Lecture No.I.
January 19, 1897. Dr. Burnham.

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Methods of Studying Nervous Fatigue among School Children.

School hygiene, or pedagogical hygiene, is based on the physiology and psychology of the development. It has to do especially with the conditions which favor the normal functions of nervous organism. But, as the human body is made of tissues so intimately connected, what affects one part affects the whole, so that the hygiene of the nervous system involves that of the whole body. School hygiene has to do primarily with the conditions pertaining to the normal functions of the nervous system. It is concerned also with all the conditions that affect the health of the child in the school room. During the last twenty-five years a large number of investigations have been made and much literature accumulated. This is imperfectly understood, first, because of the complexity and obscurity involved in the study of air, heat, etc., and second, because so little is known about it. The scientific character of the practical value of school hygiene, however, has been recently investigated with important results. The bibliographical notes which I have prepared contain a few of the important titles in the subject. Most of the literature relating to architecture, heating, ventilating, and the like, is not included in the list. Medical and physical education is not included. Only a part of the books by the authors cited is included. Only a small part of the rich periodical literature is included. Primarily the list is for convenient reference in this course of lectures, to go with a few representative books covering a wider field. I shall refer to the books by the number in the bibliography. Please remember that the list is prepared for convenience of reference in this course of lectures, and does not attempt to give all the important books in the field, but to give representative books.

The subject of school hygiene is divided somewhat arbitrarily into three parts, - first, school architecture, relating to school buildings, site, etc.; second, school sanitation, including heating, lighting, ventilation, etc.; third, the hygiene of instruction. The last of these has received the least attention. The last most concerns the teacher, and to this the teacher can especially contribute. The large part of this course of lectures will be devoted especially to this part of the hygiene, as it would be impossible in the brief time allotted to treat the whole subject of school hygiene.

I have chosen certain chapters to serve as an introduction to the field, and the literature will cover the different chapters for consideration, - namely, the Hygiene of the Nervous System and Fatigue. The importance of this subject should be emphasized. Dr. Ayer (Bib. 55) says that the most important principle in the hygiene of the nervous system is that of the proper alternation between periods of work and of rest. It is not the aim of this course, by any means, to be popular, but you will pardon an illustration taken from a popular book, on account of its special pertinence. The most remarkable case on record of nervous and muscular fatigue from voluntary stimulation of a set of muscles is that of L. A. Chittenden. During the Civil war

he was Registrar of the Treasury, and it became necessary for him at one time to sign 10,000,000 United States bonds, and this between 12 o'clock noon Friday and 4 A.M. the following Monday. In all 125,000 signatures must be made. The time usually allowed was from five to six days. In this instance the Registrar was told he might command all the resources possible, but the bonds must be regularly issued and signed in the time mentioned. He had had long experience in signing his name. His signature was made without raising his hand from the paper, and, when the bonds were placed before him and removed by assistants, ten signatures could be written per minute.

No muscular exercise is so severe, certainly none more inexpressibly dreary, as writing one's own name, hour after hour, day after day, over and over again. He called in an army surgeon to be in constant attendance, to administer food, stimulants, etc. The first seven hours passed without any unusual sensations. He had sat for this length of time so often that the muscles worked uncomplainingly. During this time more than 3700 signatures had been made. Within the first half of the eighth hour there was evidence of great muscular discontent, and the muscles broke out into open rebellion. On the afternoon of Saturday every muscle on the right side, connected with the movement of hand and arm, became inflamed, and there was pain almost beyond endurance. It was necessary to continue the work, for if it should be suspended, the inflamation would become so great that control over the muscles of the arm would be impossible, and further work would be given up. In the slight pauses made, rubbing, hot water, etc. were resorted to to alleviate the pain and reduce the inflamation, but it was comparatively ineffectual. During Saturday afternoon the pain sensibly diminished. Muscles, finding that resistance was unavailable, had to give up the contest. A series of sensations followed: A feeling of numbness, commencing in the hand, crept up the arm to the shoulder. This was less annoying but a much more serious symptom. There was a distortion of the fingers, and the pen was held in a different position. This condition of the muscles might be expected to change the form of the signature, but it did not to any great extent. Constant repetition of the same movements resulted in a signature, still a fair one. Various devices were employed to prevent sleep, - changes of position, violent exercises, walking in outdoor air, prepared food, extracts, stimulants, etc., but the weakness gradually increased. Surgeon advised Registrar to resign. At 4 o'clock Sunday morning, only a few more than 2,000 bonds remained to be signed. Although the Registrar's fingers and hand were twisted out of their natural shape, still he continued to write, till about noon on Sunday he had finished his task. The last 100 required more time than the first 1,000. The Registrar described his condition thus: "After the bonds were signed I suffered more than at any time during the process. The nervous system was so shattered that sleep was impossible Sunday night. On Monday I fell asleep from pure exhaustion." While he remained in office no day passed but what he was reminded of that Sunday's experience. After he left the Treasury, there were five years when he could never promise to perform any professional labor at a fixed date.

This act is interesting, not merely because it shows a mental strain but because it illustrates the widely related effects of local

fatigue. We might ask why there should be such results after a comparatively simple task. Studies of fatigue, made during the last year by Hodge (Bib.185), Mosso (118) and Lombard (110) and others, enable us, in part at least, to answer this question. Recall the familiar teaching of science. Modern physiology shows that the different peripheral organs of the body are controlled by nerve centres. When a muscle contracts, both are involved equally in the motion. Without the nerve the muscle is lifeless. Without the muscle the nerve is useless. We are all familiar with cases which illustrate the function of one without the other. In paralysis the muscles are lifeless because the nerve centres are stricken. Physiology has shown the intimate relation between the nerves and muscles, - the nervo-muscular system. Studies of Mosso show that when, on account of exhaustion, a group of muscles can no longer contract, the fatigue is chiefly central. Muscles will work, but their nerve cells are fatigued. Muscles are capable of work when nerve cells are stimulated by electricity.

By different recent investigators, among them my colleague, Mr. Hodge (Bib.85), researches have shown that the substance of nerve cells is actually used up during functional activity. The nucleus shrinks, and the protoplasm is filled with vacuoles. The loss is repaired only during long period of rest. Poisonous products result. These symptoms of fatigue are shown by Mosso's familiar experiment of introducing into one dog the blood of his tired companion.

We have found by experiment on men that local fatigue affects the whole of the nervo-muscular system. In the case of Mr. Chittenden the fatigue was more than in the hand and arm. It was essentially a nervous exhaustion. With our present knowledge it would be quite possible, probably, to duplicate Mr. Chittenden's exploit without injury. Muscles can do maximum amount of work when appropriate periods of rest alternate with periods of work. Same is true of nervous activity. With our present knowledge a physician would divide the time into definite periods of work and rest, would insist that former should not encroach upon the latter.

In the stress and strain of modern life, when one's work must be done as well, if not better, than one's neighbor's, and when it must be done at a fixed time, the great problem of the intellectual worker is similar to that of Mr. Chittenden, - how to do the maximum amount of work in a limited time without injury to health. There is a close analogy between muscle and nerve activity, and it is one of the most important problems to determine where the periods of work and of rest are advantageous. A few solve the problem. Darwin did. He worked four hours a day, and achieved maximum results. Most men are prodigal of nervous energy. It is faulty for one whose nervous system is built on the four-hour plan to work six. To work more than the period prescribed by one's nervous organism is over-pressure; to work less is idleness. How are we to determine, then, what this period is ? An individual may judge for himself, and it may be determined by experience. Something more than observation is needed when the period of study in the school room has been so long as to cause great fatigue. Our present method of putting a child into school, without knowing whether he is able to do the work required of him, has resulted disastrously enough. Some one has said, "We send a ship to sea without a trial voyage." The method of judging of their condi-

tion by observation, as to whether they seem fresh or weary, is little better than the nurse who judged of the baby's bath, by observing that too cold water turned him blue and too hot, red. It is difficult to get good tests of the condition of the central nervous system. The human body is like the laboratory with "No Admittance" at every door and corner. Methods of studying nervous fatigue have been already devised which may give a more satisfactory result than has been before possible. Physical effects of mental activity cannot be studied directly, but, since the nervous system is so intimately connected with the rest of the body, it is possible to study cerebral fatigue indirectly. Decrease of the ability to do muscular work indicates that fatigue of the psychic centres affects the motor centres. Test the muscular power before and after mental work. An instrument for this, called the ergograph, was invented by Mosso, - a simple affair, the arm held in the horizontal position, and a weight lifted by contracting one of the fingers. Amount of contraction is registered on a revolving drum, and the amount of the work done is estimated by the curve on the drum. It is possible to contract a muscle in a certain rhythm, say every two seconds, and continue the work to the point of exhaustion, and until voluntary contraction is no longer possible. The unit of work is a kilogram meter, - the work required to lift one kilogram one meter. The amount of work done, and the condition of the nervo-muscular mechanism, is shown by the curve on the drum.

Using this method, Mosso and his assistants (Bib.111 and 118) have made several interesting tests of the effect of mental work. His assistants tested muscular power after a lecture. The work accomplished before exhaustion was five and a fraction kilogram meters. At the same hour the preceding day it had been a little over seven kilogram meters. The result of intellectual exertion was that the work done by the finger was diminished. Tests of muscular strength before and after conducting examinations were made. For example, on the 18th of June, 1890, a series of examinations was begun. The work that could be done, contracting the finger every two seconds, amounted to nearly six kilogram meters. After the first examination, the amount of work done was 2.7 kilogram meters. Examinations continued for several days. On the last day before the examination, the work done was 5.7 kilogram meters. Afterwards it was only a little over one kilogram meter. Dr. Keller used this method to test the effect on a fourteen year old boy, of different kinds of mental work. (Bib.98.) In his first series of examinations, he had the boy read German words aloud as rapidly as possible for a period of twenty minutes. He tested his muscular power by contracting his middle finger every second, lifting a 2-kilogram weight. First there was an increase, then a decrease. First effect of mental activity was stimulating, and more work could be done; then fatigue appeared and he recovered slowly. Similar results were obtained in reading Latin words. In this case the mental work was more difficult, and the effect of fatigue was noticed sooner. Effects were noticed after singing and gymnastics. Singing fatigued him greatly. Gymnastics showed a rapid decrease of muscular strength and mental activity, as noted by the rate at which the boy could read. (See Figures 1 and 2.)

These experiments give only individual results, but they show a method by which cerebral fatigue may be indirectly tested, and by which it is possible to determine the relative mental strain involved in different forms of mental activity. Again, we may test the cerebral fatigue by testing the sensibility and sensory side of our psycho-physical mechanism, which is easily susceptible to fatigue. Reading, or looking at pictures at an art exhibition, affects the sight and dulls the senses also. Dr. Griesbach (Bib.70) has tested dermal sensibility. Two compass points are brought in contact with the skin, and must be separated a certain distance to be perceived as two; on the forehead, 3 to 5 milimeters; tip of nose, 1 1/2 to 3 milimeters; lip, 1 to 2 milimeters; back of neck, 1 inch or more. If placed nearer together than this the sensations fuse into one. The distance at which the compass points are separated at any part of the body gauges the discriminating dermal sensibility in that locality. Since the first investigation by Weber, tests have been made, and it has been found that practice increases dermal sensibility, so that the compass points may be placed nearer together and still be distinguished as two. Attention also at moment when test is made increases sensibility. It is probable that mental fatigue, as it diminishes the power of attention, would also diminish dermal sensibility. Experiments made by Griesbach, with a simple instrument called the aesthesiometer, proved that the greater the fatigue, the less the dermal sensibility, and the compass points must be placed farther apart to be perceived as two. In a series of experiments reported, precautions were taken to avoid error, and tests were made by an increase in size of the sensory circles, and both sharp and blunt compass points were used. Distances that the points could be separated were different on different parts of the body. Subjects tested were pupils and teachers in the public schools. Normal sensibility was tested at a time when they were free from work and worry, as on holidays and Sundays. Tests were made before and after work done, and on the school children it was usually made after each hour. Average pupils were chosen, neither the particularly dull nor the most intellectual. (See Figures 3, 4, and 5.)

All the curves have very much the same outline, and this increases the probability of the results being reliable. I speak of this not to show results now, but simply to call attention to a method. It is noteworthy that in the cases of students whom Griesbach tested, it was found that at seven o'clock in the morning, the time of beginning school work, the discriminating sensibility was often below normal. This might have been due to insufficient sleep. Increase of sensibility was often noticed after a period of rest, but the decrease was greatest in the afternoon when the school work began, because the period of rest at noon was not sufficient to bring back a condition of normal rest. Observations of teachers showed that they were greatly fatigued by instruction, and more fatigued by class than by individual instruction. Tests were made on weavers and apprentices, those doing mechanical work. It was shown that mechanical work influenced the sensibility less than mental work. While practice would naturally increase the discriminating sense, a decrease always appeared as the work advanced, even after repeated observation. It was apparently due to nervous fatigue. These demonstrate another method

by which nervous fatigue might be studied. A similar method might be employed in testing other senses. The sense of hearing is often affected by mental work. In regard to effect of fatigue upon the sense, the usual answer, upon inquiry, is that the hearing power is diminished, in cases of partial deafness. There is a difficulty in understanding the speech of others, distinguishing one word from another. The sounds are less sharply defined and run into one another. In some cases the hearing is increased; there is more sensitiveness to slight sounds, not noticed in other situations, especially in cases of monotonous repetition, - the tick of a clock, etc. Sight is not so keen as when rested. Reading is a conscious effort. One word or letter is frequently mistaken for another. There may be a burning sensation in the eyes. Power of attention, power of interpreting data, power of discriminating and power of inhibition are all weakened. One teacher remarks the hearing power increases in direct proportion to fatigue, while that of the pupil apparently diminishes.

Such are the first two methods of testing nervous fatigue. Both are defective. The ergograph is defective, because it is impossible to tell how much of a change is due to fatigue of mental work done, and how much is due to nutritive and other changes. The aesthesiometer is defective for the same reason. It is difficult to make tests with the compass points and be sure to always make them in precisely the same way. With both methods it is difficult to control conditions in such a way as to be entirely clear about the meaning of the results. Both methods are somewhat technical and cannot be used with a large number of students. I shall hope to speak of some of the practical results already obtained from such investigations.

Lecture No.II.
January 26, 1897. Dr. Burnham.

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Period of Study. Home Study, Recesses, etc.

In our last lecture I spoke of two methods of testing nervous fatigue among school children, - the first method with the ergograph, in which the nervous fatigue is gauged by the decrease in muscular power, and the second method by the aesthesiometer, gauged by decrease in discriminating sensibility.

To-day I have a very large subject indeed, yet I will try to finish a few minutes before the hour, so there may be an opportunity for questions. I shall have to speak very briefly indeed of some points that are very important, so if there is anything I have not made clear, if you will ask questions at that time I shall be very glad.

The third method of studying nervous fatigue is by noting the qualitative and quantitative variation in the mental work done. This method was adopted by Burgerstein (Bib.26) and by others. Data have been obtained which are difficult to interpret. The illustrations of Burgerstein might answer our purpose. He determined the ability of children to do simple arithmetical work for a long period. 162 children, at an average age of 11 to 13 years, were tested. Tests were made in the morning hours. The work was divided into four periods, of ten minutes each, with five-minute pauses. That is, after each period of work for ten minutes, there was a five-minute rest. Pauses were used for collecting and giving out papers, and with the four periods the whole time amounted to 55 minutes. This plan made the work approximately resemble ordinary school work. He had the ten digits written twice, and these two series formed the numbers for an exercise in addition. A ten-minute exercise in addition followed, and then a ten-minute exercise in simple multiplication. Both quantity and quality should be as nearly equal as possible for each period of ten minutes. The tasks were of such a length that even the quickest reckoners needed ten minutes. The results were as follows: The amount of work done - the number of problems solved - increased in each succeeding period, but the number of errors also increased. There was an increase in the quantity but a decrease in the quality. In round numbers, there were 450 more errors in the second than in the first, 700 more in the third than in the second, 350 more in the fourth than in the third. The per cent. of errors shows deterioration of work still more clearly. It increased from 3% in the second to 5.7% in the third, and 6% in the fourth. Burgerstein presents his results

by classes, giving number of figures collected in each, number of errors and number of corrections. All researches, with one exception, showed the same general ratio. The pupils tested gave signs before the end of the fourth period that their best work was reached. Burgerstein's Table - (See Fig.1) percentage of error is shown in Figure 2, per cent marked on vertical axis and periods on the horizontal. Children, according to Burgerstein, unconsciously rested during the third period and so did little better work in the last period. There is a question as to whether this is the true explanation or not. Of course a great many factors combined to produce these results, and the increase in the amount of work done was, Burgerstein thinks, chiefly due to practice. The decrease in the quality of the work was chiefly due to fatigue. This method has been somewhat modified and used by others. (See Bib.64, 87, and 101.) Dr. Hoeffner has studied fatigue by interesting modifications of this method. He counted the errors in examination papers prepared by 50 boys. They were dictation exercises. The idea of studying them did not occur to him until after the examination was completed. Nineteen sentences were dictated, and it was found that the number of errors increased from the earlier to the later by almost constant ratio. Burgerstein found that the number of errors increased with the length of time the pupils worked. Hoeffner found that the errors were proportional to the amount of work done.

The chief objection to Burgerstein's method is the fact that in his tests the work was different from ordinary school work and of a monotonous character. To avoid this error, Dr. Richter (Bib.138) has made tests with the work similar to that in schools. Other investigators have criticised the work of Burgerstein, considering the work devoid of interest and the processes of apperception not demanded of him. To meet this objection he has devised a method as follows: - Pupils were given an interesting story with the important words omitted, and they were to fill in the blanks. Friedrich (Bib. 64) has attempted to avoid the sources of error in Burgerstein by adopting the method of Hoeffner and that of Burgerstein, so that one might act as a control upon the other, and he has tested his pupils both before and after ordinary school work. Kraepelin (Bib.103) has employed a somewhat different method to either that of Burgerstein or Hoeffner, - the methods of testing one's ability to do mental work. We cannot measure poetical inspiration or genius, but it is possible to obtain in the laboratory data concerning a person's mental ability that one's own personal acquaintance could not give. Individual power of work in accomplishing certain operations: The number of small homogeneous problems that can be solved in a definite time may be used; the number of letters of the alphabet that can be written in a given time; The number of words that can be read; learning by heart a series of words; continued adding of numbers of one figure.

Kraepelin's work suggests the possibility of getting simpler tests of the ability of a child to do certain work. Tests of

susceptibility to improve by practice, resistance of fatigue, susceptibility to distraction, and the like. At first it seems simple enough to interpret the meaning of results of such tests as these, but really it is quite difficult. There are four important factors that modify the results:

First is the influence of practice. This enables one to do more work.

Second, - influence of excitement, seen in the early part of the tests. The length of time it continues varies with the individual.

Third, - influence of will, or voluntary effort, which increases one's ability to work. These three all tend to increase amount of work done.

Fourth, - Fatigue decreases the amount of work. In interpreting the results it is difficult to determine how much influence each one of these factors may have.

So much for the three classes of methods. There are some others which have been perfected, but which are not of sufficient importance to mention now.

It would be rash to make any sweeping conclusions from the results already obtained. The most important result is to demonstrate the methods by which nervous fatigue may be studied. The work already done marks a great advance. A few practical and very important inferences are justified by results already obtained.

First, it has been shown that to do the maximum amount of work intervals of rest must alternate with periods of work. Amount of rest depends on the preceding period of work. Again, through the investigations already made, it appears that there are a great many individual differences in the power to resist fatigue. Kraepelin has shown that each individual has a pace of work peculiar to himself. One individual seems to show first an increase and not until after a long time any fatigue. Again, there are those whose ability to work falls off from the first quarter of an hour. This is wont to appear in all possible tests of individual work. The susceptibility to fatigue is the fundamental characteristic of the individual. The great susceptibility to fatigue by no means depends upon the rapidity with which the individual works. The susceptibility to fatigue determines the ability to work. There are persons who work slowly and are quickly fatigued, and there are others who work quickly and can keep up work for a long time. Fatigue is largely due to toxic products. Then these are analogous to the way different people are affected by drugs, ether, etc. One requires fifty times as much chloroform as another to make him unconscious. Such differences make it impossible to lay down any universal rules for school work. It by no means follows that your child is overworked because cases of over-pressure are common. One may be in a condition of nervous fatigue and not know it. Mosso says that while the excitement of giving a lecture increases his mental power, continued work will decrease it, and this might go on for weeks and months without his being aware of it. This is in harmony with the opinions of those who think one might overwork and not know it. It may be dangerous to generalize

until more work has been done, and the different methods used with the same students, so that they may work and check each other. Questions concerning the length of the school day, study, recess, etc. must be solved at once. So it is worth while to notice, first, the school day, whether or not further investigations will show that the ordinary school day is too long. It is true that with the home study many pupils work for too long a period. Swedish children carry on work as follows: 10 years old, 6 1/2 hours,
18 " " 11 "
and some are mentally occupied not less than 14 1/2 hours. From Germany and England come similar complaints of over-pressure. Opinions differ widely in regard to the proper length of the school day. Best of the tables formed is one by Roberts (Bib.141). The interesting point in Roberts's table is that he considers physique as well as the age. He gives the physique that should be expected from children of a given age, and then gives the amount of school work that may be satisfactorily required of children of a given age and physique. He gives the number of hours of sleep and the number that should be spent in play. Children under 9 ought to sleep at least eleven hours, and not work more than three; under 15, sleep at least ten hours. If a child falls below the physique given, then he should be put back one year in this table. If Roberts is right, we often work our young children too long, they play too little, and often, I fear, sleep too little. I know a little girl in a neighboring city, aged 11 years. Her program for the day is as follows: She rises about six and works until nine, except for her dressing and breakfast. Then she is in school until twelve o'clock. She has no time in school to study. She comes home and studies during the intermission, has dinner at noon, and between the courses sits down at her desk to work; goes to school in the afternoon; comes home at four; plays from four to six. After supper she works until ten, then goes to bed to sleep until six. On the following day is the same routine. I don't know how many children do work of that kind. Some persons say that children worry so much, if taken out of school, that it is better to have them continue their work.

Second, - It appears that we are right in not beginning school until 8.30 or 9 o'clock, and the Germans are wrong in beginning at 7 or 8.

Third, - The length of each period of study; Principle and practice vary greatly. Burgerstein says that three-quarters of an hour should be the maximum time for a period of study, and that each period should be followed by fifteen minutes' rest. There was a resolution passed to this effect. Burgerstein bases his opinion upon the result of his experiments already referred to, but his results are open to serious criticism, as I have already mentioned, because the conditions were not the same as in ordinary school work. Richter's experiments (Bib.138) have an important bearing on this point. His pupils were required to solve simple problems in Algebra and inflect Greek verbs. It appears, with the work thus approximating the ordinary school course, that there was no serious fatigue, but this refers to the German schools, where recesses are more numerous than in

this country. (Richter's Program, Fig.8.) The law requires in Prussia that there shall be at least 40 minutes for recess, exclusive of gymnastics. In this country there is too little time for recess. In a long session of four or five hours there is one long recess of 15 minutes, and the pupils go directly from one recitation to another. Sometimes even this recess is neglected altogether. After each period of 40 or 50 minutes, there should be at least 10 minutes' recess, and one long recess for each three hours. Long experience in Germany shows the advantages of this plan. After a trial of many years there is no demand for lessening the time of recess, but, on the contrary, a bill was introduced into the Prussian House of Deputies to increase this period to 60 minutes. The recess for each five-hour session is as follows: A rest of 10 minutes between each period of study, and two long recesses of 15 minutes each. Young (Bib.178) has tested acuteness of vision of small objects, such as in reading, and the tests showed a diminution of power for seeing such objects after 30 or 45 minutes. This decline in power of vision becomes more rapid after a longer time. Eyes should work no longer than three-quarters of an hour without rest, and, when a school session lasts several hours, the eyes should be worked not more than 45 minutes and this should be followed by a ten-minute rest. It seems, then, tolerably clear that it would be pedagogic, as well as hygienic, to do this.

Investigations made by Friedrich (Bib.64) indicated this. He tested 51 pupils, aged from 8 to 10, before and after school work of the usual kind. The exercises were dictation, and he found that with an increase in the length of period of work, there was an increase of error. A recess of 8 minutes between the two periods of work checked this increase of error. This indicates the advantage of recess. (See Figures 3 and 4, made by Burgerstein's method, showing the effect of recess.)

Fourth, - The question is how should recesses be spent. The trend of opinion seems to be that as much as possible pupils should spend recesses out doors in free play. To what extent physical exercise is recreation from mental work is still a mooted point. On one hand, a great many observations show that children return to work greatly refreshed by gymnastics. In one class the ability to note numbers was 3% better, and in another of 46 pupils it was 7% better, after gymnastic exercises. The experiments of Mosso and others indicate that physical exercise brings an increase of fatigue and decreases the ability to do mental work. Miss Holmes found results from gymnastics were as follows: Relative as to individual, one may be refreshed by exercise that would make another sleepy. The more violent forms of physical exercise are clearly no recreation for mental work. It is relative to the form of mental activity. Gymnastic exercise may diminish ability for one form of mental work but not for another. In discriminating ability, she found the effect of gymnastics was to decrease the number of errors. Long continued mental activity tends to diminish discriminating ability. Effect of physical exercise decreases the momentum of the mind. I speak with some diffidence here, but I fancy that you will all agree with me that we may divide physical exercises into two classes, - those where the main

purpose is for recreation and those for training. The crude idea is still prevalent that all gymnastic exercise is of the former class. The investigations show the value of gymnastic exercise to be a subject of sufficient importance to have a regular place in the program of the school and not be merely a form of recreation.

Fifth, - the question of one session a day, or two. It is shown by the State Board of Education that the larger part of the High schools in the state have one session. The old plan of two and the new plan of one, each has its advantages. Which is the wiser plan is an open question. There are authorities in favor of both. More studies of the curve of work and fatigue should be made. At present the one session a day plan proves very unhygienic for many pupils. A boy I know, who is in High school, breakfasts at 6.30 A.M. His appetite is capricious; he has no luncheon except candy, pastry, and the like. He gets home at 2 P.M., after the family have had their dinner, and he eats anything he finds that suits his fancy. It is hard to find a plan of life better suited to produce dyspepsia. The question of one or two sessions is an open one. If we are to have one session, it is absolutely necessary to make provision for a wholesome luncheon, which I understand has been done in Boston.

Sixth, - The experiments of Griesbach indicate that at the periods of examinations the pupils may be in a state of chronic fatigue, so that they come to their work in the morning in an abnormal condition. Mosso and Griesbach show that the period of examination is likely to be one of extreme fatigue, both to teachers and pupils. (See Figs.6 and 7) Griesbach reports tests of over 40 pupils. Some passed written, some oral, examinations, but all results indicated great fatigue. Griesbach says, "There are many cases in which pupils make their first acquaintance with a physician for nervous disease, before or after the examination."

The period of study in most schools is too long; recesses are too few and too short. These show that the demands which the school makes upon the mental power of its pupils are too great. No child, no adult is able to continue work long with close attention. Uninteresting teachers are a hygienic necessity. Short periods of rest when the children are inattentive are advisable. The school is by no means wholly responsible for over-pressure. Improper food, irregularities of home life, late hours, especially lessons in music, dancing, and the like, lack of fresh air and suitable exercise, emotional dissipation, theatre going, parties, balls, sometimes even religious meetings, show that other causes beside the school are responsible for a part of this. Unwise division of work is a factor in producing over-pressure. The answer to all this may be that, even with our present school period, it is impossible for a teacher to instruct pupils in all the branches required by the program. In many cases the only possible way for teachers and pupils to accomplish the tasks given them is to shorten the period of study and to better divide the work.

Mr. Chas. Padget tried the following experiment in his school: He had a garden for the boys, and divided the school into two sections. One section continued in the school work, with the usual length of periods; the other section worked in the school half the time and in

the garden half the time. At the end of a certain time the latter section were superior, not only in conduct but also in scholarship. This leads me finally to the bearing of these upon education in general. One gauges education by hours, months, and years spent in the school room, by studies taken up, pages turned, and examinations passed. The other looks more at what the pupil can do, and not so much at what he has done. The former is anxious to increase the quantity of work by lengthening the school day or school year and in like ways. Representatives of the latter aim to keep pupils always at their best, to shorten the periods of study, for by so doing it is possible to quicken response and attention. From the standpoint of the latter, the work done by the nervous mechanism, under abnormal conditions, may result in irreparable fatigue.

Lecture No.III.
February 2, 1897. Dr. Burnham.

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The Physiology and Psychology of Development and the Hygiene of Adolescence.

As I said in my opening lecture, school hygiene is based on the physiology and psychology of development. Child hygiene differs from that of the adult, because a child's body is a growing organism. Education to be hygienic must be adapted to the needs of the growing organism and adjusted to its stages of development. It must be admitted that comparatively little is known about it. Important results from the study of physical growth have been obtained. So many conditions affect growth - heredity, food, exercise, hygiene, care, etc. - that it is not easy to interpret data here. When we come to study the nervous system, we know but little about its development. We can distinguish three periods in development of brain from birth. During the first seven years it reaches almost its maximum weight. The next period is one of moderate growth and development. The third period, from 14 to 25, is one characterized by the development of function. The nerve centres are developed first, those of the larger functions first; those of the smaller and more specialized are developed later. Different nerve centres have nascent periods, then periods when they proceed at a rapid rate. Not all the parts develop at the same time, any more than all the parts of the skeleton develop at the same time. Into such general statements we cannot go very far. A new physiology is needed, likewise a new psychology, to show the sequence of development of the so-called mental faculties, and their relation to each other and to the physical processes. Until we have such a science of development, no educational formula of such principles is possible. In spite of 2,000 years of talk, Dr. Strumpell in a recent paper said that pedagogy is in about the same stage of development as physics was in the time of Galileo. If written from the point of view of development, then pedagogy would have the character of a natural science. The foundations of such a science are already being laid. Consulting the bibliography, Nos.36, 41, 48, 66, 156, and 184, it will be found that contributions of prime importance have been made, and every contribution to this science is indirectly a contribution to pedagogy. Many of these studies are of importance to hygiene. It is something to show clearly that education, to be most efficient and hygienic, must be adapted to the sequence of the stages of development. Fundamental and commonplace as this may seem, it has often been ignored even in modern times. It is something, I say, to have established a principle of education. That education should be adapted to the sequence of the stage of development. We should make it our duty to find out the physiology and psychology of development, so we may adapt it to our growing children. What is already known is of great importance. For example, the fact that growth and development are not continuous, but periodical, is shown clearly to be true of physical growth, and seems to be also true of mental development.

I have chosen the period of puberty to illustrate how pedagogical hygiene should be based on the laws of growth and development. The

period of puberty is one of great vitality, and is marked by an accelerated rate of growth. In both boys and girls a period of relatively moderate growth precedes puberty. This acceleration in rate of growth has been found by many investigators to be one of rapid increase in both height and weight. Results, as found by a few representative investigators, are given on the rough charts which I have placed on the walls. These are based on the records of many thousand children, as can be seen by looking at the figures on the bottom. Annual rate of growth for boys: height, figure 1; weight, figure 2; those of girls, figures 3 and 4.

For a short résumé, for the growth of American children, consult Dr. West's paper (Bib.173). These tables, with the exception of the figures for Norway, you will find in Burgerstein (Bib.27). Again, this period of puberty is one of great vitality. One of the most remarkable results of Key's (Bib.25) investigation shows that the periods of greatest growth and development are those of the greatest power to resist disease, (chronic, not acute diseases). During the period just before puberty, the power to resist disease increases, then decreases, then at puberty it rises again. (Fig.5, two curves at top show per cent. of illness.)

Periods of maximun rate of growth are periods of maximum power to resist disease. Dr. Hartwell has made a study of the death rates of Boston children. His results are as follows: During the period of from 10 to 15 years the most rapid increase in height and weight occurs. These are the years of fewest deaths. Roberts (Bib.141) gives tables that show similar results. This, then, is the first point, - that the rate of physical growth is accelerated at puberty and is the period of the greatest vitality. It may not be necessary here, but if any of you should ever have occasion to give instruction on this subject, it may be well to utter a word of warning in regard to averages and interpretation of curves. For a wider treatment of this subject, we refer you to a paper on anthropometry by Dr. Lincoln (Bib.180) and a paper by Dr. Porter (Bib.184). The whole practical significance of American investigations depends, as Dr. Porter points out, upon the fact that an average of the central value gives a picture of the character of the group. The average does not tell us how far the individual varies from the group, but observation shows us that children of a given age vary in size within relatively narrow limits. Most of the individuals measured come near the central value. The numbers in the tables I have given do not represent the same individuals, it is to be remembered, but the chances are that a given individual will for the most part conform to the type. We must always be on our guard against averages. While averages are deceitful and statistics vain, still they are of practical value within certain limits. In interpreting a table or curve, we should know the number of cases upon which it is based. I have put this curve here on the wall (Fig.6) just for a warning. It illustrates what I have said. I read not long ago, in an article in a report by the Secretary of the State Board of Education, this astonishing statement: "Boys grow very rapidly during the period of puberty, and the brain of the boy decreases and shrinks in size. At the age of 14 it drops down to what it was at the age of 4 or 5." I could not imagine how the man could make that statement, and after wondering about it for some time I

noticed Donaldson's curve of brain growth based on this table. (Fig.2 curve in black is for boys; one in red is for girls.) At 14 there is a dip in the curve and, if taken literally, is really true that the brain of the boy shrinks. But look at the table. The number of cases examined is too small to mean anything. In interpreting a curve you must know the number on which it is based. That astonishing statement was principally due to taking that curve literally. Second, - This period of maximum growth and maximum power to resist disease in boys and in girls does not come at the same year of life. This sexual difference is shown in the tables and represented graphically in figure 7. It shows roughly that girls reach the period of accelerated growth two or three years earlier than boys. This difference was shown a great many years ago by Dr. Bowditch (Bib.19). Dr. Roberts sums up the results of a large number of observations as follows: From 10 to 15 years girls grow much more rapidly than boys, and from 11 to 14 1/2 are actually taller, and from 12 1/2 to 15 1/2 are actually heavier than boys of corresponding age. From 15 to 20 boys again take the lead and complete their growth at about 24. After 15 girls grow very slowly, and complete their growth at about the 20th year. Of course, coincident with these physical changes are equally important changes in the nervous system. Calling the period of puberty and the succeeding years up to 25 the period of adolescence, we may say that the brain aroused by new stimuli grows to greater activity. The mind of the adolescent is filled with hopes, dreams, tempestuous passions, and new ideas. Egoism gives place to altruism. Political and religious zeal sometimes become the mainspring of action. Reasoning powers come into use. He may live in an imaginary world, but activity in a real world or in an imaginary world he must have. At a somewhat later period philosophical subjects become a passion. The whole period of adolescence is often one of mental storm and stress. Not infrequently it results in insanity. The importance of this period and the interest that centres about it can hardly be exaggerated. The world's work has largely been done by adolescents. When work is not actually done at this period, the inspiration for it, the ideas and plans for it, have come in adolescent dreams. Then is the time man is capable of independent thinking. Reform is possible. Variations are possible. How conservative the world would be were it not for its adolescents ! The reformers in the church, in politics, in society, are young men and young women. It is deemed almost a breach of honor if a mature man changes his political party. Literature shows the importance of this period and reflects it. Most of the characters in fiction are adolescents, and a large part of literature has been written by adolescents. A few years ago it was found that a large part of modern philosophical work is written at this period. As one writer has said, it is the great court of appeal by which the weak children are weeded out and only the fit left to survive. It is somewhat dangerous to draw practical inferences from results that are incomplete, but a few inferences do seem justifiable.

First, - Children should be regularly weighed and measured, both for detecting over-pressure and also for scientific purposes.

Second, - The fact that the period of growth and development in the two sexes are likely to differ should have weight in determining the course of education. Although the matter has not been sufficient-

ly studied to determine just what the laws of growth require, yet it is obvious that boys and girls differ, and as they differ, their education should differ, at least at this age of puberty when there is a more marked difference between the sexes. There is a great deal of discussion in regard to the equality of the sexes. We are not concerned now with this interesting question, but it is worth while to note that there is quite a period when the girls are likely to be decidedly superior to the boys of the same age, other things being equal. The average girl of 13 or 14 is heavier, taller, growing more rapidly, better able to resist disease, and morally more developed than the boy of the same age. It is the most critical period in a girl's life. If it is necessary to modify the course of education for girls of 13 and boys of 14 years, then it would seem that we ought to consider whether education should not be differentiated between boys and girls at this period, when it is likely that girls are two years in advance of boys. It is advisable for hygienic, as well as moral, reasons that boys and girls should receive a part of their instruction from teachers of their own sex. It does not seem wise that girls should have exclusively male teachers, as happens often in Germany, nor boys exclusively women, as happens often in this country.

Third, - In both sexes the period is one when there should be many forms of activity and the acquisition of many interests. This is necessary for hygienic as well as pedagogical reasons. The acquisition of self control is recognized as one of the essentials of education. In all acquisitions, inhibition must go hand in hand with activity. For example,first we teach a child to talk, and second, we teach him not to talk. A man is uneducated who cannot express his thoughts in good language; but he is also uneducated if he cannot refrain from expressing his thoughts. Hygiene and pedagogy sometimes are in conflict; fortunately they are here in harmony. Pedagogy desires the development of many sided interests and hygiene requires the same, for in many sided interests and manifold activities it sees the possibility, perhaps the only possibility, of self control. Self control is necessary for hygienic as well as pedagogical reasons. Lack of self control is not only a symptom of nervous disorder, but also one of the causes of nervous disorder, and at this period of puberty young men and young women should acquire self control, and this can be done only by the development of many interests. The development of many interests and making them permanent is the aim of education at this time, and it is what hygiene demands also.

Adolescence is the period of self realization. One becomes conscious of a new self, independent of environment. The stronger this new self, the stronger will be the impulse to assert. One's moral development depends upon it. This impulse for self assertion shows itself in a variety of ways. A boy voluntarily endures hardships, works beyond his strength, begins to smoke, perhaps to drink, etc. Sometimes it shows itself in bizarre actions. I know of another boy who let his hair grow long, before Paderewski and foot-ball players had set the fashion. It will set up artificial obstacles for the sake of exercise. A teacher should recognize this. This self-assertion should not be checked. It is moral suicide for youth to crush it out. It should be merely directed into right channels. The teacher is in special danger of erring in discipline. Reason

should now be appealed to. Special rules should be eliminated. If possible, put the adolescent on his honor. Manhood and honor should be appealed to at this time. One school is reported where the pupils try to break all of the rules each day, and they count that day lost if they do not succeed. This period is one of pedagogical opportunity, and,without the right pedagogy, physical as well as moral defects are likely to result.

Fourth, - Teachers do not adequately understand the physiology and psychology of adolescence. Many years ago Dr. Clark (Bib.35) showed the evil results of the ignorance of teachers and parents in this respect, so far as the education of girls was concerned. But in many other ways there is a similar ignorance on the part of teachers and parents. Clouston has shown that there are certain neuroses of development, but with favorable treatment they are likely to be outgrown. In like manner, there are certain mental defects. They can hardly be called insanities, but perhaps the word "psychoses" might be used. They are frequent in adolescents, but teachers and parents are apt to misinterpret them, as the symptoms of these psychoses of development are very similar to those that would indicate mental and moral degeneration. It is one of the most serious mistakes of teachers and parents to mistake these psychoses of development for those of degeneration. Faults and defects in adolescents do not necessarily indicate criminals, but there is always the hope that they will be outgrown with proper education.

Another problem of great importance is how education should be modified at this period of rapid growth. It is no easy matter to determine this. It is not clear whether work should be increased or diminished during the period of maximum growth. It is the popular belief that work should be diminished, but whether a child is capable of more or less work at this period we do not know. Dr. Smith would argue that school work should be diminished during the period when growth is least. Certainly the popular verdict is that the period of rapid growth is the time when study should be diminished, and this will hardly pass unchallenged. The period of puberty embraces some of the most industrious years in the life of the school boy and girl, and yet they are years when the death rate is low. The question must be settled by a scientific study of a specialized character. Here is an excellent opportunity for teachers to make a valuable contribution that will act as a control upon the investigations of the anthropologist.

Now for just a word of résumé, and after that I shall be glad to answer questions. There are a great many unsolved problems in regard to the physiology and psychology of adolescence. Some of the more important are as follows: It is one of rapid change; unstable equilibrium, both physical and mental; a period of great vitality, manifested in many ways; though there is rapid growth, there is an increased power to resist chronic diseases, but a peculiar liability to certain disorders on account of it; there are new impulses and new activities, and in many like ways this increase of vitality is shown. It is,moreover, a period of adjustment, not merely of self to environment, or of mutual adjustment of mind and body, or of different systems of the body, but the nervous system is assuming its proper place

as the controlling power. It is the great pedagogical opportunity. It is the time for many things, and it is a good time to hope for recovery from many ills and defects, both physical and mental. Never give up hope in regard to any boy or girl who may have a very serious fault at this period. There is <u>great</u> hope. It does not indicate a criminal.

Lecture No.IV.
February 9, 1897. Dr. Burnham.

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The Hygiene of Instruction.

In the little bibliography there are some typographical errors. One has been corrected on most of the papers. In No.103 the word "Editor" should be omitted. This is simply a little pamphlet. The books to be consulted in connection with the lecture to-day are the following: 11, 22, 37, 38, 45, 75, 76, 100, 109, 150, 159, 164, and 172, besides, of course, the standard books and the different hand books that have been mentioned.

In this course of lectures I can merely take a few chapters in school hygiene and treat them very briefly and in a very general manner. It is rather dangerous to treat great subjects in this way.

If anthropometric study had done no more than to merely show clearly and forcibly that the education should be adapted to the sequence of growth and development, the advance in hygiene would have been great. The subject to which I wish to call attention to-day is the hygiene of instruction. This is a very important, though much neglected, part of the general subject of school hygiene. It has to do especially with the conditions that favor the development of normal functions so far as they are determined by methods of studying, manner of teaching, text books, etc. Studies of cerebral hygiene and kindred subjects throw general light upon this: On the results of such studies the hygiene of instruction is based. This points out that every subject of instruction and every pedagogical method has a point of hygienic aspect that must be studied before their true value can be estimated. It is, however, in harmony with true pedagogy, for the aim of both alike is the normal guidance of true hygiene. First, the hygienic aspects of pedagogical principles and methods should be studied. To illustrate the way they should be studied, take the subject of correlation. Few subjects have attracted more attention during the last few years. The means of properly correlating different subjects of instruction have been considered, but the subject of correlation is one of hygiene as well as studies. It has seemed necessary that many branches should be pursued simultaneously, but they should not be taught in a hap-hazard manner, without relation to each other, for the subjects are likely to become confused, and over-pressure results. It is necessary for hygienic, as well as pedagogical reasons, to avoid confusion, because confusion is a form of work. Dr. Harris demands that confusion should be avoided, and suggests that preceding the synthesis and correlation there should be rigid instruction in the elements of each branch. On the other hand, correlation is an important means of avoiding confusion in regard to hygiene. Emminghaus found that after learning a series of syllables, certain traces persisted unconsciously in his memory, so that after a month the same series could be relearned easier than a new one. This, we may suppose, was due entirely to physical causes, simply traces of neural habit, yet it is intimately related to consciousness and is important. Unconscious traces of habit not only aid in relearning an old series, but, under certain conditions, wrong acquisition makes learning a new series more difficult. This fact has been demonstrated by the fol-

lowing experiment: 80 cards were used in a pack, and there were 10 kinds of cards, each marked by an abstract word printed at the top. The subject sorted them into ten piles corresponding to the ten kinds. Each experiment consisted of sorting two packs, containing the same words, into different piles. In sorting the second pack the time was longer, and the subject seemed confused, showing a tendency to place the cards in the places they had had in the first part of the experiment. Two different reactions were associated with the same stimulus and interference resulted. They show that during the process of acquiring such a series of associations, interference is likely to occur if different series are learned, one after another, in immediate succession. Experiments in replacing old and well organized habits by new ones, like dipping the pen in the ink and placing the watch in a different pocket, show that after a series is thoroughly learned, either the old or the new one could be automatically done without interference with the other. One series showed that there is likely to be interference; the other indicated that, after paths of habit are well formed, there is no interference. If, as we may suppose,we have here typical examples of what occurs in all exercises, then pedagogical interferences seem legitimate. It is clearly important in matters of study to avoid this interference of associations. Where there is a large number of subjects crowded into a daily program, interference is likely to result, but it is necessary to have such a large number, because a child's attention can not be kept long on one thing. It is necessary, for psychological as well as practical purposes, to have variety and change in the daily program. Psychology of association indicates a kind of correlation that is necessary and hygienic. The principle is somewhat as follows: When similar mental processes, involved in learning two subjects, are essential things, and when different processes and details are required, then co-ordination or correlation is advantageous. It is itself a means of avoiding interference of associations. Similar processes are repeated in different subjects, and we know the advantage of repetition when it can be done without destroying the interest. For example, processes in arithmetic and algebra are similar and may be studied simultaneously, but where, on the contrary, dissimilar processes and details are necessary, isolation is necessary. Where two languages are being studied, it is well to study one until the associations are well organized before taking up the other. The slight differences are important, and interference is likely to result if the two are studied simultaneously. Of course if these languages were studied for general philological purposes, the reverse might be true. A great variety of problems might be added, but it is not necessary to consider them now. There is some difference in opinion, as you all know, in regard to the use of the words association and concentration, but this need not trouble us. The practical point is obvious enough. The point to be emphasized is that the practical problems of pedagogical correlation and the like should be studied from the point of hygiene and the point of association, as well as by the more pedagogical method usually adopted. So much for the hygienic aspect of correlation.

I may be more or less right in the way I have formulated the practical statement, but the general principle is clear enough. Aim of correlation is to avoid interference and confusion as much as possible.

Confusion is a form of worry, and nothing is worse for a student than worry.

A great deal has been done in the past few years in the way of enrichment of the common school course. It is necessary for hygienic as well as pedagogical reasons that many interests be developed, but along with the principles of development, another should be constantly guarded, - that of the elimination of the unessentials. When not properly guarded, school life becomes congested. In some schools there are altogether too many subjects. They are not willing to sacrifice anything useful. In many schools the program is like that described by the President of the Board of Education in Brooklyn, N.Y., who said that the curriculum is over crowded and the subjects ornamental. This made it necessary to divide each school day into short periods, allowing one subject for each period. The pupils are hurried along with results disastrous to themselves and their teachers. They have hardly time to take up one subject and learn what it is about before being obliged to lay it down and take up another. There is no time to learn anything thoroughly. Incredulous as it may seem, not one minute of time is allotted for study during school hours, recitation upon recitation following one another. If pupils desire to study, they must do it at home, because there is no time for the purpose in the school. The program in many other schools is similar. Danger to health in such a program is obvious enough. Nothing so much enfeebles recollection as leaps from one branch of the tree of knowledge to another. More important still is the elimination of all unessential elements from the process of learning. Power of the nervous system is limited. If this form of skill be gained, it is at the expense of some other. If one would acquire some knowledge, he must forego some other. It is not possible to have both. Right education is no longer a choice between what is good and what is bad, but between what is good and what is better. This is the great law of sacrifice in the law of education. It is scarcely necessary to add that to learn this law is the important lesson in education. Efficiency depends as well upon what a man neglects as upon what he does.

Second, - All educational methods in the different school subjects should be studied from the point of view of hygiene. I cannot now consider concrete methods, but must commit myself to one or two general points. To begin with the lessons for young children, - they should never be complex and difficult. We are liable to make the work too difficult at first. Again, by our methods we sometimes make things complex and difficult which nature has made simple. A precocious boy in Boston was asked to tell how many thumbs he had, and his answer was as follows: "I have one thumb on my right hand and one thumb on my left hand. If, therefore, I have one thumb on my right hand and one thumb on my left hand, I have in all as many thumbs as the sum of the thumbs on my right hand and my left hand, which is two thumbs." Logic is not for young children. Most important of all is the differentiation of material and methods according to the individuality of the pupils. That the defects in the methods and discipline are what they are is due to the fact that only strong, normal and healthy children are considered, while a large per cent. of the children in the school room are weak, sickly and abnormal. It is absolutely essential that the teacher should know the physical and mental

condition of the pupils, and adapt education to the condition of the individual.

In investigations in Sweden and Denmark it is shown that a large majority of the children in the school are likely to be suffering from chronic disease. Perhaps I cannot enforce my point better than by taking time to show the tools the children must use in their work.

First, the studies of children's eyesight. Take the studies of myopia or near-sightedness. This defect is very general, and the school has been held responsible for it. Three conditions of the eye among school children have been the subject of special investigation: Emmetropia, normal; hypermetropia,far-sightedness; myopia,near-sightedness. Hypermetropia is so common that it may almost be regarded as the condition of the normal eye in infancy. Investigations among children from 8 to 14 days old showed all, with one exception, to be hypermetropic, but it is not really a defect among young children. The hypermetropic eye seems to be the undeveloped eye. It is likely to be outgrown, and will probably develop into the normal eye. According to continental investigators, the number of hypermetropic eyes decreases from lower to higher grades of school. The number of myopic eyes increases from lower to higher in direct proportion to the number of years spent in the school room. The tables I have give typical results. First, the results of a number of investigations in various German schools: The child usually enters the lowest class at the age of 9, and leaves the highest class at the age of 18. Fig.1 shows an increase of myopia from 22% in the lowest to 58% in the highest class. About 10,000 children were examined. Fig.2 shows a decrease,from lower to higher grades,in hypermetropia. Decrease is from 27% to 24%.

Of course we do not know that these conditions apply to a country like England or America, where the conditions are different. The number of investigations in this country indicate that the same is true here, but this is not adequate and does not prove this. Carter's investigations of the children in the London schools indicate that the same may be true there. He did not find an increase of myopia from the lower to the higher grades, although he did find a large percentage of defective eyes. There are two theories as to the cause of it, - one is chiefly the school, and the other, that the cause is innate structural peculiarities of the eye. The former is held by Cohn and others, the latter by Carter and others. Both should be looked upon, but which is true we cannot say. However, the great influence of the school cannot be denied in view of the great increase of myopia from lower to higher grades. The way to prove it would be to investigate the eyes of a large number of children outside the schools. It is needless to say that it is difficult to make any such investigations among children who are not in school. Examination of German recruits shows that those who have been to school the least have a much smaller per cent.of defective eyes. Farther, it is incidental to civilization; it is not known among savages. The eyes of Patigonians were tested, and those of other savages, and a case was never found. It is probable that hygienic methods of study are one cause of this increase of near-sightedness from the lower to the higher grades, but the fact remains that about one-third of the pupils in the schools are likely to have defective eyes, and, putting it at a very low estimate,

one-fourth are likely to have defective hearing.

Table 3 sums up the results of investigations made in different countries by some twelve investigators, showing the percentage of children with defective hearing. In all cases the number is very large.

A very large number suffers from nervous disorders and other defects. It is necessary, in order that a teacher may do the best work, as well as for the health of the children, that tests of the senses be made either in school or outside. Then the teachers can to a large extent modify their methods to suit the needs of the children. Where these are not made, teachers being ignorant of the state of the pupils, greatest injustice is likely to be done. I know one little fellow of whom this story is told: He is extremely near-sighted. His parents did not know it; his teachers did not know it; he could not see the exercises on the board, and copied them from his neighbor. He was punished, and left school, though he could not read. He did not know what was the matter with himself; others did not know. What could he do ? A simple test would have shown his difficulty. Children are often thought stupid who are hard of hearing or have an adenoid growth. A slight defect of hearing is more serious than you would suppose; of all the demands upon the ear, that of comprehending speech is most severe. One hears for a time dictation exercises, and as his attention flags he fails to comprehend the words. In many cases the effect of hearing varies, especially in persons troubled with catarrh, so that people may hear a word at one time clearly and poorly at another time. These defects are often not known to even the person himself. Teachers who are troubled with inattentive pupils may find that is due merely to defective hearing. The importance of normal senses can hardly be overestimated. Vision is especially important. Not only do Helen Kellar and Willie Robin live in a world that we cannot see, but those with defective hearing may also live in a world differing from ours. The following experience is related: "One day, prompted by a spirit of mischief, I got hold of a pair of big spectacles which my father used to use. I amused myself by putting them on and taking them off, but what amazed me most was that I could suddenly clearly see the trees and far away beyond them. Outlines appeared which before had not been seen. Many things which were before confused and jumbled now stood out boldly. I had not supposed any one could see a bird, but had thought it was merely to be heard. I gave my parents no peace until they gave me spectacles." Similar cases are perhaps familiar to many of you.

I have not time to speak about investigations of the physical and mental conditions of children, but enough has been said to show that the teachers ought to see the condition of their pupils, and should adapt methods to the individual differences.

Let me say just a word about nervous diseases. A large percentage of the children in our schools suffer from nervous disorders of some kind. Investigations have not been so careful as they ought to have been. Some have exaggerated greatly the number of children with nervous defects. I have given here a couple of tables (Nos.7 and 8) showing the effect of one study. I give them simply as a sample and for what they are worth. Fig.8 shows the result of a study made in a Moscow gymnasium. It was found that the number of

neurosthenic pupils increased from 8% in the lowest class to 69% in the highest class. (Fig.8 shows the results of investigations made in a boarding school.) I don't believe any such increase would be found in our schools, and yet a large number of our children are suffering from nervous disorders, and one of these disorders, of which the teacher should have some knowledge, is chorea. Sturgis has studied a great many cases of chorea in children. In 1885 he reported 80 cases. The cause for 75 out of the 80 could have been solved. 14 were due to causes connected with the school. The point of his investigations is that he thinks that if teachers knew the symptoms they could detect chorea in the school stage, before the parents notice it and before a physician would be likely to be called. One test is to have the children raise their hands. If they come up symmetrically and at the same height, probably the children are normal in this respect. If they come up one higher than the other, the fingers spreading out and unsteady, one may suspect incipient chorea. In a number of other cases it would probably be quite a simple matter to detect this in the school stage, and it is very important to do this.

I will close by a quotation from Sturgis: "The evil comes, I am persuaded, from the fact that teachers do not differentiate their material in respect to temperament, ability, bodily health and home conditions. Their rule of conduct is too rigid and uniform. They should adapt themselves to individuals. Evil results follow from not individualizing their methods."

Fig.5 shows investigations made in Russia on 6,000 boys and 1,000 girls. Some increase is shown in myopic eyes from lower to higher grades, and a decrease in hypermetropic eyes.

Lecture No.V.
February 16, 1897. Dr. Burnham.

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Writing: Hygienic Investigations.

The books I shall especially refer to to-day are the following, in the bibliography: 9, 27, 77, 100, 144, 148, 149, and 151, and especially 27.

In my last lecture I spoke in a general way of the hygiene of instruction, and attempted to show that every pedagogical principle and method has hygienic aspects that must be studied. In applying the principles of correlation, the guide must always be the health of the pupils. The hygiene of instruction is based upon the principles of hygiene and upon the results of special investigations of school children while engaged in their usual activities.

The subject chosen for to-day is writing. The importance of the hygiene of writing is realized when one considers that a large part of the pupils' time in school is spent either in special work or writing exercises, taking notes, and the like.

Fahrner in his work estimated that the amount of time spent by pupils in writing, during education from the age of 6 to 14 years, was 2500 hours, and probably at the present time in our schools it would be safe to say that during the public school course, including the high school, one-fifth is spent in writing. The hygienic aspects of writing have received comparatively little attention until recently. The writing and not the writer has been considered. What are the demands of hygiene in regard to the writer ? In writing, the general principles of motor training have been observed. The work at first should involve the larger muscles, and consist of arm movements. This rule which follows at once is a corollary of the fundamental law of development.

Second, writing should be begun during the period when the nerve centres which control the arm, eye, and hand are developed. It is impossible to determine just the age when a child should begin to write. Results of investigations so far give really nothing but that writing should not be begun too early and not postponed until too late. In most schools it is not begun too early. The only rule that can now be formulated in regard to this whole matter is that when there is control of the larger muscles, and central movements can be made with ease and vigor, it is safe to begin the finer and more complicated movements.

Third, - As in all motor training, only the right movements should be practised and others excluded.

Fourth, - The work should be differentiated according to the individual peculiarities of the children. It should not be supposed that, because children happen to be in the same grade, they could write in just the same style and do the same work. The muscular and motor development of children in the same grade is likely to differ greatly. A particularly bad form of a class drilled in writing was reported by a writer a few years ago. Before beginning work the following directions were given to the class: "Attention. Sit erect. Feet together. Lean forward. Curve the fingers. Describe letters in the air."

Again, "Stop. Dip pens. Write." And this was done until the command came, "Wipe pens."

The work should be such that it would not injure the eyes or spine of the pupil, or in any other way be injurious to health. In my last lecture I showed that a large number of pupils suffered from defective vision. From other investigations it appears that a large per cent. of spinal curvature originated during the period of school life. About 90% of scoliosis originates during school life. There is a certain amount of evidence that goes to show that the per cent. of scoliosis increases from the lower to the higher grades. (See table 1, showing 300 cases of scoliosis.) There was a tendency a few years ago to throw the chief blame for this and myopia upon the school. It is easy to assume that the children are perfectly normal when they enter school and hygienic out of school, but recently there has been a tendency to study the subject more carefully. It is recognized now that there is a large number of other causes outside of the school, that tend to produce these defects. Structural peculiarities of the eyes are one cause of myopia. Unhygienic clothing, food, etc., especially certain diseases of development, as rickets, are recognized as causes of spinal curvature. But it is often just because children come to school with a tendency to these disorders, and because the conditions are unhygienic at home, that special care of their health must be taken at school. The important thing for the teacher is this, - are there any conditions in school life that have a share in producing these effects ? It is probable that the collapsed condition of the pupil during school work, especially writing, is one of the several causes producing spinal curvature. That mal positions are the rule and erect postures the exception has long been the testimony of writers. Fahner estimated that only one in ten sat in good position in writing. Schenk reported on 200 children. There were 160 with lower dorsal curves; 34 whose trunk inclined toward the right and twisted to the left. In the remaining six, pelvis was twisted a little to the right. Other investigations have since shown the frequency of mal positions in writing. Every teacher knows it too well from personal observation. A writer in a Swiss magazine reports as follows: "All the new pupils in my division speak up loud in a few days; all my pupils hold the pen properly in two weeks." A third boasts that out of seventy who left after instruction with him, there were not two who did not hold their pens correctly.

Then I ask these model teachers, or any of you, if you are actually able to make your pupils sit erect while writing. None of them would answer. Finally a lively discussion arose on this point, and it was decided that, by prodigious effort, it might be done, but it was one of the most difficult demands that could be placed upon a teacher, to make pupils, by any humane means, sit erect.

The same writer says that during the last twenty years a vast amount of money has been spent in exchanging old benches for new seats, but all this expenditure has not made the pupils sit properly. Observations and statistics indicate that with the usual methods of writing, 80% of the pupils sit in bad positions. The cause varies. Unsuitable seats at the desk, fatigue, improper methods of writing, etc. might be mentioned as some of these. Mal positions are found in all classes, beside that of penmanship. What can be done to

diminish this evil ? As a means for insuring a correct position, the following may be mentioned:

First, various mechanical devices. One man invented an instrument of torture, screwed to the desk and screwed against the collar bone, which was used when one did not sit erect. Another device is a support, which is clamped from chest and collar bones to chin and face. Nearly all of these mechanical devices have been condemned as instruments of torture, and are of little value.

Second, - the question of suitable seats and desks. It is absolutely necessary to have suitable seats and desks, that will fit the children. How large a number of misfits have been shown by Drs. Scudder and Hartwell in this city ! The greatest obstacle to obtaining a correct posture is the improper seat in our schools. Schubert measured the positions of 1408 children to determine the influence of good and bad seats, and that of bad light, upon the children, and the difference in the distance of the eyes of the children from the paper. We should realize the necessity of having the whole of the copy book at a uriform distance from the eyes, and to do this the seats must be well adapted.

Third, - proper methods of instruction. In studying the methods of writing in relation to posture, very elaborate investigations have been made by a large number of physicians and others. Work has been done in Germany, testing movements of the eyes, position of the head, curves of the trunk, etc., during writing. I must treat this subject very briefly in proportion to its importance. A vast amount of literature has appeared during the last ten years. Schubert (Bib. 149) gives a list of more than 150 books, most of them in German, relating to this subject. Most of them are technical in character, concerning movements of the eyes in writing; others concerning relative merits of different positions of the copy book in writing. Four positions of the copy book deserve special consideration:

1. Squarely at the right.
2. Obliquely at the right.
3. Squarely in front.
4. Obliquely in front.

In the last cases one writes uphill, as it were, but the down strokes are made at right angles to the base line and to the head of the desk. Both positions of the copy book at the right are bad; all authorities agree on this point and have for twenty or twenty-five years. The head must be turned to the right, shoulders curved more or less, the left shoulder raised while the right sinks, and the spine crooked to the left. This position is fatiguing, and the body is soon collapsed, eyes brought dangerously near the paper, and the body supported on the left arm. This position is especially bad for the eyes and spine. Again, the right eye is nearer than the left, according to Schubert's measurements, - 2.3 c. nearer at the beginning of the lines, 3.6 c. nearer in the middle, 4.2 c. nearer at the end. Hence the right eye is worked harder than the left, and is likely to be injured. There is a certain amount of evidence on this point. It appears that of 21,949 persons tested, 5,295, or 24%, were anisotropic; 3,260 had the right eye more than the left, 2,032 the left more than the right. Among the anisotropic, 62% had in the right eye a greater degree of refraction than the left, and 38% the left more than the right. This is due to the fact that the right eye is worked

harder than the left. All authorities agree in condemning positions with the copy book at the right. It would not be necessary to emphasize this, were it not for the fact that it is the usual position in the larger part of our schools to-day.

The most important recent investigations have been in regard to the relative merits of the oblique central position of the copy book and slanting script, and the straight position of the copy book and vertical script. Attempts are being made to find out which is the best. First, the distance of the eyes from the paper: Ever so slight a change is enough to alter the centre of gravity of the body. Any movement which does this makes upright sitting impossible without great muscular effort. It is a question of physics. (Results of experiments shown in table. Tables showing Schubert's results regarding vertical and slanting script.) Investigations show also that there are from 2 to 5% more near-sighted pupils in the slanting script classes than in the vertical. Where so many facts are involved, large numbers of children must be tested to give good results. Similar investigations of several thousands were made in Nuremberg, and the results show no great difference. Another investigation found that a number of children were suffering from scoliosis in the slanting script classes. The better position of pupils in vertical script classes is shown more forcibly by a table that Schubert has compiled, giving the results of investigations made in five different cities. (Fig.4.) All investigations show similar results. Important investigations in regard to the position of the body in writing have been made by others, and thus far largely favor vertical script for hygienic reasons, and the weight of testimony from other authorities is also in favor of it. As this is a practical question now being discussed in many places, perhaps it is worth while to spend a few minutes in regarding the pedagogical arguments, pro and con.

First, it is simple, and seems to be natural to the child. Some say that children naturally write a vertical script, and only with difficulty are taught to write the slanting. Again, it is more legible. It is on account of this last fact that it is required in English Civil Service, large business houses, libraries, insurance offices, and the like. One of the reasons why the script, with the down stroke vertical, is more legible is suggested by this little chart. (Fig.3.) I think you will all admit that the lower lines seem to be shorter and farther apart than the lower, but they are really all the same length and the same distance apart. About all there is to writing is the down strokes. If you take the down strokes you have nearly all. If you take the rest you have almost nothing. (Used as an illustration were the words "Worcester" and "penmanship.")

Vertical script is still opposed by a few eminent authorities; among them are Berlin and Rembold (Bib.9) and Janke (Bib.94). Let us notice some of the objections. They are often based on personal observations and prejudices, and are limited. Among the more serious objections, however, are the following: It is said that the sloping script is more beautiful. Samples given in copy books are more beautiful; I have seen vertical script, however, that is beautiful. The copies in some of the German books are really very beautiful. Again, the objection is made that the vertical script cannot be written as rapidly as the sloping script. This point is not settled,

and there is no satisfactory evidence upon it, as far as I know. It is probably true that the adoption of the sloping script in modern times, in place of the vertical script, which was largely used in the middle ages, was adopted for speed, but at the present age, with our typewriters and stenographers, speed is not necessary. Anything written outside a copy book is usually read, and any possible loss of time to the writer of the vertical script is more than offset by a gain to the one who reads it. There are, however, objections to the vertical script that should be carefully considered. One is that the movement is not so easy and natural for the arm and hand as that of the sloping script. It is difficult to tell how much of our aversion to it comes from habit and how much from the way our hands and arms are made. This point should be carefully investigated. I think it may be said, however, that the results of the various investigations made indicate that the adoption of the vertical script would do a great deal toward removing the mal positions of the writing classes. We may have suitable seats and correct methods, but the teacher must exercise her discipline. One experiment was made as follows: Instruction was given to the pupils of two writing classes, merely at the beginning of the term, in regard to holding the pens, position of the copy book, correct postures, and the like. The same instruction was given in both classes in vertical and slanting writing, and the result was that the positions in both divisions were equally bad. In another case the teacher gave instructions and took great care that they were followed. The result was that the pupils sat in equally good positions. He concludes that it is not the principle of the vertical script, but the instruction of the teacher, and the fulfilling of the various demands of holding the pen and the like, and that good positions can be obtained as well with one script as with the other, if the demands are carefully followed.

Let me now give briefly a résumé of what seem to me to be the most important points. The question of a good position in writing is a great deal more than the question of vertical versus slanting script. The kind of script appears to be one important factor among a number of others in determining the correct posture. Among others are seats, desks, light, influence and discipline of the teacher, and the like. What has been said is enough at least to show that the physiology and hygiene of writing are complicated subjects. Study should be made in all of the subjects of the school curriculum of the pupils when actually engaged in their school work. The problem is that of the physiology of development. Those of you who may have occasion to give instruction in this subject will have constantly to enforce this point. The importance of the whole subject of the hygiene of motor training is due to the fact that it concerns the motor activity of an organism during the period of growth and the development of the function.

L e c t u r e No.VI.
February 23. 1897. Dr. Burnham.

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School Sanitation and Studies of the Actual Hygienic Condition of School Houses.

Books referred to are the following: Nos.5, 8, 12, 13, 15, 29, 33, 90, 114, 139, 176, and 177, besides all of the special hand books and the reports of the Board of Health so far as they take up the subject.

What is the environment of pupils in the school, and what are the sources of discomfort and danger to health ? I shall confine myself chiefly to the sources of contamination of the air.

First, - expired air. We are still uncertain as to the constituents of expired air and their danger to health. In the out-door air we have 20 parts of oxygen, and in expired air only 16. Hence, by decreasing the amount of oxygen, if in no other way, the presence of fifty persons in any defined space tends to decrease the healthfulness of the conditions. Thus, negatively at least, it is injurious because of the deficiency of oxygen. It is probable that some of its constituents are positively more or less injurious. In the light of present investigations, one is cautious about expressing opinions. Some years ago carbon dioxide was deemed injurious, and many experiments were made upon it which proved that it could not be due to the carbon dioxide. In 1887 two men reported experiments which indicated that expired air contains a volatile or poison. In 1889 new experiments were made that corroborated the previous view. Rabbits were confined in a series of metallic cages, connected by a set of tubes, so that the expired air from the first cage was carried to the second, and so on, till the rabbit in the last cage received the expired air from all the other cages, the rabbit in the first cage only receiving fresh air. The result was that the animal in the last cage died first, and after an interval the one in the next, and so on, the one in the first cage usually remaining alive. This experiment seems to substantiate the theory that there is an organic poison in expired air. Nearly all the hand books on hygiene speak of the organic matter of expired air as largely or chiefly caused by the injurious effects of the things produced. Experiments by Dr. Mitchell and others in this country have made it doubtful whether the organic matter is harmful or dangerous. They confine a man, clothed in his working clothes, in a zinc cage for half an hour. Then a boy and girl were compelled to breathe the air. No ill effects except increased respirations were noticed. In 1892 Smith published an account of experiments in which an air tight chamber was employed. Samples of air for analysis were drawn off through a tube placed in the wall of this chamber. When one person remained in the chamber until the vitiation was ten to twenty times as great as it was at first, there was no perceptible odor or sense of oppression. Though

the air was so vitiated as to prevent a match from burning, there were no appreciable effects. Dr. Bergey, under direction of Drs.Billings and Mitchell, has made experiments which have an important bearing on the subject.

First, they wished to determine whether the condensed moisture contains organic matters, as micro-organisms, epithelial scales, etc. Cultures were made of the air and preserved twenty or thirty days. Two consecutive tests of jelly remained sterile, when the utensils were first sterilized. When special care was taken with the preparations, no epithelial cells were found. Fluids condensed from the breath of three persons were used, - one from a healthy man, one with a trachea fistula, and one with pulmonary tuberculosis. The amount of ammonia in each of these was found to be very small. Experiments were made for organic alkaloids, with negative results. Experiments were also made for gaseous mixtures in which small animals die. Some of the conclusions drawn from above are as follows: First, the results obtained in this research indicate that in air expired by healthy animals, rabbits, sparrows, guinea pigs, or men, no organic matter is found which tends to produce any special forms of disease. The injurious effects seemed to be due to a decrease in oxygen or an increase in carbon dioxide. The minute amount of organic matter contained no injurious factors. It is probably unnecessary to take this into account in providing for the ventilation of rooms. The results reported make it improbable that there is any peculiar volatile poison in the air expired by healthy men and animals, other than carbon dioxide. The results of experiments made upon animals may be applicable only in part to the human being. It does not follow that man may not be injured by living in an atmosphere containing only a small part of oxygen, etc. I have only shown that the guinea pig and rabbit seem to suffer no bad effects from living in it a few days. Results of this investigation, in connection with other researches, indicate that some of the theories upon which ventilation is based are either without foundation, or doubtful. It requires a consideration of the best methods of preventing a collection of various gases derived from heating, lighting, etc. It would be unwise to conclude that the standards of air supplied for the ventilation of rooms are much too large under any circumstances; or that the difference between the health and vigor of those who spend the greater part of their lives in the open air of the country and those in the city slums depends in any way on the conditions in the atmosphere as regards micro-organisms.

The first source of danger to health in the school room is the expired air. While the carbon dioxide, in the quantities in which it exists, cannot be looked upon as especially injurious, it has been used as the most convenient gauge for other poisons. It is not the carbon dioxide, but because it is usually found in bad company, so the amount found in the air is taken as a gauge of purity. Six parts in 10,000 is taken as a standard of purity. Any air that contains more than ten parts in 10,000 is deemed positively injurious. (See table showing amount of CO_2 found in air in different locations.)

With our best modern systems of ventilation better results have been found, for it is only with the best means of ventilation and constant care that the air can be kept pure. The subject of heating and ventilation of school rooms is a vast and complex one, and one which

I cannot treat here, but while we are still in the dark about the most harmful constituents of bad air, yet we all know that bad air is harmful. In the school room good air is necessary for pedagogical as well as for hygienic purposes. Dr. Woodbridge, in a recent paper on sanitation, says that work done in bad air is 25% below that done in good. A gain of 20% has been reported as one of the results of greatly improved sanitation in Chicago. A gain of from 15 to 20% in work done in one year has been accomplished in Europe, by moving from badly ventilated buildings to light and cheerful ones. Under the old condition about 18,000 days of labor a year were lost to the Government through illness in the forces of that department. Now there is a gain of 8,000 working days, to say nothing of the increase in working capacity of the entire clerical force.

Second, - various sources of bad odors. The cause of the unclean, musty odor which is perceptible to most persons passing from the outer air to crowded, badly ventilated rooms may be due in part to the teeth, foul mouths, etc., and soiled clothing. It may produce nausea to some especially susceptible persons, but most men become accustomed to it and soon cease to notice it after being for some time in the place. The direct and indirect effect of odors upon the comfort, and perhaps the health, of men is more considerable than perhaps can be now known. Here should be mentioned one of the sources of contamination in the air of schools, to which too little attention has been given, namely the decayed teeth of children. Many investigations have been made in England, France, Germany, and other countries. From these it appears that the majority of children have decayed teeth. In this country 30% of the total number of teeth were defective; in Hungary 15%; Germany showed a larger per cent. The teeth of 13,667 children have been examined by one man, and he found that the number of children with defective teeth varies greatly with the locality, but the number is large in all places. (See table showing this.) I mention these things to show that the presence of so many decayed teeth is a source of contamination to the air and deserves some consideration. It is impossible to have pure air where there are so many decayed teeth. A certain doctor says that, as a dentist, he is accustomed to bad odors from the mouths of his patients, but again and again he has found it impossible to stay in the room when conducting his examinations, because of the bad breath of the pupils. He pitied the teachers who have to stay six hours in such a bad atmosphere. It is evident that this is a matter of some importance.

Third, - The various sources of dust are dirty shoes, clothes, chalk, etc. Some experiments by Hessy in Berlin are interesting. He found before the school began 2,000 micro-organisms in a given space, and at the end of the school session 35,000 were contained in the same space. The number depends on the conditions which favor the stirring up of the dust. (Illustrated by table.) The air was passed through a tube of gelatine, and then the number of micro-organisms was estimated. A teacher in another school made similar investigations by a different method, and found some very interesting results. In the school where the tests were made a good deal of care was taken to keep the rooms clean. The janitor was required to sweep the rooms twice a week, the gymnasium, halls, and stairs every day. In sweeping, a large amount of sawdust was used; the seats were raised and the dust carefully removed. A few hours afterwards the seats, desks, and all

the furniture were wiped with moist cloths. In spite of these precautions a large amount of dust was found in the rooms, and this contained enormous numbers of bacteria. In one experiment a culture was made. Four plates of medium were placed in four rooms for five minutes, the children remaining in the rooms. In 72 hours micro-organism had developed. (See table.) These tests were made with great care. There are at least one million micro-organisms to a grain of dust. From this it appears that an enormous number of micro-organisms appear in the dust and pass into the air. When the air was tested on high mountains, as in Switzerland, they had to seek through two or three meters of air before finding a single bacteria. The number of micro-organisms stands in inverse ratio to the means of ventilation, the cleanliness of the room, and the cleanliness of the children. One investigator found the number increased the younger the children were. He explained it by saying that the younger children do not keep so clean as the older ones. In most of our schools I fancy the number would be pretty large. One estimated that each pupil inhaled 45,000 micro-organisms during a school session. Most of them are harmless; still some of them are likely to be pathogenic. Our health officers in Worcester found children with diphtheria sitting in seats with other children, and the disease unsuspected. It is not cleanly to breathe dust and bacteria all the time. Our habits as regards cleanliness are peculiar, and they furnish some interesting psychological phenomena. The habit of keeping the face clean is well nigh universal. Those of the better classes keep their hands clean. In this country bath towels are a necessity. In Germany it is not always easy to find accomodations for a bath. One writer made interesting investigations as to the amount of bathing possible throughout the country. If all the bath tubs were in constant use, it would be possible for each person to take a bath once in 800 years. Our ideas of cleanliness are matters of association. We have no associations of filth in its subtler forms. We turn away with disgust from dirt we can see. We do not feel the same toward dirt that can be seen only under the microscope. It is important to educate the community in regard to the subtler forms of dirt. School rooms should be washed at least once a month. Each room should be swept in moist sawdust every night, and dusted every morning with a moist cloth. There will be a reform in the matter of cleaning school houses in a few years, let us hope. It is only a question of how many cases of conjunctiva, catarrh, etc.shall develop first, and how many children die of diphtheria, scarlet fever, and other contagious diseases.

Fourth. The fourth source of danger is connected with the heating apparatus. In most of the school rooms the temperature is kept too high. Experiments by Mitchell and Bergey indicate that it is a much more serious matter to have the temperature high than we have supposed. A great part of the discomfort is likely to come from this cause. Sometimes there is carbon monoxide from the heating apparatus, and possibly other elements that cause discomfort.

There are, of course, a great many other causes of contamination to the air, and sources of danger to the health in the school room, which I cannot stop to mention. Such as I have mentioned are some of the sources in the ordinary school room. In the majority of places, perhaps, the other sources of danger result from neglect of the most

commonplace hygienic rules, and are to be mentioned as the most serious sources of danger. There is danger, of course, from the unhygienic surroundings of the school, from privies, improper means of heating, insufficient light, etc. If we could combine in one school house all of the good features found in the different ones, we should have a fairly good school house. If we should combine all the bad features, we would then have a very bad one. How many of our actual school houses approach the former and how many the latter, we do not know. The condition of the schools of Boston may be taken as fairly representative of what may be found in our large cities. I quote from Mrs. Richards' paper read before the American Public Health Association. Speaking of the recent investigations here in Boston, she says, "Half of the school houses were found to be in a condition very detrimental to health. Out of 186 school houses examined, the number of those having modern ventilation was only 16. In only 13 the proper amount of air for a pupil was found. In 27 schools, less than 150 cubic meters of air space was provided, against 250 required by law. Though 30 feet of air should be allowed each pupil, six rooms showed less than 8 feet, eight rooms, between 8 and 12, and thirteen, over 20. These conditions of poor ventilation exist in buildings, many of which are 30, 40, or 50 years old. The floors of 40% of the number had never been washed since they were laid , till 1885. It is the practice to stir up the dust by using a feather duster in the morning, in order to fill the children's throats with germs that cannot fail to be present under those conditions. The school houses were not well aired between the sessions. Only 27 out of the 186 school houses of Boston were found to have anything like adequate fire escapes, and it is probably within the limits of truth that if the laws were strictly enforced, there would be 20,000 children on the streets in Boston next winter."

An expert committee appointed by the Mayor says that buildings constantly show conditions which indicate lack of knowledge and judgment, in permitting things to be done in the way they are. This would not be allowed in progressive private work. Boston has been taken as an illustration of the condition in other cities. It is to be desired that similar tests be made in all of our large cities. Until we know what the actual condition in school houses is, we shall not know how to determine the causes of ill health in the school children, and the committee can hardly be expected to do very much in improving the school houses, when they are usually appointed to the best school houses and the worst ones are little noticed.

The subject of school hygiene, which I have treated very briefly in these lectures, is a very broad one indeed, and a very complicated one. I have spoken of only a few phases, those which are perhaps most likely to be neglected. It is somewhat dangerous to single out a few points, as I have done in this course of lectures, for all the essentials of hygiene are inter-related. The best schools cannot keep the children well if the homes are unhealthy, and the best homes cannot keep them well if hygiene is ignored in the schools. I hope enough has been said to at least serve as an introduction to the subject. I wish strongly to recommend some of the books in this bibliography. Do not be afraid of the German books. They are hard to read, as the Germans are prodigal of ink and write in a verbose style.

"Mother Nature has given of her bounty to all, - to the French, wine, to the Swiss, milk, and to the Germans, ink." I have devoted, perhaps, an undue amount of time to the German investigations, because they have studied their results so carefully. If any of you should have occasion to advocate greater regard for school hygiene, there is one objection you will be apt to meet. It is said that our fathers and mothers attended schools where nearly all of these matters were neglected. Essentials of plumbing were unheard of. They sat in unhygienic seats, and ate their luncheons there. They abused their eyes at school, and at home burned the midnight oil at will. In spite of all this, they were more vigorous and healthy than the present generation. If this objection is raised, it will hardly be worth your while to point out that in the earlier days epidemics of scarlet fever and diphtheria raged in a way not known to-day, but it may be worth while to mention the fact that school hygiene is not for our ancestors, but is for the children of to-day. They lived a quiet, fresh life, and attended school during a short period of the year. With the present surroundings and new modes of life, have come new dangers to health. Our children are born into the hurry and bustle of modern life, with these new sources of danger to health, in a new environment, and the nerves are not yet adjusted to new conditions. It is far more necessary for our schools of to-day to regard the rules of hygiene than in the days of our ancestors. It is mere decency to demand that our schools shall be clean and well ventilated. It is mere humanity to have tests made of our children's senses, so they may not be called stupid when they are hard of hearing, or have defective eyes. It would be a pedagogical as well as a hygienic gain, for teachers and pupils, to have a more rational division and alternation of periods of work and rest in the school. We should have regard for the physiology and psychology of development. We should have regard especially for the periodicity of development and not make the blunder of mistaking the psychoses of development for that of degeneration. We should consider the hygienic as well as the pedagogical aspects of all branches of education. Great reforms are sure to come in the near future in the hygienic conditions of our schools. How soon they will come will depend largely on the interest the students take in the subject, and the work they do in educating the community.