tists that we have are being used. Are there, for example, too few scientists engaged in the training of more scientists or in basic research?

This is a very fundamental question, for it relates to short and long-range objectives of our society. We have always emphasized applied science in this country. In addition, we now emphasize military applications. We threw nearly everything we had into the war and in so doing neglected basic research and teaching. Are we still going too far in that direction? Are we still risking the quality of the future of science in order to make weapons and gadgets today?

Certainly we are taking some risks. We must do so to some extent. But how serious are the risks? Have we backed up enough from our war-time policy of depleting scientific manpower resources and our store of fundamental knowledge? Can we go right ahead and expand our Federal and industrially supported science, even if, in so doing, the expansion is at the expense of science teaching in the colleges and universities? In this competition for scientific personnel, are the incentives for working in government and industrial research laboratories too much greater than the incentives for teaching?

These are important questions. Let there be no mistake about that. The future strength and vigor of American science are at stake. The progress that we are going to make on the peaceful applications is at stake. If we go too far in emphasizing short-range objectives at the expense of long-range ones, that is, at the expense of training top-notch scientists, then we risk the leadership which we may urgently want ten or twenty years from now.

These questions are as difficult as they are important. But one way to get some evidence on them is to check on the effectiveness with which we as a nation are presently achieving results (1) in applied research and development, (2) in basic research, and (3) in the training of new scientists. The staff of the President's Scientific Research Board sought answers to each of these questions. Tonight we are concerned with the third one on the training of scientists. Answers to this question were sought in several ways. Chief of these methods was, however, the request to the American Association for the Advancement of Science.

The best way to find out about the effectiveness of science teaching is to ask the scientists themselves. They were asked in several ways, but in this instance the President's Scientific Research Board turned to the American Association for the Advancement of Science as the most representative organization of scientists and asked them to give us the answer. Through the President of the Association, the request was passed on to its Cooperative Committee on the Teaching of Science and Mathematics. Their report was prepared and was then used by the President's Scientific Research Board in formulating some of the basic recommendations which appear in its report "Science and Public Policy."

SCIENCE IN ELEMENTARY AND SECONDARY EDUCATION

MORRIS MEISTER, *Principal, High School of Science, New York City*

There have been several appraisals of science teaching in recent years—all of them good and most of them useful. The unique circumstance about the appraisal which concerns us this evening is that the President's Advisors were driven to make this evaluation by the dangerous lack of Manpower for Research. Evidently, Public Policy in an Atomic Age is tied to Science and Technology. Here, as in most things, it is men that count. And we do not have enough of them for the job that lies ahead. Because we were profligate with science talent during the war, a generation of scientists was lost. Any effort to make good the shortage and improve the quantity and quality of competent men forces an examination into what science we are teaching, how we are teaching it, and how many are being taught.

This appraisal is notable in another respect. While ostensibly the President's Advisors are concerned with maintaining a full and steady flow of able scientists, they recognize the importance of a public that is literate in science. Unless the later is true, the people will not support the plans and the recommendations of men of science. The Report to the President seeks a program of science education for all—a program which is as mindful of general education as it is of science education for the specialist.

But, what does the appraisal reveal about our present program? Instead of a twelve year science sequence, beginning in Grade One, relatively few children recieve any organized science instruction until Grade Seven. In the earlier grades science teaching is, in many places, incidental. Sometimes it appears as part of the reading program and sometimes as the lesser adjunct in a social studies unit. Well trained elementary school teachers of science are few. Courses of study and textbooks show the kind of wide variation which is characteristic of an early stage of development. Equipment is either non-existent or inadequate. Teaching procedures are not well designed. There is an almost total absence of concern about locating, stimulating and providing guidance for children with potential talent in science. The only encouraging sign is a widespread and heightened interest in this field.

What is the situation in secondary schools? First and foremost is an overcrowded curriculum, in which science is hardly represented to a degree in keeping with the needs of our times. All available data indicate that the precentage of high-school pupils enrolled in science courses has been declining. The typical pupil takes two science courses during four years of work; one in general science and one in biology. The contribution which physical science can make to his education is not provided beyond the elementary concepts treated in general science. A small number take the course in physics or chemistry at the eleventh or twelfth grade level; but the courses seem to be poorly designed for purposes of general education. Since such courses are offered to heterogeneous groups, the work often fails to serve the needs of the talented pupils in these groups. High schools rarely offer training in science beyond the initial courses in biology, chemistry or physics. Very little attention is paid to the experimental methods of science or to the development of scientific habits and attitudes. Little use is made of the history of science with its adventure and dramatic action, so appealing to the interests of young people.

Another disturbing factor in the science teaching picture is the serious lack of competent teachers. It is worse in science than in other subjects. Good science teachers are being attracted by the larger salaries and easier working conditions in industry, in business and in government. There has been a decided decrease in men teachers. The teaching load of the science teacher is often discouragingly greater than that of other subjects. Frequently, the science teacher must teach, in addition, one and even two subjects not related to science. In too many instances, science teachers report inadequate teaching materials and special facilities required for good science teaching. Under conditions such as these, it is no wonder that high school science teaching is less than effective in realizing either the objective of general education or of stimulating and nurturing the potential scientist. At a time when the future of the Nation and of civilization itself depends upon better training in science, it is disquieting in extreme to find so little being done in secondary schools to identify and guide science-talented youth toward careers in science.

This, in brief is the essential indictment made by the Report to the President on science teaching in our schools. What, then, are the indicated solutions to the problem—the recommendations?

Basic to any improvement in the teaching of science for the purposes that are the concern of the President's Advisors, is a well-conceived machinery for the early identification and guidance of science-talented youth. Such machinery can operate informally in the elementary grades. A number of elementary schools have been experimenting with some very promising methods of stimulation and selection. In the ninth and tenth grades, special techniques for identifying special aptitudes can be employed. Here, one cannot over-emphasize the selective value of Science Clubs, Science Fairs and Science Congresses. These activities, when carefully planned, are the media in which science talent thrives. They are frequently the triggers which release dormant interests and abilities in young people. For many, they add the kind of purpose to school work which overcomes obstacles and contributes to sound growth and development.

In conjunction with these activities, schools can make better use of a steadily increasing variety of good aptitude tests in science, and of vocational interest inventories. The personal data thus obtained for each pupil can become part of the record of school progress which accompanies him from grade to grade. The program of guidance in the school can start with this record and include individual conferences, follow-up procedures, and the like. The guidance counselor and the science teacher are closely associated in the process of identifying science talent.

At least three general procedures are suggested by the Report, for dealing with the needs of science talented pupils, For the very small high school, only the generalized science courses are feasible; but the teacher can develop special projects, reports and teacher assistance for those able and interested in science. Science Club activities are especially valuable in this connection. Sometimes, correspondence courses in certain science fields have served a good purpose.

In the larger schools, the pupils gifted in science can be scheduled for "Major-work" or "Honors" classes under competent science teachers. In other subjects, they join with classmates from varied curricula.

A third procedure, possible in the larger school systems, is to organize one or more specialized high schools. Any city large enough to support five high schools can profitably designate one of them as a High School of Science. Under this arrangement, an organized program of selection can be carried out. Excellent results have been obtained in practice by basing the selection of students upon a written test, a study of previous school record, the recommendations of the lower school authorities and, in some instances, a personal interview. The written test consists of carefully assembled CAVD material, refined over a period of years, so that the test becomes a valid and reliable instrument for selecting ninth graders who do unusually well with a curriculum oriented in science and mathematics.

In the six annual Westinghouse Talent Searches, students from two such High Schools of Science have repeatedly been selected for honors, in numbers out of proportion to their school populations. One of these schools, with a register of about 2,000, has had from one to four "winners" in each of the six annual competitions. The curriculum of a High School of Science includes 4 to 5 years of sience study and laboratory work, 3 to 4 years of mathematics, 4 years of English, 4 years of social studies, 3 years of one foreign language, together with the usual requirements in art, music and health education. Such a curriculum does not lack in elements of general education and is quite in line wlth college entrance requirements.

A second recommendation of the Report stresses the importance of a carefully planned program of science instruction for all pupils. This program must articulate the work in high school with that in the elementary school and must aim at the steady development understanding of important science concepts. In essence, this recommendation will achieve a higher degree of scientific literacy among the citizens of a democracy. The recommendation also carries with it the implication that three years of science be required of all high school students. A strong plea is made for a year of physical science (rather than physics or chemistry) to follow the courses in general science and biology. For the science-talented students, four to five years of science are recommended. Here, courses in biology, physics and chemistry can serve a real need. Often such students can profit from an advanced course in physics, chemistry, or biology.

Another recommendation stresses the importance of adequate laboratory facilities, equipment and supplies. The Report recognizes the unique educational contributions of teacher and pupil demonstrations; but emphasizes the importance of individual laboratory experimentation. For the science talented pupil, the laboratory is the place where he learns "to put questions to nature" and where he can obtain answers to problems by the methods of science. Such laboratory work shifts the focus of activity from passive observation to active participation; it develops skill in coordination and manipulation. Individual laboratory work is a golden opportunity for developing resourcefulness in the use of physical materials and instruments of measurement.

Recognizing the shortage of highly competent science teachers, the Report urges an improved system of in-service training, techer workshops, counselling service and supervision. To quote from Raleigh Schorling's Bill of Rights for Teachers, "Every teacher has the right to an adequate amount of helpful and constructive supervision". To this "Right" can well be added the Right to teach classes that are not too large, the Right to have time in school for planning, the Right to a 45-hour week, the Right to have good materials and enough of them, the Right to work in a room that can be made pleasant and appropriate to the tasks to be learned, and the Right to adequate compensation.

The capstone recommendation of the Report concerns itself with a National Commission on the Teaching of Science and Mathematics. This Commission should be given the wherewithal for conducting certain essential studies, so that answers to very vexing problems can be obtained. A complete appraisal of science and mathematics teaching in secondary schools should be made. More carefully planned teaching materials, for both pupils and teachers, must be developed. Studies should be made of various curricular and administrative arrangements employed in small and large communities to meet the needs of talented youth. Guidance procedures for identifying science talent should be further developed. What are the most effective ways to use demonstrations, laboratory work, projects, shopwork, field excursions, and audio-visual aids? What are the important science concepts basic to effective citizenship in a democracy, in this atomic age? What is the most effective age and grade placement of these concepts in the curriculum?

These are fundamental questions. They can be answered only through intensive investigation and study. The present crisis in science teaching can be relieved if means are provided for conducting such investigations and studies.

THE EFFECTIVENESS OF OUR SCHOOLS IN THE TEACHING OF THE BIOLOGICAL SCIENCES

L. V. Domm, *Whitman Laboratory of Experimental Zoology, The University of Chicago*
Glenn W. Blaydes, *Department of Botany, The Ohio State University*

The Biological sciences bear a tremendous responsibility in solving numerous crises which human society is now facing. In biological education we must contrive more adequate training for our people in order to solve many of these impending problems.

Of all the land areas in the world only about 11 per cent or 4,000,000,000 acres are suitable for food and fiber production. There are about 2,000,000,000 human beings living in the world today. They must get their foods and fibers from this area. This means that there are available to each person only two acres,[2] or about twelve average city lots upon which his foods and fibers may be produced. In Ohio,[3] records for the average annual yields of the cereal crops extend over a period of almost a century. The average annual yields of these crops today are about what they were 100 years ago. During this period improvements have been made in crop plant varieties, methods of tillage, use of fertilizer, crop rotations, and the invention of agricultural machines, which should have increased yields, according to conservative estimates, from 40 to 60 per cent. These advances, as great as they may be, have not

[2] Milton S. Eisenhower, "Two acres for your life." *Collier's* 119 (19): 80. 1947. Variation in such estimates occur from about 8 acres to each person, as given by Raymond Pearl. "War and Overpopulation." *Current Hist.* 43: 589–594, 1936, to about 1 acre by Frank A Pearson, and Don Paarlberg, "Starvation Truths, Half-Truths, Untruths." N. Y. State College of Agriculture, Cornell University, Ithaca, N. Y. 1946.

[3] R. M. Salter, R. D. Lewis, and J. A. Slipher. "Our Heritage—the Soil." Bulletin 175, Agricultural Extension Service, The Ohio State University.