Reflections on the High School Curriculum*

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I welcome this opportunity to address the Central Association of Science and Mathematics Teachers. Your group is an important force in the training of the young people of our country and I know that you are concerned with the problems of improving scientific curricula for them. I hope that my remarks will be a helpful addition to the interchange of ideas and experiences taking place at this meeting.

The teaching of physics and the training of physics teachers have been major interests of mine for many years while I was a Professor of Physics and later Dean of the Graduate School at the University of Michigan. At the University, as many of you know, we instituted the Master's degree in science teaching to enable high-school science teachers to broaden their science training with the help of special new courses in physics, chemistry, geology, mathematics, and biology, and we have conducted many year institutes and summer institutes for them.

My interest in the high-school curriculum has been heightened by my recent appointment as Acting Director of the American Institute of Physics. The Institute is very much concerned about the high-school science curriculum and, of course, about physics in particular. At the AIP we are involved in many programs designed to strengthen the education of high-school students.

Science and technology have become extremely important in our world today. The interest being shown in the science curriculum by many individuals and groups reflects that fact. We are living in what has been variously called the Space Age and the Atomic Age. A new era of space exploration and of exciting new scientific discoveries is before us. There are great opportunities for young people today who pursue scientific studies. New fields for research and discovery are opening up. There are still frontiers to conquer in the realm of science and technology.

Equally important today is a basic knowledge of science for every citizen. Every high-school graduate must have a basic grasp of science to deal intelligently with the modern devices and equipment of everyday life, to vote intelligently in the face of the complex technological issues that face us, even to get and hold a job today. A look at any daily newspaper will provide evidence that new advances in science are permeating our everyday life. National and world political deci-

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sions are influenced, to a great degree, by scientific and technological advances. A tremendous amount of new knowledge is being added to the volume of existing knowledge. Our very existence may depend on the extent and quality of our scientific accomplishments, and of public understanding of the implications of these accomplishments.

All of these factors have a direct relation to the high-school curriculum. Because science and technology have become so important in our culture, I believe—as I am sure you do—that the physical sciences must now be granted a major role in the high-school curriculum. Greater emphasis must be placed on the physical sciences if tomorrow's citizens—the young people of today—are to understand and cope with the world in which they will live. Citizens of the future must, more than ever before, be scientifically literate.

Recognition of this need has led to increased emphasis on the physical sciences and changes in the science curricula themselves. It was felt that the traditional courses were not keeping pace with changing knowledge, and consequently were not adequately preparing students to cope with the continuous advances being made in science and technology. As a result of the interest of many individuals and groups concerned with education in the physical sciences, various curriculum-improvement studies and programs are now under way. These projects, aimed at reinvigorating the teaching of the physical sciences, are currently receiving national attention. This is truly a time of ferment and change in science education—an exciting time to be directly involved as you are in the educational process.

Each of you is a specialist in one or more areas of science, and you may be teaching one of the newer courses. This is not the place to dwell on the details of these new courses. However, in order to present an overall view of developments in the physical science curricula, I would like to mention the major course content improvement programs that are under way in chemistry, earth science, and physics. Although there are differences between these programs, they share certain common goals and are based upon similar philosophies. The scientists and educators who cooperated in developing the new curriculum programs share the following common beliefs: science education should be geared to the continual changes taking place; science should be presented in terms of modern learning concepts and theories and should stress science as an activity; education in science should increase understanding of its unifying principles; science courses should be more stimulating and interesting to students; scientific literacy should be more widespread—science should have a greater role in the education of all students. The new courses that have been developed from these beliefs differ in purpose from traditional courses. In the past, learning was too often equated with memorizing quantities of information in science. In the new courses, students are encouraged to develop an understanding of the main ideas and concepts and of their use rather than to memorize numerous facts and formulas —many of which will be out of date in a few years. Emphasis is placed on experimentation and discovery—the methods of the scientist. Science is exciting to the people who are expanding its frontiers and the new courses try to impart to the high school student some of the thrill and enthusiasm that science arouses in its practitioners and to show its beauty and intellectual challenge.

First, let us look at the teaching of chemistry in high schools. Two new curriculum programs under way are the Chemical Education Materials Study (known as CHEMS) and the Chemical Bond Approach (known as CBA). The CHEMS program, which began in 1959, is strongly based on laboratory experimentation. The CBA program, initiated in 1957, uses chemical bonds as a central theme and emphasizes theory and experiment. Both the CHEMS and CBA programs stress the concept of the laboratory as a place to experiment and they provide reasonable depth in selected areas, rather than a broad superficial scanning of the entire field.

As a result of increased interest in the teaching of the earth sciences, the Earth Science Curriculum Project was started. This project is concerned with the development of new earth science courses and the improvement of existing courses. It is conducted by the American Geological Institute, is designed mainly for the 9th grade level, and it incorporates material from several different fields of science.

In physics, two major projects have been or are being carried on. The first of these to be developed was the Physics Course of the Physical Science Study Committee. The PSSC course, as it is generally called, was formulated in 1956 by a group of physicists at the Massachusetts Institute of Technology, with the leadership of Professor Jerrold Zacharias. Since that time, the PSSC program has had considerable acceptance by schools and teachers throughout the country. Many of you are undoubtedly well acquainted with this course and may be teaching it. The program stresses development of the ability to reason and makes many provisions for reinforcement of learning. Deeper treatment of fewer topics is provided. Emphasis is on laboratory work which, with relatively simple materials, is made a real learning experience. It is a complete course, with special texts, laboratory manuals, films, apparatus, and teacher guides. The PSSC program was designed to appeal to the able student who often plans to study physics in college. It is a challenging course for both students and teachers.

The other major physics curriculum revision program is a relatively new development. It is called Project Physics and it was initiated in

1962. Project Physics was designed to be appropriate and appealing to a wide spectrum of students—not only to future scientists, but to those who will concentrate in other areas or not go to college at all. To familiarize you with the progress and aims of Project Physics, I would like to quote the following item which appeared in the September, 1964 issue of the *Educational Newsletter* published by the American Institute of Physics:

"A three-year project in course-content development for high-school physics shifted into high gear at Harvard University this summer with the receipt of grants totaling $531,800 from the U. S. Office of Education . . . Project Physics is aimed at the development of a new kind of physics course—one presenting physics not only as a lively and fundamental science, but also as an activity that is closely related to achievements in other sciences and to the cultural life of our times. The chief aim of the course is to give students a solid grounding in physics, including its recent developments. A series of important additional aims will give the course a somewhat different form from existing physics courses. As the occasion arises, the text or supplementary reader will stress the humanistic background of the sciences: the way modern physical ideas have developed, and the lives of the men and women who made key contributions; the interaction between physics and other sciences, especially chemistry and astronomy; and the fact that physics feeds into contemporary technology and in turn is stimulated by it. The course will also touch on the methodology of science, as illustrated by specific developments in physics."

The five curriculum-improvement projects in chemistry, earth science, and physics which I have just described are being accepted in many schools. Since they are still considered experimental, they are continually subject to review and are being adapted to specific situations and needs as they arise.

These projects, however, are not the only new science courses being given in the high schools. Many other programs are under way at the present time. For those who are interested in knowing about these projects, I refer you to the Information Clearinghouse on New Science Curricula. This was established at the University of Maryland under the joint sponsorship of the University and the American Association for the Advancement of Science. The Clearinghouse serves a valuable function in coordinating information about new curriculum projects.

As a physicist, and because of my affiliation with the American Institute of Physics, I would like to talk in more detail about the special role of physics in the high-school science curriculum. The justification for giving physics special consideration arises from the fact that it is one of the physical sciences in which the teaching problems are particularly severe and in which much cooperative effort is needed.

The need for strengthening the teaching of physics was recognized early. Physics initiated the current wave of course revision in 1956 when the PSSC project began. The early interest shown in the improvement of physics programs can be attributed to the fact that the problems of physics education are considered to be critical. Some problems are common to all the physical sciences in the high schools, but there are special problems that confront us when we consider the teaching of physics in the high schools.

The two major problems are: an acute shortage of qualified teachers to meet present needs and low enrollments of students in physics courses in relation to the increasing importance of the subject. The various factors that cause these problems must be dealt with, if the critical situation in physics education is to be improved.

The teacher-shortage problem in physics is an extremely difficult one which does not seem to have any easy solution. The present rate of turning out new physics teachers is completely inadequate. The secondary schools of the United States need about 3,000 well-prepared new physics teachers each year to meet losses from the profession and to increase the numbers of well-qualified teachers of the subject. At the present time, approximately 500 graduates are being certified to teach high-school physics each year, and it is estimated that only two-thirds of these—some 300—actually enter teaching. The remainder take positions in government and industry which frequently offer more substantial inducements. Because there is a general manpower shortage in physics, and the demand for men and women physicists outstrips the supply, it is urgent that the secondary schools take steps to increase the attractiveness of high-school physics teaching. A stepped-up recruitment program is indeed necessary to bring more graduates into physics teaching. The difficulties faced in this regard are expressed in the following passage from *Physics in Your High School*, a handbook of the American Institute of Physics:

> "Probably no profession makes its demands in more varied ways than does teaching. In addition to the well-known requirement of a scholarly professional education, the teacher's job ideally calls for the organizing skill of an executive, the friendly warmth of the salesman, the sensitive human understanding of the psychiatrist, the inspirational leadership of an evangelist, the audience contact of the actor, the sense of responsibility of the surgeon, and an ability . . . to operate effectively and with satisfaction at the level of children. In addition to these desirable attributes, found to a greater or lesser degree in all successful teachers, a physics teacher must have technical understanding, considerable mechanical skill, and a willingness to continue studying for the rest of his professional life to keep abreast of his rapidly developing field. Talents and traits of this order are not easily found or cheaply hired by schools against the competition of industry which wants its employees to have most of these same qualifications."

Related to the teacher-shortage problem is the need to improve the education of high-school physics teachers. A great number of in-service teachers do not have adequate preparation to teach physics. Of the approximately 17,000 teachers of physics in the secondary schools, two-thirds have had less than the usual minor of 18 semester hours of college physics. In addition, since only the largest or most specialized high schools have enough classes for a full-time physics teacher, almost all physics teachers must at present teach other subjects. A study by the American Association for the Advancement of Science showed that, of all teachers of high-school physics, 81% teach only 1 or 2 classes, while 15% teach 3 or 4 classes, making a total of 96% part-time teachers of physics.

Because most teachers must divide their attention between physics and other subject areas, the resultant lack of specific preparation for physics teaching is understandable. However, sub-standard preparation is *not good enough* for today's vital needs.

The undergraduate preparation of physics teachers was carefully considered by the National Association of State Directors of Teacher Education and Certification, in conjunction with the American Association for the Advancement of Science and many professional scientific societies. Their published *Guidelines* contain recommendations for the subject-matter preparation of physics teachers, both in undergraduate programs and in fifth-year programs toward a master's degree. The *Guidelines* represent a goal toward which teachers should strive.

In order to keep physics teaching current with new developments, in-service education of teachers must also become more widespread. Adequate teacher preparation and continuing education are essential in raising the quality of physics courses to the necessary level.

Remarks pertinent to the problems of teacher recruitment and preparation were made by Dean Athelstan F. Spilhaus in his preface to the booklet entitled *Careers in High-School Physics Teaching*, published by the American Institute of Physics. Dean Spilhaus is head of the University of Minnesota's Institute of Technology and formerly served as Commissioner for the United States Science Exhibit of the Century 21 Exposition at Seattle in 1962. He is best known, however, as the author of educational science cartoons "Our New Age" which appear in the so-called comic section of many Sunday newspapers. I quote from Dean Spilhaus:

" . . . Well-prepared physics teachers for secondary schools are in demand today as never before. Physics and the other basic sciences and their technological applications have entered every part of our national life. Space probes and manned orbital flights . . . have caught the nation's interest. The public is coming to understand the national importance of science and to be curious about what science is. Young people especially want to know more about it. Schools throughout the nation are responding to this increased emphasis upon science. They seek to provide each student with basic scientific knowledge and to give students with special scientific talent an educational foundation for their college studies. The schools need science teachers of great competence to meet these responsibilities—teachers to work closely with boys and girls, inspiring them and assisting them toward greater understanding of science. Particularly is this true in physics—a school subject that has long been neglected, but is now showing great vitality. New physics programs have been developed and are being tested. . . . As new school buildings rise across the country to meet the surging enrollments of the 1960's, better physics classrooms and laboratories are coming into being. The schools are buying physics apparatus, books, films. . . . But these excellent programs and material facilities will have been provided in vain unless inspiring and well-educated physics teachers are available. . . . "

In addition to the manpower problem, physics education is also confronted with the problem of low student enrollments. Physics has failed to attract its share of the rapidly increasing total enrollment of the secondary schools. At the beginning of this century physics was almost a universal requirement in the secondary school curriculum. By 1962 the percentage of twelfth-grade public school students taking physics courses had dropped to 22.2%. It is significant to compare absolute enrollments in high-school science courses for the period 1958–62. During this period physics enrollments remained almost static. In contrast to physics, absolute enrollments in chemistry in 1962 were up 31 per cent over 1958, with 38 per cent of all eleventh-graders taking chemistry. Biology enrollments increased 48 per cent, and 82 per cent of tenth-graders were studying biology in 1962.

Various reasons can be given for the lack of interest in physics shown by high-school students. Some say that physics courses have acquired a reputation for being difficult, dull, unrewarding, and unrelated to the students' experience and goals. Guidance counselors and parents perhaps discourage even capable students from taking physics, fearing that a poor grade will lessen their chances of getting into college. Physics has been considered too difficult for the average student, and very few girls enroll in physics courses. The physics teacher in some cases, it is rumored, tries to make the course difficult. And there has been the criticism that fair rewards for work in physics courses have not been provided and that good grades are harder to get than in other courses. At a recent meeting where high-school physics was being discussed, Dr. H. R. Crane of the University of Michigan, President-elect of the American Association of Physics Teachers, summed up these views when he said:

"Physics courses are too hard for the largest group of high-school students. The grading system for physics courses does not take into consideration the difficulty of the subject compared to other subjects, and there is little later reward in terms of the recognition given in college to high-school physics. The high-school course should be made more palatable and its appeal broadened. . . . A physics course does not have to be hard to be good."

Physicists and educators hope that new course content in physics will aid in the solution of the enrollment problem by attracting more students to the study of physics. This certainly is a pressing need, when the goal of universal scientific literacy is kept in mind. As someone aptly said, it has become more *complicated* to become a good citizen, and a better understanding of science is therefore needed for all citizens. Much needs to be done to change the nature of the high-school physics course and to make physics the fascinating study it should be. Physicists often speak of their profession by saying "physics is fun." We must strive to help the boy and girl have some fun from his high-school physics course.

There are several other problems facing physics education, in addition to teaching manpower and enrollment difficulties. One of these is the problem of how to include new developments without increasing the work load of the course. To telescope the mass of new knowledge into the standard time program presents difficulties. Planners of course revisions are working to find a satisfactory solution to this problem, since at present there does not seem to be any end to new developments and discoveries. Much has to be done to introduce physics concepts into elementary-grade science. Children are capable of learning some of these ideas at an earlier age than we have assumed in the past. Some excellent programs are going on to assist the schools in strengthening pre-high school science teaching, and physics has much to gain from such efforts.

Related to these changes which are continually taking place in physics is another problem—the constant need for new laboratory equipment in order to keep laboratory instruction current. The cost involved in the purchase of laboratory apparatus is a consideration in many school districts. The National Defense Education Act fortunately provides financial assistance for the purchase of apparatus, and these opportunities should be investigated by teachers and administrators.

A further consideration in physics education is the relation of the high-school course to the college course. There must be coordination and cooperation between secondary schools and colleges to provide a suitable sequence of studies for those students who will go on to higher education. An example of this type of cooperation at an advanced level is the Advanced Placement Program in Physics of the College Entrance Examination Board which enables extremely able students to receive college credit for advanced physics work undertaken in high school. For those students who do not get advanced credit for high school physics the course is still an important and valuable preparation for a college course in physics or for courses in chemistry or geology. Educators and physicists at secondary school and college levels must work together for the improvement of the curriculum and for integration of the work of the two programs.

The picture I have just painted of the situation in high school physics may seem rather grim. It is, indeed, a very serious situation.

However, there is a brighter side to the picture as well. At the present time, many people are actively engaged in finding solutions to the problems confronting physics education. The new curriculum projects have been mentioned earlier. The American Institute of Physics and its Member Societies are also involved in many action programs which we hope are contributing to the strengthening of physics education in the secondary schools.

The American Association of Physics Teachers has assumed a significant role in helping the professional growth of the high-school physics teacher through the publication of its new journal *The Physics Teacher*. In its pages opportunity is provided for an interchange of ideas and information useful in the physics classroom and teaching laboratory. I hope many of you are acquainted with this journal and I hope too that you are finding it useful. I know the editor would appreciate any suggestions you might have to improve it.

The AAPT also sponsors an activity which lends encouragement to outstanding performance in physics teaching at the secondary school level. Through its High School Awards Program, each year ten high schools throughout the country are singled out for excellence in physics teaching. Among the schools honored in recent years several are in the Central Association area. Undoubtedly, we have here today some of the physics teachers from these award-winning schools.

Another program is the Visiting Scientists Program in Physics for Secondary Schools, sponsored by the American Association of Physics Teachers and the American Institute of Physics, with support from the National Science Foundation. Under the Visiting Scientists Program, outstanding physicists from colleges, universities, and industrial and government laboratories make visits to high schools, where they spend a day as the guest and colleague of the physics teaching staff. The visiting physicists engage in such activities as giving a talk to the school assembly, the science club, or a physics class, and holding conferences with teachers, science counselors, or school administrators on topics relevant to instruction in physics. The Visiting Scientists Program is providing opportunities for teachers and students to meet professional physicists and is serving to arouse increased interest in physics among high-school students. This program is also strengthening lines of communication between secondary school physics teachers and professional physicists. Last year 165 physicists made visits to 242 high schools under this program. These schools are of course only a fraction of the 15,000 offering high-school physics but the visits are having a real and growing impact and the AIP hopes to get support to continue them.

The Regional Counselor Program in Physics, sponsored jointly by the American Association of Physics Teachers and the American Institute of Physics, is aimed at promoting local cooperation for the improvement of high-school physics teaching. Under this program, physicist-counselors are at work in all fifty states, the District of Columbia, and Puerto Rico, to aid physics education in their particular locality. Regional Counselors are chosen for their competence in physics, interest in the improvement of physics teaching, and ability to work effectively at the local level. These dedicated individuals volunteer their time, in the interest of helping to solve the critical problems of physics education. The local situation determines the specific program of activities each Counselor engages in, but some typical activities are: participating in local meetings at which science education is to be discussed, reporting to the national Regional Counselor Office on new educational programs and happenings in their localities, distributing career booklets and information about new developments in national programs affecting physics teaching, and setting up local action groups with teachers and administrators.

An important activity of the AIP is the publication of booklets concerned with strengthening physics education and providing career guidance. The handbook *Physics in Your High School* was written to assist school administrators, faculty, and school board members in their efforts to upgrade high-school physics education. The 136-page booklet, which is now being revised, offers suggestions as to what should be taught in the physics course, gives ideas as to what a good physics course will cost, and includes an appendix of resource materials—books, apparatus, and films.

The career guidance series of booklets begins with *Why Should You Study Physics in High School?* This tells eighth and ninth grade youngsters what one does in a high-school physics course and why physics is part of a good education. As the student reaches the point where he is considering the choice of a career, the AIP offers four guidance booklets: *Physics As a Career*, *Rewarding Careers for Women in Physics* (which is specially written with the problems and needs of the young woman in mind), *Careers in High-School Physics Teaching*, and *Careers in College Physics Teaching.*

These booklets all receive wide distribution through the visits of the physicists participating in the Visiting Scientists Program and through the work of the Regional Counselors. In addition, thousands of copies of each booklet are supplied by the AIP in response to written requests from teachers, guidance counselors, and students themselves.

But in spite of the many activities that are under way and the excellent teaching of physics that is taking place in some schools, the problems of low enrollments in physics classes and shortages of physics teachers remain with us. Why does this situation persist? What can we do about it? These are the questions that the AIP believes deserve an answer. After considerable review, the AIP decided that a study should be made in depth of the problems of reinstating physics as an essential element in the school curriculum. Dr. Victor J. Young, a physicist interested in and concerned with the manpower problems of industry, was invited to join the AIP staff to conduct the study, which is still going on. Dr. Young, with the help of Leonard O. Olsen (Professor of Physics at the U. S. Naval Postgraduate School, Monterey, California) is having personal interviews with key people in many sections of the country and in various areas—the schools, government, higher education, and industry. From these face-to-face discussions are coming many ideas and proposals for possible action programs to increase high-school enrollments in physics and to improve physics education in general. This study reveals that there is no simple, easy way to solve the problems; however many practical suggestions are emerging.

The AIP is now proceeding to develop programs in the different areas of need. The next step will be to find support to carry on some of the activities. The involvement of the physics community and particularly of the physics teacher is essential to the accomplishment of any of the plans that may be initiated.

Many of you teach subjects other than physics or perhaps together with physics. I have emphasized the problems of physics not only because I am a physicist but because I believe that a strong and growing enrollment in high-school physics is vital to the strength and progress of our nation. I do not mean that biology, chemistry, and general science are not important but I think physics has a really indispensable place in the high school. It is noteworthy that Russia and most other European countries have put physics into a central position in the curriculum.

The place of physics in these countries indicates that they think some knowledge of it is necessary for the advances they intend to make in space, in military equipment, and in economic progress. Physics used to have such a place with us. I believe we must consider regaining some of the ground we have lost or the next few years will show that we are suffering from this failure.

There is much that has been done, and much that still remains to be done, in solving the problems of science education in the United States. Continued experimentation and a pluralism of efforts to improve the teaching of the physical sciences are greatly needed. Teachers must be willing to try the new curriculnm programs, evaluate them, and adapt them to the local situation.

The quality and vitality of high-school science courses can have far-reaching effects on the career decisions of young people. Our future supply of scientists could be increased by the spread of interesting and well-taught science courses in the schools. It is paramount, therefore, that we instill an interest in science, not only in the minds of future scientists, but in the minds of *all* who aspire to be educated citizens. One of our major goals in the high-school curriculum should be the development of a high quality of *scientific literacy*.

The lag in the teaching of high-school physics comes at a time when the work of physicists was never more exciting or important and when the demand for trained physicists seems impossible to satisfy. Graduate enrollment in physics is the largest ever, publication of research and the support of research in physics has been doubling every four or five years, the work that physicists do in satellite research, in lasers, in new communication devices, and in defense systems is making news every day. Polls on the careers that high-school students rate the highest show nuclear scientists and scientific research workers near the top of the list. It seems inevitable that these facts must stimulate interest in more and better high-school physics.

Solution to the many problems that face science education in the high schools today depends on the cooperative efforts of teachers, administrators, scientists, and the public. You who are actually working with boys and girls in high schools are in a favored position to recognize the needs, and suggest solutions to these problems. I hope that we may have the benefit of your ideas and suggestions. Potential contributions of the physical sciences to the high-school curriculum will be realized only through cooperative efforts of this sort.

FATS, SMOKING ATTACKED IN WAR ON HEART DISEASE

Take excess fat out of the American diet and reduce the danger of heart trouble.

Animal fat on the dinner table and cigarette smoking are both spotted as dangers to be avoided, not only by persons overweight or with high blood pressure, but by everyone.

The 1964 report suggests that all Americans eat less animal fat and substitute vegetable oils or other polyunsaturated fats in their diets. Even though "final proof is not yet in hand that dietary changes will prevent heart attacks or strokes," the report says it is time to apply lessons from worldwide research indicating a relationship between the amount and type of fat consumed, the average cholesterol levels found in a population and the reported incidence of coronary disease.

Cigarette smoking is another important risk factor in "coronary proneness," the report says, pointing out that it has been conservatively estimated that at least 100,000 premature deaths occur in the United States each year from heart disease associated with this cause.