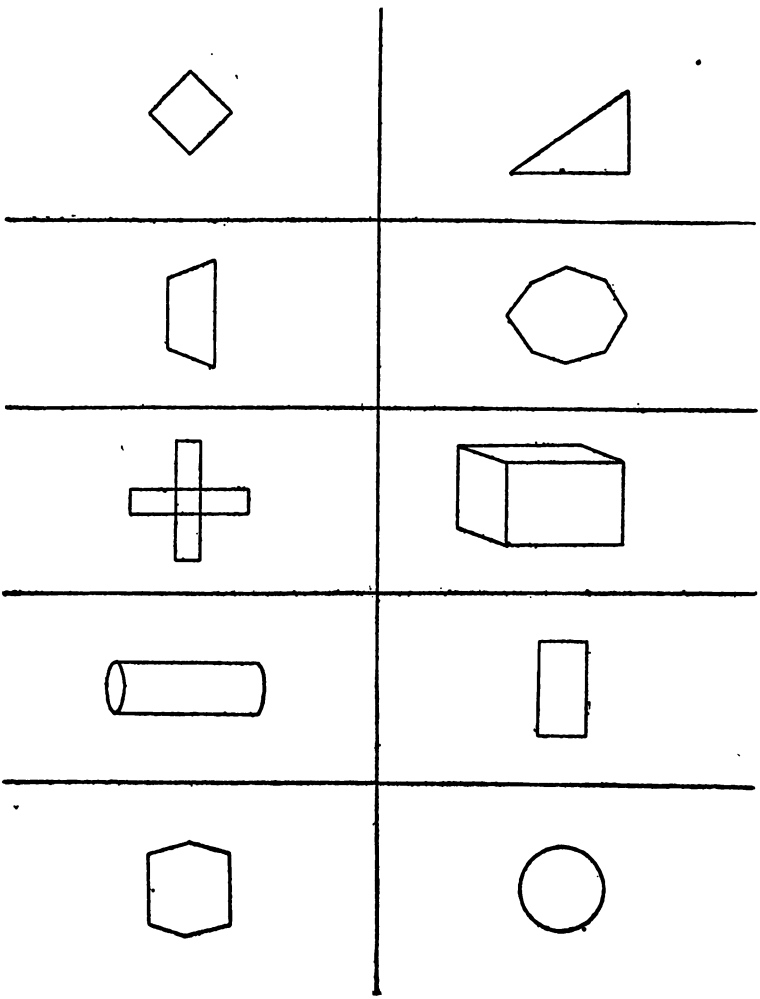

Fig. 7.

tion the material was put out of sight and five minutes were allowed to record observations.

Test 10. June 10. A pumpkin seedling was treated in a similar manner to Test 9.

Test 11. June 11. A colored chart of a grape flower was exposed for 30 seconds and 5 minutes' time was allowed for recording. This was not used in the comparison of the series.

Test 12. June 11. Another figure of ten lines (Fig. 8) was indicated by tracing the figure with a pencil point in the air. When completed the pupils drew what they had seen.

Test 13. June 12. A colored chart of the wild carrot was exposed for 30 seconds and 5 minutes were allowed for a description. This test was not used in the final comparison.

Series III. November 6 to 14.

After the summer vacation, the writer, having in an advanced class all of the pupils that had both remained in school and had been promoted and not having had time yet to rate the papers of the second series, deemed that it might be useful to give a third series of tests. The pupils were now studying zoölogy and physiology, whereas during the previous term they had been studying botany. The pupils were reminded of the previous tests, told that they would learn their results (which had been delayed because of the interruption of the investigator's plans by other imperative demands) and were asked to undertake a third series of tests.

The third series could not be conducted until November, and unfortunately, the biological material available afforded little variety and was, I think, on the whole more difficult to describe. Besides, the pupils had not studied botany since June, and moreover,

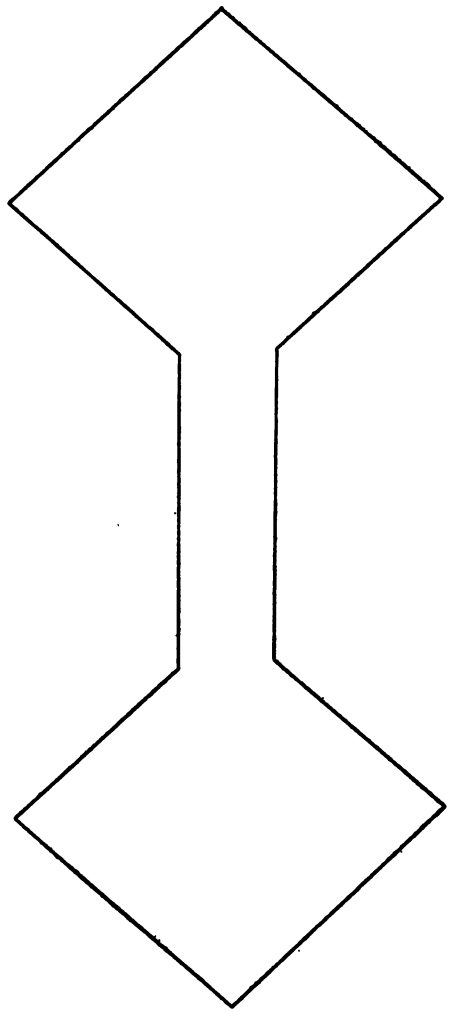

Fig. 8.

they may have thought that botanical material would not count toward their grades in a zoölogical course.

Test. 1. Nov. 4. Pupils received branches of willow. Ten minutes were allowed for a complete description.

Test 2. Nov. 6. Another picture was exposed for 30 seconds, and five minutes were allowed for writing.

A typical Holland scene was indicated by the wooden shoes and the peasants' caps of the boy and girl in the foreground. The girl (holding a baby in her arms) was standing on a wharf, while the boy who was seated on a pile was just pulling something out of the water at the end of a long line attached to his fishing pole. In the background were lawns, trees, and several small houses.

Test 3. Nov. 6. Each pupil received a flower of sweet alyssum and was allowed five minutes for recording observations.

Test 4. Nov. 8 A chart with 10 nonsense syllables of two letters each, printed on oak tag, was exposed for 30 seconds and one minute allowed for recording. The arrangement was like that of Fig. 1, but the syllables were: gi, re, qo, ib, om, ep, da, uh, av, cu.

Test 5. Nov. 8. Honeysuckle branches were distributed and eight minutes given for descriptions.

Test 6. Nov. 11. A nonsense figure (Fig. 9) was exposed for 30 seconds and one minute was allowed for its reproduction.

Test 7. Nov. 11. A chart (Fig. 10) with 10 geometrical figures was exposed for 30 seconds. Three minutes were given for reproduction.

Test 8. Nov. 12. A chart with ten two-place figures (like Fig. 4) was exposed for 30 seconds. One minute for recording.

Test 9. Nov. 13. Each pupil received a pressed fern frond, was allowed one minute for observation, and five minutes for description from memory.

Test 10. Because of inability to obtain any material, suitable for comparison with these tests in the other series, the test was omitted.

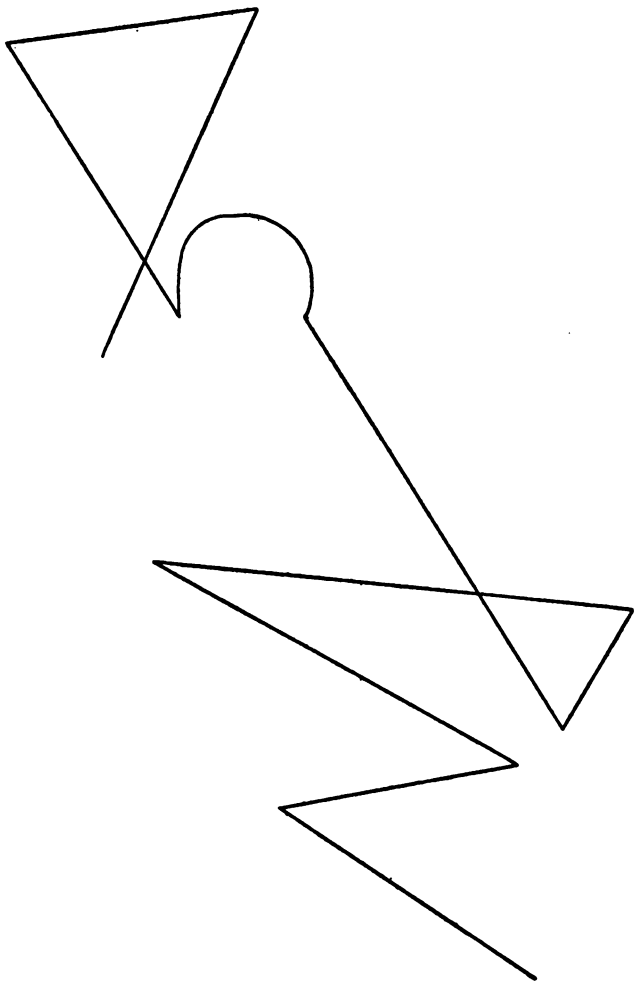

FIG. 9.

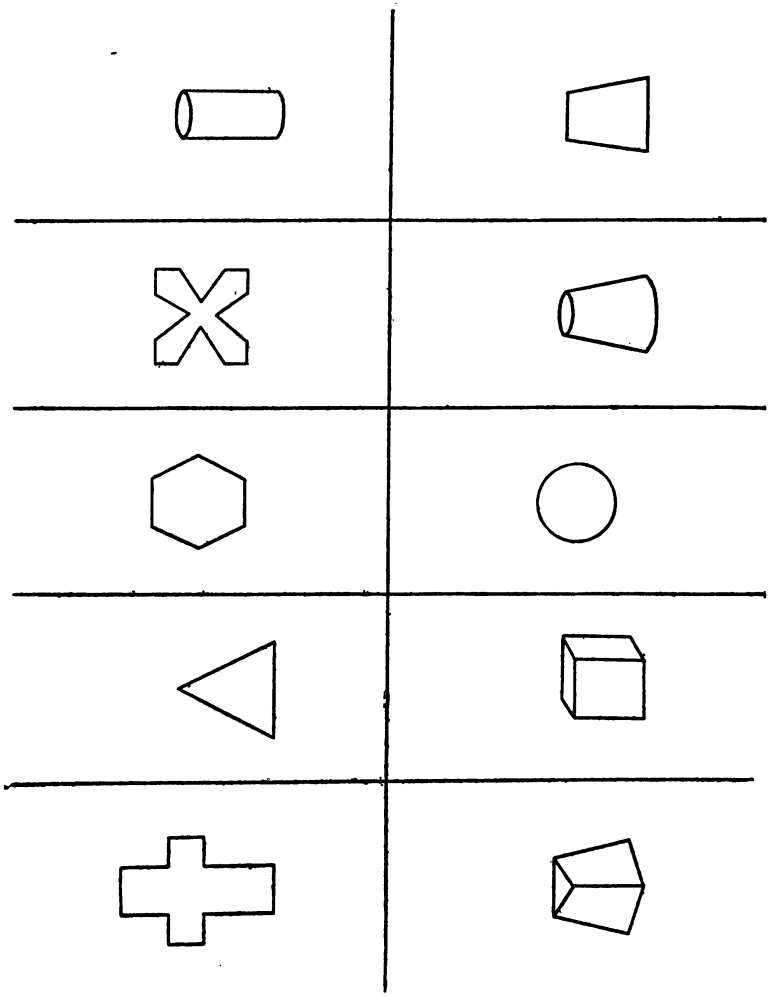

FIG. 10.

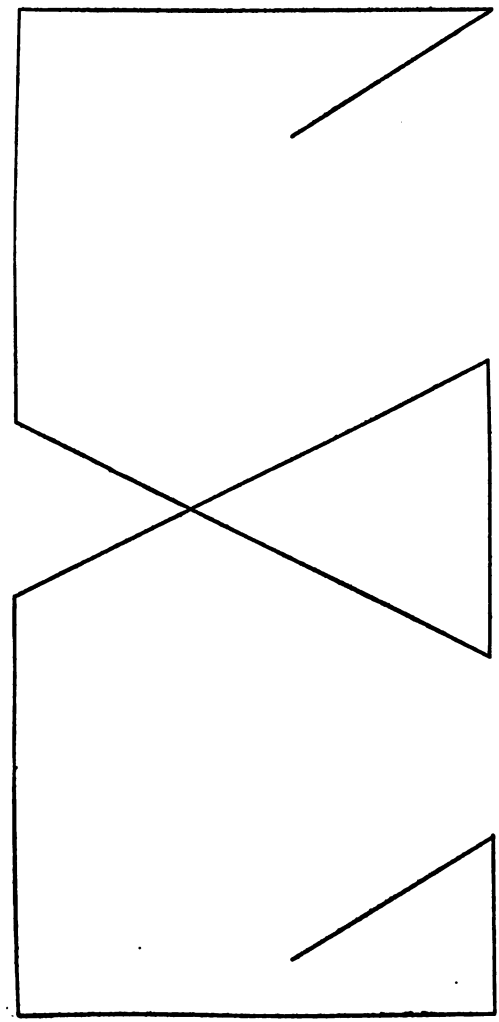

FIG. 11.

Test 11. Nov. 14. The chart of the buttercup flower was exposed for 30 seconds and 5 minutes were allowed for description. This test was not used.

Test 12. Nov. 14. Another figure of ten lines (Fig. 11) was outlined in the air with the tip of the experimenter's pencil. The pupils reproduced it on paper.

Test 13. Nov. 15. A chart of the poppy flower was exposed for 30 seconds and five minutes allowed for description, but it was not used in the series.

The following tabular arrangement will serve to bring the arrangement of the test material into compact presentation.

SERIES 1

No.	*Date*	*Test*	*Exposure*	*Time for recording*
	April			
1	22	Horsechestnut stem		10 min.
2	23	Picture	30 sec.	5 min.
3	23	Forsythia flower		5 min.
4	24	10 syllables	30 sec.	1 min.
5	24	Lilac leaves		8 min.
6	25	Nonsense figure	30 sec.	1 min.
7	25	Geometrical figures	30 sec.	3 min.
8	26	10 2-place figures	30 sec.	1 min.
9	29	Scouring rush	1 min.	5 min.
10	29	Maple seedling	1 min.	5 min.
11	30	Pea chart	30 sec.	5 min.
12	30	Figure in air		
	May			
13	1	Potato chart	30 sec.	5 min.

PRACTICE SERIES

	Date	*Material*	*Recording*
	May		
1	15	Description of the lilac flower	Ten minutes for each test
2	16	Description of the box-elder leaf	
3	17	Description of the stem, leaf, and flower of gill-run-over-the-ground	
4	20	Description of flower-stalk and flowers of the lily-of-the-valley	
5	21	Description of the horsechestnut flower	
6	22	Description of the buttercup flower	
7	23	Description of the mustard flower	
8	24	Description of the dogwood flower	
9	27	Description of the deutzia flower	
10	28	Description of the columbine flower	

SERIES 2

No.	*Date*	*Test*	*Exposure*	*Time for recording*
	June			
1	3	Sassafras stem		10 min.
2	4	Picture	30 sec.	5 min.
3	4	Syringa flower		5 min.
4	5	10 syllables	30 sec.	1 min.
5	5	Forsythia leaves		8 min.
6	6	Nonsense figure	30 sec.	1 min.
7	6	Geometrical figures	30 sec.	3 min.
8	7	10 2-place figures	30 sec.	1 min.
9	10	Moss plant	1 min.	5 min.
10	10	Pumpkin seedling	1 min.	5 min.
11	11	Grape chart	30 sec.	5 min.
12	11	Figure in air		
13	12	Wild carrot	30 sec.	5 min.

SERIES 3

No.	*Date*	*Test*	*Exposure*	*Time for recording*
	Nov.			
1	4	Willow stem		10 min.
2	6	Picture	30 sec.	5 min.
3	6	Alyssum flower		5 min.
4	8	10 syllables	30 sec.	1 min.
5	8	Honeysuckle leaves		8 min.
6	11	Nonsense figure	30 sec.	1 min.
7	11	Geometrical figures	30 sec.	3 min.
8	12	10 2-place figures	30 sec.	1 min.
9	13	Fern frond	1 min.	5 min.
10				
11	14	Buttercup chart	30 sec.	5 min.
12	14	Figure in air		
13	15	Poppy chart	30 sec.	5 min.

VII. Marking the Tests and Use of the Scores.

The author was assisted in the marking of the tests by her sister, who had had four years of office experience in one of New York's elementary schools. She rated the 4th, 7th, and 8th tests of each series. Both rated together the 6th and 12th tests of each series. The author herself rated Tests 1, 2, 3, 5, 9, 10. Tests 11 and 13 were discarded.

Rating of the Tests of Series 1.

Tests 1, 2, 3, 5, 9, 10 were rated in the following manner: one credit was allowed for every descriptive noun, adjective, verb, and adverb. In fact, every word or statement presenting an idea, a modification of that idea, or an action, was allowed one credit. Credit was not allowed for the same word repeated in several connections. The rating therefore indicates the sum total of the observations made in regard to the object.

Tests 4, 7, 8 were rated in the following manner: 10 credits were allowed for each correct syllable, correct geometrical figure and correct two-place number which was also correctly placed; thus as there were 10 of each, it was possible to obtain 100 per cent. If the correct syllable, correct geometrical figure, or correct two-place number was displaced one more to the right, left, above, or below, one credit was deducted, if two places to the right or left, two credits were deducted, etc.

Tests 6 and 12 were rated in the following manner: one credit was given to each correct line of the ten comprising the figure. It was not required that the figures of Test 12 should be entirely symmetrical, but full credit was given for each line that indicated that the subject knew approximately the direction of the lines.

Use of Results of Series 1.

The average was obtained of the results of each pupil's work in the eleven tests. These averages formed the basis of the division of the classes for the practice series.

In each class, the boy receiving the highest average was placed on the non-practised side while the boy with the next highest average was placed on the side to receive practice. This was continued until the list was exhausted. The same method was followed with the girls.

Rating of the Practice Series.

All of the ten tests of the practice series were rated by the investigator in the same manner as were Tests 1, 2, 3, 5, 9, 10. The tests were rated in the order in which they had been given: No. 1 first and No. 10 last.

Rating of the Tests of Series 2 and 3.

Test 1 of Series 2 was rated and then Test 1 of Series 3 was rated for the same pupil. The grading of these tests was then carefully compared with the rating of Tests 1 of Series 1 to avoid as much as possible any discrepancy in the rating. This method was followed for each pupil throughout the six tests.

Tests 4, 7, 8, of the 2d and 3d series were rated in the following manner: After the assistant had carefully reconsidered her marking of Test 4 in Series 1, she rated Test 4 of Series 2 and then of Series 3. The same method was followed in Tests 7 and 8.

Tests 6 and 12 were rated by both markers, working together. Each pupil's three test papers in the three series were compared individually to establish improvement or decrease of ability of that particular individual. The investigators then agreed upon the rating to be allowed each test.

Method of Treating the Scores.

Averages were made for each pupil in each series from the rating given to each test as described above.

Ratings of Tests 1, 2, 3, 5, 6, 9, 10, and 12 were reduced to the percentage basis by multiplying each rating by the fraction in each test of each series required to make the highest rating 100 per cent. for that test in that particular series.

On the basis of the data acquired by both methods, tables have been made to compare the practised and the unpractised pupils of each class in two respects in regard to (1) their ability in the biological tests and (2) their ability in the non-biological tests.

In case of the occasional absence of a pupil, the figures for that test had to be omitted from similar tests in each of the three series, in other words, the series were made homogeneous.

Therefore, another table was made, consisting only of pupils who had been present at all the tests of two or more series, while still another table was compiled of the data of those pupils who had been present at all three series of tests.

Tables showing the basis of the division for the practice groups are presented.

The class ratings in biology of the test pupils for the year during which the tests were performed, are recorded together with their ratings in the state examination.

From all of these various tables, comparisons and conclusions are made, and finally the results of the present investigation are compared with those of other workers in the pedagogical field.

TABLE I. ORIGINAL SCORES.

Class I, Series I.

	Tests													
Boys	1	2	3	4	5	6	7	8	9	10	12	Total	Aver.	Age
Garratt	14	23	20	69	21	10	71	60	22	18	7	335	30.45	14
Hart	12	11	18	70	18	6	28	59	12	13	2	249	22.63	14
Hugger	18	19	16	68	8	10	70	79	18	14	10	330	30	13
Jaegers	8	15	6	80	14	6	80	70	8	10	8	305	27.72	15
Johnston	16	27	6	80	7	3	57	37	7	17		257	25.7	14
Lefkowitz	5	14	17	47	13	8	43	40	19	15	5	226	20.54	14
Rhodius	22	41	22	49	21	6	50	60	27	11	2	311	28.27	13
Riconda	10	23	17	49	8	5	49		12	11	8	192	19.2	14
Waller	29	23	32	78	23	8	69	70	16	14	6	368	33.45	14
Walsh	17	19	16	60	11	4	37	50	15	13	2	244	22.18	15
Weber	14	23	15	70	14	8	50	58	14	11	5	282	25.63	14
Wetjen		9	16	50	7	8	70	67	8	1	4	240	24	13
Wild	22	18	18	40	13	6	42	67	11	4	9	250	22.72	13
Girls														
Clute	26	30	23	40	14	9	60	73			4	279	31	17
Cohen				80	19	4	75	83	26	20	2	309	38.62	13
Conradi	21	21	20	48	15	3	60	29	13	22	1	253	23	14
Engels	35	30	26	69	25	6	60	50	24	19	9	353	32.09	13
Geffert	22	34	16	100	11	5	80	70	19	23	9	389	35.36	14
Haag	17	20	15	70	15	4	48	50	10	16	5	270	24.54	14
Hamilton	21	37	28	49	29	7	79	50	24	24	3	351	31.9	15
Howard	33	30	19	68	27	4	38	38	17	21	1	296	26.9	14
Ilch	36	47	33	80	37	6	40	39	25	24	7	374	34	13
Kolsch	27	29	16	50	29	1	36	80	17	22	3	310	28.18	13
Kelly	25	32	30		25	3	60		21	21	5	222	24.66	15
Kelly, K	24	34	20	70	20	8	40	69	16	18	7	326	29.63	14
Krumholz	25	39	23	90	23	6	50	74	28	18	7	383	34.81	13
Manwaring	29	39	21	60	17	4	70	50	10	17	3	320	29.09	14
McGreevy	28	39	32	70	31	8	70	60	26	30	4	398	36.18	15
Millang	17	27	20	50	22	9	70	50			7	272	30.22	16
Murtagh	16	24	21	50	11	1	50	56	13	12	4	258	23.45	14
Perry	26	17	10	69	13	6	60	58	14	13	3	289	26.27	13
Savage	28	24	19	79	18	8	60	70	11	13	6	336	30.54	14
Schmidt	31	40	26	60	33	9	60	60	23	28	8	378	34.36	13

TABLE 1. ORIGINAL SCORES (Continued).

CLASS I, SERIES II.

	Tests											
Boys	1	2	3	4	5	6	7	8	9	10	12	Total
Garratt	36	24	24	90	22	10	80	80	22	24	8	420
Hart	16	27	21	59	13	7	30	80	20	14	3	290
Hugger	8	26	15	70	8	10	70	100	12	13	10	342
Jaegers	20	13	19	79	18	10	66	77	17	19	4	342
Johnston	22	19	10	70	13	8	90	50	15	10	8	315
Lefkowitz	26	27	20	40	36	10	60	30	20	23	7	299
Rhodius	41	44	24	60	22	9	80	40	22	22	5	369
Riconda	11	18	18	60	12	7	80	80	13	16	9	324
Waller	19	13	18	60	15	10	79	92	14	11	7	338
Walsh	12	35	13	70	12	6	70	50	16	9	1	294
Weber	16	28	18	79	14	9	90	80	15	13	7	369
Wetjen	22	9	9	77	15	10	70	53	10	10	5	290
Wild	24	18	10	57	9	5	49	49	14	9	8	252
Girls												
Clute	30	28	22	60	26	10	80	89	20	19	2	386
Cohen	27	32	14	40	26	9	60	71	23	23	3	328
Conradi	25	24	16	50	25	9	47	58	15	18	7	294
Engels	35	30	28	38	40	8	60	36	24	31	7	337
Geffert	28	22	18	100	27	9	100	100	26	20	7	457
Haag	36	32	23	59	19	7	70	54	21	19	3	343
Hamilton	37	35	33	50	35	8		70	25	29	3	325
Howard	34	40	23	89	31	2	50	26	22	19	3	339
Ilch	31	39	27	60	22	7	90	74	23	22	6	401
Kolsch	37	27	19	76	31	5	47	57	19	22	0	340
Kelly	38	27	26	50	29	5	80	42	19	21	0	337
Kelly, K.	26	37	16	70	18	9	90	74	16	16	6	378
Krumholz	29	24	19	60	25	8	80	68	22	17	3	355
Manwaring	25	29	22	60	20	7	90	80	24	19	4	380
Millang	33	22	24	80	29	10	50	77	19	18	2	364
Perry	34	14	15	30	13	8	78	80	14	12	1	299
Savage	25	20	20	90	21	7	70	70	17	16	5	361
Schmidt	42	35	30	58	39	8	60	48	22	31	9	382

TABLE 1. ORIGINAL SCORES (Continued).

CLASS I, SERIES III.

	Tests										
Boys	1	2	3	4	5	6	7	8	9	12	Total
Garratt.....	20	36	27	70	25	10	60	60	14	5	327
Hugger.....	28	19	13	60	6	10	80	58	13	7	294
Johnston....	29	37	12	80	18	10	50	70	13	9	328
Lefkowitz...	25	27	27	40	27	10	50	50	15	8	279
Rhodius.....	21	39	20	70	24	10	60	69	20	7	340
Waller.....	22	33	20	90	22	10	70	70	13	4	354
Walsh.....	24	26	13	68	15	10	56	59	6	2	279
Wetjen.....	25	20	10	48	15	10	59	46	22	3	258
Wild.....	23	23	19	80	11	10	58	49	17	5	295
Girls											
Engels.....	34	29	24	38	28	9	70	69	24	2	327
Geffert.....	23	37	22	80	24	10	52	72	14	5	339
Hamilton...	26	32	31	50	24	8	50	46	23	10	300
Howard.....	22	44	29	60	30	6	60	50	18	5	324
Ilch.....	34	44	28	69	26	10	67	54	28	10	370
Kolsch.....	32	38	19	40	27	9	20	53	13	2	253
Kelly, K...	17	36	20	80	24	9	50	57	22	10	325
Krumholz...	27	34	20	80	29	9	80	63	17	10	369
Manwaring..	33	38	21	60	26	10	59	60	27	5	339
Millang.....	25	21	18	50	31	10	39	79	21	8	302
Murtagh....	25	29	23	79	22	9	55	60	13	3	318
Perry.....	18	32	23	40	14	8	50	60	20	3	268
Savage.....	30	26	24	60	23	10	60	70	17	2	322
Schmidt.....	29	39	27	50	29	10	79	20	31	10	324

TABLE 1. ORIGINAL SCORES (Continued).

CLASS II, SERIES I.

	Tests													
Boys	1	2	3	4	5	6	7	8	9	10	12	Total	Aver.	Age
Andrews	23	46	28	50	27	2	40	60	19	20	5	320	29.09	14
Bernhardt	25	30	29	65	20	4	50	50	14	24	3	314	28.54	14
Demarest	23	29	27	69	29	9	80	68	24	19	7	384	34.909	14
Dinneen	24	27	25	67	19	5	69	67	18	18	4	343	31.18	15
Franklin	35	28	24	59	28	5	90	55	22	22	5	373	33.9	12
Friedland	28	32	22	60	17	3	50	39	24	24	0	299	27.18	13
Hartell	15	25	19	80	19	5	50		18	14	3	248	24.8	15
Mullady	24	14	18	77	17	6	50		24	16	3	249	24.9	14
Schuler	20	32	20	90	22	3	50	69	22	18	10	356	32.36	13
Smyth	26	11	22	70	15	9	50	67	13	14	6	303	27.54	14
Vandevel	20	30	20	60	29	6	70	55	14	17	7	328	29.81	17
Girls														
Blanc	35	34	22	100	20	9	70	66	28	20	8	412	37.45	14
Blumen	17	33	17	50	13	6	80	50	8	18	4	296	26.9	14
Brady	22	16	13	70	18	7	50	59	17	14	9	295	26.81	15
Dalessan	20	30	17	80	19	4	60	80	21	19	7	357	32.45	14
Dehn	14	26	9	70	9	5	70	67	10	13	5	298	27.09	15
Gannon				69	26	7	59	66	15	21	9	272	34	14
Geissen	12	35	25	77	16	9	70	90	13	13	8	368	33.45	14
Grodzic	14	30	18	90	16	10	80	60	15	17	5	355	32.27	14
Hynes	30	29	34	58	20	6	59	30	16	24		306	30.6	15
Inglis	23	34	24	90	18	7	60	80	16	21	6	379	34.45	13
Keane	19	11	18	79	9	5	50	29	9	15	2	246	22.36	15
Luft	23	25	30	90	18	5	68	58	22	21	5	365	33.18	14
Lutz		48	34	57	26			39	21	26	2	253	31.62	14
Meyer	16	18	17	90	23	6	40	79	18	15	4	326	29.63	13
Rehm	34	29	16	70	20	5	60	84	20	19		357	35.7	13
Rudolf	25	33	24	60	22	4	69	49	19	24	6	335	30.45	13
Schnering	19	21	15	80	16	4	46	70	13	15	10	309	28.09	15
Schreiner	19	22	20	30	17	2	90	27	20	25	3	275	25	13
Wunder	19	42	36	57	29	3	79	44	31	34	7	381	34.63	12

TABLE I. ORIGINAL SCORES (Continued).

CLASS II, SERIES II.

	Tests											
Boys	1	2	3	4	5	6	7	8	9	10	12	Total
Andrews	32	43	28	39	19	9	60	59	20	22	6	337
Bernhardt	34	22	24	70	22	9	79	90	17	25	5	397
Demarest	42	27	28	69	36	7	70	70	20	26	6	401
Dinneen	25	24	18	48	15	6	87	69	10	11	4	317
Franklin	34	41	30	90	16	10	100	64	19	25	6	435
Friedland	40	35	32	60	34	9	50	56	29	25	4	374
Hartell	24	16	17	80	19	7	70	50	21	15	3	322
Mullady	21	22	14	60	30	8	54	57	25	20	2	313
Schuler	23	25	25		30	6	75	77	23	21	6	311
Smyth	31	18	26	60	29	10	60	78	20	21	7	360
Vandevel	29	27	27	70	28	6	60	67	19	19	6	358
Girls												
Blanc	37	35	25	100	27	9	100	67	24	27	8	459
Blumen	24	25	16	69	21	10	100	59	19	17	5	365
Brady	22	20	16	50	22	7	80	80	17	18	9	341
Dalessan	25	33	17	100	13	8	80	60	14	23	3	376
Dehn	21			60	10	9		89	18	13	2	222
Gannon	29	30	17	62	22	7	79	70	17	21	3	357
Geissen	29	24	24	70	22	10	100	80	17	18	7	401
Grodzic	29	26	22	100	20	10	98	68	11	16	4	404
Hynes	34	28	24	50	18	9	53	44	19	24	3	306
Inglis	35	39	22	90	30	10	90	80	20	25	5	446
Keane	19	22	12	48	12	7	76	40	11	8	3	258
Luft	29	23	28	57	30	8	69	71	25	21	7	368
Lutz	46	37	33	50	33	5	64	58	27	33	2	388
Meyer	20	25	15	70	22	8	70	87	19	11	6	353
Rehm	29	27	22	69	16	5	79	70	26	13	9	365
Rudolf	30	34	25	58	20	10	90	43	29	19	7	365
Schnering	18	24	17	80	20	9	80	69	19	16	3	355
Schreiner	25	33	34	70	24	9	69	50	19	16	6	355
Wunder	35	38	20	59	33	9	90	49	22	22	6	383

TABLE I. ORIGINAL SCORES (Continued).

CLASS II, SERIES III.

	Tests										
Boys	1	2	3	4	5	6	7	8	9	12	Total
Andrews....	17	34	20	49	32	10	50	38	24	5	279
Bernhardt...	29	33	25	68	23	10	50	60	13	5	316
Friedland...	20	36	28	38	23	7	49	80	18	5	304
Hartell.....	28	15	16	80	17	9	60	56	18	2	301
Mullady....	30	27	13	60	22	8	43	69	19	3	294
Schuler.....		37	23	59	25	7	60	36	23	3	273
Girls											
Blanc.....	40	33	28	90	24	10	67	70	26	5	393
Blumen.....	31	44	17	78	18	7	90	53	19	5	362
Brady.....	22	25	14	40	16	10	80	60	23	5	295
Dalessan....	25	36	19	64	16	10	50	80	14	6	320
Gannon.....	27	33	14	80	21	7	64	68	13	2	329
Geissen.....	29	38	19	70	19	10	90	70	21	10	376
Grodzic.....	16	36	21	59	14	10	90	50	17	4	317
Inglis	32	41	30	70	27	10	80	80	27	5	402
Keane.....	10	17	10	47	12	10	49	38	7	3	203
Luft.....	22	32	23	68	25	10	70	56	18	4	328
Lutz.....	37	45	28	60	33	9	80	80	29	5	406
Meyer.....	30	32	16	40	21	10	58	59	19	2	287
Rehm.....	23	31	18	59	24	10	69	38	13	5	290
Rudolf.....	30	32	26	80	22	10	90	50	22	6	368
Schreiner....	25	33	23	70	24	8	80	59	17	4	343
Wunder.....	37	35	27	62	36	6	48	30	24	6	311

TABLE I. ORIGINAL SCORES (Continued).

CLASS III, SERIES I.

	Tests													
Boys	1	2	3	4	5	6	7	8	9	10	12	Total	Aver.	Age
Alliano	15	27	13	78	14	7	70	67	12	14	3	320	29.09	15
Archimal	26	33	24	39	24	8	80	74	25	21	3	357	32.45	12
Baldelli	27	21	15	59	21	7	90	69	15	21	3	348	31.63	14
Bonomo	22	33	25	60	30	10	90	70	25	23	4	392	35.63	14
Cohen	25	32	23	49	18	6	70	59	16	8	5	311	28.27	14
Cullum	20	24	26	40	21	2	80	60	22	21	7	323	29.36	15
Duff	28	39	16	80	27	5	90	70	22	30	6	413	37.54	14
Friedman	17	22	26	66	13	8	70	60	20	16	8	326	29.63	15
Miethke	27	31	13	36	18	4	60	30	17	19	7	262	23.81	14
Ruppell	29	37	18	80	24	9	100	86	20	26	7	436	39.63	13
Steiner	13	24	13	56	18	0	40	56	9	11	6	246	22.36	12
Timmann	20	28	22	30	31	3	60	70	16	19	7	306	27.81	14
Girls														
Brown	27	31	26	90	17	3	48	70	16	14	3	345	31.36	15
Busby	20	32	26	68	19	3	77	70	18	20	6	359	32.63	13
Duffy	28	27	26	90		5	48		27	15		266	33.25	14
Duro	17	26	19	80	16	7	60	70	16	23	4	338	30.72	14
Gallo	16	33	24	79	12	4	48	79	18	24	3	340	30.9	15
George	18	35	19	80	15	6	50	48	16	20	0	307	27.9	15
Hacker	24	25	25	50	25			80	23	22	8	282	31.33	15
Hill	19	27	14	90	15			100	23	19	3	310	34.44	14
Johnson	22	22	17	90	20	3	58	70	16	16	4	338	30.72	14
Morton	15	18	20	90	22	6	89		20	17	8	305	30.5	14
Netz	14	33	19	50	20	5	60	76	17	24	4	322	29.27	14
Sbarra	16	20	14	90	19	7	68	80	11	23	2	350	31.81	14
Schulz	19	23	6	50	18	4	79	90	11	17	2	319	29	14
Weed	23	21	19	50	14	2	59	50	19	13	2	272	24.72	16
Woodbury	27	29	29	60	32	5	90	68	19	16	5	380	34.54	13

TABLE I. ORIGINAL SCORES (Continued).

CLASS III, SERIES II.

	Tests											
Boys	1	2	3	4	5	6	7	8	9	10	12	Total
Alliano		25	13	60	11	10	80	41	8		3	251
Archimal		26	26	50	31	8	90	50	28	37	8	354
Baldelli		18	22	70	20	6	80	73	21	20	7	337
Bonomo			23	70	35	10	100	100	28	36	7	409
Cohen		30	24	50	30	6	40	69	22	19	4	294
Cullum		24	23	60	24	5	70	79	22	21	6	334
Duff		35	34	70	31	5	70	70	30	34	4	383
Friedman		32	24	70	23	8	90	40	21	22	3	333
Miethke		25	20	80	32	9	100	68	22	22	3	381
Ruppel		33	21	80	24	8	80	100	29	27	2	404
Steiner		23	21	69	27	9	80	39	15	21	4	308
Timmann		42	27	59	35		70	69	26	26	2	356
Girls												
Brown		38	29	58	31	5	58	38	27	24	4	312
Busby		31	26	80	23	6	80	58	18	18	6	346
Duffy		32	34	49	15	5	37	68	19	21	8	288
Duro		36	24	37	26	6	70	70	20	25	4	318
Gallo		36	18	69	19	4	90	80	24	22	3	365
George				80	13	0	70	69	15	17	2	266
Hacker		33	21	60	24	9	90	100	18	27	8	390
Hill		30	9	78	19	10	100	90	18	14	8	376
Johnson		30	18	90	21	4	86	90	16	16	5	376
Morton		27	20	78	13	6	90	60	22	9	5	330
Netz		39	16	68	23	9	70	60	21	18	3	327
Sbarra		17	15	68	24	9	90	90	18	25	3	359
Schulz		27	8	50	24	6	80	80	16	20	4	315
Weed		24	25	70	18	6	80	100	13	13	4	353
Woodbury		31	18	64	29	9	85	39	20	16	4	315

TABLE I. ORIGINAL SCORES (Continued).

CLASS III, SERIES III.

	Tests										
Boys	1	2	3	4	5	6	7	8	9	12	Total
Archimal....	35	45	24	60	29	10	84	75	24	5	391
Baldelli.....	24	30	16	70	13	10	79	58	27	5	332
Bonomo.....	26	38	27	46	36	7	80	78	29	2	369
Cohen.....	39	34	23	30	33	10	76	38	29	2	314
Cullum.....	25	40	29	50	21	8	40	82	27	3	325
Duff.....	34	45	27	69	36	10	70	60	24	4	379
Friedman...	17	36	22	39	24	10	50	70	27	6	301
Miethke....	27	31	13	60	23	10	60	59	27	8	318
Ruppel.....	27	38	25	70	27	10	90	37	25	3	352
Steiner.....	28	33	21	50	22	8	40	70	17	2	291
Girls											
Busby.....	30	38	28	100	23	10	80	78	28	5	420
Duffy.....	29	39	27	56	22	3	50	66	28	5	325
Duro.....	24	30	15	50	19	10	59	66	24	2	299
Gallo.....	33	37	22	68	20	9	68	40	21	3	321
Hacker	26	39	31	50	39	10	70	50	26	5	346
Hill.....	30	27	21		32	10	90	70	14	3	297
Johnson.....	22	33	16	39	19	10	70	80	24	3	316
Morton.....	24	33	19	70	13	9	80	80	22	8	358
Netz.....	13	38	17	46	16	7	67	69	21	6	300
Sbarra.....	23	22	14	80	16	10	58	70	16	2	311
Weed.....	25	32	22	49	16	9	50	50	13	5	271
Woodbury...	28	31	28	48	21	10	88	58	29	4	345

Explanation of Table 1

The original ratings and totals of each pupil in Series I, II, and III, together with the average of each pupil in Series I and the age at the time of the tests of Series I, are presented in Table I.

Blanks indicate that pupils were absent from the tests.

As absences were so frequent, it seemed advisable during the tests of Series II and III, in order to have sufficient data to secure results, to require the pupils to perform the tests either before or after school as soon as possible after their return. No deviation from the method of procedure occurred. A careful record was kept of those who did not perform the tests with the class. As far as could be discovered, there seemed to be no great difference between the ratings secured when the test was performed independently and the average ratings of that pupil when the tests were performed with the class. Of course, it is impossible to state whether the pupil's rating in a particular test would have been higher or lower if performed with the class. Sometimes a pupil did better and sometimes worse.

Comparison of Practised and Unpractised Groups.

Table 2 is based upon the scores of the practised and unpractised pupils in all three series, reduced to percentages as explained above under *method of treating the scores.*

In computing it we disregarded absences and also the omission of Test 1 in Series II by Class III and Test 10 from Series III. As the absences are about equally divided among the practised and unpractised, no very great discrepancy is made with such large totals.

From the summary, that Table 2 provides, it will be noticed that in Series 1, in each of the three classes, the unpractised boys and unpractised girls have higher totals than the practised. This, of course, is due to the intentional division for the practice groups to favor the unpractised.

In spite of the omission of Test 1 from Series 2 by Class 3, it is interesting to note that there is an improvement in Series 2 over Series 1 by the practised boys of Class 3 and by both the practised and unpractised girls.

With two exceptions, the unpractised boys of Class 3 and the unpractised girls of Class 1, there is an improvement in Series 2 over Series 1. These two exceptions are undoubtedly due to the omission of Test 1 by Class 3 from Series II and in the case of the girls of Class 1, by the omission of the whole eleven tests of Series II by one girl of the unpracticed half.

The increase of Series II over Series I of the seventeen practised boys, even with the omission of Test 1 of Series II by Class 3, is 1342.80. Disregarding absences, these seventeen boys performed 187 tests in Series II, thus making an increase of 7.18 for each individual test. Whereas the increase of Series II over Series I of the 17 unpractised boys with the omission of Test 1 of Series II by Class 3 is only 399.88, thus making an increase of only 2.13 for each of the 187 tests in Series II.

The twenty-five girls of the practised half of Series II, even with the omission of Test I by Class 3, show an increase over the twenty-six girls of Series I of 1436.98. Disregarding absences, these twenty-five girls performed 275 tests in Series II, thus there is an increase of 5.22 for each test. Whereas the twenty-

TABLE 2.

COMPARISON OF PRACTISED AND UNPRACTISED GROUPS IN ALL TESTS.

	Practised						Unpractised		
Class	Boys	Series I	Boys	Series II	Boys	Series III	Series I	Series II	Series III†
I	12	3143.04	12	3963.28	8	2532.78	3344.63	3627.60	2362.35
II	10	3121.47	10	3538.55	6	1816.04	3300.55	3534.46	1781.72
III	12	3879.82	12	*3985.30	10	3499.54	4048.53	*3931.53	3432.99
Total	34	10144.33	34	11487.13	24	7848.36	10693.71	11093.59	7577.06
Increase in Series II		1342.80						399.88	
Class	Girls	Series I	Girls	Series II	Girls	Series III	Series I	Series II	Series III†
I	20	6249.87	18	6630.22	12	4124.03	6429.35	5941.74	4011.01
II	18	5683.01	18	6651.89	12	4104.17	5848.47	6200.93	4144.15
III	14	4119.51	14	*4207.26	8	2735.44	4228.09	*4449.69	2606.43
Total	52	16052.39	50	17489.37	32	10963.64	16505.91	16592.36	10761.59
Increase in Series II		1436.98						86.45	

* Test I omitted.
† Test 10 omitted.

five girls of the unpractised half, show an increase of 86.45 in Series II over the twenty-six girls of Series I. Thus for the 275 tests, there is an increase of only .31 for each test.

With regard to Series III, with the exception of the girls of the unpractised half of Class 2, the totals of the practiced half are higher than those of the corresponding unpractised half in each class for both boys and girls.

It is self-evident that these figures are necessarily inexact, but even with this crude comparison, the general trend of the results of the experiment can be foreseen.

Comparison of Practised and Unpractised Halves in Regard to Ability in Biological and Non-Biological Tests.

Table 3 shows the comparative results of the practised and unpractised halves in the Biological tests and in the Non-Biological tests.

In this computation, if a pupil was absent from a test in Series I or Series II, the corresponding test for this pupil was omitted from Series II or Series I, thus making the two series homogeneous.

In Class (1), one girl in the practised half and one in the unpractised half were absent from most of the tests of Series II, therefore their tests in Series I had to be omitted, although, of course, these latter had helped to form the basis of division for the Practice Series. The ratings of the unpractised one were much superior to those of the practised one in Series I.

In Class 1, there is an extra boy on the practised side; in Class 2, an extra boy on the unpractised side; and in Class 3, an extra girl on the unpractised side. Their percentages were not added in the totals of Series I and II, but in Series III of Class 2, the ratings of the extra unpractised boy were included in place of one who had left school.

In Series II, Test 1 was omitted by Class III and, therefore, had to be omitted in Series I for that class.

Test 10, in Series III was omitted by all three classes.

TABLE 3.

Comparison of Biological and Non-Biological Tests in Series I and II.

	Practised					Unpractised				
		Biol.		Non-Biol.			Biol.		Non-Biol.	
Class	B	I	II	I	II	B	I	II	I	II
I	6	1345.24	1614.64	1797.80	2268.64	6	1193.43	1064.62	2155.20	2439.24
II	5	1586.83	1555.62	1534.64	1932.93	5	1474.27	1697.33	1725.32	1771.13
III	6	1355.96	1803.54	2135.24	2181.76	6	1333.33	1496.78	2216.20	2434.75
Totals	17	4288.03	4973.80	5467.68	6383.33	17	4001.03	4258.73	6096.72	6645.12
			4288.03		5467.68			4001.03		6096.72
			685.77		915.65			257.70		548.40
Class	G					G				
I	9	2555.00	2979.25	3150.12	3329.20	9	2641.27	2523.60	2964.28	3245.75
II	9	2560.21	2772.88	3122.80	3575.01	9	2429.39	2410.76	3269.68	3579.16
III	7	1434.81	1600.23	2147.64	2447.03	7	1542.05	1523.14	2291.28	2541.05
Totals	25	6550.02	7352.36	8420.56	9351.24	25	6612.71	6457.50	8525.24	9365.96
			6550.02		8420.56		6457.50			8525.24
			802.34		930.68		*155.21			840.72

* Decrease. B = Boys; G = Girls.

TABLE 3 (Continued).

Gains or Losses in Series II over Series I.

		Practised				Unpractised			
	Class	Biol.		Non-Biol.		Biol.		Non-Biol.	
		Gains	Losses	Gains	Losses	Gains	Losses	Gains	Losses
Boys	I	269.40		470.84			128.81	284.04	
	II		31.21	398.29		223.06		45.81	
	III	447.58		46.52		163.45		218.55	
	Totals	716.98	31.21	915.65		386.51	128.81	548.40	
Girls	I	424.25		179.08			117.67	281.47	
	II	212.67		452.21			18.63	309.48	
	III	165.42		299.39			18.91	249.77	
	Totals	802.34		930.68			155.21	840.72	

TABLE 3 (Continued).

NUMBERS OF THE TESTS OMITTED TO SECURE BETTER COMPARISON.*

		Biological		Non-Biological	
	Class	Practised	Unpractised	Practised	Unpractised
Boys	I		1	12	8
	II			8	4, 8
	III		10	6	2
	Totals		2	3	4
Girls	I	9, 10, 9, 10	1, 3	7, 4, 8	2
	II	1	3, 1, 3	12, 6, 7	12, 2, 7, 2
	III	3	5	6, 7, 2	6, 7, 8, 12
	Totals	6	6	9	9

* Tests omitted from Series 1 if absent from Series 2 or vice versa, in order to make the comparison of practised and unpractised of Series 1 and 2 homogeneous. The entire set of tests of Murtagh of the practiced half and McGreevy of the unpracticed of Class 1 were omitted because of protracted absence.

TABLE 3 (Continued).

COMPARISON OF BIOLOGICAL AND NON-BIOLOGICAL TESTS IN SERIES III

	Practised			Unpractised		
Class	Boys	Biol.	Non-Biol.	Boys	Biol.	Non-Biol.
I	4	916.62	1616.16	4	793.45	1568.90
II	3	747.34	1068.70	3	701.38	1080.34
III	5	1519.88	1979.66	5	1421.05	2031.94
Totals	12	3183.84	4664.52	12	2915.88	4681.18
Class	Girls	Biol.	Non-Biol.	Girls	Biol.	Non-Biol.
I	6	1753.43	2370.36	6	1571.81	2439.20
II	6	1578.87	2525.30	6	1593.97	2550.18
III	4	1114.86	1620.58	4	1083.27	1507.74
Totals	16	4447.16	6516.24	16	4249.05	6497.12

In Series III, a corresponding number of pupils on the practised and unpractised side were used for the comparison of totals. The integrity of the practised and unpractised sides was preserved as far as was possible, considering the withdrawal of some of the pupils.

From this summary provided by Table 3 it will be seen that there is a decrease in the totals of the Biological tests of Series II for the unpractised boys of Class 1 and the unpractised girls of Classes 1, 2, and 3, while the practised boys alone of Class 2 show a slight decrease.

Both practised and unpractised groups of all classes, both boys and girls, show an increase in Series II in the Non-Biological tests; but the greater increase in the case of both boys and girls is on the side of the practised group.

The division for the practice group was based on the average of the original ratings of the eleven tests of each pupil in Series I, regardless of the distinction between Biological and Non-Biological material, but this summary shows that in each case except the girls of Class I, the unpractised side had higher totals in the Non-Biological tests of Series I than the practised half, and in every case, they had higher totals in the Non-Biological tests of Series II, except the boys of Class 2 and the girls of Class 1, but, as has been said, the greater *improvement* was in the practised group. It would seem that the superior pupils in the Non-Biological tests were in the unpractised groups, but that something had caused an improvement in the practised groups, although they could not attain to the superior position of their rivals.

The seventeen boys in the practised group in the Non-Biological tests gained in Series II 915.65; thus

in each of the 102 tests there was an average improvement of 8.97, while the corresponding unpractised half gained only 548.40—an average increase for each of the 102 tests of 5.37.

The twenty-five girls of the practised half in the Non-Biological tests made a gain in Series II of 930.68, or an average of 6.2 for each of the 150 tests, whereas the unpractised half gained 840.72, an average of 5.6 for each of the 150 tests. Could it be that the increase of the practised group was due to a transfer from the practice series? Or, is it possible that the unpractised group may have been nearer their physiological limit and therefore could not increase in proportion to the practised?

Turning to the Biological tests, as has been noted, only one of the practised divisions, that of the boys of Class 2, lost slightly, while four of the unpractised lost. It is difficult to explain this loss. If the Biological material of Series II was more difficult, then it would be hard to explain the great gain of both boys and girls in the practised group.

When the first series of tests was performed, most of the biological material was comparatively new to the subjects; that is, they did not know any of the technical or scientific terms used in describing stems, flowers, leaves, buds, etc. In the course of their school work between the tests of Series I and II, the pupils learned many technical terms. I felt that this would lower their ratings in the second series, because they might be able to use a single word which would express about the same meaning as a sentence had been required for in the first series. To my surprise, I found that this was not always the case. May it not be possible that the unpractised did exactly this very thing, while

the practised, having had ten extra biological specimens to describe, had acquired some skill in enumerating more at length the characteristics necessary to distinguish one from another?

It happened that when the Biological were separated from the Non-Biological tests of Series I, the advantage in the Biological tests in each class of boys and in Class 2 of the girls was with the practised group. In only one class, the boys of Class 2, did the unpractised reach a higher total in Series II than the practised group. Therefore, we cannot assume that the physiological limit had anything to do with these tests, as far as the boys were concerned, since those that were better made more improvement, while with the Non-Biological tests, the reverse was true. With the girls, while the advantage was slightly in favor of the unpractised group in Series I, the totals of Series II showed a decrease, while the practised side showed considerable increase.

In the Biological tests the seventeen boys in Series II made an improvement over Series I of 685.77; thus for the 85 tests, there was an increase of 8.06 per test; whereas the unpractised boys made an increase of 257.70, or for the 85 tests, of 3.03 per test. The twenty-five girls of the practised division, in Series II made a gain of 802.34 over Series I, or for the 125 tests, of 6.41 per test, while the unpractised side lost 155.21, or for the 125 tests, 1.24 per test. Clearly in Series II, the advantage seems to be with the practised side.

In computing the average gain or loss per test, no allowance was made for the omission of Test 1 from Series II by Class 3 nor for absences from the tests, therefore the average per test would be slightly greater,

but since practically the same number of tests was omitted by both sides, as can be seen from the table of "Tests Omitted," no material difference would be made in the relationship of the practised and unpractised sides.

The summary of Series III shows the comparison of the totals of twelve boys and sixteen girls in the practised and unpractised groups in both the Biological and Non-Biological tests.

Here there is seen in general the same relationship as was shown in the comparison of Series I and II.

In Series III, the twelve boys of the practised half have a higher rating than the unpractised in the Biological tests, as they did in both Series I and II; while in the Non-Biological tests, the advantage is with the unpractised as it was in both Series I and II.

The sixteen girls show an advantage in the practised side in both Biological and Non-Biological tests, which was just the opposite in Series I, while in Series II, the Biological ratings of the practiced were much higher and the Non-Biological were slightly lower. More accurate comparison will be made later, but all these data seem to show a general advantage in favor of the practised side.

TABLE 4.

COMPARISON OF SERIES I AND II.

Net Gains and Losses When Made Homogenous for Corresponding Pairs of Pupils.

		Practised		Unpractised	
Class	Boys	Gains	Losses	Gains	Losses
I	12	372		149	
II	10	171		156	
III	12	201		219	
Total	34	744		524	
Class	Girls				
I	18	387		56	
II	18	350		212	
III	14	160		28	
Total	50	897		296	

TABLE 4 (Continued).

COMPARISON OF PUPILS IN SERIES I AND II AND III.

Net Gains and Losses Made Homogeneous for Corresponding Pupils in All 3 Series.

		Practised				Unpractised			
Class	Boys	I and II		I and III		I and II		I and III	
		Gain	Loss	Gain	Loss	Gain	Loss	Gain	Loss
I	8	250		159		2		21	
II	6	112		19		124		4	
III	10	37		53		246		36	
Totals	24	399		231		372		61	
Class	Girls								
I	10	134		14		52			28
II	12	191		30		158		56	
III	8	122		62		57			53
Totals	30	447		106		267		56	81

TABLE 4 (Continued).

SUMMARY OF PUPILS PRESENT AT ALL TESTS.

Net Scores.

		Practised					Unpractised				
*Class	B	I	II	I	II	III	I	II	I	II	III
I	8	1121	1378	828	1019	946	1230	1301	916	899	943
II	8	1335	1463				1329	1516			
III	8	1213	1318	1148	1222	1167	1266	1456	1179	1366	1224
Totals	24	3669	4159	1976	2241	2113	3825	4273	2095	2265	2167
			3669		1976	1976		3825		2095	2095
			490 Gain		265 Gain	137 Gain		448 Gain		170 Gain	72 Gain
Class	G										
I	10	1710	1899	1353	1455	1329	1708	1794	1346	1424	1386
II	10	1703	1914	1321	1479	1342	1728	1878	1318	1445	1369
III	10	1527	1644	853	961	911	1635	1742	937	1002	899
Totals	30	4940	5457	3527	3895	3582	5071	5414	3601	3871	3654
			4940		3527	3527		5071		3601	3601
			517 Gain		368 Gain	55 Gain		343 Gain		270 Gain	53 Gain

* Series III. 14 boys, 22 girls.

TABLE 4 (Continued).

COMPARISON OF ALL PUPILS WHO WERE PRESENT AT ALL TESTS OF SERIES I AND II.

Net Gains and Losses.

		Practised		Unpractised	
Class	Boys	Gains	Losses	Gains	Losses
I	8	257		71	
II	8	128		187	
III	8	105		190	
Totals	24	490		448	
I	10	189		86	
II	10	211		150	
III	10	117		107	
Totals	30	517		343	

TABLE 4 (Continued).

COMPARISON OF PUPILS WHO WERE PRESENT AT ALL TESTS OF SERIES I, II AND III.

Net Gains and Losses.

		Practised				Unpractised			
		I and II		I and III		I and II		I and III	
Class	Boys	Gain	Loss	Gain	Loss	Gain	Loss	Gain	Loss
I	6	191		118			17	27	
II	0								
III	8	74		19		187		45	
Totals	14	265		137		187	17	72	
Class	Girls								
I	8	102			24	78		40	
II	8	158		21		127		51	
III	6	108		58		65			38
Totals	22	368		79	24	270		91	38

In Table IV, a comparison is made of the original ratings based on Table I of the practised and unpractised groups.

Test 1 of Series II was omitted by Class 3, and Test 10 of Series III was omitted by all three classes. If a pupil was absent from a test, that test was omitted from his ratings in each of the other series, and also from the ratings of all of the series of his partner. Thus pairs of pupils, chosen when division for the practice groups was made, are compared in exactly the same tests in each of the three series.

The Table giving the comparison of Series I and II shows more improvement of the practised group in

every class except the boys of Class 3. In Series I, in every case, the unpractised group had higher ratings than the corresponding practised group. In Series II, this is true only in the case of the unpractised boys and girls of Class 3. But the total improvement is greater for the practised group. The seventeen boys of the practised group made a gain of 744 in Series II over Series I. With fourteen of the 187 tests omitted, the practised boys made an average gain of 4.3 per test in their ratings while the corresponding unpractised boys gained 524 in Series II with an average gain per test of 3.02.

The twenty-five girls of the practised group made a gain of 897 in Series II. Omitting 34 of the 275 tests, the practised girls made an average gain of 3.72 per test, while the unpractised girls gained 296 in Series II, an average of 1.22 per test.

A comparison of the 24 boys and 30 girls in Series I, II and III, shows the greater improvement to be in the practised group. This is true for both Series II and Series III. The only loss is in Series III by the unpractised groups of girls in Classes 1 and 3.

A summary of the 24 boys and 30 girls present in all the tests, again shows the advantage to rest with the practised group. Twelve boys performing eleven tests each, with a total of 132 tests, gained 490 or 3.71 per test, while fifteen girls performing a total of 165 tests, gained 517 or 3.13 per test. The twelve boys of the unpractised group gained 448, with an average of 3.39 per test while the fifteen girls gained 343, average 2.08 per test. The seven boys of the practised group in Series III compared with Series I showed greater improvement than the unpractised, and the eleven girls showed a very little more improvement than their corresponding group.

A comparison of pupils who were present at all tests of Series I, II and III, again shows for the fourteen boys and twenty-two girls, the former to manifest greater improvement for the practised group in both series, while the girls show a greater improvement in Series II but very little difference in Series III.

TABLE 5.

Class I, Series I.

Division of Classes for Practice Groups.

Boys	*Average*	*No. of Missing Tests*	*Boys*	*Average*	*No. of Missing Tests*
Garratt	30.45		Waller	33.45	
Rhodius	28.27		Hugger	30.00	
Johnston	25.70	1	Weber	27.70	
Hart	22.63		Wild	22.72	
Walsh	22.70		Wetjen	24.00	1
Lefkowitz	18.60		Riconda	19.20	1
Total	148.35		Total	157.07	
Jaeger	27.72				
Girls			*Girls*		
*Engels	32.09		Kolsch	28.18	
Geffert	35.36		McGreevy	36.18	
Schmidt	34.36		Krumholz	34.81	
Hamilton	31.90		Ilch	34.00	
Millang	30.22	2	Savage	34.66	
Manwaring	29.09		Kelly, K.	29.63	
Haag	24.54		Howard	26.90	
Murtagh	23.45		Perry	24.18	
*Kelly	24.66	2	Conradi	19.44	
Clute	33.30	†	Cohen	43.83	†
Total	298.97		Total	311.81	

* Indicates names should have been transferred, because of higher averages.

† Six experiments alike.

TABLE 5 (Continued).

Class II, Series I.

DIVISION OF CLASSES FOR PRACTICE GROUP.

Boys	Average	No. of Missing Tests	Boys	Average	No. of Missing Tests
Andrews	29.09		Vandevel	29.81	
Friedland	27.18		Smyth	27.54	
Hartell	24.80	1	Mullady	24.90	1
Franklin	33.90		Demarest	34.90	
Dinneen	31.18		Schuler	32.36	
Total	146.15		Total	149.51	
			Bernhardt	28.54	
Girls			*Girls*		
Rehm	35.70	1	Blanc	40.4	
Inglis	34.45		Wunder	34.63	
Luft	33.18		Geissen	33.45	
Grodzic	32.27		Dalessan	32.45	
*Rudolf	32.90		Hynes	30.60	
Schnering	28.09		Meyer	29.63	
Brady	26.81		Blumen	26.90	
Schreiner	25.00		Dehn	27.09	
Lutz	28.50	†	Gannon	34.33	
Total	276.90		Total	289.48	
			Keane	22.36	

† Six experiments alike.

TABLE 5 (Continued).

Class III, Series I.

DIVISION OF CLASSES FOR PRACTICE GROUPS.

Boys	Average	No. of Missing Tests	Boys	Average	No. of Missing Tests
Duff	37.54		Ruppel	39.63	
Archimal	32.45		Bonomo	35.63	
Timman	27.81		Alliano	29.09	
Friedman	29.63		Baldelli	31.63	
Cohen	28.27		Cullum	29.36	
Steiner	22.36		Miethke	23.81	
Total	178.06			189.15	
Girls			*Girls*		
Hacker	31.33		Hill	34.44	2
Busby	32.63		Woodbury	34.54	
Brown	31.36		Sharra	31.81	
Duro	30.72		Johnson	30.72	
Weed	24.72		Gallo	30.90	
Schulze	29.00		Netz	29.27	
George	30.50		Duffy	33.25	
Total	210.26		Total	224.93	
Morton	30.50	1			

TABLE 5 (Continued).

SUMMARY OF PRACTICE GROUPS.

Class	*Boys*	*Practised Total Average*	*Unpractised Total Average*
I	12	148.35	157.07
II	10	146.15	149.51
III	12	178.06	189.15
Total	34	472.56	495.73
			472.56
			23.17
Class	*Girls*		
I	20	298.97	311.81
II	18	276.90	289.48
III	14	210.26	224.93
Total	52	786.13	826.22
			786.13
			40.09

From the results of the tests of Series I, the three classes were divided into two groups, one for the extra practice and the other for comparison. In each class, boys and girls considered separately, the two pupils having their averages from the original ratings of Series I, Table I, nearest alike, were chosen for comparison and the one with the higher rating was placed in the unpractised group. In case of absence from one or more tests, the same test was omitted from the nearest pupil's average. In three cases, through faulty manipulation or computation, pupils having higher ratings were placed with the practised group. It is possible now, to see a few changes that might have made an improvement. But in every case, in every class, the higher total for both boys and girls was in the unpractised group.

The summary shows that in Series I, the unpractised group of boys was ahead in their averages by 23.17 while the unpractised girls outran the practised by 40.09.

TABLE 6.

CLASS MARKS IN BOTANY, FEBRUARY TO JUNE, 1912; ZOOLOGY, SEPTEMBER TO FEBRUARY, 1913.

CLASS I.

	Practised						*Unpractised*				
	February to June, 1912.										
Boys	*1*	*2*	*3*	*4*	*Total*	*Boys*	*1*	*2*	*3*	*4*	*Total*
Garratt	83	70	80	80	313	Waller	55	55	40	60	210
Rhodius	70	80	80	80	310	Hugger	60	80	70	75	285
Johnston	60	55	50	65	230	Weber	63	60	70	73	266
Hart	50	45	55	40	190	Wild	60	57	50	60	227
Walsh	62	55	70	65	252	Wetjen	60	50	65	67	242
Lefkowitz	55	60	62	65	242	Riconda	65	50	50	40	205
Total	380	365	397	395	1537	Total	363	352	345	375	1435
Jaegers	70	75	75	75	295						
Girls						*Girls*					
Engles	75	80	82	83	320	Kolsch	80	83	80	85	328
Geffert	70	75	77	75	297	McGreevy	75	60	65	60	260
Schmidt	80	82	85	85	332	Krumholz	78	80	85	85	328
Hamilton	55	60	65	65	245	Ilch	72	70	70	73	285
Millang	77	82	85	85	329	Savage	70	55	60	60	245
Manwaring	78	75	75	80	308	Kelly, K.	74	72	70	72	288
Haag	70	60	65	70	265	Howard	75	80	75	80	310
Murtagh	70	68	60	65	263	Perry	73	50	60	65	248
Kelly	55	55	60	47	217	Conradi	60	50	60	60	230
Clute	60	55	60	62	237	Cohen	70	60	50	45	225
Total	690	692	714	717	2813	Total	727	660	675	685	2747

1—March.
2—April 30.
3—May 31.
4—June 28.

TABLE 6 (Continued).

CLASS II.

	Practised						*Unpractised*				
	February to June, 1912.										
Boys	*1*	*2*	*3*	*4*	*Total*	*Boys*	*1*	*2*	*3*	*4*	*Total*
Andrews	55	60	70	65	250	Vandevel	60	78	80	75	293
Friedland	62	65	60	65	252	Smyth	70	72	60	65	267
Hartell	70	65	62	65	262	Mullady	65	60	70	68	263
Franklin	78	85	87	87	337	Demarest	78	75	70	75	298
Dinneen	70	60	60	63	253	Schuler	55	78	75	75	283
Total	335	335	339	345	1354	Total	328	363	355	358	1404
						Bernhardt	72	60	60	65	257
Girls						*Girls*					
Rehm	73	75	70	80	298	Blanc	75	90	90	87	342
Inglis	82	88	90	87	347	Wunder	84	92	93	90	359
Luft	74	92	88	87	341	Geissen	72	72	80	80	304
Grodzic	73	80	80	82	315	Dalessan	70	60	50	60	240
Rudolf	79	82	83	82	326	Hynes	72	55	50	50	227
Schnering	80	80	82	83	325	Meyer	70	65	60	65	260
Brady	70	60	65	65	260	Blumen	70	80	80	80	310
Schreiner	72	76	75	75	298	Dehn	65	50	45	40	200
Lutz	78	85	85	83	331	Gannon	70	55	50	60	235
Total	681	718	718	724	2841	Total	648	619	598	612	2477
						Keane	70	55	50	45	220

TABLE 6 (Continued).

CLASS III.

	Practised						*Unpractised*				
	February to June, 1912.										
Boys	*1*	*2*	*3*	*4*	*Total*	*Boys*	*1*	*2*	*3*	*4*	*Total*
Duff	75	80	70	80	305	Ruppel	63	72	83	80	298
Archimal	80	92	85	86	343	Bonomo	70	80	83	80	313
Timman	65	70	55	60	250	Alliano	50	70	50	60	230
Friedman	65	64	50	60	239	Baldelli	75	80	80	80	315
Cohen	70	80	70	70	290	Cullum	60	80	75	75	290
Steiner	68	50	65	65	248	Miethke	80	70	65	70	285
Total	423	436	395	421	1675	Total	398	452	436	445	1731
Girls						*Girls*					
Hacker	72	78	79	75	304	Hill	63	60	65	60	248
Busby	80	92	85	88	345	Woodbury	80	75	85	85	325
Brown	70	80	75	70	295	Sbarra	78	60	70	73	281
Duro	80	70	73	75	298	Johnson	75	85	86	85	331
Weed	76	70	73	75	294	Gallo	70	74	78	75	297
Schulze	75	55	50	45	225	Netz	79	85	87	85	336
George	55	50	55	40	200	Duffy	80	82	70	80	312
Total	508	495	490	468	1961	Total	525	521	541	543	2130
Morton	60	60	60	60	240						

TABLE 6 (Continued).

CLASS I.

	Practised						*Unpractised*				
	September to February, 1913.										
Boys	*1*	*2*	*3*	*Total*	*State Exam.*	*Boys*	*1*	*2*	*3*	*Total*	*State Exam.*
Garratt	75	70	70	215	70	Waller	50	56	70	176	70
Rhodius	70	70	87	227	87	Hugger	75	63	80	218	80
*Johnston	65	70	71	206	*71	Weber					
Hart						Wild	60	55	62	177	62
Walsh	65	60	60	185		Wetjen	70	63	70	203	
Lefkowitz	70	61	62	193	62	Riconda					
Total	280	261	279	820	219	Total	255	237	282	774	212
Girls						*Girls*					
Engles	80	75	80	235	79	Kolsch	80	65	73	218	73
*Geffert	70	60	73	203	73	McGreevy					
Schmidt	83	75	70	228	63	Krumholz	80	82	90	252	90
Hamilton	70	50	62	182		Ilch	70	50	65	185	65
Millang	85	83	81	249	81	Savage	68	45	50	163	
Manwaring	80	75	75	230		Kelly, K.	75	70	68	213	68
Haag						*Howard	70	65	74	209	74
Murtagh	65	65	73	203	73	Perry	65	45	50	160	
Kelly						Conradi					
Clute						Cohen					
Total	463	423	441	1327	369	Total	438	357	396	1191	370

* Omit.

TABLE 6 (Continued).

CLASS II.

	Practised						*Unpractised*				
	September to February, 1913.										
Boys	*1*	*2*	*3*	*Total*	*State Exam.*	*Boys*	*1*	*2*	*3*	*Total*	*State Exam.*
Andrews	70	55	55	180	55	Vandevel					
Friedland	70	53	63	186	63	Smyth					
Hartell	65	66	68	199	68	Mullady	70	70	60	200	60
Franklin						Demarest					
Dinneen						Schuler	75	62	75	212	75
						Bernhardt	70	65	65	200	65
Total	205	174	186	565	186	Total	215	197	200	612	200
Girls						*Girls*					
Rehm	83	85	87	255	87	Blanc	82	85	90	257	90
Inglis	85	85	80	250	78	Wunder	90	85	97	272	97
Luft	80	77	82	239	82	Geissen	70	80	82	232	82
Grodzic	80	75	75	230	*75	Dalessan	70	50	65	185	
*Rudolf	83	80	75	238	*66	Hynes					
Schnering						*Meyer	60	50	60	170	
Brady	70	70	70	210	90	Blumen	73	68	88	229	88
*Schreiner	80	80	75	235	*72	Dehn					
Lutz	80	65	83	228	*83	Gannon	65	50	40	155	
Total	478	457	477	1412	337	Total	450	418	462	1330	357

TABLE 6 (Continued).

CLASS III.

	Practised						*Unpractised*				
	September to February, 1913.										
Boys	*1*	*2*	*3*	*Total*	*State Exam.*	*Boys*	*1*	*2*	*3*	*Total*	*State Exam.*
Duff	75	75	78	228	78	Ruppel	80	83	80	243	78
Archimal	85	90	95	270	95	Bonomo	75	80	75	230	70
Timman						Alliano					
Friedman	65	80	75	220	70	Baldelli	85	90	95	270	95
Cohen	75	80	80	235	80	Cullum	75	80	79	234	78
Steiner	72	65	62	199		Miethke	75	80	81	236	*81
Total	372	390	390	1152	323	Total	390	413	410	1213	321
Girls						*Girls*					
Hacker	80	75	77	232	77	Hill	70	65	65	200	
Busby	82	85	80	247	77	Woodbury	90	89	96	275	96
Brown						*Sbarra	78	50	50	178	
Duro	80	62	65	207		Johnson	85	85	96	266	96
Weed	75	75	72	222	71	Gallo	70	63	68	201	68
Schulze						*Netz	82	85	78	245	*73
George						*Duffy	80	63	77	220	*77
Total	317	297	294	908	225	Total	315	302	325	942	260
Morton	65	50	50	165							

TABLE 6 (Continued).

SUMMARY OF TERM'S RATINGS. NET SCORES.

February to June, 1912.

		Practised	*Unpractised*
Class	*Boys*		
I	6	1537	1435
II	5	1354	1404
III	6	1675	1731
Total	17	4566	4570
Class	*Girls*		
I	10	2813	2747
II	9	2841	2477
III	7	1961	2130
Total	26	7615	7354

September to February, 1913.

Class	*Boys*		
I	4	820	774
II	3	565	612
III	5	1152	1213
Total	12	2537	2599
Class	*Girls*		
I	6	1327	1191
II	6	1412	1330
III	4	908	942
Total	16	3647	3463

State Examinations.

Class	*Boys*		
I	3	219	212
II	3	186	200
III	4	323	321
Total	10	728	733
Class	*Girls*		
I	5	369	370
II	4	337	357
III	3	225	260
Total	12	931	987

Table VI records the class ratings in biology of the test pupils during the one year of the test.

Too much reliability must not be placed upon regarding these marks as actually showing the degree of intelligence or ability of the pupil in general or in biology in particular. Various other factors besides general ability and intelligence are considered in giving the ratings, some of which are absence, attention, preparation of home-work, ability to recite the lesson, neatness, accuracy, preparation of a note-book, ability to pass an examination, effort, etc.

The March rating had been given before the beginning of the tests and the April rating was given during the tests. From the computation of the totals of the March ratings, it will be seen that upon the basis of school marks, the unpractised boys are slightly inferior to the practised, while the unpractised girls are superior to the practised girls. The April rating shows exactly the reverse to be true. The May mark shows a similar condition to that obtaining in April. In the June rating, the comparative positions are still unchanged, the unpractised boys lead and the practised girls.

The summary of the totals of the term's ratings shows the unpractised boys to be superior by four credits while the practised girls are superior by 261 credits. With seventeen boys, the advantage of the unpractised group is only .23 per pupil, while the twenty-six practised girls are superior to the unpractised to the extent of 10.03 per pupil.

Thus, it might be said that the boys' practice groups were very evenly divided in ability when based on class ratings.

Anti-disciplinarians might also claim that the superiority of the girls of the practised group might have some influence on their greater improvement, which otherwise might be ascribed to the transfer of practice.

The totals of the ratings of the second term's work show the same comparison. The unpractised boys excel their opponents by 62 credits, while the practised girls outrun the unpractised by 184 credits. If this means anything, it points to the better boys being in the unpractised group while the reverse is true with the girls.

At the conclusion of the first term's work, one practised and one unpractised boy, and three practised and three unpractised girls failed to be promoted as indicated by the percentages below 60 in the fourth rating. Thus, as regards deficient pupils according to school ratings, both practised and unpractised sides were equal.

Of those who were promoted and remained in school during the second term, one practised boy, one practised girl, and four unpractised girls failed to be promoted, thus indicating, on the basis of school ratings, that four of the poorest girls were on the unpractised side.

At the close of the first term, 94.4% of the 36 boys in the tests passed the work and were promoted while 88.8% of the 54 girls also advanced a grade.

At the close of the second term, 96% of the 25 boys studying biology and who had performed the three series of tests, successfully completed the work, and 87.8% of the 41 girls studying biology and who had also been in all three series of tests, passed on to a higher grade.

At the end of a year's work in biology, 24 boys of the original 36 who began the tests, were still in school and promoted to an advanced grade an average of 66.6%. Likewise, 36 girls of the original 54 were promoted, an average of 66.6%.

At the conclusion of the first year's work in biology, a state examination is given by the Regents' Department of the University of the State of New York. Of the 52 of the test pupils of all series who took this examination, 98.07% passed.

From a consideration of these percentages and remembering the statistical data in regard to the great mortality in the first year of the high school, it is evident that if these series of tests cannot be claimed to have profited these pupils it can at least be said that they were not detrimental. Personally, recalling the experiments of Dallenberg, I am inclined to believe them in some degree accountable for the very satisfactory showing in the state examination.

Comparing the state examination ratings of the 10 pairs of boys and 12 pairs of girls, we find that the unpractised boys exceed the practised by an average of .5% per pupil while the unpractised girls exceed the practised by an average of 4.6% per pupil. Thus again, the unpractised boys show superior ability according to examination ratings; as do also the unpractised girls, contrary to former comparisons. As only the better pupils entered the state examination and only 44 of the original 86 test pupils are compared, it would be unwise to emphasize this comparison of the practised and unpractised groups.

TABLE 7.
Computed from Tables I and V.

	Number of tests improved in				Number of tests decreased in				Tests omitted		Number of pupils in tests	
					Biol.		Non-Biol.					
	Ser. II	Same Ser. I & II	Ser. III	Same Ser. I & III	Ser. II	Ser. III	Ser. II	Ser. III	Ser. II	Ser. III	Ser. II	Ser. III
Practised Boys' Class												
1	49	3	26	3	6	7	7	4	1		6	4
2	32	7	13	2	9	7	6	7	1	1	5	2
*3	43	5	32	4	1	2	21	12	7		7	6
Totals	124	15	171	9	16	16	34	23	9	1	18	12
Girls'												
1	57	9	39	5	6	8	20	17	18	1	10	7
2	55	11	47	5	13	9	16	15	4	4	9	8
†3	42	9	29	3	7	4	8	11	11	3	7	5
Totals	154	29	115	13	26	21	44	43	33	8	26	20
Unpractised Boys' Class												
1	37	8	17	3	12	9	7	10	2	1	6	4
2	35	2	10	1	4	2	12	4	2	3	5	2
*3	39	8	37	6	7	5	15	12	8	0	7	6
Totals	111	18	64	10	23	16	34	26	12	4	18	12
Girls'												
1	50	6	41	4	17	10	23	15	14		10	7
2	52	8	42	3	15	13	18	19	6	3	9	8
3	36	7	24	4	10	6	12	13	12	3	7	5
Totals	138	21	107	11	42	29	53	47	32	6	26	20

* Bernhardt and Jaegers counted with Class 3.
† Morton counted in Ser. III.

Table 7 was computed from Table 1, comparing the practised 18 boys and 26 girls with a similar number of unpractised in Series 1 and 11 and the practised 12 boys and 20 girls with a similar number of unpractised in Series I and III.

In every class for both boys and girls, the totals of the number of tests which remained the same and in which improvement was made in Series 11 is greater for the practised pupils. In Series 111, the totals of the tests which remained the same as in Series I and in which an improvement was made is greater for the unpractised in two of the six cases, the boys of class 3 and the girls of class 1.

In Series II, the unpractised boys decreased in 7 more biological tests than the practised and in the same number of non-biological; whereas the unpractised girls decreased in 16 more biological and 9 more non-biological than the practised girls.

In Series III, both practised and unpractised boys decreased in the same number of biological tests while the unpractised boys decreased in 3 more non-biological tests. The unpractised girls decreased in 8 more biological and 4 more non-biological than their practised opponents.

Three more tests were omitted by the unpractised boys in both Series II and III, while the unpractised girls omitted one less in the biological and 2 less in the non-biological than their corresponding practised neighbors.

The conclusions to be drawn from this table are necessarily similar to those presented heretofore. Throughout the advantage is with the practised group.

SUMMARY OF ALL TABLES OF COMPARISON OF SERIES I AND II

	Practised						*Unpractised*					
BOYS												
Table	**Ser. II**	**Av.**	**Biol.**	**Av.**	**Non B**	**Av.**	**Ser. II**	**Av.**	**Biol.**	**Av.**	**Non B**	**Av.**
II	1342.80	7.18					399.88	2.13				
III			685.77	8.06	915.65	8.97			257.70	3.03	548.40	5.37
IV	744	4.3					524	3.02				
V							Ser. I 23.17					
VI							4	.23				
VII	Increase 124		Decr. 16		Decr. 34		111		Decr. 23		Decr. 34	
GIRLS												
II	1436.98	5.22					86.45	.31				
III			802.34	6.41	930.68	6.2			Decr. 155.21	Decr. 1.24	840.72	5.6
IV	897	3.72					296	1.22				
V							Ser. I 40.09					
VI	261	10.03										
VII	Increase 154		Decr. 26		Decr. 44		138		Decr. 42		Decr. 53	

CONCLUSIONS.

Combining the results and conclusions noted in the seven tables with their several sub-divisions, some conclusion may be reached in regard to the object of our search—the transfer of special practice in biological material to non-biological.

In the summary of all the tables, we see from Table 2, that the average gain per test of the practised boy in the 11 tests is 7.18 while that of the unpractised boy is 2.13; the average gain per test of the practised girl is 5.22, that of the unpractised girl only .31 per test.

Table 3 shows that in the biological tests, the average gain of each practised boy was 8.06 per test for the 5 tests while the unpractised showed a gain of 3.03. The practised girls averaged 6.41 gain per test, while the unpractised lost 1.24 per test. In the non-biological, the practised girls gained 6.2 per test for the 6 tests while the unpractised gained 5.6; the practised boys gained 8.97 per test and the unpractised boys gained only 5.37 per test.

In Table 4, based on the original ratings, the practised boy gained 4.3 per test to the unpractised's gain of 3.02; while the practised girls exhibited a gain of 3.72 to the unpractised girls' gain of 1.22.

Table 5 shows that at the end of Series 1, when the class had been divided into practice groups, the group of unpractised boys had a total score 23.17 higher than the practised, while the unpractised girls had a total of 40.09 higher than their opponents.

Table 6 gives the ratings of the pupils in their biological class-work and shows the unpractised boys

to excel the other group by an average of .23, while the practised girls surpass their fellow competitors by 10.03 per pupil.

Table 7 shows that the practised boys gained in 13 more tests and the practised girls in 16 more tests than their opponents. The practice boys lost in 7 fewer biological tests and the girls in 16 fewer biological tests than the unpractised side; while the practised and the unpractised boys lost in the same number of non-biological tests but the practised girls in 9 fewer than the opposite side.

It is evident from these general summaries and comparisons that the practised pupils have done better in the second and third series than the unpractised. The question difficult to solve is: "What is the cause?" No doubt growth, familiarity with procedure, benefits of class-work and study, and desire to excel, have all contributed their share toward the gain, but these factors may have aided both sides equally. We have no means of telling. Then why the difference?

Judging from the division of the practice groups, the better pupils in these tests were on the unpractised side. While the class term marks showed the better boys to be on the unpractised side, the contrary was true as far as the girls were concerned. The March rating showed the reverse condition of affairs. Very little significance can be attached to class marks as denoting general intelligence or superiority, because so many extraneous factors enter in.

Considering Table 3, we would naturally expect both practised boys and girls to earn in the second series a bigger gain than their opponents in the biological tests; but how shall we explain their greater efficiency in the non-biological tests, other than to ascribe it to the effects of the practice series?

Feeling that the balance of arguments and scientific proofs were against formal discipline when this investigation was begun, I am forced by the results obtained to admit that in this experiment, the proof seems to be on the affirmative side.

A valuable lesson, I think, can be drawn from one phase of this investigation. By consulting the tables and summaries, it will be seen that sometimes one division does not fall in line with the general trend, but that a larger number outweighs the negative and shows positive results. This would warn us against drawing conclusions from experimentation with too few subjects, as has been done in several of the investigations cited in the historical part.

As can be seen by the averages per test of Tables 2 and 4 the boys have done better than the girls, although the curves of the practice series seem to indicate that the girls are superior in that series. This may be ascribed to the boys' general lack of intensive application to uninteresting or monotonous work but it is likely that greater effort was put into the shorter tests of the three series.

COMPARISON OF RESULTS WITH THOSE OF PEDAGOGICAL EXPERIMENTS.

Winch found that boys of the same age and standard were slightly superior to girls in immediate visual memory. As many of the tests of this experiment were of a similar type to those of Winch, it may be stated that this investigation supports Winch's conclusion.

Winch found in his experiments on memory that a steady improvement was shown in both the practised

and unpractised groups but that the practised group was superior. This conforms exactly to my conclusions.

In his experiments on the "transfer of numerical accuracy" he found in some of the series that the lower practised side after practice reversed positions with the higher unpractised. This investigation gives the same results.

Wallin in his spelling tests found that his "data furnished conclusive evidence in favor of transfer."

Starch found from 20 to 40 per cent. more improvement in the practised observers in arithmetical operations; and ascribes it to "identical elements"; as did Thorndike and Woodworth in their investigations. Ruediger found evidences of transfer in his tests on ideals and ascribed it to "identity of aims."

In our own investigation there are certainly conclusive evidences of transfer. The improvement in the biological material can be ascribed to "identical elements," but the "identity of aim" and "identity of procedure" and "identical elements" were common equally to both sides, except for the advantage for the practised in the biological tests. The greater increase of the practised must be ascribed to some intangible psychological effects of practice.

Thus a few more data have been added to the big problem of the High School and along slightly different lines from those along which experimental tests have been attempted heretofore.

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APPENDIX

GRADUATES OF THE HIGH SCHOOL

Class I—Boys

Practised	Unpractised
Garratt	Weber
* Rhodius	Wetjen
	Riconda

Class I—Girls

* Engels	
Manwaring	* Krumholz
	Ilch
	* Howard

Class II—Boys

Friedland	* Schuler
Hartell	
† Franklin	

Class II—Girls

* Rehm	* Blanc
* Inglis	* Wunder
* Luft	* Geissen
Rudolf	Blumen
* Schreiner	
* Lutz	

Class III—Boys

Archimal	Ruppel
* Cohen	* Baldelli
	Cullum
	Miethke

Class III—Girls

* Hacker	* Woodbury
* Busby	Duffy
Duro	

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* Graduated Jan., 1916.
† Graduated June, 1915.
Others graduated in June, 1916.

Participants in Tests	Graduates	
34 boys	15 boys	44%
50 girls	20 girls	40%

	Practised	Unpractised
Boys graduated in Jan., 1916.....	2	2
Boys graduated in June, 1916.....	4	6
Boy graduated in June, 1915.....	1	0
Totals.....	7	8
Girls graduated in Jan., 1916.....	8	6
Girls graduated in June, 1916.....	3	3
Totals.....	11	9

The commencement program furnished the list of January and June graduates.

Of the original 84 pupils in the tests, 35 have graduated; 40% of the girls and 44% of the boys. It is interesting to note that 18 were in the practised group and 17 in the unpractised, thus showing that on the basis of graduation, the groups were nearly evenly divided.

Of the 7 graduates among the practised boys, 1 graduated from the four-year general course in 3½ years, and of the 8 graduates among the unpractised, 1 graduated from the three-year co-operative course in 4 years; thus indicating a still more even division of the two groups.

Of the 9 graduates among the unpractised girls 1 graduated from the three-year household arts course in 4 four years. It would appear, that as far as graduation is concerned, the better girls were in the practised group.

These general deductions fall in line with inferences made heretofore. It would be futile, however, in this connection to attempt to draw any conclusions in regard to the main object of this monograph.