GENERAL SCIENCE,

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The topic of general science is an exceedingly broad and difficult topic to discuss. All over the country today, there seems to be the demand for a course in general science, and recently a good many textbooks have been written with the titles, *General Science*, *Elementary Science*, *Introduction to Science*, etc., and these textbooks should be taken as representing the trend of thought along the line of general science teaching. That the concept and purpose of general science has many angles and has many opponents as well as many friends is to be expected.

In order to introduce the topic, I would like to consider for a moment the questions, "Why should we teach science?" and "What are the purposes and results anticipated?" Science has not always been taught in our schools after the customs of today. Time was, when physical science received almost no recognition as an educational subject. What has occurred in the last twenty years to make the teaching of science in our high schools more and more necessary?

In attempting to answer the questions, I feel somewhat like the colored preacher who rose before his congregation of a Sunday morn and said, "Brederen, dis mawnin' I'se gwine to define fer you dé indefinable, I'se gwine to explain de inexplicable, I'se gwine to unscrew de inscrutable." Certain it is that the great demand for science teaching and better science teaching depends directly upon the fact that since the days of Lavoisier, Bunsen, and Boyle, science has made a tremendous inroad in the number of pages in the book of knowledge. In no other field of learning has there ever been such enormous progress in a hundred years; yes, in fifty years, as shown by the development of modern science. Thinking back but a generation, we do not find the universal telephone, the transcontinental telephone, nor the ordinary telegraph in its present high development, not to mention the wireless telegraph and telephone. The automobile that is so necessary to our business world today was then only a toy; the flying machine existed only in the mind of "Darius Green." And I say that the reason why we must teach science in our schools is because a great proportion of human knowledge of today is of a scientific character.

One of the purposes of teaching science is to give the student

information and he who would teach science must select the items that are worth while. For example, whoever writes a book on special general science presumes to pick out from the mass of possibilities those items which he deems either most useful from the standpoint of the home, or of educational training, or most fitting for further and more detailed study of science later on. An examination of most of the general science textbooks which have been recently published discloses the fact that the selection of items of information has been to a large extent influenced by the individual taste and training of the writer. In other words, a specialist in biology will write a general science textbook, and the items of information which he deems most useful and necessary are unquestionably those items of biology with which he has most to do, and so his text is biology with certain extracts of information from other fields of science. In exactly the same way, the specialist in physiography builds his course around the physiographic items of information, I have made the preceding statements with a view to showing you that the selection of items of information for a course in general science will most likely depend upon the particular field in which the author is more or less a specialist.

I should say that these items of information which are to be selected for the youth of our nation should and must depend upon the particular environment of the pupil. The boy or girl from the immigrant home in our cities must have a different need from the boy or girl who has been raised and is living on the farm, and again a different phase of the topic must be presented to the girl who comes from the home where she is not expected to take any part in the home duties. The selection of items of information is one that only the man on the job can do since he is the only one who can see to the best advantage the needs of the particular pupil. If we are to teach general science, and if we are to begin the teaching of that general science in the grades below the high school, I should say unhesitatingly that items of information should be drawn from the *home, street, and health environment* of the boy or girl. These items should be chosen and so grouped as to give unity, and they must be progressive in character. They must be so presented by the teacher as to make the pupil believe that he is initiating something. The pupil must be made to feel that he is contributing to the general welfare of his class and his teacher, his home, and town. In other words, the pupil from the beginning must

be made to feel that he is a *producer* in every sense of the word.

A second reason for teaching science which almost every teacher will give is training, and here again I ask, "For what?" Are we going to train our boys and girls to become specialists in biology if that is our field, or are we going to train them to be specialists in electricity if that is our interest? For what are we going to train our boys and girls? I understand the word training to have the significance of mental training as well as a training for some vocation or profession. Hence we must answer both questions.

As to training accomplished by the study of either special or general science, I believe it should impress upon the pupil the great moral question of truth, it should teach him the moral question of duty toward others and toward himself, it should so train his mind that he will at least begin to study properly, that he will form the beginnings of the proper habits of attention, that he will form the habit of reading a paragraph critically and of selecting from the topics those topics of most importance. In other words, the training should give him the beginnings of those mental functions which are so necessary to the successful citizen, proper mental habits, independence of thought, and high moral standards.

From the industrial or practical standpoint, science should train the pupil for something useful, there should be a definite object in the mind of teacher and pupil. Here I wish to quote from papers written by pupils studying general science in the seventh grades of our Junior High School in answer to the question, "Do you find the study of the history of stones interesting?" I am selecting one or two at random from a large number that are equally to the point. A girl says, "I think it is very nice to know all about the different kinds of stones, and I think it is also very valuable because it is helpful to us in many ways when we grow older. For instance, if we wanted to be science teachers it would be much easier to learn when we have had it when we were small, and also if boys wanted to be masons or any other trade that has to do with stones it would be helpful to them in many ways to know all the things about stones which we learn about in science." Another girl says, "It is interesting to study the history of stones because when going anywhere and finding a peculiar stone, friends are always interested in asking the name of it." A boy says, "I find the study of stones very interesting because I am interested in the earth and because of the

minerals which it contains." Another girl says, "I find the study of stones interesting because it is a study of natural things that teach us a good many things. They help men when they become contractors to know the stone and its qualities without having to be taught because it was taught him when he went to school." I have given direct quotations taken from the papers which show that the boy and the girl in the seventh grade are looking ahead to what they are going to do, and so I say science teachers must consider "Training for what?" Please notice also the references made to the fact that they are coming to "know things without having to learn them" which expresses a great pedagogical principle.

If I should ask you for still another reason for teaching science, you would undoubtedly say "Culture," and Yankee-like I ask, "What is culture?" Does culture consist in the ability to read the classics, in the ability to talk intelligently of the great literary writers of the past and the present and the possibilities of the future? Does culture mean the ability to paint a beautiful picture or to appreciate art? Again I say, "What is culture?" As a definition of culture, I am going to give a quotation taken from an article in the *North American Review* of October, 1915, by A. Lawrence Lowell. He says, "So far as culture is concerned, our problem is to develop in harmony with our own institutions a type of education that will cause young people to enjoy the things the world has agreed are beautiful, to be interested in the knowledge mankind has found valuable, and to comprehend the principles the race has accepted as true. This is culture, and to impart it is the function of the American college." To Dr. Lowell's wonderful conception of culture, may I presume to add that to impart this culture is a function of the *whole educational system*? Culture, like the morality, cannot or should not be taught abruptly after a textbook method, but the science teachers must constantly and adroitly impress the intangible elements of culture and morality upon their boys and girls. There is perhaps no better vehicle for the subtle teaching of moral truths and acts than science. Certainly, no field of knowledge offers any greater opportunity for culture, as defined by President Lowell, than science.

If we have agreed that science shall be taught in our schools whether as general science or as specialized science, we must inevitably come to the discussion of the method. An examination of the most of our science textbooks today, chemistries, phys-

ics, biologies, astronomies, etc., shows an attempt on the part of the author to present the facts of the special science from the *logical viewpoint* to the very best of the author's ability as a *mature student*. And then this same mature scientist, having so presented his thoughts, expects the *immature pupil* of the high school or the seventh or eighth grade of the public school to accept these facts in the same logical order. Permit me to quote from President Butler's annual *Columbia University Report* of November 2, 1914, concerning this question. What he says is directed to the university teachers, but I would like to apply the same statement to the elementary and high school science teachers. He says, "The two mistakes into which college teachers are most likely to fall are, first, that of failing to give the students such primary and introductory explanations as will serve as an academic chart for the voyage to be undertaken, and, second, that of confusing the logical with the psychological order of presentation of facts. The real good teacher knows that the logical order is the result of mature reflection and close analysis of a large body of a related phenomena, and he knows, too, that this comes late in the history of intellectual development. He knows also that the psychological order, the direct order for the teachers to follow, is the one which is fixed by the intrinsic value and practical significance of the phenomena in question. The good teachers will not try to force the logical order of facts or phenomena upon the immature student." If what President Butler has to say of the teachers of college students is true, how much truer it is concerning us, and yet I respectfully call your attention to the fact that our textbooks are fashioned after the logical method of mature minds, and yet we wonder why the student fails to comprehend. Some one has aptly stated the difference between the logical and the psychological method by saying that we should have the student "heft the thing, not weigh it."

An ordinary, casual study of the statistics concerning the science education in the United States, together with discussions of science teachers over the country, brings one inevitably to the conclusion that the method of teaching science almost wholly as special science as has been done in the past dozen years is unsatisfactory. Examination of the United States Bureau of Education reports shows that in the past twenty years there has been a decided decrease in the amount of special science called for in our public high schools. If our students, advised by their teachers, are taking less and less of the special science,

there must be a tangible reason to explain the fact. Why do our boys and girls neglect the study of science to such an increasing extent? One of the reasons undoubtedly is that science teachers come before the students as specialists fresh from their college training, and expect and hope that their young boys and girls will absorb and assimilate the same type of science with which their college training has saturated them, and they have been inclined, therefore, to discourage many students of certain types of mind from pursuing their subjects. Especially in physics the high degree of quantitative accuracy demanded by many good teachers has discouraged many of our students. In fact, the time has not long since passed when many students deliberately planned that it would be necessary to spend two years to get the credit for one year's work in physics, because of the large number of failures. To a less extent perhaps, these facts are true in other courses. I have already referred to the fact that the textbooks in science are for the most part unsuited to the immature mind. Another reason why the science election by pupils has diminished is the pressure put on them for the study of classics, history, etc., because the majority of teachers are more directly interested in these subjects than in science. For example, in a small high school of six or seven teachers, probably only one will be interested primarily in science, and hence the bulk of advice for students actually comes from the six other teachers, whose primary interest is of a classical character. Moreover, the type of physics and chemistry taught for the most part in our high school is such as to induce many college professors to say they would as soon a student would enter college without those special courses as with them. Also, the work has not as a rule given the student much worth while for the needs of life. Our colleges and our merchants and manufacturers want boys and girls who can *think*, not repeat.

It is evident then that a rearrangement of our science methods and science topics is necessary if we are to succeed in developing a more and more increasing interest in science on the part of our pupils and give them something worth while. This reorganization must extend from the high school into the grades if we would produce the best results.

You will all admit, I think, that it is impossible for any one student in the high school to take a year or even a half year of consistent work in each of the special sciences, biology, botany, zoology, physical geography, geology, astronomy, physiology,

physics, chemistry, etc., and yet I think not one would consider for an instant omitting all references to astronomical facts simply because the special subject of astronomy for various and good reasons is not generally advised as best for the high school. Neither would you cut off all information concerning botany or the weather, simply because a student was unable to spend the required amount of time in those special sciences. If you admit this fact, we are forced to the conclusion that all students should be given such an elementary training in general science as will introduce them to some of the more interesting and more useful parts of each of the sciences. This, I believe, is the justification for general science. I would not have you suppose that I would do away with the study of special science as a special subject, but I do want you to understand that I am decidedly in favor of all students getting a certain minimum amount of training in the fundamentals of science thought, of science information, and in the scientific method, and that I believe that this should be started below the high school. The time was when our English teachers taught their work under the head of rhetoric, composition, grammar, English literature, American literature, etc., and now we find the progressive English teachers are teaching English, they are teaching the rhetoric and composition always wherever and whenever these special subjects most readily suit the purpose at hand. Another reason why I believe that we should teach our students some fundamental general science is because today we must supply for the city boy and the city girl those experiences which they have missed and which the boy or girl on the farm or the village has obtained. This first-hand information and observation must be produced somewhat artificially for these young boys and girls who, because of their environment, have been unable to acquire it naturally.

In order to better our science teaching then, I would say that it is necessary in the first place to reorganize our science methods and to rewrite our science textbooks for the study of the special science. I believe that it is necessary to offer as preliminary work to the subject of the special science a certain carefully planned course in general science. In order to do this, it will be necessary to extend the study of science into the grades below the high school, preferably as low as the fifth and sixth grades. To accommodate a satisfactory reorganization of our science work, it will be necessary to increase the length of the school day. To obtain the best results of the study of science, it will be

necessary to have study more closely supervised by teachers who themselves know how to study. If you will think back into your own experience, you will find that the great majority of your questions do not provoke any higher type of mental action than memory. In fact, nearly the whole fabric of our text work in science is founded upon that one form of mental activity, memory. I believe that if we would best train these young minds, we must diminish the number of questions that require repetition only, and increase the number of questions which require thought. Certain it is, that a teacher of science, whether it be general or special science, cannot go before his class and ask questions which stimulate thought without thoughtful daily preparation, whereas too often we find teachers asking questions that come to mind at the instant.

In order that our general science and our whole science study in the elementary and high school shall be of the greatest value it will be necessary to give our students special guidance in their choice of subjects. It was my duty to assist boys just entering high school to copy their registration blanks and, when these blanks were passed out for them to copy, several boys called my attention to the fact that the schedule did not contain the subjects they wished to study. For example, they pointed out that they did not want to study "that stuff," called Algebra or Latin, but that they wanted to take electrical or mechanical engineering. And here again I want to call your attention to the fact that these boys, like those boys in the seventh grade to whom I referred earlier, are looking ahead and planning on what they are going to do in the world.

The old idea that a study of Latin, for example, even if disagreeable to the pupil, is of value because it gives the pupil the habit of accomplishing a disagreeable task, with the view that this habit of "overcoming the disagreeable task" would be transferred to some other subject which might be more to the liking of the student, is superseded by the more rational psychology today. We agree that "disagreeableness is not necessarily educative." We hope that habits formed in the study of one subject are transferred and utilized in the study of other subjects, but one of the great reasons why study of Latin is so much worth while is because of the continued study of one subject. In other words, a pupil begins the study of Latin in the first year of high school, or before, and continues constantly to study the topic of Latin throughout the high school course, and if he goes to college he

will continue to study Latin for another four years. It is this continued application of his mind along a definite road that gives him the power to transfer the ability gained here to the accomplishing of tasks in other lines. I would claim for science that same great advantage if we can have a continued study of science. I would suggest then, for your consideration, the reorganization of our science work on the following basis: Granted that our science work today is not entirely satisfactory, granted that science teaching is of the utmost importance, I would recommend then that our science work be started in the early grades of the grammar school and that this science work be continued by teachers who are suitably equipped to give it the consideration and thought necessary for success. I would suggest that this science for the grades in the grammar school and for the first year, and perhaps the second year, of the high school be what is known as general science in that it is not a special science. I believe that in the first year of high school the general science would naturally take the trend of a biological character, since our boys and girls are then at the age when they should be impressed with the great physiological and hygienic views necessary to their good health. The second year of the high school general science should quite possibly take the trend of physical science. The student arriving then at the third year of his high school experience will have had more than four years of consistent, carefully directed study and thought along the lines of general science. He will be prepared to enter profitably into the study of any of the special sciences, physics, chemistry, physiography, botany, etc., that environment and need indicate. Best of all, if he never goes further than the end of the second year, he will at least have that peculiar enrichment of mind and experience that cannot be obtained except through science study. Let us treat the immature mind psychologically to develop the logical mature mind.

CLASS ROOM SAYINGS.

Slang is vulgar use of words usually hanging around the outskirts of a town.

Simultaneous equations are solved by *exterminating* one of the unknowns.

A boy in beginning algebra was asked to explain his solution of a system of linear equations involving x and y . He replied that he would first *illuminate* x .