1 January 1965, Volume 147, Number 3653 SCIENCE

The Changing Environment of Science

What are the effects of the so-called scientific revolution upon science?

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I suppose it is fair to say that scientists as a class have deeper concern about the present state of the world than most groups. This concern is natural and understandable. It undoubtedly had its origin in World War II in such dramatic developments as the atomic bomb and biological warfare, which disclosed new and awesome possibilities of man's destroying himself through the findings of scientific research. Since that time the picture has broadened and changed considerably. With the cessation of active warfare the contribution of scientists to the development and use of military weapons and devices has lost much of its compulsive quality and has returned to a more normal state.

However, the change of greatest import to scientists developed as an outgrowth of the cold war. It is the general realization that the entire future of a country, not just its military might but its economic strength and welfare, depend markedly upon its progress in science and technology. This has brought scientists into prominence as the potential saviors of their countries, a most embarrassing position for any group but especially for ours. In the past we have tried to avoid publicity; it is a disturbance to calm and concentrated thinking. Rightly or wrongly, approbation of the public has been of relatively little importance to us; it is the recognition and respect of our colleagues that counts. In normal times our allegiance is strongly to our science; to attempt to direct our efforts toward causes of national importance is ordinarily confusing and disturbing. We have a fundamental conviction that the country's cause is best served when we are given *carte blanche* to work as we see fit, since we know very well that the greatest progress in science is made when that is the case. But this is an oversimplification. We must admit that the demands of technology have been present from the very beginning. Archimedes produced his engines of war, Galileo studied the operation of well pumps, Newton gave serious attention to navigation, Jenner had his cow pox problem and Pasteur his beer project and the prevention of infection. And, as a matter of fact, such pressures have been responsible for much important progress in science itself. For some time now the feedback from technological innovations, themselves stimulated by basic research, has made countless techniques and instruments available for fundamental research.

Thus, in an important sense the conflict between science and technology is not in itself a real conflict of interest. The conflict occurs principally because of the competition between the two for money and manpower. The public, unable to distinguish clearly between them, gets into the act by insisting upon prudent, economical, and understandable use of its (public) funds—that is, tangible and useful results. Unfortunately for many academic scientists, life has a way of presenting insistent practical problems whose solutions require their attention.

Within science itself, however, one finds an increased sense of responsibility for our future. This is not due solely to the strengthening of the popular image of the scientist; it is heightened within science itself—in many areas which give high promise of progress, notably in biochemistry and genetics; in nuclear physics, with its potential for power from nuclear fusion; in exploitation of the oceans for food and minerals; in attempts at weather modification, and in the exploration of outer space. This promise is augmented by the extension of knowledge to such incalculably remote domains as the atomic nucleus and galaxies nearly at the boundary of the known universe, not to mention the almost unbelievably complicated structure and behavior of the living cell.

This sense of responsibility is spurred by the reputation scientists have acquired with the general public, which has served both as a stimulant and a sobering influence. On the one hand every country has come to believe that its salvation lies in technology—usually misnamed science. The technical industries have looked to their research departments and their research analysts for the most dependable forecasting of profitable lines for future development. The man on the street seems to view all this with mingled feelings. On the whole he is grateful for progress in health measures, communication, housing, transportation, and the many technical conveniences which both simplify and complicate his existence, despite occasional feelings of resentment over the increasing novelty and complexity

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This article is adapted from the presidential address delivered by Dr. Waterman, retiring president of the AAAS, on 28 December 1964 at the Montreal meeting.

that surround him. When it comes to major events, such as possible devastating nuclear war, fallout, or the costly but intriguing conquest of space, the element of anxiety is added. "Why isn't there some way," he asks, "to keep our technological advances within safe and prudent channels? Why must these troublesome questions arise? Can't scientists be persuaded to work only constructively? If they can't do that, why don't we limit their activities by providing money only for selected desirable and noncontroversial enterprises?" Indeed, some would go so far as to advocate a moratorium on research in the natural sciences, on the one hand to avoid such disagreeable issues as those posed by nuclear and biological warfare and, on the other, so they say, to allow the social sciences to catch up and solve these vexing problems before the natural sciences make them too tough.

Science Policy

In the meantime, how has modern society been dealing with all this? What degree of attention are nations giving to this subject? To what extent do their governments participate in the conduct or support of scientific research and development? What sort of policies are emerging? These are questions which the Organization for Economic Cooperation and Development (the OECD) has canvassed among its member countries, a task for which we owe it a debt of gratitude (*1*).

In the OECD observations regarding general aspects of science policy, the following points were apparent. In the first place, education is a critical factor, since it must provide the human resources for technological progress and because it creates a favorable psychological climate. Next there must be up-to-date provision for the numbers and skills required in the labor force. An important consideration is the training of potential research workers, and especially of future managers. It appears to be generally agreed that scientists and engineers of high capability are desirable in management positions, in both industry and government. Finally comes the training of the research scientists and engineers themselves. This necessitates high quality in the graduate and postgraduate facilities at universities and institutes of technology.

Immediate potential for meeting these criteria of course exists in a number of countries. In others, further development is required, and in general this becomes a responsibility of the respective governments.

All countries face the problem of securing a satisfactory output of trained scientists and engineers. In most countries this problem is caused by a very rapid rise in research and development expenditures over the past decade; this rise greatly exceeds the increase in the gross national product (*2*). Generally speaking, the ratio of R&D to the per capita GNP is high (1 to 2 percent) in the large industrial countries; in these, industry performs two-thirds or more of the R&D. In countries where there is strong emphasis upon agriculture, forestry, mining, and fishery—such as Australia, Finland, Canada, and Norway—the ratio of R&D to the per capita GNP is lower and industry performs only about one-third of the R&D. In almost all countries the government finances most of the R&D (*3*).

In practically all countries fundamental research is primarily conducted at universities and nonprofit institutions and is increasingly receiving support from government. In the United States, the United Kingdom, and France the government finances applied research and development largely through contracts with industry. Such financing occurs to a much lesser extent in Canada, the Netherlands, and Japan. In Canada, I understand, nearly half the total R&D is performed in government laboratories.

Whereas earlier, in most countries, provision for R & D funds was chiefly the responsibility of the Ministry of Finance or the equivalent office, the more advanced countries are giving increasing attention to the formation of top advisory councils to their governments, which work in cooperation with the finance office. Likewise, in the more advanced countries the influence of the national academies of science has grown, in providing advice to government and in setting the national and international tone for scientific achievement.

Such is the situation facing us and other nations at this stage of development, and such are some of the ways in which we and they have moved to meet our problems.

Because of the mounting commitments to science and technology, much talk and some concentrated thought and study have been directed toward improving the effectiveness of our efforts through planning, management, and education. There have also been attempts to evaluate the impact of the national effort upon our economy and our national achievements. These are important questions, and it is earnestly to be hoped that the current efforts will stimulate concerted and continuous study among economists, social and natural scientists, educators, and administrators. The issues are complex and are not likely to be solved by *ad hoc* committees or conferences alone.

Insofar as this activity sharpens the focus of our attention upon the identification and definition of worthy objectives, their relative priorities, and the feasibility of proposed means of achieving them, it must be regarded as very worth while. However, two important caveats should be heeded:

1) The planning for the identification and pursuit of technological objectives, no matter how feasible or worthy, should not be permitted to monopolize the national effort at the expense of science, and of basic research in particular. Such a policy leads in the long run to diminishing returns and ultimate stagnation.

2) Any attempt to forecast detailed money and manpower requirements for free research in the component scientific disciplines is, in my opinion, a questionable undertaking, no matter how experienced and distinguished the reviewing body. Applied research will always receive this kind of attention. But such attempts for free research introduce a concerted extrapolational bias into the system and sound an authoritarian note. Besides, what stronger motivation can there be for creative, original research than the individual scientist's own evaluation and decision as to the most promising course for him to pursue? As history abundantly proves, the capital discoveries in science generally lie in the unknown and cannot be predicted or planned for—and these may occur in any branch of science.

Effects of Changed Environment on Science

I shall not pursue further this topic of the impact of science and technology on society. Rather, my purpose is to invite your attention to the effects of this radical and sweeping transformation of activity upon the progress of science itself, stressing science in its traditional sense of the "search for truth." In the dynamical center of this interpretation lies basic research—the systematic and specialized search for knowledge and understanding. But of course science is more than this; it is the organized and classified body of knowledge which results from the search. Research is merely its frontier.

With the recent universal recognition that science and technology are essential to the progress of civilization, and with the attendant glamor which attaches to research, the environment for science has altered. For most of its history the devotees of science have been attracted to its study not primarily for the purpose of securing information that might be useful in some practical way but, like Kipling's elephant's child, out of "satiable curtiosity," in the search for new knowledge no matter where or what it might be. With this motivation dominant, the search for knowledge in science has proceeded without boundary or limit. Scientific exploration mushroomed out in all directions, encompassing a range which would have been impossible under concerted planning. Of course many extremely important advances occurred by reason of some practical need or incentive, but by and large the scope and range of scientific investigation was not dictated by such considerations.

During the present century the technical industries, whose existence depends upon successful practical development and production, have increasingly come to conduct research themselves. Many of them have even recognized the advantages of pursuing basic research in areas where such work will lead to better understanding of their technological problems. This trend was accelerated during and after the war by such sensational results of research and development as atomic energy, radar, and the transistor. Nowadays no progressive technical industry or government bureau would attempt a large developmental enterprise without careful survey of the underlying research and, where necessary, inclusion of such research as part of the developmental process.

Mission-Related Basic Research

However, a larger proportion of support is provided for applied research than for basic research; in the U.S. the ratio is about 2 to 1. There is a corresponding majority of scientists employed by industry and government as compared to academic and other nonprofit institutions. For engineers the ratio is of course much higher than it is for scientists.

But this is not all. There has been a steady increase in the support of basic research which may be termed "mission-related"—that is, which is aimed at helping to solve some practical problem. Such research is distinguished from applied research in that the investigator is not asked or expected to look for a finding of practical importance; he still is exploring the unknown by any route he may choose. But it differs from "free" basic research in that the supporting agency does have the motive of utility, in the hope that the results will further the agency's practical mission. A considerable body of basic research is receiving support because it is so oriented. Thus, basic research activity may be subdivided into "free" research undertaken solely for its scientific promise, and "mission-related" basic research supported primarily because its results are expected to have immediate and foreseen practical usefulness. Much of the emphasis upon basic research in the areas of cancer and solid-state physics illustrates "mission-related" characteristics. Since the support of "mission-related" research is easier to justify, when budgets become tight it tends to survive at the expense of "free" research. This tendency, when coupled with the present preponderance of "mission-related" research support, could prove a serious detriment to the progress of science, by curtailing free research and by concentrating too much effort on trying to solve practical problems that currently appear insoluble. As Oppenheimer has pointed out regarding progress in research (*3*), "in the end you will be guided not by what it would be practically helpful to learn, but by what it is possible to learn."

Some idea of the relative magnitudes of national funds provided for "mission-related" and for "free" research, respectively, may be obtained as follows. Let us assume that all funds available in the following categories are provided for "mission-related" basic research: basic research by industry, by government laboratories, and by academic institutions from grants or contracts received from government agencies having practical missions. The latter chiefly include the Department of Defense, the Atomic Energy Commission, the Aeronautics and Space Administration, and the departments of Health, Education, and Welfare, Agriculture, Commerce, and Interior—agencies authorized and encouraged to conduct and support basic research related to their missions. On these assumptions, about 80 percent of the total national funds for basic research are provided for the "mission-related" variety, and only 20 percent for "free" basic research. These figures are far from precise, of course; the assumptions are oversimplified, and many agencies are liberal in their interpretation of what basic research may be useful to them. But the approximate magnitudes of the figures are significant, and illustrate my point.

Two observations concerning this are in order. First, if industry were to confine the research activities of its laboratories strictly to applied research and if the government were to place similar restrictions on agencies with practical missions, leaving the support of basic research entirely to a single federal agency, to private foundations, and to universities, it is reasonably certain that the support of basic research would drop to a mere fraction of its present figure. Second, while this might be attractive in budget circles, such a course would be disastrous not only to science but also to technology.

In raising the question as to the extent to which basic research is supported for essentially practical reasons, I wish to be entirely clear on one point. It is not my purpose to question the importance and desirability of applied research or of basic research which is intended to provide better insights into developmental applications. Both are highly desirable and necessary, and science should play a direct part in their encouragement. They appear to be logical steps in the march of civilization in that they represent progress in providing for necessities such as food, housing, health, communication, transportation, and the national defense. They also contribute attractive innovations in our way of life—comforts, pleasures, opportunities for using leisure, and freedom from routine and drudgery. Of longer-range significance are their effects upon control of our environment; upon extension, in magnitude and in kind, of our sources of commercial power; and upon the discovery and exploitation of natural resources. Above all, whether we like these developments or not, of one thing we may be certain: the forward march of technology is inevitable. This is an important lesson of history, from the discovery of fire and the invention of the wheel and the lever onward. It is a lesson which has withstood the ravages of heat and cold, famine and pestilence, and many ideological conflicts. The convincing proof of this doctrine is contained in science itself—the science of evolution—as the powerful contribution of technology toward survival, and indeed toward increasing domination over environment. During the present century, we are witnessing perhaps the greatest triumph of this doctrine in the conversion of all mankind to acceptance of the thesis that science and technology are essential to survival. This appears to be a thesis to which one must subscribe if one believes in the progress of civilization as we know it.

Historical Philosophical Role

But is this the whole story? From time immemorial man has evolved religions and philosophies representing his conviction that there is more to life than merely its physical aspects. Through imagination, study, and inspiration he has put forward philosophies, modes of conduct, and ways of life that concern the motivations and the aims of the individual and of society. From quite early times science has been thoroughly involved in much of this thinking, as evidenced by the earlier designation of natural science as "natural philosophy." From the record it is clear that, even after this term had fallen into disuse, science continued to have profound influence on philosophical thinking. It still does; witness the number of distinguished scientists of the present century who have written authoritative works on the subject—men such as Whitehead, Eddington, Jeans, Bridgman, and Dubos.

To what extent does this motivation for science still exist? How important is it? Are we observing, or failing to note, the gradual development of a monopoly by research oriented toward practical ends? There will of course always be individuals who firmly believe in the independence of research activity and who strongly wish to carry it on in the traditional academic manner. Will this group diminish in numbers or become frustrated? At the same time there appears to be a rapidly growing body of scientists employed in industry and government whose motivations are mixed, who believe in the support of basic research of the free variety but feel that "mission-related" basic research should have a higher priority, and still others who believe that research should be justified entirely on the basis of its specific utility.

Any uncertainty as to the importance of this question should be dispelled by looking into the history of science and noting: (i) the impressive discoveries made solely in the interest of pure science, and (ii) the statistical evidence that most of the body of science ultimately achieves practical utility.

Thus, even if we admit the requirement of utility as the prime justification for basic research, we still must allow free research to be included. It must be concluded that, in the long run, practical accomplishment will be greatest if in the support of basic research there is no limitation of the research to areas of foreseen practical importance.

I am reluctant to leave this topic without mentioning the thesis to which many, including myself, subscribe, to the effect that completely free research is highly important in its own right, not solely because of the probability that it will progress more rapidly and ultimately produce practical and tangible benefits, but because of its stimulating effect on the imagination and its philosophical implications concerning the universe and man's place in it. Who can say that ultimately this may not be the most important consideration of all?

Source of Strength

I wish now to consider a different but related feature of my topic: What is the secret of the power and influence of science in the most fundamental sense? Is its source of strength at all in jeopardy? If so, are there any steps we ought to take to safeguard its future?

This body of knowledge—science in the modern sense—has steadily developed over the past 400-odd years into a most imposing edifice. Once science had discovered the art of experimentation it found a way to test hypotheses and speculation regarding the nature and behavior of the physical world and thus established a powerful base for drawing objective conclusions. This, together with the development, along with mathematics and logic, of techniques of classification and analysis, united the findings of science into a structure of extraordinary strength and stability. Furthermore, this technique has had a highly democratic flavor: anyone can challenge the alleged facts and theories of science. If he can prove his point within the scientific community by observations, experiments, or reasoning that others can repeat and verify, then his contribution becomes an integral part of the body of science. Science has thus acquired a respect and confidence on the part of literate mankind that is unique. In consequence, the findings of science have a logical validity which is unmatched in other fields of human thought. At the same time, in a most interesting manner science remains flexible, since important new findings may necessitate revision of existing points of view. Generally speaking, and contrary to popular view, these revisions commonly take the form of refinements or increased generality and only occasionally bring about a revolutionary overthrow of existing principles. The impressive result is that the edifice of science has a strength and stability which is dynamic and resilient rather than static and brittle.

How do we account for these characteristics? They appear to be due to the maintenance of a broad base of inquiry; to the exercise of a lively imagination; to the utmost objectivity in search and logic; to a sense of proportion and urgency in the selection of scientific objectives. One must also recognize the necessity of built-in mechanisms for coordination, cross fertilization, and collaboration, and finally—most important of all—of a creative dedication. These are high ideals, not commonly encountered or possible to the same degree in most other areas of human affairs and requiring a high degree of motivation and integrity.

These principles and this code of behavior are thoroughly learned by every researcher, beginning with his years of graduate study. It has been a source of the greatest strength to the body of science that, on the whole, these principles have been scrupulously observed. There has been no means of enforcement other than public opinion within the scientific community. Just as the standing of an individual in his field of research rests primarily with his colleagues, so too does his reputation in his behavior as a scientist. The real strength of this philosophy lies in the fact that these principles are essential for sound progress in science.

Thus, much of the power and stability of science has rested upon the sense of dedication and integrity of the community of scientists. Not only has this been thoroughly incorporated in their indoctrination but it has been further developed and fostered as a code of honor among scientists: to be scrupulously objective in their research, in their reporting, and in giving credit where credit is due. It would seem that the chief reason for the almost universal observance of this code has been that the scientist desires the respect and confidence of his colleagues, rather than recognition before any other audience. Anyone departing from these rules of behavior is ostracized by his kind.

Encroachment of Other Loyalties

In most careers, however, loyalties and motivations are more complicated. They involve such considerations as allegiance to, and recognition by, one's employer and his organization, one's community, church, political party, and friends, and the public generally. An interesting question is the extent to which these other loyalties are increasing in importance among scientists and encroaching upon loyalties to the scientific community. If so, will this warp or weaken the edifice of science or retard its progress?

Profit institutions such as industrial laboratories are, of course, clear examples of organizations that require strong loyalties in carrying out purposes related to the well-being of the organization. The same may be said of government establishments. Because of the increasing proportion, in the scientific community, of scientists employed by industry and government, these considerations are inevitably coming to receive more and more emphasis.

Likewise, with increasing dependence of colleges and universities upon the federal government, federal support of scientific research at these institutions becomes more and more strongly related to their health and strength. Again, this may be manifested in tangible or intangible pressures on the part of academic institutions for their scientists to engage in sponsored activities which are deemed essential to the growth and welfare of the institution and which may bring with them the necessary financing.

Also, in the "project" type of support, members of the scientific community are becoming directly and increasingly motivated toward engaging in research which is regarded as important by a sponsoring agency of the government rather than by their employer. Since most federal support is directed toward practical goals which will serve the needs of the country, there are incentives for an individual to engage in research which will receive this support and therefore may come under the heading of "mission-related" rather than "free" research.

Let me say again that research motivated toward practical ends is a necessary and desirable thing; the potential danger here is the extent to which this objective dominates the scope and purpose of basic research. It was succinctly formulated by Vannevar Bush when he remarked that applied research drives out basic, and I am now using the statement to include also the possible encroachment of "mission-related" basic research upon the "free" variety.

By the way, what will happen if the ceiling on R&D funds is held more and more tightly? If we believe in substantial support for free research, with its admittedly vague and uncertain potentialities, how are we going to protect it? Will it have to depend upon income from capital funds—if so, from what sources? Or will its advocates try to oversell it by extravagant claims?

The influences that govern scientists in their choice of research and their choice of employment are more complex than ever before. Today's ivory tower is more apt to be built of reinforced concrete or stainless steel. These influences are many, some major and some detailed. For example, in addition to the competition between applied and basic research, there are considerations such as needy areas, attractive sources of funds, national or humanitarian causes, "big" versus "little" science, and deference to the plans of one's department or institution. A different kind of influence on research is represented by the following: too much assistance to thesis-writing graduate students, with an eye toward grant or contract renewal; hasty writing and issuance of research reports, scanty in detail and acknowledgment; a tendency to keep a weather eye on funds for extra salary or other perquisites. Further complications are provided by administrative requirements which seem essential to management in large organizations as a means of accounting for public funds, but which distract and hamper the researcher.

But I do not wish to sound too pessimistic. As a matter of fact, I have had rather extensive contact over the past years with scientists in senior academic administrative posts and can assure you that, by and large, they understand these problems and try to hold them within manageable limits. The real danger lies in the fact that in such an extensive enterprise there are bound to be abuses. If these are not dealt with forthrightly they may spontaneously proliferate until there is clamor for formal corrective regulation.

If one were to classify the sources of influence, the first and obvious category would be money—money for projects, buildings, research equipment, salaries, and many minor perquisites. A second category would be the employing institution, in its desire for income, growth, and prestige. One would also have to list the increasing effect of personal advancement or gain associated with the positions of high responsibility, salary, and prestige which are now available to scientists.

Even science itself is providing dilemmas for an individual scientist. Should he join an interdisciplinary team in which his specialty is needed, join a large research center such as a high-energy particle accelerator installation, take part in an extensive planned program, such as oceanography or the study of pollution? Or should he remain aloof as an individual investigator? And what about his responsibility toward teaching?

Conclusion

Of course the consequence of all this may be the broadening out of a scientific career into one more closely integrated with society in general. This is natural enough, and surely after careful consideration most would agree that this result is desirable. My question today directly concerns the necessity for maintaining the strength and integrity of science in the face of varied opportunities, responsibilities, and distractions: How should this strength and integrity be safeguarded? If the involvement of scientists in social affairs brings with it questionable or dangerous consequences to society, then society will take steps to formulate regulations for their prevention, with possible grave effect upon science. Similarly, in science itself, if the course of science and the behavior of scientists appear to scientists themselves to be damaging to its strength and progress, then a normal reaction on their part would be the formulation of rules and regulations to prevent such abuses.

However, in order to maintain and protect the independence and creative quality of basic research in science, one should, I believe, conclude that such modes of regulation should only be attempted as a last resort, and even then as sparingly as possible. It should be clear that the most effective means of maintaining the objectives and initiative that have always characterized science is still the cultivation and retention of a strong sense of competition, cooperation, and integrity on the part of all scientists. All we need do is to continue and strengthen our time-honored traditions. But this is not going to be easy. We shall have to distinguish clearly between our conduct in our science and our behavior in the presence of issues that go beyond science alone. Judgment and objectivity are still required on such issues; the main differences are that these decisions, in contrast to science, require the weighing of opinions and pressures, as well as facts, and the attempt to make value judgments between items that are not comparable. Moreover, in the world of science, compromise has no place; in the world of affairs it must often be reckoned with, and occasionally sought.

I cannot close without mentioning a great opportunity before us which may and should become a most effective avenue for the healthy growth and influence of science. I refer to the progress made in international science programs. As is well known, science has always transcended national boundaries, and scientists of all nations have communicated and collaborated in all its disciplines. There are two categories of research for which international collaboration is especially well suited. The one includes matters of urgent public concern, and is typified by the World Health Organization and the World Meteorological Organization. Of the nature of applied research and development, these matters are, appropriately, planned and sponsored by formal agreement among governments under UNESCO. Such problems as population control, insurance against war, famine, drought and pestilence, and the development of natural resources belong in this category. In all these, science can provide a unique input, the effectiveness of which will depend directly upon the recognition of this fact by governments and people everywhere, and upon intelligent and widespread support by them.

The other category is research concerned with fields of basic research, such as geophysics and astronomy, which require concerted global observation and collection of data. Frequently this is an interesting combination of "mission-related" and "free" research. The International Council of Scientific Unions is performing meritorious service in providing a focus for these endeavors. The outstanding example, of course, is the International Geophysical Year (IGY) and its offspring—the Indian Ocean Expedition, the International Year of the Quiet Sun, the Earth Mantle Project, and the International Biological Year. Unique among these is the Antarctic Research Program, where the IGY program is continued under a 12-nation treaty, expressly and solely for purposes of scientific research.

It is in such areas that scientists are eminently qualified to plan and to operate, and it is in the highest interests of both science and government that they do so. Plans thus formulated may be submitted to their respective governments for support and any formal arrangements needed.

But, beyond this, we stand at the threshold of scientific findings that will pave the way for developments of a different order of magnitude and novelty than the world has ever known. A few are already in sight—notably the exploration of space; others are as yet beyond the horizon. Some will present severe social problems; some may be dangerous; some will be extremely expensive. All will present questions for society that go far beyond the natural sciences alone; they will strongly involve the social sciences and the humanities. They will provide inspiration for the arts. To solve these problems will require many of the skills of our civilization, the utmost in statesmanship, and a general understanding and appreciation on the part of all.

The significance of these developing enterprises in science and technology, their hazards, and their excessive cost in money and manpower point to the overwhelming desirability of international cooperation. Herein lies our great opportunity as scientists—to take the lead in collaboration with our colleagues in other lands and to support our governments in furthering such collaboration.

It would be a tragedy indeed if these undertakings were to become the subject of national or sectional ambition under conditions of unfriendly competition. On the other hand, if we can help achieve an atmosphere of collaboration, in friendly competition, we may look forward to continued healthy progress in our ideals and in our accomplishments for the future of mankind.

References and Notes

1. See *Science, Economic Growth and Government Policy* (Organization for Economic Co-operation and Development, 1963).
2. Canada's increase was once interrupted by a sudden change in provision for industrial development of military aircraft.
3. Exceptions are Japan and the Netherlands, where the manufacturing industry is well developed and there are no large defense, nuclear, or space programs.
4. J. R. Oppenheimer, *The Flying Trapeze: Three Crises for Physicists* (Oxford Univ. Press, New York, 1964).