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The Role of Scientists in the Furtherance of Science¹

Detlev W. Bronk

President of the Rockefeller Institute

MY THOUGHTS on this occasion are colored by memories of the first meeting of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE I attended during the initial term of my graduate study. That, which was my first scientific meeting, was an inspiring experience for which I shall always be grateful to the Association. As a beginner in research, I was stimulated by the contagious enthusiasm of accomplished investigators who told of the experiments they had performed, of their observations, and of the new knowledge they had thus acquired. I well remember an evening in Hart House, at those meetings in Toronto, when I listened on the outer fringe of a small group of physicists who were telling one another of their work and visions, now far exceeded. Then I knew, for certain, that for me there could be no other satisfying life than the life of a scientist, lived in the friendly companionship of scientists. The pinnacle of my desire was the sanctuary of a simple laboratory, with ample time for inquiry and contemplation.

I have seldom known the tranquility I imagined. But thirty restless years since then have been years of rewarding satisfaction that has far exceeded my expectation. I have found that intellectual adventures and the quest for understanding can go forward in times which are not tranquil.

In such periods of rapid change it is well to stress the continuity of science and the values of our heritage from those who were our predecessors. For there is enduring vitality in the purposes and ideals which motivate scientists and enable them to further science under various and changing conditions. But the record of history reminds us that the continued progress of science requires that scientists actively resist adverse social pressures. Continued progress cannot be assumed if we drift unwittingly under unguided forces.

To assure the wholesome development of science, we need from time to time to reconsider its status in our changing culture and to reformulate conditions suitable for the furtherance of science. There is especial need to do so now. Science shapes the lives and thoughts of men and the destiny of nations; many who are not scientists are thus tempted by the will to serve or by the lust for power to control the policies and conditions under which scientists must work. Scientific research and knowledge are essential elements of mod-

ern life; the changing patterns of civilization are influenced by and, in turn, have a profound effect on the nature and the course of scientific activity.

This is justification for inclusion of some who are neither scientists nor professional scholars in any field among administrators and trustees who play a powerful role in guiding the affairs of science and its uses. It does not justify their lack of understanding of science and the conditions under which it can flourish. It does not justify the present inadequate representation of scientists on councils that formulate the policies of scientific institutions and determine the destiny of peoples in this scientific age.

Two things are needed. Men of affairs and social influence need more knowledge and appreciation of the traditions, ideals, and significance of science. Scientists are in part to blame for such lack of awareness. In the process of education, and in our reports to the public, we have emphasized too much our discoveries and their useful applications. We have inadequately revealed science as a great intellectual adventure. Unless this quality of science is more generally comprehended, we shall be subject to adverse pressures that result from lack of understanding.

Those best able to formulate the policies under which scientists do their research and teaching and make their social contributions are scientists themselves. Accordingly, a second need to which I have referred is for more scientists as trustees of our universities and research institutions and as administrators of governmental and private organizations concerned with science and technology. There is need for more scientists in the higher levels of government.

One of the basic and admirable characteristics of our culture is the traditional willingness of public spirited men and women to give their unselfish service to the furtherance of our free institutions, as trustees of our heritage and our future. So, too, is self-sacrificing service to the affairs of democratic government. If these traditions are to be adapted to the requirements of our present culture, more scientists, engineers, and physicians should be on boards of trustees and in the legislative and executive branches of government.

Schools and universities devote much of their resources to scientific teaching and research. But few scientists are on their governing boards. The men who formulate our laws, and those who administer the affairs of government, deal with the problems of a scientific age. But you will with difficulty find trained scientists or engineers in Congress or in presidential cabinets. I have a high regard for the wisdom of law-

¹This address was delivered by Dr. Bronk, the Retiring President of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, at the Annual Meeting, Dec. 1953, at Boston, Mass.

yers, industrialists, and financiers. I have no less regard for the wisdom of countless scientists whom I have been privileged to know. Society needs their participation in its guidance. This they can best do by serving on governing councils, not as mere advisors and correctors of unwise actions.

This role of scientists in the furtherance of science is now of practical importance when the course of science is so largely influenced by financial pressures.

Curiosity and ideas are powerful directive forces in research. But the opportunity to follow our curiosity is limited in some degree by the availability of material resources. This is emphasized by the difficulty of conducting much of modern research in schools and colleges and by the growing dependence of universities on research grants and contracts. If it were our national policy to give available funds to faculties to use as they thought best, we could rely on the curiosity of scientists and scholars to further science. But, while funds come through budget makers, appropriations committees, and fund raisers, the effective development of science requires that policies be determined and executed by scientists who are also men of affairs.

We have an especially significant role to play in the formulation of national policies when authoritarianism and the suppression of inquiry and free discussion are fostered by fear of change. The continuing vigor and vitality of our nation and our sister democracies require courageous leaders who are intellectual adventurers, as scientists must be.

During times of rapid change, which greatly tax men's courage, it is natural that there should be widespread desire for the illusory tranquillity of the past. It is natural in these times of stress that men and women should occasionally grow weary and then regret the sacrifice and effort necessary to sustain the progress of civilization. But the record of the past reveals no time when the spirit of inquiry was secure against the threat of timid, reactionary forces. That spirit was secured by valiant effort and sustained by faith in man's power to grow in dignity and knowledge. In the history of mankind, I find no times of which man can be proud in which men did not use their power to increase their understanding and use newly discovered knowledge to change their way of life. In change there is hope and growth; in security there is only atrophy of the spirit.

As a scientist, I think of intellectual adventure in terms of scientific research and inquiry. As members of the greater community of scholars, we should think of science as encompassing all significant knowledge which enriches life. Science in that broader sense is a great odyssey of the human spirit. Because it is just that, I do not see this age of accelerated science leading to the catastrophic decline of western culture nor to the hobbling of man's spiritual aspirations predicted in the poet's line: "Never glad, confident mornings again." The future I envision is one of glad, confident mornings of new days of greater satisfaction.

I should not have such hopes if science were merely

the means of satisfying the material wants of man. My hopes would be still less if the use of science were to secure our present state.

Those who attribute the woes of the present to the rapid advance of science should reread the record of human travail. As Dorothy Stimson, historian of science, says of the days in which modern science began its slow progress three centuries ago: "Wars raged, dictatorships threatened, and people were driven out of their homelands to seek refuge in far countries. Men's personal liberties were at stake. Censorship confronted the daring writer, and Milton was fighting for the freedom of the press. It was a time of violent change."

The violence of those times cannot be charged to scientific progress. Rather, it was the restless urge for change to better ways that fostered the development of science. Unstable ages, such as those and ours, have been the greatest ages in which were formed the salient movements toward human progress.

Progress requires courage. If we are to fulfill our rightful role in the furtherance of science, we need abundant courage. For this we are fitted by tradition and by the nature of our calling, for we are discoverers and teachers of new knowledge which is usually challenged and disputed. And so, there is no place in science for timid men and women who are unwilling to defend their necessary freedom for inquiry and free unprejudiced discussion. The furtherance of science requires courage to withstand the pressure of reactionary forces.

In the traditional spirit of science, the courage of intellectual explorers is tempered with humility. We, who must question the fallible authority of men and man's inadequate formulation of natural laws, have no right to the certainty of arrogant opinions. If we are to fulfill our rightful role as partners in the councils of state and in the guidance of public and private institutions, we shall require the humility that is derived from awareness of our limited competence and knowledge.

Having said what I have said regarding the role of scientists outside their laboratories and classrooms, I would also say that we impede the progress of science by requiring men who are able teachers and investigators to abandon science for administration. The two roles are not incompatible; they need not be inconsistent if we do not make a fetish of administration, as we are prone to do in this country where the administrator is more respected than the scholar.

I have often thought with nostalgia of the Trinity College I knew at Cambridge. It is true there are some administrators hidden away in an obscure building. There is a vice-chancellor who serves as president for a term of years, but he continues to be a creative scholar. The college has a master, but he too is a scholar such as Adrian who succeeded George Trevelyan who followed J. J. Thompson. Much of the administration is assigned to one who is significantly referred to as Junior Bursar. There are committees, but the one I have heard most prized is the one on college

wine which lubricates the flow of sparkling conversation.

And so I was disappointed this past year when I read in the biography of Sir Harold Butler, lifelong civil administrator that he was, this of Oxford, no less than of Cambridge:

It seems a sad frustration of purpose that the time and effort of so many men capable of higher things should be frittered away on details of organization and finance. The gift of teaching or the capacity for original thinking and research is much less common, and therefore much more precious, than administrative ability. When one finds the same sort of busy absorption in current affairs as is so familiar in the financial world—college meetings, university committees, faculty boards, close schedule of interviews and appointments, colloquies with government departments—one wonders whether the mechanics of university life is not submerging its spirit and obscuring its goal. At moments an uneasy suspicion invades my mind that to some professors university politics and the vast web of interlocking and overlapping bodies, by which the university is over-organized, offers a more attractive field for intellectual enterprise than does the severe discipline of learning. In any case, for most of those caught up in the details of administration there could be little scope for sustained reading, still less for sustained reflection which is a much more exacting enterprise. For them there is little leisure for the contemplative life by which the finest fruits of the spirit are nurtured. The repose, the peace of mind, the freedom from pressing material care seem to have vanished. Until they are recovered, our culture will be the poorer.

I must assume that growing populations and the increase of research, new knowledge, and education create new conditions. But I still believe that scientists can fulfill their broader functions while remaining scholars.

It is customary to think of scientists as only teachers or investigators. There have been many notable exceptions, such as Benjamin Franklin. Research has been for them an essential and a continuing way of life, which they did not permanently abandon while they engaged in other fields of action. Those other duties stimulated their curiosity regarding nature. They enriched the civilization of their times by bringing scientific knowledge and ideals to bear on social problems, as did Franklin when he issued this enlightened communication to the commanders of all armed ships acting by commission from the Congress of the United States at war with Great Britain in 1779:

Gentlemen, a ship was fitted out from England before the commencement of this war to make discoveries in unknown seas under the conduct of that most celebrated Navigator and Discoverer Captain Cook. That is an undertaking truly laudable in itself because the increase of geographical knowledge facilitates the communication between distant nations and the exchange of useful products and manufactures, extends the arts, and science of other kinds is increased to the benefit of mankind in general. This, then, is to recommend to you that should the said ship

fall into your hands, you would not consider her as an enemy, nor suffer any plunder to be made of the effects contained in her, nor obstruct her immediate return to England.

Only a statesman who was a scientist would have written that; only a scientist who was a statesman would have had the opportunity to send that message.

The swift progress of modern science and the complexity of instruments of investigation make it difficult to participate in broader spheres of action. But the intimate interdependence of science and all other phases of modern life requires that scientists accept such obligations. A. V. Hill, our distinguished guest from the British Association, is one who has shown that the assumption of such obligations is not inconsistent with the continuing life of an investigator. Following his brilliant investigations, for which he received the Nobel Prize, he devoted much of his time for ten years to the duties of Secretary of the Royal Society. He was an active member of Parliament during Britain's most trying years. Throughout two wars he played a leading role in her defense. And yet, his lecture last evening was brilliant proof that he is still a creative scholar back in his laboratory with his beloved galvanometers, thermopiles, and muscles.

We need to revise and broaden our concept of a scientist's functions and his role in society. Unless we accept that broader role, our work and we will be controlled by those who do not understand the requirements for the furtherance of science.

One such role that we must play is that of resisting pressure to devote too much effort to research of immediate practical value. I know of no significant distinction between fundamental and practical research. Pasteur's investigation of practical problems revealed knowledge of great fundamental significance. Faraday's fundamental discovery of electromagnetic induction certainly was necessary for the subsequent development of electric power and light and traction. The botanical research of Gregor Mendel, in the garden of a monastery, initiated increased production by modern agriculture. The theories of Willard Gibbs laid the foundation for much of our chemical industry. Their research was of practical value, but, excepting that of Pasteur, it was not undertaken for any obviously practical purpose.

To foster research of immediate practical value at the cost of exploratory research has consequences not unlike the squandering of natural resources. Both impair the welfare of future generations. We who have benefited so richly from the discoveries of our predecessors have an obligation to our successors. As scientists we can fulfill that obligation by pushing forward our explorations on the frontiers of knowledge, for the achievement of material objectives, as did Pasteur, or merely in the quest for knowledge, as did Faraday.

Too great emphasis on research that is of present value has a harmful influence on the education of scientists. It encourages training for immediate useful service at the expense of education which is a foundation for continued intellectual growth and ulti-

mate competence to solve unanticipated problems of the future. It fosters undue specialization.

If those who support science think the goal of science to be quick answers to practical questions, scientists will be trained for limited objectives. As society accepts the responsibility for supporting more scientists, more men and women will be recruited who are content to fit themselves for a small sphere of scientific action. There is useful work for them to do, and organized research will undoubtedly increase their usefulness. But if the quality of scientific training is determined by the needs of those who are content to be mere technicians, those who would be more will suffer.

Now that science is no longer in its simpler childhood, it may be too much to hope that many can encompass the range of attributes attributed to Newton by Einstein when he wrote: "Fortunate Newton, happy childhood of science. . . . In one person he combined the experimenter, the theorist, the mechanic, and, not least, the artist in exposition." Despite the growth of science, we can resist the pressures of mass education, organized research, and the economic lures and limitations of quick achievements.

In these times, when modern science gives to selfish few the power to control the thoughts and lives of many, there is need for vigorous emphasis on scientific inquiry as an intellectual adventure of those with unsuppressed curiosity.

Those who have done most to further science did not cultivate a fugitive and cloistered virtue. They were partners of many others in a great undertaking in which they used intellectual inquiry as a powerful means for promoting the growth of man's spirit. They did not abandon inquiry because the consequence of inquiry and research is change.

To wonder and to wander lead upward in the trend of life. When man ceases to wonder and to wander from necessity or choice, he ceases to ascend in the scale of living beings. Physical wandering is still important, but as the geographical frontiers are passed the value of man's spiritual adventures increases: adventures of thought, adventures of emotion, adventures of aesthetic experience. The desire for security and the suppression of curiosity inhibit the intellectual and spiritual development of man.

When science seemed less important, scientists were freer to do as they wished to do. Nowadays, there are many who are willing to support science, provided they can organize and direct scientists' activities—about which they know but little.

The continued progress of science requires that scientists interpret to those who are not scientists, their potential contributions and the nature of their competence and limitations. To secure those conditions in which scientists can most effectively pursue their search for truth demands that we vividly define our motives and objectives.

Many of the most important discoveries of scientific research have come from intellectual adventures of individual scientists. No one directed Newton to discover the laws of gravitation. No one organized Fara-

day's discoveries in electricity for the benefit of the modern electric age. No one suggested to Roentgen that he discover x-rays for the diagnosis of human ills. No one instructed Niels Bohr to pave the way for the production of atomic energy. Many scientific discoveries will continue to elude direction and organization as surely as would the creation of great music or poetry, or sculpture or art. Much of scientific research is exploration of the unknown and I, for one, do not believe that it is possible to direct the course of an explorer through unexplored territory.

Scientists have a second purpose. It is their desire to bring order out of chaos. Curiosity lures scientists to the search for new knowledge through observation and experiment. The wish to relate facts and fit them into a consistent pattern is the motive which causes them to formulate natural laws and the concepts that make scientific facts meaningful and usable.

Those who suddenly comprehend the relations of previously unrelated facts, and thus see their relevance, experience a deep esthetic satisfaction. It is in that phase of scientific endeavor that facts and observations are formed into the structure of knowledge, which is the foundation for further discoveries. This is the role of the scientist's creative imagination. Without freedom and leisure for the play of his imagination, a scientist becomes only a fact gatherer, dealing with the bare bones of science, unarticulated and unclothed with the flesh of meaning.

This subtle process, from which so much of human value comes, has been described with rare insight by John Livingstone Lowes in *The Road to Xanadu*. In that study of the ways of poetic creation there are these passages:

"The ways of the creative process are not the monopoly of poetry. In the field of science, too, the imagination draws the immense confusion of phenomena within the unfolding conception of an ordered universe.

"For years, through intense and unremitting observation, Darwin had been accumulating masses of facts which pointed to a momentous conclusion. But they pointed through a maze of baffling inconsistencies. Then, all at once a flash of vision came. Only then, and not before, could he slowly frame the great statement of the theory of evolution," which has reshaped men's thoughts.

Considering the work of Newton, Lowes goes on to say: "The leap of the imagination from the fall of an apple in the garden at Woolsthorpe to an architectonic conception, cosmic in its scope and grandeur, is one of the dramatic moments in the history of human thought. But in that pregnant moment there flashed together the profound and daring observations and conjectures of a long period of years; upon the instant of illumination followed other years of rigorous and protracted labor before the *Principia* appeared."

Thus to bring order out of chaos and attain understanding is one of the great roles of the scientist. As we plan our new age of science we shall do well to preserve an environment in which this purpose will be

nurtured, despite the urgency of present needs. For it is unlikely that the scientist's imagination will often leap to a specified goal. A chaos of facts will seldom fall into an ordered, predetermined pattern useful for a certain end.

Our colleges and universities have long provided a congenial atmosphere for the furtherance of science. They are best suited to integrate all fields of knowledge and to nurture free inquiry and speech. Their faculties inspire and educate our successors in an atmosphere of intellectual adventure. But this will cease to be so if lack of funds limits teachers to the teaching of science that is carried forward in wealthier laboratories outside our educational institutions. Universities will be deflected from the fulfillment of their proper functions if they are required to earn a hand to mouth existence by doing the odd jobs of science.

If universities are to fulfill their vital mission in modern society, they require greater freedom in the use of funds for the work of scientists who cannot honestly define detailed projects because they are explorers on the unexplored frontiers of science. They require more support of men and less of projects favored by administrators who are unversed in science. They need no less support of science, but more support of other scholars who are partners of scientists in the advancement of knowledge. It should be more

generally recognized that the faculties of universities are best able to plan the balanced development of their scholarly activities without direction from others. At a time when vast resources are needed for research that can no longer be performed by individual scientists, universities need to be fortified in their primary devotion to the intellectual development of men. Only thus will the future of science be assured.

Scientists will best fulfill their role in universities if they focus their efforts on the cultivation of the bold adventurous spirit which scientists share with all others who foster lives worth living.

This was expressed in cogent words by the distinguished predecessor of Earl Stevenson who is our distinguished host on this occasion. Said Arthur D. Little: "Ours is the duty and the privilege of bringing home to every man the wonders, the significance, and the underlying harmony of the world in which we live to the end that all undertakings may be better ordered, all lives enriched, all spirits fortified."

This great Association of scholars has a rich heritage from the inquiring minds of those who had the spirit of adventurers and the courage to defend their freedom to seek and state the truth. It is our high mission to preserve that freedom for those who will follow us in the furtherance of science.



The Duty of Dissent¹

E. U. Condon

Corning Glass Works, Corning, New York

YESTERDAY noon I happened to turn on the television set and there was a sidewalk interview going on with my former boss, Harry Truman. He was asked "Do you think that our basic freedoms are being threatened?" To this the former President replied, "They are being threatened, but they are not in danger!" That remark did my spirits a lot of good, depressed as they occasionally are by the rubbish that is being peddled so violently and vociferously these days.

We hear a lot of talk these days about our freedoms and our liberties, which, as former President Truman opines, are being threatened but are not in danger. Occasionally a voice is raised to remind us that liberties and freedoms imply duties and responsibilities. Usually before long it turns out that the writer or speaker is weaving a neat little argument to prove that the duties and responsibilities take the form of pres-

ures toward conformity, and thus act as curbs on the liberties and freedoms.

What I want to express briefly is that conformity, in the sense of uncritical adherence to some established doctrine, is a deadening thing to the scientific and intellectual growth on which progress depends. This being so, we have not merely the freedom and privilege of critical examination of the ideas and facts and interpretations put before us for our acceptance, we have a positive duty to exercise that privilege by active use of our critical faculties, a duty without the exercise of which we cannot be said to have discharged the responsibilities of democratic citizenship.

It is this attitude toward new data and new conclusions that we find well developed in scientific research at its best. It is this attitude that is often so sadly lacking in the politician's approach to social problems, and that is so sorely needed there, even though its use in the political field is so much more difficult because of the emotional connotations of many social problems. It is, I am convinced, the lack of this attitude in handling political problems which, more than anything, retards progress in this field.

¹ At a luncheon meeting Dec. 28, 1953, on the occasion of the presentation of the AAAS-George Westinghouse Science Writing Awards, Dr. Condon, as president of the AAAS, made the principal address from which this is taken. Parts dealing with personal reminiscences of his days as a newspaper reporter in California, 1918-1921, have been omitted.