THE PRESENT STATUS OF SCIENCE

IN

THE SECONDARY SCHOOL.

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THE PRESENT STATUS OF SCIENCE IN THE SECONDARY SCHOOL.

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History.

To us who see the application of scientific laws on every hand, it may seem strange to say that there was a time when science did not exist. Yet according to some philosophy this seems to be true. With the development of the mind of man, not only the more easily observed laws have been determined, but even those in operation from the smallest physical change through the most mysterious biological changes have been carefully worked out.

The first science we have any record of was among the Greeks. Aristotle, who stood among them as "master of those who know" said that a body could not be hot and cold or wet and dry at the same time. Some of their earliest thinkers said that earth, air, fire, and water constitute the four elements. Under the influence of their philosophic minds, Thales discovered the solstices, Pythagoras, in opposition to the general belief, said that the earth is not fixed, and Aristarchus later discovered it real motion.

Aristotle, through his band of helpers, gathered special observations in botany, zoology, and physics. His strong objection to the atomic theory of Leucippus and Democritus showed that the Greek mind was limited in its conceptions. Their study of light is shown by the mention of optical activity among them. Heropheles even dissected a human body which led to the discovery of the nerves of sensation and motion later.

The Arabs contributed enormously to our knowledge of science, especially chemistry and physics. Their attempt in the eighth century to find perfection led to an analysis of the metals. They said that the differences between them were due to the relative qualities of their constituents and to the degree of purity exhibited by the metals themselves." Roger Bacon later affirmed concerning their attempt to convert the baser metals into silver and gold, that it was as absurd to wish to transform lead into silver and copper into gold, as to pretend to make something out of nothing.[1] His insistance that metals are perfect in their native state showed that he understood science better that his predecessors.

The Frenchman, Lavoisier, disproved the "phlogiston" theory of the seventeenth century by showing that the weight of substances before and after burning is the same. Only a century ago, John Dalton found by experiment that a metal when burned always gained the same in weight. About 1850, Bunson and Kirchoff invented the spectroscope for analysis by means of spectral lines. Just recently have radium, neon, krypton, argon, and helion been discovered.

In the fifteenth century Conrad Gesner made the first zoological cabinet and founded the botanical garden at Zurich, Dr. Gilbert made discoveries in magnetism, and Galileo established the principle of the pendulum.

The study of chemistry was at first mostly by those who expected to become physicians. It received a strong impetus in the eighteenth century by the establishment of chairs of teaching it in France. With the addition of illustrative material it was introduced inti England in the first half of the nineteenth century by Davy, and brought to a "high state of perfection" by Hautman. Thomas Thompson opened the first laboratory and later introduced it at Glascow. They were then constantly introduced ar different places. It seems that one was established at Princeton University in 1795.[2]

The first secondary school to open laboratories for individual work by the students was in the city of London by one Mr. Hill, in 1947. Laboratory work was introduced in Boston in 1865.

In Germany, the teaching of science was intriduced

1. Charles Baskerville in Scientific American, Aug. 31, 1907, p. 142.
2. Encyclopedia of Education, Vol. I, p. 586.

into the school towards the close of the sixteenth century, but was not firmly established until the rise of the real schulen. It was taught at first as an undifferentiated mass covering every branch which comes under that name. Its importance in the industries, however, caused its introduction into the reorganized königliche realschule. It was not firmly established in all the secondary schools until the syllabus of 1882 was passed.

The introduction of science into the schools of Germany and the importance attached to teaching it was probably due to the influence of Bacon's philosophy which was promulgate in this country by Ratke and Comenius. It was only in the eighteenth century that the secondary schools recognized the utility of certain forms of scientific knowledge. On this principle, science has been prescribed for all the Prussian schools since 1816.

Biology was later in receiving attention than physics and chemistry. It seems not to have been considered so important. Thousands of intelligent people thought of botany as a science that gives names to plants. This very idea seems to have proved effective in keeping it out of the schools for years. Darwin's "Origin of the Species" in 1809 tended towards changing biology from purely a medical study to one for its culture and scientific knowledge. It also led to the equipment of laboratories with compound microscopes.

About thirty years later, biology with its unsuitable texts and laboratory guides was introduced into America. The most successful attempt to present to young students the prevailing ideas of the biology of the period was made by Dr. Asa Gray. He began in 1842 the publication of a remarkable series of textbooks which were the means of giving that subject a permanent place in the secondary schools of the United States. It is only within the last fifty years that biology has attained to any thing like a prominent place in this class of schools. It is given in most normal schools to those who are preparing to teach.

Agriculture was somewhat different from the other sciences in its introduction into the schools. Although it has furnished "the staff of life" since earliest ages, yet no one seemed ever to think of formulating a science of agriculture. consequently knowledge of this subject had to be accumulated, extended, and popularized before agricultural instruction below the colleges could become possible. This process was greatly aided by the introduction of nature study, the school garden movement, and a demand for practical instruction in both elementary and secondary schools.

Progress in agricultural education was slow at first but results soon began to appear. There were men who knew how to discover the laws of plant and animal growth. With the discovery of these principles, young college men took them up and succeeded better than their fathers. This made agriculture respected in the universities and it soon gained a permanent place in all the state institutions.

c o le. The ecales practique of France, which seem to have been agricultural schools, were established in 1875. The first successful agricultural high school of the United States appears to have been established in connection with the University of Minnesota in 1888.[1] Since that time they have been organized in some form throughout most of our country.

Why so Much Stress on Science?

The movement which led to the establishment of departments of science in the different colleges, and turned so much attention to it even in the secondary school, began with the scientific philosophers. Roger Bacon, about 1270, in the face of persecution, published his Opus Majus, which was the result of his philosophy and

1. Encyclopedia of Education, Vol. I, p. 64.

years of research in the different phases of science. This emphasized the scientific tendencies and caused others to take them up. But since philosophy percolates through a people so slowly, and is so long in producing effects, it was almost in modern times before the full tendency of Roger Bacon's works was realized.

Francis Bacon, in the first half of the seventeenth century, added new impetus to the development of science, his favorite study. He based his conception and method of education on science as shown in his New Atlantis. He claimed that every thing could be learned if it were only brought together in concrete form so that it could be quickly taken by the senses. His ideas were expressed in his Novum Organum.

The scientific basis for education was further pursued and developed by the great nineteenth century philosopher, Herbert Spencer, who said that of all knowledge, science was of the most worth since it fulfills the needs of man in his five phases of living and acting.

The attention given to science in modern life came, not only because of a philosophy embodying scientific principles, but because of the demand for scientific knowledge in order that man might better adjust himself to his environment. Louis XIV gave encouragement to trade and industry. His minister Richelieu wrote that in a well regulated state there was a need of more masters of mechanical arts than of liberal arts.[1] This shows that even in the early part of the seventeenth century there was a reaction against classical studies in favor of the practical. This was, no doubt, brought about by the discovery of the forces and resources of nature and the invention of machinery. With the development of these came the later conception

1. Encyclopedia of Education, Vol. I, p. 589.

of science in all its phases. Man began to realize that if he was to be of service to himself and his fellowmen, if he was to preserve and care for himself and conserve the race, if he was consciously to adjust himselt to his environment, he must become acquainted with as many of the principles of science as possible. This definitely leads to the reasons why science is taught in our schools.

Object in Teaching Science.

Mr. C. R. Mann gives three philosophies of physics which are probably in a great degree at the basis on which most teaching of science in the secondary school has rested. The first is that stated by the col ege entrance requirements, that the course should teach the "laws and principles of elementary physics." The second says "The first course should give the pupil a general survey of the whole field of science." The third centers it ideas about the "development to the utmost of the powers and latent abilities of that hope of the nation, the human child itself."[1]

The first of these seems to involve only a kind of mechanical memory. By this process, the pupil gains only a "hodge podge", as Mr. Mann says, of jumblig memories, which may be recalled by means of a few catchwords and phrases. He gets only enough of the so-called high school science to make his units for admission to the college. In order to cover the required amount of ground it was necessary to enlarge the course until it became so cumbersome that it was impossible for the pupils to make even a pretense at memorizing them all.

The second philosophy is the basis of only a smattering idea of the subject. No student can gain much knowledge of a science in the high school course if he is

1. C. R. Mann in Science, March 7, 1913, p. 351.

to cover such a broad field.

The third comes nearer meeting the demands of the life of the middle ages. than that of modern times. It is based on the old idea of faculty psychology. It is now generally conceded that no one man can be well prepared for every phase of work. After a liberal education has been obtained, this is the age of specialization. Furthermore it only develops the powers of the mind without providing for their expression.

Mann and Twiss said, 1905, an attempt has been made(1) to interest the student in observing carefully and accurately first the familiar things about him and then the things in the laboratory, (2) to interest him in detecting analogies and similarities among things observed, (3) to train him in keeping his mind free from bias and in drawing analogies tentatively, (4) to make him see the value of verifying the conclusions and accepting the results whether they confirm or deny his inferences.[1]

These reasons for teaching science have in view the formation of a cold, logical mind. While the processes involved may to some extent cultivate the powers of observation on concrete objects, yet they deal more with abstractions which are not easily comprehended by by pupils of immature minds. These reasons have in view in addition to the training of the senses, the discipline of the mind.

Another phase of science, especially in regard to physics and chemistry, is found in the words of Whitman, who says, "College preparatory physics has developed from a study which was a discussion and reasoning upon natural phenomena to a subject which is rigidly mathematical; from a subject of qualitative observations to one of exact measurements".[2] He on the same page condemns this practice

1. Teachers College Record, Jan. 1910.
2. School Science and Mathematics, Feb. 1909, p. 146.

with the words, "The teaching of exact quantitative measurements in the secondary schools to give pupils the habit of accuracy is almost a failure".

The real study of biology began in the first half of the sixteenth century. Its flame of life, however, was very low until it was fanned by Darwin, Huxley, and Spencer. It gradually advanced until it grew from a study for discipline to one of practical value. Its real purpose seems to be to cause the people to realize the sacredness of physical life and preserve themselves pure. This is the work of the minister, physician, and parent materially aided by the teacher through the teaching of biology. Mr. Wood said, "If we can get the youth to feel the significance of life with its progress and expression, and its relation to man, we are accomplishing our task so far as biology is concerned".[1]

Twenty years ago, Emperor William II ineffectively directed attention to the practical side of education by calling a conference of the schoolmen of Germany to consider what could be done to bridge the chasm that yawned so wide and deep between the work of the schools and the daily lives of the pupils. The same idea is emphasized at present by the pupils dropping out of school because there is doubt in the minds of both pupils and parents as to whether the education offered by the schools is of any advantage to them. This is especially noticeable in the rural and village schools because they have not that education which deals most directly with their own life, business, and pleasure. Here is one strong reason why high schools should include practical science in their curriculum.

Benjamin Franklin would have in his ideal school science courses to furnish information for conversations

1. School Science and Mathematics, March, 1913, p. 541.

and letter writing, to enable the merchants to understand commodities in trade, the handicraftsman to improve his business by new inventions and mixtures, and to help the farmers improve their land.[1] The most important recommendation in the light of the present tendencies was for elementary lessons in agriculture through school gardening and excursions to neighboring fields. He was practical enough to see that the masses needed this more that htey needed classics, and he was far-sighted enough to advocate what the people have been more than a century in realizing. Franklin lived in a day when every energy needed to be directed towards the mastery of the forces of nature which were promising just at this time a tremendous change in industrial education.

The rural people of to-day are slowly coming to see the truth of Franklin's idea by learning to believe that the education which will be of greatest value to them is that which deals most directly with their own conditions of life, business, and pleasure. As the high schools are the so-called "people's colleges" and are supposed to fit the people for life, subjects which would give such results should be in their courses.

Mr. Richards, in the preface of his "Cost of Living as Modified by Sanitary Science" touches another very important reason why a knowledge of science is necessary when he says "The broad view of sanitary science, that it means a knowledge of all that physical and mental environment which leads to the highest utilization of man's powers for the progress of civilization, and not mere study of germ diseases, seems to be lacking even in the educational world". The knowledge he mentioned is strictly necessary for the preservation of health, but it is only a means to an end.

One other phase in the object of teaching science is that of preparation for professional service. "Probably

1. Cloyd's Franklin's Educational ideal, p. 37.

there is no more important problem to be solved in the industrial communities of the country to-day that the proper preparation of the new generation for efficeent, skillful, intelligent, and loyal labor".[1]

This writer further brings before us the fact that from the schools of Austria, Germany, and France, more than two millions graduate annually and go out to become discouraged and prove unsuccessful and aimless. This presents to my mind the thought that the same conditions may prevail in our own country. If we expect our people who stop with the high school course, and in most cases those who go on to college, to be well enough grounded in the different sciences to have a feeling of confidence, the study of this subject must be taken up below the college.

The objects of teaching science do not stop with making men capable, self-sustaining, physically comfortable, and able to appreciate intellectual enjoyment, but each of these objects has an ethical aspect. Men who are materially well-to-do and intellectually happy, can hardly help being good men and citizens.

I believe then that the right teaching of science includes Pres. Elliot's six essentials of education, which are;

1. Careful training of the organs of sense.

2. Practice in grouping and comparing different sensations and drawing inferences.

3. Training in making records of observations, comparison, and grouping.

4. Training of the memory to hold records.

5. Training the power of expression.

6. Steady inculcation of those supreme ideals through which the human race has been uplifted and ennobled.[2]

1. Proceedings of American Institute of Electrical Engineers, p. 1467.
2. Report of Commissioner of Education, 1892-3, Vol. II, p.1467.

Place of science in the curriculum.

Having thus shown some reasons why science should be taught, the next thing to consider is its place in the curriculum.

It would be needless to repeat that science has slowly developed exceptto show that as the race has passed through the different stages in the development of civilization, the child, according to the recapitulation theory, must pass from the simplest principles observed in nature to the more complex ones logically reasoned out from observation. G. Stanley Hall,says that as the study of history is begun by stories told to the children and repeated by them, so science should begin through a heroology of that subject.[1] He probably meant by this that as soon as the child is in possession of his organs of sensation he is ready to look interestingly upon some object in nature from which may be developed scientific principles.

He probably meant further that by the study in the biography of scientists, these principles might be better impressed on account of a greater interest aroused. By this means the teacher through the years of physical growth can direct the intellect in its acquaintance with its environment, and lay the foundation for further investigation through the increased observational powers. Following this primary course may come a second or popular stage which puts more stress on classification and function. A third stage is the one of acquaintance with anything that has "go" about it. This corresponds to the high school age of the pupils. The fourth has to do with pure science whose place is in the colleges and universities.

The above discussion shows that science is not confined to any one stage of the educational progress, but should extend through the whole course. There is only one

1. G. Stanley Hall's Adolescence, Vol.II, p. 155.

period when the high school course fits in. That this is the opinion of those in charge of making out curricula is shown by an examination of the general school catalogues. It is very probably based on the philosophy which separates the environment of man into three or five divisions. If the child is to grow into a well developed person he must receive instruction in all the divisions, one of which is science.

It seems to be impossible, in the light of the courses of study made out by experts, and in the light of the present-day psychologists, to say just what year any one particular science should be taught. Besides, Mr. Colvin leaves with us the thought that it is not best to confine a subject to one short period of time.[1] Based on this it is best, if possible, to make the study of each subject cover more that a year's time.

Furthermore, the sciences are all so related that it is almost impossible to teach one without bringing in its connection with the others. Mr. Barto says, "A pupil can make little headway in the study of agriculture unless he knows something of physiography, geology, botany, zoology, physics, and chemistry".[2] This shows that the best results of teaching science comes through an understanding of their relations with each other. As a further proof of this, Mr. Hollister, on page 231 of the paper just referred to, said after visiting a certain consolidated school, "I have not seen such science teaching before--the students have such zest and earnestness in their work, so full of meaning and purpose. When I went into the classes in agriculture, I found the explanation of it. Here was the place where they were applying what they got from zoology, botany, and physics. If the agriculture was not good science, I don't know where to find it".

Not only are the sciences thus closely related to

1. Colvin's Learning Process, 175.
2. School Science and Mathematics, May 1901, p. 227.

each other, but they are closely associated with other subjects. The science observations can be made the basis of recitations, writings, compositions, and general work, from the elementary schools through the colleges. A knowledge of science also enables a better interpretation of history, literature, and art.

Preparation for Science Teaching.

Mr. J. P. Doster says that a teacher of physics should have a working knowledge of the related sciences.[1] This is no less applicable to the teachers of the other sciences. It is to be seriously doubted whether a teacher of one branch of science who knows nothing of the others can teach that one successfully. The teachung of modern science is coming to be in a large measure a study of the application of the scientific laws to the affairs of life. The true teacher then must be able to go beyond the text and interpret the scientific principles of the immediate environment of the student body. He should be broad enough to omit the parts of the text which present those subjects in which the pupils may never be interested, and, if I am not saying too much, write a new text by including in the course those things which are in the home life of the pupils but not in the text.

This makes it strictly necessary that the teacher have an ability of research gotten in most cases only by taking extended courses under more expert supervision. He must be able to plan his experiments from the immediate vicinity of the school as far as possible, ans so that they will have a real motive behind them. The incompetency and unwillingness on the part of the teachers to organize work to meet the needs of half of the people has led the Iowa state legislature to consider a bill for a second independent system of schools.[2] This is probably to a great

1. Physics, Its Development and Science of Teaching, p. 14.
2. Science, March 7, 1913, p. 352.

extent due to the inability of the teachers through a desire for uniformity to adapt themselves to the calls of the environment.

The science teachers should be open minded so that they will be free to follow Mr. Woodhull's plan for physics teachers, that is visit other schools, see what others are saying and doing about vitalizing the teaching of science by the use of practical applications and interpretation of every day life through the inductive method and the simplification of subject and apparatus.[1]

A general idea of the qualification of the teachers of the secondary schools in Alabama may be drawn from the following data. Of 118 teachers of whom reports could be obtained in 49 County High Schools, 39% have received the A.B. degree, 4.9% the A.M., 10.4% the B.S., 2.4% the M.S., 15.3% have only normal school training, 18.5% have been to college but are not graduates, and no definite information was obtained about 19.5%. Of 240 teachers in 78 other high schools of the state 29% have the A.B. degree, 3.3% the A.M., 9.6% the B.S., 1% the M.S., 20.5% have only normal school training, 20.5% have been to college but are not graduates, and no definite information was obtained about 17.1%. These figures seem to show that a good percent of our teachers have good qualifications so far as scholarship is concerned.

Although the teachers have the preparation suggested above, they can not produce the best results unless the intellects of the pupils have been trained by the proper science courses in the elementary schools. The pupils should have such training and instruction previously as will enable them to study a well-written text understandingly and follow the instructions of the teacher.

From general observation and from the discussions

1. Teachers College Record, Jan. 1910, p. 5.

on method which are to follow, it seems that it is not necessary to have expensive apparatus , or to have such a large amount. Psychologically, the simpler the apparatus is the better. Then the pupil will direct his attention more to the principle illustrated than to the fineness of the instrument. I would suggest that as much as possible of the apparatus be made by the pupils. This is peculiarly fitting for the students of the high school, because they are so full of activity and energy. The students can also perform some experiments with apparatus outside of the building and in this way be brought into contact with the real forces of nature.

As to the amount invested in science equipment, there is very little data at hand except from the county high schools of Alabama. Eleven of the fifty-two schools report no laboratory. In the forty-one others the amount varies from $8 to $450. The average is $110, and the whole amount invested is $4545. These figures are exclusive of $50 invested in domestic science , $60 in manual training, $10 in physical egography equipment, and $10 in equipment for agricultural teaching. A few figures from a small number of other high schools show that their laboratories are better equipped. This is probably due to the fact that they are older than the county high schools and in most cases have a larger appropriation for the work.

Texts.

Given a teacher and asufficient amount of simple apparatus as described above, the texts serves only as a guide. Prof. Doster says that text-books are necessary as a basis of work but may be a curse.[1] Thus we see that there is a place for the book in teaching a subject but it must be kept in its place. The German teachers use no book. If our teachers had the special training those of

1. Prof. J. J. Doster, Dean of the Department of Education, University of Alabama.

Germany receive we would not need to stress the kind of text to be used. But since all teachers do not come up to such a high standard we must furnish the students with the best text possible.

An examination of a few old texts in physics, plant culture, and chemistry shows that they were wholly unfit for use in the secondary schools. They are only a compilation of the facts determined before their publication. They seem to have been written principally for use by those who intended to study medicine. The language in most of them is too difficult to be understood, readily.

A comparison of these with modern books shows an improvement in the illustrations used as well as an increase in the number. The text of Blake on botany, published in 1830, hasonly six pictures, and Thornton's of 500 pages givesonly diagrams. while the latest are full of illustrations on most every page. The examination further shows that they contain little or no suggestions leading the students to do research work. In fact they were not written for high school students. It was only when the study of the growth of the child began that there was a demand for high school texts.

Books are intended to aid the teachers in their discussions and explanations by presenting the subject as a logical whole. This gives a broad view. The book can not be localized in any district except the one for which it was written. It presents the views of one writer who gives his experience and the results of his reasoning. Consequently they can not be taken from his environment and introduced into another without becoming abstract. Concrete facts appeal to the high school students more strongly than abstractions.

Again as Prof. Doster says the method of the book is never up-to-date. New teaching ideals are constantly worked out but must be practiced some time before becoming popular enough to be incorporated in a book. Because text-books written on a plan too much out of the ordinary and introducing radical changes in the method of presentation are not well received, publishers refuse the manuscripts. This makes it impossible for them to contain the best methods.

The latest books usually give the topic of the paragraph and the principal thought in bold face type and italics respectively. They furthermore give suggestions how the teachers may supplement the book, and a number of useless subjects once included for their disciplinary value have been omitted because education is tending towards utilitarianism and because the required amount of discipline can be obtained through useful subjects.

Another point of a good book is the presence in it of portraits and short biographical sketches of the prominent men connected with the subject. The pupil is much more interested in a natural law of he knows something of the life of the man who discovered it. The first texts contained none of these but the later ones show this improvement.

Method in Teaching Science.

Previous to the introduction of illustrative material in the teaching of science, this subject must have been taught from the text-book alone, or by the lecture method, or by a combination of both. In the first the teacher only investigated the pupil's memorized knowledge of the text. This caused the learning of science by rote. The old psychologists thought it had a cultural value. It gave the student only memorized information instead of fitting him to solve the scientific problems constantly coming up. Furthermore the spirit of research must have been smothered, and the desire for a knowledge of science on the part of many completely stifled. Under these conditions it is not surprising that there were few scientific discoveries and inventions before the beginning of the eighteenth century.

The illustration method was some advance over the one just discussed. The conscientious teachers, in their efforts to make clear the meaning of the texts, began to draw illustrations on the blackboards. From these the students gained some clearer idea of the laws they were memorizing.

The introduction of objects into the schoolroom brought nature study with its appeal through the senses. This furnished a basis for agriculture and botany. No doubt it was soon seen that the teaching of all science would be improved by the use of illustrative material. The first introduced was used by the teacher before the class during the recitation. It was an easy transition from this form to that of the students doing individual work in the laboratories. Mr. Woodhull says that physics teaching in the high schools, before the colleges took a hand in the matter in 1886, was powerfully influenced by the Pestalozzian movement to teach from the object rather than from the book. He further added that in 1837 the school committee at Boston ordered a few articles of physical apparatus for each grammar school of that city.[1] This idea has continued to spread until now it is the general opinion among all educators that science can not be successfully taught without laboratories, and that every high school without one is not properly equipped.

With the introduction of the laboratory, came a storm of discission over the division of time between it and the class-work, also as to which should precede,, and the proper method of laboratory work. With reference to the first, it is generally agreed that the time devoted to the

1. Teachers College Record, Jan. 1910, p. 19.

laboratory work should not fall far under 1/3 or 1/4 of that given to the class-room work. Both have a place and one should not be stressed to the exclusion of the other.

The class-room work should precede since as much of the useless process as possible in the "trial and error" method of learning should be eliminated. This gives the pupil some idea of what he is to look for. But he should not be told the details of the work. His judgment and reasoning faculties are exercised by selecting the proper manipulation. This order gives direction to the laboratory work and eliminates a large amount of useless waste of time. The order usually recommended is, (1) oral instruction, aided by the use of illustrative material, (2) study of the text-book, (3) laboratory work.

The actual laboratory work, it seems, should be under the direct supervision of the instructor, but it should not be his purpose to make many clear explanations. He can give general directions and suggestions, and by the proper questioning lead the student to understand clearly the obscure points of the experiment. It is not his business to meddle. It is much better to let the student derive his own conclusions even though it may take some time.

Quite an interesting discussion on laboratory work is given by Franklin and McNutt who say, "We have tried the system in which a young man is given experiment so and so and told to read it up in a manual where a complete theory of the experiment is given, where the object is stated, where the apparatus to be used is minutely described, and where the work to be done is completely specified. As might be expected, the result is an entire lack of interest on his part. Recently our system of laboratory work has been altered. A question which will appeal to a young man's sense of values is now proposed, for example, 'How much heat gets into this refrigerator in twenty-four hours?', and he is left to think out htee details of the test, coming to the instructor only when he feels completely lost. Half a hundred exercises of this kind have been devised, and the response of the young men is something good to see".[1]

This method appeals to me as being one which will arouse interest, train the students in analyzing phenomena, help them to acquire the scientific mode of investigation, do away with mathematical puzzles, and "post-mortem dissection of laboratory apparatus, and, above all else, give motive to the work.

In biology, I believe the laboratory is more indispensable than in physics. The manner of the work in it may be very unsatisfactory as shown by Mr. Kelly's observations. He says the course in his school, after six years of unsatisfactory work, was reformed to be constructive rather than destructive. It then had two purposes in view; first to give the pupil a broad general view of the field of science, and awaken him to the possibilities of the work; second to show that the science of the school-room and the outside world are one and the same thing. The course was also made to include some physics and chemistry. A distinct improvement followed.[2] This shows that, even though the subject is one which will ordinarily appeal to a high school boy, intensive study will cause loss of interest.

All studies make the strongest appeal when they are motivated. This seems to be no longer an age when the pupils study to please the parents or teacher. There must be some strong appealing reason for studying. When the student sees where the learning of a principle or subject will be of some real benefit to him he will be more zealous in his pursuit of it. The study of the refrigerator experiment mentioned has a practical appeal, and the study of the principles of botany may be applied in agriculture.

1. Bulletin for the Promotion of Engineering Education March 1912, p. 378.
2. Teachers College Record, Jan. 1910, p. 65.

Dr. B. F. Lovelace of Johns Hopkins University strongly urges that no school undertake the teaching of chemistry without making provision for individual laboratory work. The observations of the students here can be made the basis of class discussion in connection with the text-book. In fact it is recommended by some prominent educators that the class-room work consists of informal discussions. By use of the laboratories and these discussions, science learning is placed on the inductive method so warmly advocated by Bacon.

The present development of agricultural clubs, furnishes, it seems to me, the best possible means of motivating the study of agriculture and utilizing the farm as the laboratory. An hour's excursion to some boy's acre of "brag" corn or pig pen after the study from the book of corn raising or stock improvement is the best possible illustration of the principle studied.

It is needless to say that the students must keep notebooks of the observations made. The nature of the records will be determined by the aim of the teacher for giving the course. Since one purpose of the science course in the high school is a broad view of the whole field, the notebooks will not contain enough mathematics to make the students think that they are taking a course in that subject rather than one in science. In the biology notebook there are presumably drawings representing the different processes of growth. In that of chemistry, a careful record of the reactions and the possible reasons for them. In that of physics, the different combinations of apparatus and the observations of what action takes place or what forces are in play. In the agricultural notebook there is the opportunity of recording observations in all the relatedsciences. Finally the information should be transferred to permanehtly written reports which should include all inferences and deductions. The outline generally followed in making these reports is'

Experiment No.__________ Date__________.

1. Object.
2. Apparatus (best to give drawing).
3. Manipulation.
4. Observations.
5. Calculations.
6. Conclusions.

The Present Emphasis on Science in Schools.

The people of the present age live under conditions quite different from those of any previous time. Somd of nature's most hidden treasures have been searched out and are used in innumerable ways. The invention and use of machinery and the preservation and perfection of physical form and life depend on a knowledge of science. The person who knows something od the laws of biology can better promote the welfare of the human race and give greater development to the animal kingdom on which man leans. The one who is acquainted with the principles of botany, chemistry, geology, and geography can increase the yield of plants in which we are all interested.

At one time some of these principles, together with those of domestic science, were probably taught in the home and work shops. Now the attention of the homes has been turned in a great measure to other things, and the shops are usually looking for a person who can do the work. It seems then that education along these lines must come from some other place, and the school is the only logical source. This makes it necessary that our secondary schools be very liberal so that every boy and girl may have the opportunity to prepare for some line of work and at the same time get some broadening culture.

As a consequence of this necessity, science is being stressed more or less in nearly all schools of to-day, especially in the high schools. The teachers are striving to meet the demands made upon them by preparation for the work. Scientific courses are being pursued moregenerally in the colleges and universities. Graded science courses are being worked out so that when the pupil reaches the high school he will have a basis for further study of this subject. Nearly every means possible is used to procure the proper laboratory equipment.

With such increasing preparation for the teaching of science it would seem reasonable to think that advantage would be taken of the opportunities offered. The following statistics have been compiled from the secondary schools of Alabama for the year 1912-13.

	31 county high schools.		49 others.	
	Males.	Females.	Males.	Females.
Enrollment.	1167	1126	2414	3420
Subjects.	Percentage taking.		Percentage taking.	
Agriculture.	60	52	28	18.1
Biology.	24	23	5.2	4.9
Chemistry.	5	4	5.9	6.1
Physics.	10	10	16.4	14.1
Physiology.	18	19	28.3	17.6

From the table it seems that especially the county high schools are stressing agriculture. About one-fourth of the students in them are taking biology while very few in the others are enrolled in this course. Chemistry, physics,and physiology have fewer students enrolled in them than it seems they should have. The table also shows that the number of the girls taking science courses is about equal to that of the boys.

Some idea of the effect of the work done in the secondary schools may be drawn from the following data; In the year 1912-13, of eighty-five students who took the mid-year examination in physics I at the University of Alabama, 57% of those making A had previously had a course in the high school, 61% of those making B, 73% of those making C, 55% of those making D, 17% of those making E, and 25% of those making F. There were only four who made F. A glance at these figures shows that a higher percent of those making the better grades had had physics in the high school than of those making the lower grades.

Conclusion.

A brief survey of the history of science as was given in the beginning of this treatise shows great development of this subject. Once it was considered of very little importance. Only a few people devoted any time to it's study. However, these were gifted with inquiring minds, and one after another the different principles were discovered. Thus physics and chemistry came to be recognized as very important in interpreting the intellectual environment, biology as very useful in the conservation of physical life through the application of scientific laws, and agriculture has been raised to a level somewhat commensurate with its importance. Other sciences have also received attention in their respective fields.

The object in teaching science was at first rather informational. Later, with the development of psychology, its disciplinary value was stressed. But it was only when its bearing on life, and the way in which it reveals the world, were recognized that any proper conception of the purpose in teaching it was formulated. Since it is now known that science develops in man those qualities which best fit him for adapting himself to his environment, it is made to occupy a more important position.

The secondary school is only a part of the process through which the child passes in his progress to manhood. It fills a place not occupied by any other part of the educational scheme. In it seems to be the place for those subjects which appeal more directly to the youth. Therefore it is necessary that there be sufficient preparation of the teachers and students and the proper equipment to give that training which the nature of the boys and girls demand.

From a comparison of the condition of science teaching in this class of schools of to-day with the standards set up for this work, it appears that the status of science in the secondary school is not what it should be. Although it is not ideal, yet there is reason to believe that they are producing results. The teachers as a rule are prepared to do a fair quality of work. Yet this is greatly hampered by the admission of pupils who have had very little or no preparation in this subject and by the lack of laboratory equipment.

Although science in the secondary school is not what we would have it to be, the most hopeful sign seems to be the tendency towards the further development of this phase of high school work. The old adage that "where there is a will there is a way" is no where more clearly illustrated than in the rapid increase of interest and improvement in this work. It is receiving attention at all educational gatherings. Models of the work done in them are being put on exhibition and the principles are being taught through their application in actual life.

The place of the high school is becoming recognized as one which can be filled by no other. In my mind it may safely be predicted that in the secondary schools practical science has found its proper place, and will soon be recognized as one of the most important subjects taught.

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