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Science and Society: Some Policy Changes Are Needed

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For 20 years after the close of World War II, science received unprecedented and, in some respects, unquestioned support from the American public. The remarkable scientific contributions to military victory in 1945 provided a basis for this support, a basis that was extended by scientific advances in medicine and cold war pressures—especially Sputnik.

Annual increases of 25 percent were not uncommon for government science budgets, and these funds became an important part of university budgets. The universities were encouraged, through matching funds and special grants, to add buildings and doctoral-level programs. In addition, even larger sums were appropriated for major development projects that were carried out primarily in industry and were usually, but not always, sponsored by the military.

These expenditures were productive. The spectacular and extremely difficult Apollo program has been remarkably successful. Several diseases were conquered. And there was a great flow of basic research reports that added to our understanding of nature and received international recognition. In economic terms, research and development activities contributed new products, increased productivity in old industries, and were credited with a substantial portion of the growth in gross national product.

In spite of these clear successes, there has been, since about 1964, a new questioning and criticism of science. In part, this was a natural response to the pressure of Vietnam war expenditures: the greatly increased science budgets were obvious targets for possible savings. Nevertheless, the previously accepted rationale for the support of science has been questioned by some and sharply attacked by others.

Generally this questioning has been intended to be friendly and constructive. For example, in 1964 the Congress asked the National Academy of Sciences to prepare a report in response to the following questions: (i) What level of federal support is needed to maintain the United States in a position of leadership through basic research in the advancement of science and technology, and their economic, cultural, and military applications? (ii) What judgment can be reached on the balance of support now being given by the federal government to various fields of scientific endeavor, and on adjustments that should be considered, either within existing levels of overall support or under conditions of increased or decreased overall support?

Not all questions have been so sympathetic. The New Left asserts that most of the present operations of science are within the military-industrial complex and seeks their elimination. Older writers have also attacked science and technology. For example, André Malraux says that "the most basic problem of our civilization" is that it is "a civilization of machines" and that "we, for the first time, have a knowledge of matter and a knowledge of the universe which . . . suppresses man."

In his presidential address to the American Association for the Advancement of Science in December 1968, Don Price described the situation in which science finds itself as an "attack simultaneously from two sides—from a political reaction and from a new kind of rebellion." He called for a review and possible revision of the entire political strategy of science. Scientists themselves are raising new questions about the social value of their work and, more particularly, about the new products which business or government may develop on the basis of scientific discoveries. I believe, with Price and many others, that we need to review the relationship between science and society. Is the old rationale for support of science valid, or does it need to be changed? Regardless of the variety of reasons that individual scientists may have for their personal work, we need a coherent and generally accepted rationale for public support of science.

Generally speaking, I see no sign that many people really want to abandon the conveniences that technology has contributed to society. I doubt that André Malraux wants to abandon the use of electricity or modern plumbing or to forego all forms of motorized transportation. But if he retains these conveniences, he must continue to live in a world full of machines. Man need not be suppressed by machines. He is supposed to be master of his machines, but he has failed to exercise that mastery as positively and as perceptively as he should have.

Lewis Mumford has ascribed many of our troubles to our extending the logical positivist viewpoint of science to society as a whole. It is true, I believe, that there has been a tendency to attempt to extend the quantitative methods of physical science and engineering to inappropriate areas. Thus, for example, in the humanities and some parts of the social sciences, fruitless efforts have been made to deal quantitatively with intrinsically qualitative topics. Also, we have been too eager to adopt any technological advance in a glamorous area such as aviation without waiting to examine all of the consequences. For example, we rushed ahead with the development of the SST without first deciding whether it would really be a

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benefit or a detriment to society generally. The remedy is not to suppress science itself. Rather, society in general must exert its mastery over the resulting technology and, especially, be willing to say no to an unnecessary new technology.

There is, I believe, an area in which the complexity of technology endangers the decision-making processes of American society. Since the framers of our Constitution were well aware of the dangers of an unchecked executive, they designed a careful balance of power between the President and Congress. There has been, however, a tendency for Congress to acquiesce to the President and his staff on matters of technical complexity. I believe it is very important for Congress to maintain its traditional role, even in technical areas. The Senate is seeking to regain its influence: witness the debates on the ABM and the action taken on the SST.

There is no question about the complexity of issues such as the ABM. The technological factors are extremely complicated—indeed, I recall that for many years an antiballistic missile was thought to be utterly impractical by experts in missile engineering. Now it is believed, with good reason, that the ABM is feasible, but it is by no means clear how well the proposed system would actually work or whether another design would be better. Only professionals in this technology have informed opinions on these questions, and they do not agree. Also, since secrecy is necessary, only those with access are informed. The President and his associates, as well as members of Congress, must base their decisions on the testimony of these professional scientists and engineers. Another factor in the ABM situation is intelligence about the weapon systems of Russia, China, and possibly other countries. Here there is even more secrecy: only a very limited number of people have first-hand access to the intelligence data.

The operations, both in intelligence and in research and development, are either in, or related by contract to, executive departments or agencies. Hence, the expert opinions are available initially and directly to the representatives of the President and become available only indirectly, if at all, to Congress. Unless the Congress insists on comparable access to professional testimony, it cannot compete with the President in decision making.

Looking at this situation from the other side, we note that the President and his immediate associates are just as dependent upon the advice of technical experts as Congress is. There is, therefore, no reason that Congress, if it informs itself properly, cannot play its full constitutional role in complex decisions of this type. Executive decisions are not infallible; indeed, I do not think their "track record" is very good. Their greatest weaknesses might be described as tunnel vision, which is frequently reinforced by undue deference to the President.

Most people find arguments unpleasant and like their associates to agree with them most of the time. In making executive appointments, any President tends to choose people with views similar to his own. However, even if the Chief Executive encourages differing views, it is discouraging to be repeatedly on the losing side of internal debates and constrained in openly expressing one's personal views. Therefore, individuals who find their views almost never accepted tend to seek more pleasant or fruitful activities. Hence, the longer a given administration remains in office, the greater the chance that there is no real consideration of different viewpoints.

On the other hand, it is certainly the President's right, if he chooses, to present an apparently united front to Congress and the public on major matters of controversy. Indeed, it would be absurd if the Secretary of Defense were to advocate before Congress a position on a military question that differed from the President's position. Even part-time advisers realize that, after expressing their views to the President in confidence, they must use great discretion in expressing those views elsewhere until the President has made his own decision. After the President has reached his conclusion, and if it is contrary to the adviser's own view, the adviser should at least offer to resign before publicly attacking the President's view. It is easy to see how these factors may lead an administration into a position where important differences in judgment never come to the attention of the President.

The basic pattern in Congress is different. Representatives and senators are elected by many different constituencies and are under no obligation to suppress their personal views, even after decisions are reached in committees or at other intermediate levels. Most of their actions are in public view; even when a congressional committee takes testimony in executive session, a witness is not restrained from subsequently expressing his viewpoint to the President or to a committee of the other house of Congress. Open difference of opinion is intrinsically more acceptable to the Congress than to the White House.

Congressional decision making has, of course, serious weaknesses. One is slowness: hence, if a prompt decision is essential, it must be delegated to the President. Modern technology has created some situations, most notably the use of intercontinental ballistic missiles in case of attack, in which an instant decision is essential. But this does not really constitute a departure from constitutional processes, since Presidents have always been authorized to order the defense of the United States against an attack on U.S. territory.

Another inherent characteristic of congressional decision making is the role of committees. I believe that the complexity of modern problems makes the effective use of committees more important than ever. Congressmen must specialize, and it is better to take the testimony of experts before a committee than before a full house. Some congressional committees have a good record in dealing with complex problems, but others have not. Good staff support is essential, but a weak or bad chairman can destroy the effectiveness of a committee. Therefore, it seems to me that Congress must find some means of replacing an unfortunate choice of a chairman without losing the advantage of reasonable continuity of service.

The balance of power incorporated in our Constitution is still both feasible and very desirable. I believe Congress can make good policy decisions on matters which involve complex technology. Indeed, the intrinsic tendency of Congress to invite differences of opinion is a good counterbalance to the tendency of the Executive Branch toward tunnel vision. But there is serious need for congressional reform, in order that all or most committees can attain the level of effectiveness that a few committees have demonstrated to be possible.

I now review more specifically a few of the major characteristics of science as they relate to the rationale for public support, and discuss possible changes that may be needed.

First, science has both cultural and practical aspects. The great generalizations about the properties of nature comprise some of the foremost intellectual achievements of mankind. Many scientists find their primary personal satisfaction in imaginative experiments and beautiful theories. The rest of society recognizes this cultural aspect of science and participates insofar as it can. In its 1964 questions to the National Academy of Sciences, Congress included "cultural" as well as "economic and military" applications of science.

But let there be no misunderstanding: Congress does not appropriate over a billion dollars a year for science primarily for the cultural enjoyment of descriptions of discoveries. It is the potential of useful applications that justifies the large sums of money. Thus, with respect to this point, I reaffirm that science has both cultural and practical values to society, but that the justification of public financial support rests primarily on the practical aspects.

Second, consider the relationship between basic science and applied science. There is a continuous gradation in research activity from the basic to the most immediately applied. In particular, there are projects of an intermediate type that may be specifically related to an immediate development and yet still be of basic significance. There should be rapid and effective communication throughout this entire range of scientific and engineering work. Basic discoveries should be made known in order to invite applications; in addition, advances in technology frequently make possible new basic experiments. University scientists should be informed about major practical problems so that they can know of possible relationships with their own work and can communicate their own results effectively.

At the same time, there is a real difference between typical basic research and most applied work. The specific problems for basic research are best chosen by the individual investigator. Indeed, his imagination and originality are the keys to the significance of his contributions, although perseverance, skill, and many other qualities are also essential. The freedom in academic circles of the professor to select his own research activities and the stimulus to the imagination of the uninhibited questions of students make universities the best location for most basic research. The absence of immediate and identified applicability is also consistent with the style of thesis-research in which students are allowed to make their own choices of experiments and to learn from their mistakes as well as their successes.

While some important new products and processes arise from the individual inventor, most practical developments require the coordinated work of many people before they are ready for general use. A major technological development program requires that various parts be accomplished at the times required, if possible. Although many individuals should participate in planning the program, each person has an obligation to perform his own task thereafter. The director of the program must have the authority to orchestrate the effort and to change individual assignments when new information so dictates. The major industrial and governmental laboratories are organized along these lines, and they have been remarkably successful in many cases.

The problem of communication has become more difficult as the volume of research and development work has increased. Communication itself has become a major subject of investigation, and many new systems have come into use.

I believe it is appropriate to reaffirm this general picture of the relationship between basic science and applied fields with emphasis on the continuing need to improve communications and other connections between basic and applied science. Also, those purists who disdain applications should be reminded that it is the useful aspect of science that justifies most financial support. At the same time, those individuals who would press all research work toward immediate practical problems should remember that they would thereby be killing the goose that lays many golden eggs.

Third, let us consider how practical developments come to fruition and, in particular, how choices are made among various possible new products or processes. For many years, we have held a sort of laissez-faire view that scientific knowledge would automatically yield economic and social progress. It was assumed that economic forces would lead to the completion and implementation of the useful and desirable developments. In the military area, and to some extent in medical and agricultural fields, there are no adequate economic incentives outside of government; therefore, the White House and Congress must decide on support for development of possible new weapons and new treatments for human, animal, and plant diseases. However, in cases where the product or process can be expected to generate normal income, we have left it to business to decide which possibilities to pursue. The protection of patents is an essential aspect of this development process. This system has often worked well, and many useful products have become available at moderate cost.

A major weakness in our past decision making was failing to recognize that new products or processes might have adverse side effects on the environment. The laissez-faire method does not take into account these social costs and is therefore incomplete. Our present crises in air and water pollution and in solid waste disposal are convincing scientists, engineers, and industrialists that the costs of protecting the environment must somehow be introduced into our decision-making processes.

Action is taking place in various areas, but much more will be needed. The government must be the first to assume responsibility for establishing more adequate standards and in other ways requiring industry to include the cost of protecting the environment in its cost of operation. Until these new arrangements can take effect, government must also sponsor programs to solve environmental problems. These solutions, if they are to be reasonable in cost, will require new developments to which science must contribute a great deal.

Solving the present pollution problems will be difficult and expensive, but we are now proceeding with that task. I want to emphasize the more uncertain but equally important problem of anticipating the environmental effects of proposed new technologies. By the spring of 1969, Representative Emilio Daddario (D–Conn.) and a few others were urging action in this area (which has come to be called "technology assessment"). Since then, several professional groups have studied the problem and issued committee reports, and Daddario has held hearings on this subject.

It will not be easy to foresee all of the damaging effects of a new product or machine, but we should try to do so. Scientific knowledge is now extensive enough that most of the possibly harmful effects can be identified and research can be undertaken to determine their seriousness. In many cases, the only problems will fall in areas covered by standards of waste disposal that should soon become much more comprehensive. But occasionally a new deleterious effect may be anticipated. It will be especially important to advertise this fact and urge that it be considered before commitments are made.

Once a new technology is established, it becomes exceedingly difficult to correct it: many jobs are now involved and much capital has been invested. The controversy over the SST showed how much harder it is to stop an operation than to prevent or postpone its starting. A modified technology that would accomplish the positive purpose and still avoid the damage may be possible, but the change is a lot easier at the design stage than after the plant has been built.

Bills that would establish technology assessment agencies have been introduced in both the House and the Senate. A new assessment group would do studies and would contract for research by others; eventually, it would issue reports and recommendations. In most proposals, it would not have regulatory power. Its recommendations would, however, go to Congress, the President, and the public, and would not be easily ignored. If the anticipated problems fell within the jurisdiction of an existing regulatory agency, that agency could act; otherwise, Congress and the President would have to take the needed action.

In summary, one may say that there is need for a significant change in our processes for deciding upon practical development programs. We must not only assess the benefits, but the harmful effects of a new technology as well—particularly the effects upon those not directly involved. I believe we can still support the view that practical benefits will arise from additions to our knowledge about nature, but our decision making must be improved to select more effectively the truly beneficial developments.

Fourth, and last in this series of topics, is a consideration of the magnitude of our activities in basic science and in the training of scientists. While it is important, and to an individual scientist possibly sufficient, to establish that basic science benefits society, a congressional committee must allocate funds among various activities on the basis of their relative contributions.

In the years immediately after World War II, the appropriations for basic science were small, and it was argued successfully that basic research was so valuable that it should be expanded substantially. Essentially, the only limit placed on the rate of expansion was the maintenance of high standards of quality. There was little or no discussion of a limit to this expansion. By 1960, however, science appropriations were no longer inconsequential, and questions began to be asked about the eventual size of our basic research program. Almost simultaneously, however, Congress began to seek additional funds to allow more uniform geographical distribution of federal support for research. In addition, the space program expanded rapidly. This expansion created a big demand for highly trained manpower and provided additional funds for traineeships and buildings, as well as for research. Consequently, the questions about the eventual size of our research effort did not seem very urgent, and they were not answered satisfactorily.

The 1965 report of the National Academy of Sciences, in reply to the questions from Congress, proposed an essentially demographic approach to funding and advocated further increases in proportion to increases in population and cost of research. Very large projects, such as major particle accelerators, large telescopes, and so on, were expected, and it was agreed that special decisions must be made in these cases. But the report also advocated continuing the old policy of providing support in the less expensive areas for all highly qualified investigators, a policy that it concluded would require increases of about 15 percent per year in appropriations. It is evident that Congress has not accepted this argument recently.

We must acknowledge that there are factors which yield a diminishing rate of return for further growth of basic science. Clearly, increased expansion will involve less than the very best scientists. Communications are also impeded by the flood of research reports; hence, additional reports of less than outstanding significance make it more difficult to learn of the really important discoveries.

The importance of research training should be emphasized, as it serves both to develop human potential in full and to facilitate transfer of new basic science throughout other activities in which it may be of value. Since graduate students perform much of the basic research work, there is a real relationship between the number of research students and the magnitude of our research activities. We have now, for the first time in 30 years, an easing in the demand for scientists. The sharp reductions in the aerospace industry have caused significant unemployment. Although it is not clear just how much overall unemployment exists, it is clear that the supply of scientists fully meets the demand in positions where research training is really valuable. We can no longer argue that research funding ought to be expanded in order to train more students.

I do not have a precise prescription or detailed formula to offer for the optimum size for our program in basic science. Indeed, I believe we should place our major emphasis on quality and not quantity. One of the requirements for quality is reasonable continuity of support. Scientific organizations must be willing to accommodate moderate reductions as well as increases in the size of their operations, but they can and should argue strongly for gradual change and continuity of general policy. Rapid fluctuations would be disastrous.

While I am inclined to estimate that the demand for scientists on the doctoral level will rise again in a few years and that there will be a new shortage, I cannot predict this with certainty. Therefore, I think it would be better to reduce slightly the number of research students and postdoctoral fellows, if fund limitations so require in the next few years, rather than to endanger the quality of our programs.

We should also anticipate, as far as possible, shifts in emphasis to correspond with needs of society. For example, our environmental problems now demand much more attention than they have received, and their solution will come through science, if at all. We need ecologists, obviously, but we also need scientists and engineers from many other disciplines, who will bring their knowledge to bear on these problems.

Although science can hardly expect to regain the almost unquestioning popular support and acclaim which it received a decade ago, I think that most people still believe science to be valuable to society. Man still wants to increase, not decrease, his understanding of nature and his capacity for controlling his environment. Scientists and engineers must help citizens generally, and especially the Congress, deal with the problems raised by technology. If scientists make realistic and effective adjustments in scientific education and research to fit the needs and problems of society today, public confidence and support will be regenerated. Such renewed confidence is not assured; it must be earned by flexible and responsible action related to the needs and desires of mankind.