THE FUNCTION OF OUR SCHOOLS IN PRODUCING SCIENTISTS

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It has been my privilege and opportunity to observe and to participate for many years in the teaching of science on the elementary, secondary, and college levels. I have witnessed science and its application through a period in which it has given us marvelous drugs and many ways of diagnosing our ills and many ways of improving our health. It has brought about wonderful improvements in transportation, communication, and has given us luxuries of every sort. Recently it has given us a most powerful tool—the atomic energy with all its potentials.

Now, if I have any contribution to make in the field of science I choose to make it in the field of science education and particularly in the field of teaching, for in this field lies a lifetime of interest and experience.

In this new age of progress in which science is playing such an important part in our lives, we need a better understanding of science in all its aspects. It is only through the general understanding of its principles and applications that we can expect to continue advancement and leadership of our American Democracy. More and more we are going to need a general understanding of science for ourselves in our daily living and for those in positions of authority who understand and direct the forces which develop a constant and growing need for a supply of trained science personnel—personnel to make new discoveries in drugs and techniques, new machines, and new ideas for better conditions of mankind.

This places our educational system, and particularly the teacher, in a strategic place. How can we expect to obtain the desired growth in the various fields of scientific development without a carefully planned emphasis upon the basic educational principles underlying the development of scientists?

The disturbance caused by two world wars within one generation followed by a period of rapid development in many fields of human progress has stimulated a general interest in science. Industry has been adding millions to her annual expenditures for research and new scientific developments. The federal government has increased her budget from year to year in order to improve our plants and animals and to control their enemies. Congress has been willing to appropriate almost unlimited amounts for research and for development of new machines and new weapons. The demand for engineers, technicians, and research workers in the many fields of endeavor, as well as a need for an enlightened public concerning science and its practical application in this new age, has placed a tremendous responsibility upon our entire school system. Educators and scientists alike have pointed out the maladjustment which exists between needs for scientific knowledge in our human population and the production of the end product through our school system.

After watching the growth of science in our elementary and secondary schools, and institutions of higher learning for many years, I can recognize

that much progress has been made through the efforts of curriculum builders, conscientious teachers, and school officials. The help of outside agencies in promoting scholarships and other types of encouragement to youngsters and students who possess an interest and ability in science has been encouraging. However, I am convinced there remains a great opportunity to improve the achievements of our entire educational system in the field of science. We need to organize the sciences into a more effective and coordinated program as an instrument of education if we are to lead the forces of social advancement in this new age.

In my opinion the greatest improvement in science education during the last decade has come in our elementary schools. It is true also that in this area the greatest opportunity for effective remedy lies. It is in this formative period in the life of an individual that science instruction will stimulate interest and arouse curiosity which often proves to be the starting point in a successful career. It is during the period from the ages of six to twelve that the child learns to read and the desire to learn is stimulated. A vast amount of information opens up to him and he begins to manifest a keen interest in his environment. He becomes intrigued by everything that is alive. He is fascinated by the toys and machines that move as well as the sky above and the rocks and streams below.

The good teacher understands that the use of science in her daily work is fundamental in the child's educational development. She will make constant use of the vast storehouse of subject matter material which is always present in the child's environment. The interest in science at this early age is, as many scientists will testify, the beginning of a scientific career. The teacher who fosters this interest and helps to solve the child's problems in science multiplies his chances of continuing the interest into the secondary schools and into the higher fields of education.

It has been reported that potential scientific careers can be discovered in these early years. Some of the signs which indicate scientific potentialities in the boy or girl are his curiosity in what makes things work and how he can improve them; his ability to observe carefully; his ability to concentrate and work untiringly to solve a problem; his interest and capacity to do mathematics and his willingness to work independently. If a child manifests these characteristics they are worth more for guidance than any tests now devised. Yet, a teacher must remember that in this early period a child's curiosity can be easily encouraged or it may be frustrated beyond recovery.

Granting that much progress has been made in promoting science in the elementary school system, I would like at this point to indicate some of the weaknesses which exist and suggest some possible solutions for consideration. First, may I point out that many elementary teachers do not feel adequately prepared to teach science. Even when the curriculum has a definite place for science, teachers too often ignore the subject and say that children know more in this field than they themselves. Other excuses sometimes given include not enough time for the subject; no place for materials; or it takes too much time for preparation—none of which are really valid reasons. The one excuse which is seldom heard is that the child is not interested in science.

The result of this neglect on the part of many elementary teachers is that many youngsters who have potential possibilities are sadly neglected and lost to the field of science.

Second, an analysis of the background of many elementary teachers shows that they are poorly prepared in the field of science. This may not be the fault of the teacher but a weakness in the institution in which the teacher was trained. Professors of science are usually specialists in some particular field and regardless of how efficient they are in presenting their subject to science students they may be utterly inefficient in presenting the needed material to the prospective elementary teacher. These instructors usually make their courses too difficult and too technical to meet the needs of the non-specialist. To be a good instructor of science on the elementary curriculum the instructor needs a broad background and should have enough basic understanding of children and the educational principles involved to choose wisely and present effectively science material to meet the needs of prospective teachers.

In some colleges and universities the science staff is not particularly interested in the elementary field of teacher-training and therefore this job is left largely to the Department of Education. Here we may have an array of Ph.D.'s, Ed.D.'s, Ed.M.'s, Ll.D.'s, etc., but too often these staff members have had courses concerning all the fields of how to teach, but little knowledge of the subject matter they are to teach. Naturally in this case the department will be loaded with required and elective courses in education. The prospective teacher under such guidance may therefore have little interest in science as a basic subject for meeting the educational needs of children. Or she may make much use of the many interesting and valuable elementary science books now coming from the press, but she will use them to stimulate reading and not to teach science. In my opinion there is a wide difference. These science books with their excellent choice of material, beautiful illustrations, and appropriate vocabulary are superb for motivating reading, but they should also be used for creating a scientific attitude in the minds of children.

Many elementary teachers need encouragement and stimulation to undertake the problem of teaching science. Superintendents, principals, and supervisors have an opportunity to be of great service and in turn to make a big improvement in the school program and its function in developing the educational growth of the child.

School officials have this opportunity but too many make little use of it. Perhaps this can be explained in many cases by the lack of science training which the officials themselves have had. Again the requirements for administrators on their college curricula have placed emphasis on how to teach the various subjects and how to handle the various school and community problems, with too little opportunity left for acquiring a knowledge of the basic courses of education. The result of such a background is too often lack of interest and too little knowledge of science to appreciate its value in the welfare of the child.

Another weakness in our elementary program appears when dealing with children who manifest an interest in science and mathematics. These youngsters are often in the upper percentile and should be able to progress

more rapidly through the more difficult subjects. They should have some special attention and encouragement. They should be kept busy lest they lose interest and consequently become habitual loafers. This situation may mean the loss of promising young scientists to society.

In our present educational system of training teachers the colleges are providing many courses with the idea of giving teachers and school administrators a background for dealing with the handicapped child. Such courses include: Problems of the slow learner; problems of the non-reader; treatment of special disabilities in reading; personal adjustment of the child; handicapped school children; education of the slow learner; etc., but, little attention has been given to the problems of educating the exceptional child. Therefore, many teachers and administrators find themselves at a loss to direct the above-average or brilliant student and he too often becomes the neglected child.

If the public schools are dedicated to the task of providing equal and maximum opportunities for each child, then there should be no discrimination. Each child from the slowest learner to the most gifted should have those educational experiences which will give him the maximum growth which the schools can offer to him. With this objective, the subjects of science and mathematics will become key subjects in guiding capable youngsters into the various fields of scientific leadership.

Now if we focus our attention upon our secondary school system, we will find much to commend in the progress it has made. New buildings, new equipment, new modes of transportation, new courses have been added and the growth in the number and convenience of the high schools has been phenomenal. May I cite one example to show this progress? When I was a youngster, there was only one high school in my county, Vigo, and it was located in the county seat of Terre Haute. Now there are twenty-three and every township except one has at least one junior or senior high school and the city of Terre Haute has eight. My first experience in high school was in one room with one teacher who taught Latin, Algebra, Ancient History, English, and no more. Music, gym, science, home economics, agriculture and industrial arts were unheard of. How times have changed. Now, after a half-century of progress we find ourselves in a new situation—a situation in which science is playing a most significant part in our daily lives and our future thinking with every indication that a greater development is rapidly on the way.

Our high schools have done much to keep pace with this rapid growth, but there are some definite needs for changes if these schools are to do their share to produce the needed scientists for this modern age.

It was upon this occasion 27 years ago that the late Frank B. Wade, then president of the Academy, criticized our high school system for doing too much testing and not enough teaching of basic subject matter material. Said Mr. Wade, "*More Scientific Education; Less Educational Measurements.*"

Since then we seem to have passed the testing fad until now it has assumed its proper place in the educational program, but the need for more emphasis on science is even greater today than it was in Wade's day. Of course, since his day the population of our high schools has increased

many hundred per cent until now nearly everyone of eligible age may be admitted, and our high schools have been reorganized until they attempt to accommodate all regardless of their ability or interests. Some of these students are barely able to read and probably never will do much better, but they are provided with the opportunity to learn many skills which will enable them to become useful citizens. This is a great change in public attitude toward its responsibility in education. It is a good example of democracy in action.

To make the necessary change to fit this philosophy of education the curriculum has had to be revised and many new types of experiences have been added. Many high schools are now offering courses giving credit in carpentry, brick laying, auto mechanics, printing, practical arithmetic, and English, athletics, and music of all sorts, as well as many other satisfying and useful courses. Any of these courses may be challenging and necessary to the career of the student, but many are organized and taught in such a manner as not to be most challenging to the serious minded student who is looking toward a professional career. These courses offer temptations to the science-minded individual. Taking them limits the amount of time to be spent in the basic subject matter courses. They are frequently an enticement to bad habits of study. Even under our best guidance programs the counselors find it difficult to persuade the scientific and mathematical-minded students to follow the less spectacular courses.

The effect of this temptation may be a factor in the reduced enrollment in our high school science classes. According to Professors Heiss, Obourn, and Hoffman—"In 1900 twenty per cent of the high school student population studied physics. Today less than six per cent of the high school students are enrolled. Only about half of the nation's high schools now offer the subject."

Again, as in the elementary schools, we find too little effort to provide the rapid learner with enough difficult and useful problems necessary to direct him into the career most useful to his welfare and to society. The gifted youngster seems to be the forgotten man of our educational system. High school teachers as well as all others should be aware of the opportunities and the responsibilities for developing in youth those qualities of mind which will be of greatest worth in meeting the social and economic problems of which they are capable.

The fact that there is such a shortage of well-trained scientists for teaching and for research in industry and government indicates that students are being lost somewhere along the line. Much of this loss through the junior and senior high schools may be attributed to an inadequate curricula and the poorly-trained teachers too often found in the smaller high schools. Here we find the bare minimum of courses in science scheduled with poor facilities for doing good work.

I have known several teachers of science in Indiana who were struggling along with classes in biology, general science and even in chemistry and physics with little or no equipment and no allowance by the school officials for the purchase of supplies. It seems to be a common practice for teachers to spend the entire semester in the classroom without making a single excursion into the field or to an industry, or even worse, without

applying the scientific principles of science to life situations. This state of affairs leads to a textbook course in which the student receives little encouragement to challenge his scientific ability.

This lack of interest and support of science is further shown by the type of teacher employed. Granting the fact that there are an insufficient number of science teachers, too often it is the home economics teacher who is in charge of the biology classes. She may be an excellent teacher in her field but she may also be teaching biology on a permit and manifesting little interest in the subject. The teachers of physical sciences as well as mathematics, too, are often teaching on permits with their major interest in social science, athletics, or other subjects.

These are unhealthy situations which will require many years to adjust. In the meantime it will be necessary for more students to become aware of the opportunities in the various fields of science. It will be the responsibility of teachers and school officials to provide better conditions for learning science and to place greater emphasis upon guidance toward scientific careers.

The present dire need for many more capable science students in our high school classes has been recognized by industries for some time. They are aware of the fact that unless an adequate number of strong high school students is maintained our colleges and universities cannot meet the growing demand for engineers and technicians so badly needed. Industry has for a number of years suffered from a shortage of well educated and skilled personnel and is now offering scholarships and other inducements to the more promising high school graduates who will pursue their science studies into our colleges and universities.

According to Time Magazine—"Few people know how much industry already contributes. In 1954 business will donate well over $60 million to private U. S. colleges, plus additional funds for research and equipment. Du Pont will parcel out more than $700,000, most of it for chemistry students' research. Union Carbide has gone even further. It is planning a $500,000 program which will eventually provide 400 scholarships a year for more than 30 colleges to administer without strings of any kind."

Another good example of how industry recognized the importance of this problem is the work done by the Bausch and Lomb Optical Company. In 1932 this company became aware of the growing shortage of scientists and decided to establish a Science Award Program. This program was designed to give recognition to outstanding science students in our secondary schools and to encourage these students to seek careers in science. Since the establishment of this program, 22 years ago, over 22,000 students have been given Bausch and Lamb Honor Awards. The company reports the following—"There is a wealth of evidence pointing to the fact that awards have had a tremendous impact on the careers of thousands of the winners. . . . In 1951, for example, a study of *American Men of Science* revealed that 148 winners of the Science Award Medal had already achieved scientific status. . . . In the period between 1933 and 1940 a tabulation showed that 94 per cent of those receiving awards attended college, 44 per cent received two or more degrees, 54 per cent were elected to honor

societies, 85 per cent were actively engaged in scientific or educational careers."

One of the most attractive of these inducements comes from the Talent Science Search made by the Westinghouse Educational Foundation and is being promoted in Indiana by this Academy through the leadership of R. F. Lefter and his committee. In this plan Westinghouse offers to the seniors of 27,000 public, private and parochial high schools of the United States an opportunity to compete for the $11,000 in scholarships to continue their education in science. From the fourteen thousand or more entries in this annual contest forty will be selected as national winners and receive a five-day all expenses paid trip to Washington, D. C., to attend an Annual Science Talent Institute. Another 260 of this group will be recommended to colleges and universities of their choice. Many of these will receive offers of financial assistance toward a college education from other sources on the basis of this honor.

During the past year, in cooperation with the Westinghouse Educational Foundation, the Indiana Science Talent Search Committee selected 30 of Indiana's contestants as state winners from the 98 who completed entry requirements for the Search. These state winners and their teachers are invited each year to Indianapolis for a luncheon as guests of The Indianapolis Times. To see and hear these junior scientists demonstrate their projects leaves one absolutely amazed to find such talent among our high school boys and girls.

As you well know, the State Academies of Science are promoting Junior Academies of Science. In Indiana this is being done through H. H. Michaud and his committee. We of the Senior Academy can feel a sense of pride in the results of this project and should continue to cooperate with it. These young scientists will hold their annual meeting in this building tomorrow, with over 200 boys and girls representing 35 or 40 science clubs from the high schools of Indiana in attendance. The encouragement given to these clubs will no doubt do much toward stimulating their members to continue their science interests.

It may be noted that a high percentage of the Science Talent Search contestants, as well as the Junior Academy of Science Club members, come from the larger high schools. Few entries and practically no winners of the Westinghouse contest come from small high schools. Likewise the science clubs of Indiana are in our larger schools. Perhaps this can be expected but certainly it does not indicate there are no boys and girls in the smaller communities interested in science or capable of pursuing scientific careers.

Since our institutions of higher learning must depend upon the secondary schools for their recruits in engineers and technicians, and since there is such a shortage in trained personnel in all fields of scientific endeavor it behooves these institutions to use every legitimate means available to meet this demand.

The large sums which have been given or appropriated for buildings and laboratories are important for good work, but the greatest factor for attracting and developing good scientists lies in the teaching personnel. The teacher problem in one form or another is always with us and always

will be, but it is doubtful if any phase of our educational program needs more immediate attention than the supply of skilled science teachers on all levels.

A lifetime of teaching does not necessarily qualify one to dictate how a science teacher should be educated or how he should conduct his classes. The field is too broad and too varied for that, but such a background of experience enables one to draw certain provisional conclusions. Among these which apply to teaching on the college level are:

A more comparable salary scale for the college instructor with that of industry. Too often the prospective teacher is lured into business and industry by the higher salaries. If the colleges are to maintain a high standard of professional personnel they will need to employ some of their best product for their staff.

College officials when employing staff need to recognize that good research men, good mathematicians, or good engineers are not always good teachers any more than good teachers are always good in the practical field of science. Therefore, due consideration for the ability to teach effectively should be fundamental and of primary importance.

College classes in science and mathematics are frequently too large to give the student the proper guidance. Too little attention is often given to the inexperienced graduate assistant who has much of the responsibility in helping the perplexed freshman with his problems. A freshman thrust into the strange life of a college very definitely needs the personal help of the best teachers.

While I do not feel competent to judge the merits of the teacher-training program in our colleges, I have a strong feeling that some science departments are neglecting this important responsibility. We need good instructors of science and mathematics in our colleges as badly as we need good engineers or good researchers in industry, and some institutions would do well to make a re-evaluation of their teacher-training program in the light of this need. In the employment of instructors, institutions should remember that just because a person is an expert in a particular field does not necessarily mean that he can be a successful teacher in this field. To expect the highly-trained chemists, or physicists, or mathematicians to instruct without some knowledge of the learning processes or the techniques of teaching is expecting too much. All teachers in our public schools are required to take many so-called professional courses before they are allowed to teach. No doubt this phase of their education is overemphasized, but since there are no such requirements for teaching on the college level, it would seem advisable that some professional preparation would be quite useful. The instructor with no professional training may be a good teacher, as is often the case, but he has learned to be one the hard way and no doubt would be a more skillful teacher had he received some specific training for the job.

Lest I be misunderstood by the emphasis herein made on the importance of the teacher and the schools in the production of scientists I wish to make clear that I am fully aware of the many other factors which must enter into the making of a scientist. First of all he must be born with a good mind and with many of the attributes necessary for scientific develop-

ment. Scientists, like other great men, must come from ancestry capable of producing great men.

Then to achieve distinction one needs to come under the influence of one or more persons who can inspire him and arouse his ambition to succeed; and here is where the teacher has a golden opportunity. We are familiar with the effect which Professor Winslow had upon the life of Charles Darwin or the scores of scientists who sat at the feet of Louis Agassiz, or the many good scientists who were inspired to distinction through tramping over the hills of southern Indiana with David Starr Jordan, or sitting in the classes of Roscoe Hyde at Terre Haute and Johns Hopkins University.

To be sure science in education has developed slowly but substantial progress has been made. Nevertheless the present status of our educational program in science is somewhat disturbing. In the light of the tremendous scientific advancements made during the last two decades I feel very definitely that our educational program has not kept pace. It is true that our citizens have become much more aware of the scientific progress being made, but much of this information has come from other sources rather than through the schools. The press, radio, and TV sets are powerful forces in informing the public of scientific progress. These are all stimulating forces and when added to other forces such as the science fairs, the science talent search program, and the many science clubs, they should form powerful factors in aiding the elementary and secondary science programs. The college students also have much to encourage them toward science careers through scholarships and other economic inducements. The demand for more and better prepared graduates for science teaching and for research in industry will assure an increased interest in the various fields of science and mathematics.

Now, as we pass the mid-century mark, I beg to conclude with the happy thought that we are evidently passing the most critical stage of our science educational problems and the outlook is full of promise. We can expect a richer science program in our elementary schools. Our high schools and colleges will have larger enrollments with better-prepared teachers. We can look forward with unshaken confidence that our educational system will not fail us in this hour of need. Our progress has become too dependent upon the good teacher, the scientist and his laboratory for a long continued delay.

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