GENERAL SCIENCE

Basic Science Needed

Practical developments are based on fundamental knowledge, but during the war inquiry into laws of nature had to be laid aside. Science is a collective endeavor.

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Address delivered at the Awards Banquet of the Science Talent Institute in Washington, D. C., March 5.

➤ THE young men and women who are here this evening to receive awards in the fields of science have had many congratulations showered upon them during their visit in Washington. I hope it will not overtax their patience to have me add my congratulations to the others. Ingenuity, intelligence and industry exercised in an atmosphere of tolerance and cooperation have made this country great. These qualities are exemplified in the work of the young award winners here tonight. I am happy to take part in honoring them and in commending them for the qualities of mind and character they have shown. I would also like to congratulate them on the field in which they have chosen to work. Science will always offer a challenge to intelligence and imagination. Today, however, the circumstances of a scientific career in this country are very different from what they were thirty or forty years ago. It may be helpful to these young people and it may well be worth while for all of us to review both the strength and the limitations of science in the world today, and to discuss what it means to be a scientist in this country in the middle decade of the 20th century.

We should consider both aspects of modern science; basic science and applied science, or technology. Basic scientific research is motivated solely by a desire to understand the laws of nature; in such work possible utility is irrelevant as a motive however important it has proved to be as a consequence. In applied science, the driving motivation is practical utility; the objectives are structures, machines, or processes of practical value to mankind; here understanding the laws of nature is irrelevant as a motive although increasingly important as a method. Both branches of science are essential to our progress.

In the past fifty years there has been a great change in the methods by which we improve our technology. Fifty or a hundred years ago, most machines and processes came from simple inventions. They were developed by men working for a specific objective without very much knowledge of the general laws of nature. In short, these men were inventors and not scientists. They were effective in developing a great number of mechanical devices, for our early inventors, even if they lacked formal education, were more or less familiar with mechanical laws through common experience. Some useful machines continue to be made by inventors of this type, but by and large the growing importance of chemical and electrical processes and the great complexity of even our mechanical machinery today have forced our technology to depend more and more on engineers and scientists who have had a thorough grounding in the natural sciences. Men who are designing industrial machines today may need to understand such abstract subjects as thermodynamics, the theory of relativity, and quantum mechanics. The difference in motivation between basic science and applied science remains, but the difference in method is no longer clear. So-called "useless" research has turned out to be often extremely useful research. If we are interested in continuing technological progress, we must continue to support basic scientific research, for if we do not have further discoveries in basic science today, we shall have no developments in technology tomorrow. Even in a period of emergency like the present, we must continue to inquire into the laws of nature because the better we understand these laws, the better we are able to make them work for us and through them to devise machines or weapons that may, in hard fact, be necessary for our survival as a free nation.

Especially Important Now

Actually, it is even more important at the moment for us to encourage basic science than it was before the war, for during the years 1941 through 1945 basic science came to a halt in this country. In these war years, we used all available scientists from our universities and government laboratories on immediate war technology drawing heavily on our reservoir of basic knowledge. Furthermore, in the last fifteen or twenty years, the gap in time between developments in fundamental research and the final development of practical machines has almost disappeared. The result is that today we have no backlog of basic science from which to draw new technological developments. What we are developing in technology today depends on the basic research of the nineteen thirties. It is important that this be understood and that universities, foundations, and government itself give full support to fundamental research, even when we cannot see where this kind of research will lead. The man who spends his time asking so-called "idle" questions about the laws of nature may be more important to this country in the near future than the worker in applied science who develops a new device or a new weapon based on the principles discovered twenty years ago.

Collective Endeavor

Science, increasingly in modern times, is a collective activity. Every scientist stands on the shoulders of his predecessors. He must know what others have done before him and he must also know what his contemporaries are doing and thinking. Furthermore, it is now frequently necessary for him to work from day to day as a member of a team. Apparatus and problems are often now so complex as to require simultaneously the combined efforts of several men. In the general sense, scientific progress has always been a collective effort. It is now frequently so in a detailed sense. This poses a real problem for both scientists and scientific administrators. Originality will continue to be the most important trait a scientist can have. It must be valued and preserved. But the personal eccentricities that often accompany it can be very destructive of teamwork. Individual scientists must now learn discipline in their method of work as they have long disciplined their thinking. On the other hand, administrators of science will find that a scientific group which is easy to manage is probably unimaginative to the point of mediocrity. The chief criterion of excellence must remain intellectual power and achievement.

Science substitutes knowledge and understanding for superstition and fear. Over the centuries it has shown us again and again what can be achieved by reason and cooperation, by men working together in an atmosphere of disciplined freedom. This is historically the strength of science and has not changed since the days of Copernicus or Darwin. We must keep this strength.

Today science has become essential to the defense of a free society, and to the further growth of that society. The same qualities of free inquiry, free criticism, ingenuity and enterprise that make it possible for science to give us new machines, new medicines and new weapons also are essential for growth in every other aspect of our national life. Science and freedom are mutually dependent. But there is one limitation: No man and not even the Congress can change the laws of nature. Spending a billion dollars will not change these laws although it may help us to make use of them. We must not expect startling developments overnight in our necessarily slow efforts to understand how nature works. According to current headlines, a quick expenditure of millions of dollars will give us almost overnight airplanes that will fly eighty times around the earth without refueling or submarines that will cruise indefinitely on a teacup of atomic fuel. Such exaggerated statements render no service to science or to the country.

Makes One Humble

Perhaps it is just as well that every new development requires long and painstaking study. Such study is apt to make a man humble, and humility is the beginning of wisdom. But one could wish that this fundamental limitation of science were more widely understood in this country.

What does it mean to be a scientist in the middle of the 20th Century? In his most recent book, Science and Common Sense, President Conant of Harvard has said: "Whether we like it or not, we are all immersed in an age in which the products of scientific inquiries confront us at every turn. . . . Therefore, every American citizen in the second half of this century would be well advised to try to understand both science and the scientists as best he can." This seems to me wise advice, so let us consider what the choice of a career in science will mean to a young man or woman in the years ahead of us.

Not Afraid of Work

The fact that you young people have won the awards which you are receiving tonight suggests that you are not afraid of hard work and study, and that you have some measure at least of ingenuity and originality. If you intend to follow a career in science, it is well that you like to work hard and to think. As in any other career involving intellectual effort, you will find a great deal of drudgery; you will not be doing always what you think you would like to be doing; you will not have brilliant or original ideas week by week or month by month. Certainly, you will never have valuable ideas unless they are made against a background of well-ordered information and thorough knowledge of your field. Once that knowledge is acquired, you will still find that there is a great gap between having an idea and demonstrating its value either in experimental or theoretical work. The path between the conception of an idea and its realization is long and arduous, but there is one compensation—it is seldom boring.

Whether a scientist is engaged in basic research or in applied technology, he will face certain conditions of work in the next two or three decades of this disturbing century. The only assumption we can reasonably make about this period is that it will be one of tension, nationally and internationally. We may not have to fight a full-scale war. We profoundly hope that we shall not. But we know now that we must prepare to resist aggression with all our strength for the foreseeable future. We shall have to increase greatly the armed forces of this country and we must use our material resources and our skilled manpower in the wisest possible way. In every aspect of civilian life, the first concern of each citizen must be the long-range value to the country of what he is doing. In the period ahead of us, no citizen can be deferred from national service in this sense. A young man using his skill in a laboratory may well be of more value to his country than if he were in uniform. The wise use of our manpower must be our first concern.

Ability Must Have Wise Use

The award winners here tonight, like other young men of their age across the country, will be asked to spend something over two years in military training after they have reached their eighteenth birthday. Whether or not transfer to college for promising students will shorten this training period remains to be decided by the Congress. I hope such a plan will be worked out, for the only criterion that should guide us is the wisest use of each man's ability. I believe this country faces dangers so great that we can no longer afford to waste manpower and resources as we have done in the past. We shall maintain the free society of the West only if we are cooler, cleverer and more skillful than our enemies, and only if we use the manpower and resources at our command with foresight and judgment. Young men have a right to ask of us, their elders, that they be wisely used. But they also have an obligation to serve where they are asked to serve. Two years of military training may be a valuable experience for a young man. It may teach him a good deal about human relations and the world he will live in. It need not necessarily be time wasted, even for a soldier who intends to be a student. If he will keep a sense of proportion and a sense of humor, his military training may in some ways have values comparable to the first two years of a general college education. Do not misunderstand me. I am not saying that being in the armed forces is preferable to being in college; I am merely saying that it isn't as bad as it is made out to be, and that military discipline does have certain values.

After military service, or its equivalent, is over there are certain conditions that a scientist in this country must expect to find in the next ten or twenty years. I can assure him, especially if he goes into university work, that he will not be wealthy—but then, in the next twenty years probably nobody else will be either. Wealth has never been a major incentive for men of inquiring minds. They do not particularly seek it and they are seldom impressed by it. A scientist must also expect to be considered a little peculiar because he obviously likes to think. His habit of questioning everything about him, and of always being willing to try new ways of doing things, rather than the conventional way, will probably bring down on his head the dark suspicion that he is a radical. In science this kind of unconventionality has brought every advance we have, but the scientist must remember that relations among human beings are very different from the clear objectivity of science, and far more complex, and that there are many factors present in fields outside his own that he cannot evaluate fairly unless he gives them an equal amount of study. Scientists are often called naive in public affairs, but I think it would be more accurate to call them incurably optimistic about human relations outside their own field because they had such success with human relations inside their own field. Experience has taught them that men working together in a spirit of mutual tolerance and cooperation can achieve miracles, and they are impatient to carry this great experience into other fields. This is a natural enthusiasm, but it needs to be tempered by patience and wisdom.

In the next twenty years a scientist, whether in or out of government, must expect to work under limitations of secrecy in almost every branch of science. These limitations on discussion, publication and free interchange of ideas are, of course, opposed to the whole tradition of science and will inevitably hamper its growth. Our constant effort must be to limit secrecy to those areas where it is necessary for national safety and to remove it as quickly as we can from all other areas. This involves constant review and revision, and is today one of our most important responsibilities. In the future, government will need increasingly men who understand both the values of science and the realities of the political world. I believe that scientists in the next twenty years will play a far more important role in government than ever before, and I hope they will accept government service if they are asked to do so.

Integrity Vital

As we prepare to defend this country and our allies against the possibility of aggression in the period ahead of us, we must all remember that no country is stronger than the integrity of its individual citizens. Because scientists are more apt to have access to secret information than other groups, they must be even more conscious of this fundamental truth. The scientists of this country are a high-minded, intelligent and loyal group of men and women. Thousands of American scientists have had and still have access to secret information upon which the safety of this country depends, and daily these scientists fully understand the nature of this public trust. It is very rarely indeed that a scientist fails to carry into public life the integrity that is the hallmark of his profession. All Americans, no matter what their occupation, will need to remember in the period ahead of us that no possible excuse can exist for a man to break his word of honor. If he does not believe in the objectives of the society for which he works, he is free to criticize those objectives, but he is never free to betray them. Criticism is a very different thing from betrayal and this again is something all of us will need to remember as we stand firmly for defense of our constitutional rights at the same time that we work for the defense of our country.

There are many thoughtful men who are frightened by the developments of modern science. I do not share that fright. Those who work in modern science know that it is based not only on objective analysis but also on originality of mind and on cooperation, tolerance and integrity. All scientists depend on the work of their predecessors and progress through the cooperation and honest criticism of their colleagues, criticism which is instantly accepted if it is valid. Men and women have of course developed these same qualities in other fields. I believe that if men are intelligent enough to create mathematical formulae, airplanes, radios, and atomic weapons, they are also intelligent enough to learn how to live together. I believe we will achieve this, and not be destroyed by the tools we have made. I hold firmly to my conviction that we are greater than our tools. For this reason I believe that the prize winners here tonight will ultimately practice their profession in an era of peace.

As scientists in the second half of the 20th Century, you will have an opportunity to join that happy company of men who have felt a compulsion to inquire, to understand, to interpret, and to create. Such men, whether artists, scientists or statesmen, have enriched the vigorous and free society that is our heritage. You will know the pleasure of thought, the exhilaration of building a structure of logic based on established facts and under the discipline of inexorable laws. You will test your ideas by experiment, or see others test them. You will know what it is to struggle through a problem alone and suddenly find the truth as if by revelation. To use your mind in this way is one of the great experiences of life. I hope that each of you who have won these awards tonight will share in this experience.

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MEDICINE

Germ Chemicals Heal

➤ SUCCESSFUL use of two chemicals from hemolytic strep. germs to speed healing of infected wounds is reported by Drs. Joseph M. Miller, Milton Ginsberg, Raymond J. Lipin and Perrin H. Long of the Johns Hopkins School of Medicine (JOURNAL, AMERICAN MEDICAL ASSOCIATION, Mar. 3).

Drs. Miller, Ginsberg and Lipin are also associated with the Veterans Administration Hospital at Fort Howard, Md., where the patients were treated.

The two chemicals are called streptokinase and streptodornase. They act to liquefy blood clots, pus and other waste products produced in certain types of infections and injuries. Removal of this material from infected and wounded areas is necessary for healing and growth of healthy tissue.

The strep. chemicals do not act like antibiotics to check the growth of disease germs, but they may be used with antibiotics if these are needed.

Bedsores, rectal infections, amputated stump infections, pilonidal cysts with abscesses, soft tissue infections and collections of blood in the chests were the types of conditions treated.

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GEOLOGY-PHYSICS

Earth Structure Studied

➤ THE PULL of the sun and the moon on the earth should provide new knowledge about how the earth is constructed.

As the moon moves around the earth and the earth around the sun, the gravitational forces they exert are different in different parts of the world. But these variations are often greater or less than would be expected merely because of the positions of the moon and sun.

Studies carried out in Honolulu and on the California coast show variations about 132% of that which should be expected from a theoretically rigid earth, Dr. Louis B. Slichter of the Institute of Geophysics of the University of California at Los Angeles reports (SCIENCE, Feb. 23).

The earth, under the crust, may be stiffer at some points than at others, accounting for the difference. Or there may be other reasons connected with the earth's structure which causes these variations.

The variations will be investigated further to see whether they give any clues as to what the inside of the earth is like.

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