GENERAL SCIENCE

Encouragement of Science

Our political life can learn from the spirit of science the need for open-mindedness, persistent freedom of inquiry and resistance to dogma.

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Address delivered at the Awards Banquet of the Science Talent Institute in Washington, D. C., March 6.

➤ WE are here tonight to honor you and to celebrate the high promise of your future as scientists. We are happy to be with you. We think of that future with respect and curiosity. We think of the discoveries which you will make. We think of the questions to which we today have no answer, and to which you will come to know an answer. Even more, we think of the answers that we have today, and of the new questions that you will put to those answers. We think of how altered and how deepened our knowledge of the world will be before you are through with it. My first wish to you is that you may make and that you may share in the making of great and beautiful discoveries which enrich our knowledge of the world of nature and of man. I have a second wish for you; but that must come at the end of my talk.

I do not propose to talk to you of such topics of the day as the hydrogen bomb and the statutory provisions of the National Science Foundation. If these matters are not in a very different state when you shall have come to assume the full responsibilities of citizenship, you will have reason to reproach your elders for your inheritance.

Improved Material World

Science has profoundly altered the conditions of man's life. During the last centuries, the discoveries in science, and their applications to practice, have changed the material conditions of life. They have changed as well many matters of the spirit. They have changed the form in which practical problems of right and wrong come before us; they have changed the focus of moral issues, both for the individual and for governments. They have given us new methods for defining the meaning of problems that face us, and for judging whether or not our solutions are just.

The most manifest of the changes are the material ones. Yet even here it takes a certain perspective to see their true extent. Advances in the study of man and other living forms have extended our lifespan by decades. Discoveries in physical science have immeasurably lightened our toil, and enriched our lives. They have given leisure to an ever-widening group of men. They have made a reasonable education not a special privilege, but a common right. They have made the world, in its physical dimensions, a small place, and established the means by which people in remote parts of the earth can communicate with each other, can get to know each other, and can learn to work together. They have put at the disposal of everyone the resources of physical power, of ease and of knowledge that were in the past reserved for the few.

Not all of the changes in material well-being that science offers are realities. Yet the very fact that they are possibilities has changed the nature of the responsibility which we bear, both as individuals and as a community of men and women banded together in government. In the Greek cities, political democracy, and civilization itself, appeared possible only on the basis of a slave economy. Technology, born of science, has altered that; it has enabled mankind, as it has forced mankind, to deal with the issues of slavery as a moral issue. Poverty has always been an ugly thing, and in its extremes a desperate one. Today it is an evil, in the sense that it lies within human hands and human hearts to abate it. Science can provide us, for the first time in history, with the means of abating hunger for everyone on earth.

A New Situation

Perhaps nowhere has the impact of science more clearly altered the specific terms of a great political issue than in the effects of scientific development on warfare. This is a can of worms with which I have myself unhappily been egaged for some years. It would not be honest to say—as it would be folly not to hope—though it would not be foolish to hope—that the very terror of modern weapons would in itself put an end to war; it would even be foolish to say that because of this terror the abolition of war and the maintenance of peace have become the one absolute, final objective of all political decisions. There are other things in man's life, his freedom, his decency, and his sense of right and wrong, that cannot so lightly be subjected to a single end. But what we need to remember is that war today has become, and is increasingly becoming, something very different from what it was a century ago or a millenium ago. We need to recognize the new situation as new; we need to come to it with something of the same spirit as the scientist's, when he has conducted an experiment and finds that the results are totally other than those that he had anticipated.

Four months before Hiroshima, in the last days of his life, President Roosevelt's thoughts turned to these questions. In the last words that he wrote, in words he did not live to speak, the President looked to the future, to the atomic age. He looked to the past, to the days of the founding of the Republic. He wrote:

"Thomas Jefferson, himself a distinguished scientist, once spoke of the 'brotherly spirit of science, which unites into one family all its votaries of whatever grade, and however widely dispersed throughout the different quarters of the globe.'

"Today science has brought all the different quarters of the globe so close together that it is impossible to isolate them one from another.

"Today we are faced with the preeminent fact that, if civilization is to survive, we must cultivate the science of human relationships—the ability of all peoples, of all kinds, to live together and work together, in the same world, at peace."

Science has greatly extended the range of questions in which man has a choice; it has extended man's freedom to make significant decisions. Is there anything in the methods of science itself, or in the spirit of science, which can help in the making of these decisions? To what extent is there a play on the word *science* which can mislead us and take us up false roads when we speak of this science of human relationships? Is there anything we can learn from the relevance of science to politics?

Science, Practical Problems Differ

If we are to answer these questions, and answer them honestly, we must recognize important and basic differences between problems of science, and problems of action, as they arise in personal or in political life. If we fail to recognize these differences, we shall be seeking magic solutions and not real ones. We shall delude ourselves into laying aside responsibility, which it is an essential part of man's life to bear.

In most scientific study, questions of good and evil, or right and wrong, play at most a minor and secondary part. For practical decisions of policy, they are basic. Without them political action would be meaningless. Practical decisions, and above all, political decisions can never quite be freed from the conflicting claims of special interest. These too are part of the meaning of a decision and of a course of action, and they must be an essential part of the force of its implementation.

Political decisions are unique acts. In politics there is little that can correspond to the scientist's repetition of an experiment. An experiment that fails in its purpose may be as good or better than one that succeeds, because it may well be more instructive. A political decision cannot be taken twice. All the factors that are relevant to it will conjoin only once. The analogies

of history can provide a guide, but only a very partial one.

These are formidable differences between the problems of science and those of practice. They show that the method of science cannot be directly adopted to the solution of problems in politics and in man's spiritual life. Yet there is relevance of a more subtle, but by no means trivial kind.

In trying more fully to explore this relevance, I should like to start with a text. This text is a letter* written by Thomas Jefferson to a young man who had enquired of him as to the usefulness of his studies of science. It was written in the middle of the year 1799, the year in which Napoleon abolished the Directory and began to assume dictatorial power in France, the year before Thomas Jefferson was elected for the first time as President of the United States. Jefferson and the diverse brave and hopeful men who with him laid the foundations of our own government had learned much from the peoples of other nations. Many of their highest political ideals and their most powerful political instruments were built on the experience, the insight and wisdom of European scientists and philosophers. Even today we need to remember that this was so, and that there may be much that we can learn from others, and that we should be glad to learn, as in turn by example, we should be glad to teach.

Jefferson's letter starts with a survey of the subjects in science which he believes young Munford ought to pursue. I will quote one characteristic passage which may strike a familiar and homely note for you:

"The science of calculation also is indispensible as far as the extraction of the square and cube roots; Algebra as far as the quadratic equation and the use of logarithms are often of value in ordinary cases: but all beyond these is but a luxury; a delicious luxury indeed; but not to be indulged in by one who is to have a profession to follow for his subsistence."

Thomas Jefferson's Words

But that is not really the part of Jefferson's letter which I commend to you. Here it is:

"I am among those who think well of the human character generally. I consider man as formed for society, and endowed by nature with those dispositions which fit him for society. I believe also, with Condorcet, as mentioned in your letter, that his mind is perfectible to a degree of which we cannot as yet form any conception. It is impossible for a man who takes a survey of what is already known, not to see what an immensity in every branch of science yet remains to be discovered, and that too of articles to which our faculties seem adequate."

*I am indebted to Dr. Julian Boyd of Princeton University for the copy of this hitherto unpublished letter.

And later, in the same letter, still more explicitly:

". . . and it is still more certain that in the other branches of science, great fields are yet to be explored to which our faculties are equal, and that to an extent of which we cannot fix the limits. I join you therefore in branding as cowardly the idea that the human mind is incapable of further advances. This is precisely the doctrine which the present despots of the earth are inculcating, and their friends here re-echoing; and applying especially to religion and politics; 'that it is not probable that any thing better will be discovered than what was known to our fathers.' We are to look backwards then and not forwards for the improvement of science, and to find it amidst feudal barbarisms and the fires of Spital-fields. But thank heaven the American mind is already too much opened, to listen to these impostures; and while the art of printing is left to us, science can never be retrograde; what is once acquired of real knowledge can never be lost. To preserve the freedom of the human mind then and freedom of the press, every spirit should be ready to devote itself to martyrdom; for as long as we may think as we will, and speak as we think, the condition of man will proceed in improvement. The generation which is going off the stage has deserved well of mankind for the struggles it has made, and for having arrested that course of despotism which had overwhelmed the world for thousands and thousands of years. If there seems to be danger that the ground they have gained will be lost again, that danger comes from the generation your cotemporary. But that the enthusiasm which characterises youth should lift it's parracide hands against freedom and science would be such a monstrous phaenomenon as I cannot place among possible things in this age and this country."

To me there are two striking impressions which this letter of Jefferson's makes, even beyond its eloquence and its beauty. The first is that the letter is suffused with the idea of progress, that ideal that owes so much to the development of science and that in turn has provided the great enriching human faith in which scientific discovery and invention has flourished. Jefferson is confident that an increased understanding of the world will lead to progress; he is convinced that the barbarisms of the past cannot stand up against enquiry and understanding and enlightenment; he is confident in man and sure that as men know more they will act more wisely and live better. In our contemporary expressions of hope that catastrophe could be averted and civilization yet be saved, that confidence has lost much of its robustness.

Relevance of Science to Politics

The second point is that for Jefferson there is something in the ways of science that is relevant to political life. Even in religion and politics, he holds that it is probable that things better will be discovered than what was known to our fathers. This conviction that new knowledge is possible, and that not all the answers are known, is of course the stuff of the day to day life of the scientist. Science itself does progress; new knowledge is possible; and new knowledge, because it does not destroy or ignore the old, can only increase our understanding. The very idea of the development of science is an example of progress, and of progress which in no true sense can ever be reversed. But this is only part of the story. It is true, as Jefferson knew, that in the large, science has flourished in conditions of human freedom, and that its growth is parallel to the growth of democratic institutions. Today, looking back on more than a century and a half of further history, we can be even more sure of this. We have seen not only the inspiriting example of science and democracy flourishing together, but the tragic examples of their foundering together. We express the hope that of this tragedy we shall soon have seen the end.

Freedom of Inquiry

What are these lessons that the spirit of science teaches us for our practical affairs? Basic to them all is that there may be no barriers to freedom of enquiry. Basic to them all is the ideal of open-mindedness with regard to new knowledge, new experi-

ence and new truth. Science is not based on authority. It owes its acceptance and its universality to an appeal to intelligible, communicable evidence that any interested man can evaluate.

No Dogma in Science

There is no place for dogma in science. The scientist is free to ask any question, to doubt any assertion, to seek for any evidence, to correct any error. Where science has been used in the past to erect a new dogmatism, that dogmatism has found itself incompatible with the progress of science; and in the end, the dogma has yielded, or science and freedom have perished together.

Our own political life is predicated on openness. We do not believe any group of men adequate enough or wise enough to operate without scrutiny or without criticism. We know that the only way to avoid error is to detect it, that the only way to detect it is to be free to enquire. We know that the wages of secrecy are corruption. We know that in secrecy error, undetected, will flourish and subvert.

Let me be clear. Science is not skepticism. It is not the practice of science to look for things to doubt. It was not by a deliberate attempt of skepticism that physicists were led to doubt the absolute nature of simultaneity, or to recognize that the ideas of strict causality embodied in classical physics could not be applied in the domain of atomic phenomena. There is probably no group of men who take more for granted in their daily work than the scientists. Common sense, and all that flows from it, are their principal basis for what they do in the laboratory and for what they make of it on paper. But for scientists it is not only honorable to doubt, it is mandatory to do that when there appears to be evidence in support of the doubt. In place of authority in science, we have and we need to have only the consensus of informed opinion, only the guide of example. No scientist needs to order his colleagues to use a new technique of experiment or to enter a new field of discovery. If he has done this, it will be an invitation to his fellows to follow.

These then are some of the attitudes of mind, these are some of the disciplines of spirit which grow naturally in the scientist's world. They have grown there in part as a result of a humane and liberal tradition in political life, and in part as a cause of that. The open mind, the reliance on example and persuasion, rather than on authority, these are the heritage of the centuries in which science has altered the face of the earth. Science can help in diverse ways in preserving and extending this heritage. Its very universality speaks across frontiers to make truth manifest in lands otherwise darkened; its material applications create the preconditions in leisure, in education, in means of communication—for the converse of men with each other. Science provides the material and the intellectual basis for a world in which example and understanding can help all men to improve their lot and fulfill their hopes. Today we need to remember that our country, founded on these practices, and grown strong by their exercise, owes its strength to them. In this time of crisis, we need to cherish that strength.

A World of Confidence

And this brings me to my second wish for you. I wish you not only the joy of great discovery; I wish for you a world of confidence in man and man's humanity, a world of confidence in reason, so that as you work you may be inspired by the hope that what you find will make men freer and better—in which, working as specialists in what may be recondite parts of the intellectual life of the time, you are nevertheless contributing in a direct and basic way to the welfare of mankind.

Science News Letter, March 18, 1950

MINING

Liquid Fuels Produced at Costs Near Petroleum

➤ LIQUID fuels from oil shale and coal can now be produced at costs competitive with petroleum products, the Secretary of the Interior revealed in his annual report to Congress.

Refined products could now be obtained from oil shale at an actual cost averaging 7.3 cents a gallon, and from coal at 10.8 cents a gallon. If produced by a private company, these fuels could have a wholesale price of nine and 14.5 cents a gallon respectively with a sufficient profit margin.

Further reduction in costs is certain as our knowledge is extended, the Secretary said. With emphasis now centered on operation rather than design and construction of laboratories and demonstration plants, the synthetic fuels program has entered its most valuable period and is making rapid strides.

The capital investment now required for a plant producing 10,000 barrels a day of crude shale oil, or 8,840 barrels a day of refined products, is about $41,381,000. This would cover mining, retorting and refining. Diesel oil and fuel for jet planes would be the primary products. Motor gasoline could be produced readily by modification of the refining process.

The estimated capital investment for a modernized coal-hydrogenation plant of 30,000 barrels a day capacity is $246,800,000. High-octane gasoline would be the principal product. Byproducts would include liquified petroleum gases and phenols, for which there is a growing demand.

Operation of a limited number of coal-hydrogenation plants to produce chemicals as a major part of the products may be very attractive, the report states. In addition to phenols, coal-hydrogenation plants can produce important quantities of benzene, toluene, naphthalene and tar bases.

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● RADIO

Saturday, March 25, 3:15 p.m., EST

"Adventures in Science" with Watson Davis, director of Science Service over Columbia Broadcasting System.

Dr. John D. Mizelle, Department of Zoology, University of Notre Dame; Dr. Fernandus Payne, Professor of Zoology at Indiana; Dr. Lawrence Baldinger, Dean of College of Science, University of Notre Dame; and Dr. Ralph W. Lefler, Department of Physics, Purdue, will discuss "How Nature Helps Mankind."