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Presidential Address: Leadership in Mathematics and Science

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Leadership in Mathematics and Science*

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The events of the past six or eight months have been highly upsetting to us as a nation because our scientific superiority particularly in the field of rockets, missiles and satellites has been seriously challenged. As a nation we are especially concerned because of the close relationship of this field of activity with that of national defense. The American public including its military and political leaders seem to have been caught off-guard even though it must have been realized that no nation and no group of scientists could possibly have a monopoly on any particular area of science. A nation or group of scientists willing to pay the price should certainly be able to surpass the efforts of those making a less concentrated effort in the corresponding field of endeavor.

Also it is possible to cite times in history when the groundwork for certain scientific discoveries was completely laid and the discovery itself had to emerge across the threshold of one nation or another, or from one scholar or group of scholars or another, as to which, being largely a matter of chance. Such seems to have been the case when Newton in England and Leibniz in Germany independently and almost simultaneously discovered the calculus. It is also possible to gain some comfort from examples of younger less mature scientists succeeding in scientific discoveries when older more seasoned scholars had failed. Such was the case in 1912 when G. D. Birkhoff, a young American mathematician of unestablished reputation, proved an important geometric theorem which Poincaré, the world's greatest living mathematician of the day, had discovered and been unable to prove. Likewise in 1922, a relatively unknown Finnish mathematician, Karl F. Sundman, who as far as I know had never even published a scientific paper previously, succeeded in solving, in a certain sense at least, the celebrated problem of three bodies after many of the most capable astronomers and mathematicians of the previous several hundred years had attempted the same and failed.

Even though there is little doubt that we are living in one of the most glorious ages in the history of science, there is no question about the overall seriousness of our present national dilemma. It has been well known for some time that in this scientific age our national supply of trained personnel in the sciences and mathematics has not been keeping up with demand. This is one reason why the members of our Junior Academy deserve our complete cooperation and en-

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couragement. I would at the start plead with each member of the Senior Academy to do all within his individual power to assist young men and women to develop interests in the fields of science, to encourage more capable students to go on to higher levels of attainment and especially into fields of science teaching at one of its various levels.

We should not at present be discouraged nor should we in panic drop our over-all well-balanced research program in favor of an all-out intensive effort in one particular area. We should, however, carefully take stock of our present situation, study our credits and debits and plan our future program in a highly effective manner. This must of necessity be a long-range program and we cannot afford to underestimate or to risk inadequacy or failure. We must plan our future using intelligence and foresight rather than permitting it to be dictated by emotional and political forces.

Let us for a moment review our national background and the forces which acted to make the United States a strong nation. Our ancestors were ambitious, well-disciplined, mentally able and physically vigorous individuals. Although there were many hardships to overcome or endure, our ancestors had extremely good senses of values and generally entertained the greatest of respect for learning and especially for science. The natural resources available to them seemed almost unlimited. Sons and daughters subjected to such home environments usually did not deviate too far and for these reasons our country grew and flourished. As long as individuals vividly remembered conditions in former home lands and keenly appreciated the boundless opportunities of this country, there existed strong motivations for work and intensive application.

The settlers, interested in well-rounded opportunities for their children, set up educational institutions at an early date. Through the years a huge educational machine numbering thousands of secondary schools and hundreds of colleges and universities was developed. The policy of educating all, even encouraging those of mediocre ability and subsidizing those less able financially to pay the costs of higher education, was developed. We have undertaken to give high school education to more than 80 percent of our youth, two years of college to 30 percent and a bachelor's degree to 15 or 20 percent. No nation in history has ever attained even a third of these goals. Such a system of mass education I believe is desirable and one of which we may be justly proud.

As time advanced and our country grew, life became easier and much of the keen appreciation of the opportunities held so dear by our ancestors gradually grew dim. The population became so large that immigrants from abroad were absorbed without appreciable influence on our culture and educational programs. Youngsters now

take their educational opportunities for granted and at times consider these even burdensome. Their senses of value have grown distorted and distorted sons and daughters grow into distorted parents. Professional educators have given way under the resultant pressures. Sound courses in reading, writing and arithmetic or at the higher levels in language, science and mathematics have been forced to give way to the more popular and less challenging courses in general mathematics, social adjustment and the vocational areas. Old fashioned teaching methods which instilled discipline, respect and thoroughness in the student have been largely replaced by so-called modern, popular, apologetic and patronizing methods. Textbooks are made to appear like picture books and to read like story books. Classrooms are designed for comfort and attractiveness. Teachers are expected to be pleasant and agreeable. Report cards bear marks designed to indicate how the student performs relative to his abilities rather than how he performs relative to desired and expected achievement. Is it a wonder in the light of all such special inducements that youngsters lack incentive and motivation and take little interest in excelling in scholastic activities?

In many cases we have furthermore watered down the courses and actually abandoned the teaching of thorough courses in fundamental science and mathematics in the elementary school and in the high school. Youngsters are then unable to discover their abilities and interests and even if they should do so later, they will be seriously handicapped in their progress. A student will not major in college in an area in which he has had no preparation or in which his preparation has been inadequate. Teachers and parents have built up the illusion that science and mathematics courses are difficult and should therefore be studied only by the most able. In some cases the student must even obtain special permission to take certain mathematics courses and certain science courses in high school by showing that he is either highly capable or that he will need such courses for anticipated college admission. In the nation as a whole a very small fraction of the high school students study any considerable amount of mathematics. Less than half of the high schools offer physics and usually when such courses are offered they are taken by relatively few students. One wonders what high school course might be chosen to better train a student in accurate thinking and sound reasoning than a course in geometry or algebra. Personally, I believe only the most hopeless and mentally deficient should be excused.

It is not often that one of the great American philanthropic foundations gets concerned. Here is an excerpt from the report already several years old by Dr. John Gardner, President of the Carnegie Corporation of New York:

"There is grave cause for alarm in the failure of our schools

to provide more youngsters with a reasonable command of mathematics. It is a problem which merits the attention of all men and women accustomed to concerning themselves about the future of America.

"What we are facing is not a shortage of talent, but of *trained talent*. Intelligent youngsters are not in short supply, and if we had made good use of the resources available to us we would be in no difficulty. This is not an easy fact for us to grasp. Throughout history, human societies have managed to be extremely wasteful of individual talent. Even a generation ago the world did not reckon highly intelligent, highly trained men among the most marketable commodities. Now for the first time in history a radically different condition exists. The nation needs its talented and highly trained men and women and it needs them badly.

"The national need for men with scientific and mathematical competence exists at all levels. It is not just that we need more creative scientists at the Nobel Prize level."

The survey of mathematics teaching carried out by the Carnegie Corporation uncovered the surprising fact that high school students even with high I.Q.'s do poorly in mathematics and take little of it. The survey uncovered what many college teachers have known for some time—although all states require education courses for teacher certification, in one-third of the states the high school mathematics teacher need not have taken any mathematics course in college. The elementary school teacher is not required to have had even high school mathematics training. Too often the teacher is a local mother interested in earning extra money, with little real knowledge of the course content and little real interest in her work. She then tries to learn the subject matter of her course from the same textbook used by the students and often she is not as successful in so doing as the more alert students who soon realize this fact and lose interest and incentive.

That we are badly in need of capable, well-trained secondary school science teachers was also emphasized by Dr. James R. Killian, Jr., now President Eisenhower's special assistant for science and technology. In a paper on "Meeting the Nation's Scientific Manpower Needs," he wrote in part:

"The quality of American science and engineering depends also upon the strengthening of science teaching in the secondary schools. Last June (1956) the teachers' colleges and other institutions producing teachers in the nation graduated less than 250 teachers of physics for our secondary schools and half of these were attracted by industry and government away from

teaching. At present rates of education, we will train only half the number of science teachers we will need to stay where we are during the next five years. We have a shortage of science teachers, first as a result of their being attracted into other more remunerative fields—mainly industry—and, second as a result of the inadequate status and emphasis given to science in the secondary schools. In remarking this, I hasten to make clear that I do not feel that the teaching of science should be given such overriding attention and privilege in our public schools that other fields are weakened and the curriculum distorted. That is not the way to solve the problem; but I do think the evidence is clear that in the secondary schools science and mathematics teaching has suffered more than teaching in any other field. If we are to make headway in educating more teachers of science and in improving the teaching of science, the schools of science must do more than they have done so far to help in encouraging and preparing more of their students to go into secondary school teaching."

It is obvious that if we are to survive as a top nation, we will need to combat the anti-intellectualism of our youth and radically revise our educational program. We must instill in our youngsters a desire to excel scholastically and reward them for scholastic attainment just as liberally as we reward those with athletic ability. We must start with the parent and first convince him a change in attitude is essential. Recently newspaper and magazine editors as well as radio and television broadcasters have been extremely helpful in re-educating parents by devoting much space and time to the details of our educational difficulties in light of the dramatic advances in rocket and satellite technology. The parent in turn must impress his son and daughter with the seriousness and importance of doing his school work well and convince him that education is a privilege and opportunity not to be taken lightly. Good study habits and an appreciation of scholarly activities must be developed early. The motivation students receive from parents is exceedingly important. There must be an insistence that each student make use of his full capacity for academic achievement and development.

Technology begins where science leaves off and technological progress is based squarely upon the work of the scholarly scientist behind the scenes. It might be helpful if the public were reminded of this situation more often. Even though scientists are modest, they might well attempt at times to communicate to the general public their aims and results in simple everyday language.

With parental assistance and cooperation, the elementary and high school teachers would be able to exert much more pressure on their students and insist on much higher standards of achievement. They

would also be able to insist on more advanced curricula with emphasis on the critical fields of science and mathematics. Teachers especially in the high schools should insist on a higher quality of achievement than they now generally do.

There is little doubt that high school students applying themselves seriously to their studies could learn much more in much less time. The publicized superior achievements of the Russian educational system are not characteristically Russian but are more truly all-European in scope. Mathematics and the sciences enjoy tremendous popularity abroad. Two years ago a French visitor to our campus in Ames informed me he was greatly surprised at the relative lack of respect for mathematics and science on this side of the Atlantic Ocean. This visitor pointed out that even French artillery officers are required to study mathematics up to and including the level of tensor analysis. France has produced great mathematicians for many years by giving mathematics a highly favored position in its curriculum.

Any long range program designed to ensure the survival of America as a top nation must be built around a plan making full use of the talents possessed by its citizens. The immediate need requires more and better physical scientists and engineers, and indirectly, more and better science and mathematics teachers at all of the various levels. We must not, however, neglect the social and biological sciences even though present concerns seem to lie more in the physical and mathematical areas. We must strive for a well-rounded program of activity and our emphasis must be on teaching as well as research. Competence in research may not be considered vitally essential to teaching at the secondary school level and possibly not even at the level of the undergraduate college. On the other hand competence and interest in teaching may not be considered too essential to the professional research scientist. For the highest levels of accomplishment, however, an individual must have both a sincere interest in and the ability to teach as well as sincere interest in and the ability to do research. Fifty years ago there were few positions for the research scientist (except possibly in chemistry) which were not connected with an educational institution and which did not involve some teaching. This situation has completely changed. Now many industrial concerns engage research scientists as also do certain federal agencies and certain organizations set up solely for the purpose of carrying on research by contract and otherwise for government or industry. The scientist not interested in teaching has no difficulty in finding proper employment and certainly the well-trained teacher not interested in research likewise has many employment opportunities.

We must continually recruit young men and women capable of carrying on advanced scientific work and investigation as well as

young men and women capable of teaching and inspiring students to master the sciences. Not all individuals are sufficiently able but many are and more of these should be actively encouraged. Prospective young scientists and teachers frequently seek the answers to certain questions which we may list under four topics. To these we should be prepared to give convincingly informative replies. They are: 1) Interest and abilities needed, 2) Nature, scope, vitality and dignity of science, 3) Preparation and training required and 4) the rewards to be expected. I will endeavor to say a few words concerning each of these.

Interest and ability, although quite distinct, yet often go together. Young men and women aspiring to a career in science either as a teacher or a research scientist must conscientiously feel that they possess at least to a reasonable degree the natural gifts required. Individuals aspiring to a career in a college or university will generally be expected to devote a good deal of time and energy to undergraduate teaching and in addition will be expected to exhibit some research ability. College teachers as well as scientists regard research in comparison to all other activities as not only awe-inspiring but almost sacred and the most dependable single basis for advancement.

No student need hesitate to choose mathematics or an area of science for a vocation because of any fear that his subject when compared with others may be found inferior in scope or vitality and progressiveness or in dignity. Science in our day proceeds so rapidly and in so many directions that the ablest men are unable to follow all the developments and are therefore obliged to specialize within one small area within the general field. This is indeed a golden age of science. Flourishing scientific societies exist in all of the great cultural nations of the world and sponsor extensive scientific journals of all kinds.

The period of preparation and training for a career in science is inclined to be long and extended. This is one reason why the Federal Government is presently considering new legislation dealing with science education. Even in the past, the promising student has had many opportunities of financial assistance to help meet the expenses of the long training period. It appears that in the future the opportunities for such assistance may be even greater.

It is not difficult to appreciate that the life-work of the scientist is richly compensated even though few of the compensations are material. A major compensation is the joy of life-long contact and intimate association with the eager minds of young students and/or life-long companionship with men dedicated to science and fields of scholarship. The scientist has special opportunities for study, research and writing. The scientist's subjects are honored ones and

his life is one of perpetual contact with fundamental thought. He knows well that science is essential to the prosperous conduct of human affairs and to the support and progress of civilization. Let us hope that the material compensations will be improved much more within the immediate future. This is most important in order to maintain desired leadership in science.

Federal support designed to alleviate our education difficulties should be primarily designed to give the gifted student better educational opportunities. Such students are entitled to special consideration and encouragement in as much as they will furnish the scientific leadership of tomorrow. It is well known that the most able one or two per cent of today's students will be responsible for at least 98 per cent or 99 per cent of the scientific advances of tomorrow. In addition to continuing our educational programs for the masses we must whenever possible set up special educational programs for the gifted. At present we fail to utilize the full abilities of such students. We need to give more incentive and encouragement to the gifted that they may achieve their utmost.

It is not difficult to describe proposed federal education legislation in its present status. What will happen in the next few weeks, however, is highly uncertain. Several different bills have been introduced in the Senate and House of Representatives but two of these are receiving most attention. These are the Administration bill introduced in the Senate by H. Alexander Smith of New Jersey and in the House of Representatives by Carroll D. Kearns of Pennsylvania and the bill introduced in the Senate by Lister Hill of Alabama and in the House by Carl Elliott of Alabama.

Although these two bills differ in a number of respects, they are fundamentally similar in that they place emphasis on efforts to improve the quality of education. Each proposes to strengthen the teaching of science and mathematics by helping to provide higher incomes for teachers who meet certain standards, by summer school work in subject matter fields, by aid in the purchase of laboratory equipment, and by other means. Each bill proposes to make matching grants to the states to improve student testing and guidance programs in the hope that able students will be more clearly identified, encouraged to take the courses that are appropriate to their talents, and helped to prepare for college work.

At the college and university level, each bill includes provisions for a substantial number of four-year undergraduate scholarships (10,000 a year in one bill and 40,000 a year in the other), and each provides for graduate fellowships for students who are likely to become college teachers.

Dr. Dael Wolfle, Executive Officer of the A.A.A.S., considers it unlikely that either of these bills will ever be voted on in its original

form. Senate and House Committees have held extensive hearings and are now about ready to make some compromises and to prepare new or modified bills that will be reported to the House and Senate. There is considerable uncertainty as to what will be reported by these committees and even more uncertainty as to how the voting will go on the floor.

The two principal uncertainties seem to be these:

1. Will the emphasis on improving quality and raising standards be retained, or will some more restricted aspect, such as scholarships, be retained while the other provisions are abandoned?
2. Will the emphasis on improving quality and raising standards be retained, or will provisions for school construction be substituted for, or added to present proposals?

School construction bills have strong support this year as proposed means of combatting economic recession. School construction proposals would result in defeat of the provisions for improving quality and might as in the past turn into heated arguments over integration. The result would very probably be the defeat of school construction proposals, and if school construction is tied in with other proposals, perhaps defeat for those proposals as well. There is, however, a better opportunity this year than ever before to adopt legislation aimed at basic improvements in education.

Many constructive changes in secondary school programs have already taken place. If the public in a democracy such as ours is made properly aware of its dangers and difficulties, leadership is generally forthcoming and the citizenry will join forces to meet the occasion. We are indeed living in a glorious period in the history of science and we are most eager and determined to make this also a glorious period in the history of our nation.

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