In sum, there is no doubt that the NSF changed considerably from the "pure" science image it had for its first 19 years. In part this was undoubtedly a consequence of the pressures of the times and of the perceptions of the nation's needs by the White House, OMB, and the Congress. But a large share of the responsibility was McElroy's. Although dedicated to basic research, he also appreciated the strategy of promoting the practical approach for solution of societal problems and, at the same time, securing funds for scientific research. It is apparent that the trend started then has continued and even accelerated. However one may view these changes, it remains evident that McElroy perceived the approaching events and the needs they reflected and that he successfully capitalized on them for the benefit of the nation and of science.

Academic Administration

In February 1972, McElroy resigned from the NSF directorship to become chancellor of the University of California, San Diego. Having spent his entire adult life in academia and being offered the opportunity to lead a young, high-quality institution of higher education, it is understandable that he found the opportunity irresistible. Furthermore, as he himself said, acceptance of this job took him "from the hectic environment" (of Washington politics), which he had not sought, back to an academic environment that was more compatible with his long-standing interests. In his 3 years at UCSD he has worked to balance the sciences and humanities, is overseeing an $80 million construction program, and has guided the establishment of a fourth college, a 50 percent expansion of the medical school, and the creation of several new academic departments. He has continued to strengthen the ties of the university to the San Diego community by establishing a community board of overseers, personally participating in many community civic activities, and fostering joint programs between the university and local corporations. He lives on the La Jolla cliffs overlooking the Pacific Ocean with his second wife, the former Marlene Anderegg, who is also a biochemist, and their young son Eric.

To those who know him, Bill (rarely Mac) McElroy is a vigorous, direct realist who knows and understands science and scientists and has definite ideas about their expanding potential societal roles. He is by nature an optimist, endowed with an agile mind, a quick sense of humor, and an infectious laugh. He retains the friendly informality of his native Texas and is impatient with protocol and stuffiness. Inherently competitive, he likes nothing better than a hot poker session, a tennis match, or a round of golf. Although he no longer plays football, he is an ardent fan and retains a figure not too much changed from that of the Stanford end of almost 40 years ago. A verbal, pragmatic, driving activist, restive with small detail, he has learned the ways of politics and is equally at ease with senators and undergraduate students. Impatient with immobility, his quick and facile mind is capable of improvisation when that becomes necessary and, when all else fails, he is inclined to revert to the old football dictum—when in doubt, charge through the center of the line. It is predictable that during the tenure of office of this likable, brilliant, and active man, AAAS will not sit still.

The Scientist and the Politician

Roger Revelle

In 1889, John Wesley Powell, explorer, geologist, and ethnologist, was the retiring president of the American Association for the Advancement of Science. Major Powell was the founder of the U.S. Geological Survey and the Bureau of American Ethnology; he was an enthusiastic advocate of the creation of a Federal Department of Science. In his monograph on the lands west of the 100th meridian he was the first to show that a shortage of water would limit the development of the West. One might have expected him to use this presidential platform to present his views on some broad issues of science and society, but the traditions were different in those days. His presidential address consisted of a dissertation on "Evolution of music from dance to symphony." It was only in the 1920's that retiring AAAS presidents began to talk about broader issues, usually in terms of science as a great human enterprise and the duty of our Association to defend it and spread its benefits among mankind.

Recognition of the social responsibility of scientists and technologists for the uses of their discoveries came after World War II when the terrifying threats posed by nuclear and thermonuclear weapons became clear to all. But science and technology were still thought of as essentially neutral. Their work could be used for good or ill, depending on the decisions made by other sectors of society. Scientists could try to influence these decisions, but, in their capacity as scientists mainly on technical grounds. Scientists and politicians should maintain an arm's length relationship with each other.

The Necessity for Cooperation

Today this comfortable arm's length relationship will no longer do. The threats to civilization are too real and too immanent for anything other than the closest kind of cooperation among politicians and scientists in the search for ways out of our present dilemmas, in increasing public understanding of the issues involved, and in mobilizing the confidence and will of the people.

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Many events have converged to create our present precarious situation. Among its outward signs are environmental decay; the depletion of resources; the rise of ever more pervasive, ever more unresponsive, bureaucracies, both corporate and governmental; the economic contradictions of capitalism, as they manifest themselves in double-digit inflation, combined with economic stagnation or decline; the tragic gap between the rich and the poor countries with the resulting threats of rapid population growth, starvation, and social collapse; above all the malignant insanity of the arms race, and the strategy of mutual terror. But the real crisis of the West may exist within ourselves—in a failure of nerve, a loss of self-confidence and a sense of pupose, a widening disillusionment with technology, and with economic growth based on technology —in short, a loss of faith in the inevitability or even the possibility of human progress, the great idea that has powered our civilization for 300 years.

When I speak about science it must be understood that I am talking about both science and technology, for in our times they cannot be separated. This was not always true. The most important physical inventions in human history—fire, fermentation, farming, and the working of metals—all occurred before the natural sciences were born. Likewise, the most important social inventions—birth control and cities—were made without benefit of the social sciences. But ever since some people began to realize they could learn about nature through the combination of theory and experiment which we now call science, the possibilities of applying this knowledge have been in the forefront of Western thought. Francis Bacon said that we seek knowledge of nature to extend our dominion over things. Three hundred and fifty years earlier, Roger Bacon had written, "Machines may be made by which the largest ships, with only one man steering them, will be moved faster than if they were filled with rowers. Wagons may be built which will move with incredible speed and without the aid of beasts. Flying machines can be constructed in which a man may beat the air with wings like a bird." And Descartes said, "We can have useful knowledge by which, cognizant of the forces and actions of fire, water, air, the stars, the heavens, and all the other bodies that surround us, knowing them as distinctly as we know the various crafts of the artisans, we may be able to apply them in the same fashion to every use to which they're suited, and thus make ourselves masters and possessors of Nature."

Today, science and technology might be described as having a kind of incestuous relationship because technology is both the mother and the daughter of science. Most modern technological developments, including jet airplanes, computers, contraceptive pills, and hybrid corn, not to mention such mixed blessings as the control of nuclear energy, could not have occurred without the knowledge and understanding gained by science. And scientific discovery depends more and more on our ability to supplement our eyes and ears with complex instruments based on new technologies.

Some of the Difficulties

In discussing the need for cooperation between scientists and politicians, we must start by being aware of the difficulties. First, scientists and politicians have little mutual empathy. The personalities, methods, motivations, roles, and orientation of scientists and politicians are each foreign to the other. The politician is publicly egotistical, gregarious, garrulous, and has a strong gambling instinct. The scientist, at least in his own image, is publicly modest, introverted, relatively inarticulate, and seeks certainty rather than risk. In the past, the best science has been conducted within a narrow discipline, whereas the politician's methods are multidisciplinary in a way those of scientists can never be; they include the ancient arts of rhetoric and myth-making, appealing to the emotional and the irrational in other men as well as to their calculating self-interest. The scientist is motivated by the need to explain, predict, and control phenomena. The politician is motivated by a desire for power. Or to make the contrast more exact, scientists and technologists seek power over nature; the politician seeks power over men. The scientist's role in society is to gain knowledge and understanding; the politician's is to decide and to act. Indeed, in our democracy he alone has the obligation, as the people's elected representative, to make decisions as to what society shall do and to take responsibility for those decisions. In his search for truth, the scientist is oriented toward the future; the politician's orientation is usually here and now. He desires quick visible payoffs for which he often seems willing to mortgage the future. For the politician in a democratic society, infinity is the election after the next one.

Many barriers must be overcome before an effective working relationship can be established between politicians and scientists.

1) Most politicians are lawyers, and lawyers feel most at ease in adversary proceedings in which conflicting viewpoints and evidence are presented as a basis for decision. Scientists generally shun such proceedings, preferring to work in committees or otherwise cooperatively, to examine facts and hypotheses in order to find agreement or to clarify disagreements.

2) Scientists like to categorize themselves in professional disciplines or subdisciplines. Politicians and lawyers traditionally resist classification and tend to think of themselves as generalists rather than specialists.

3) Politicians and lawyers are interested in the particular rather than the general. They do not seek universal truths or broad generalizations, but are content with determining as best they can the facts that bear on a particular situation. Scientists are much more interested in regularities that underlie or explain an entire class of phenomena.

4) Politicians and lawyers need the best possible answers as soon as possible. They are not interested in the scientist's search for certainty and his patient testing of hypotheses. They want to know and use the present state of the art, and in this respect they are more closely akin to engineers than scientists.

5) Technological advances all too often outpace political institutions. In his speech at the centennial celebration of the National Academy of Sciences, President Kennedy said, "Whenever you scientists invent a new technology, we politicians have to make a new political invention to deal with it."

6) With regard to the social sciences, politicians tend to believe, with some justification, that they know as much or more about human behavior from a practical point of view as the psychologist or the sociologist. They are unsympathetic with the tentative nature of the social sciences and the wide

divergences of opinion among social scientists concerning the existence and character of regularities or laws of human and societal behavior. Moreover, like other shamans, they do not like to have their secrets exposed.

7) The main task of the politician is to mediate among competing social pressures—to arrive at compromises that are most acceptable or least unacceptable to most people. The scientist tends to take an uncompromising position which reflects the truth as it is known at a particular point in time.

On Advice-Giving

How can the politician and the scientist work more closely together? One way is to give each other advice. Scientists have long accepted the idea that they should advise politicians, but they are liable to react with alarm and incredulity when it is suggested that politicians should advise *them*. The fact is, of course, that nowadays politicians advise scientists in the most forcible and direct possible way—by granting or withholding support for research and development. I would argue only that this process of mutual advice-giving should contain a better feedback mechanism. The scientist should advise the politician concerning the advice in the form of financial support that the politician gives the scientist. And similarly, the politician should advise the scientist concerning the kinds of scientific and technical advice and the conditions under which it is given that will be most useful to him.

Limitations of scientific advice. When scientists advise politicians both groups need to recognize the limitations of the process.

Most scientific questions of interest to politicians contain a nonscientific, and often what Alvin Weinberg has called a "transcientific element." This is in part because the politician needs answers under time and action constraints that are incompatible with scientific certainty, and in part, as Victor Weisskopf has pointed out, because a complete description of a phenomenon in scientific terms may not contain the elements of the phenomenon that human beings consider most relevant. Political decisions in such situations must be based on judgments that are outside the realm of science. Transcientific questions that go beyond scientific certainty necessarily involve large areas of judgment in which individual scientists disagree. This disagreement is hard for the politician to deal with because he has difficulty in recognizing what, in the scientist's advice, represents scientific certainty and what are elements of judgment, estimation, and uncertainty. In other situations, the politician may accept the scientist's word that there is not enough information for scientific certainty without recognizing that nevertheless there is enough for political action.

The scientist can help the politician evaluate the costs of making different kinds of mistakes, but insofar as these costs depend on value judgments, the scientist can give no more help than any other citizen.

It is often stated that scientists and technologists can give useful advice to politicians about the character and time scale of future technological developments, but this is true only to the extent that the basic scientific discoveries or technical inventions have already been made. Otherwise, the scientist can only limit himself to predictions that physical and biological laws will not be violated. By pointing out to the politician the intractable nature of many scientific and technical problems, he can help the politician suppress his natural tendency to solve these problems by political action. He can help him to avoid legislating a cure for cancer.

The same difficulty exists, a fortiori, in forecasting the technical developments that society will want or should want in the future. So-called normative technological forecasts depend on today's values and ideologies, which in a world of change may change at least as rapidly as technology itself. Normative technological forecasts are likely to be useful only if they are self-fulfilling prophecies.

The scientist can advise the politician on how to cure human ills, but not on how to produce human happiness. He must resist the tendency of the politician and the public to look upon him as a member of a remote omniscient priesthood even though public faith in science and scientists may be essential for the health of both science and society.

Two kinds of scientific advice. Politicians need and can utilize scientific and technical advice given in several different ways. These can be conveniently classified as inside and outside, or, if you will, in-house and out-house. The scientific adviser who is inside the system must be completely inside it. He must accept the politician's rules of accountability and responsibility, which always mean discretion and loyalty and often anonymity. In other words, he should be a professional rather than an amateur. If he differs with his boss, he should resign, but not go public.

Scientific and technical advice from outside the political system is also useful especially if it serves to educate the public as well as politicians. It may be given by supposedly impartial committees formed by academies and scientific associations or even by scientific and technical pressure groups. Scientists can often give the most effective advice by "taking their case to the people."

Does the President need a science adviser? It is clear from what I have been saying that the presence within the Executive Office of the President of a group of full-time knowledgeable specialists, containing a mix of social and natural scientists from different disciplines, is essential to maintain the long-range effectiveness of science and technology in the United States, to develop broad strategies for science policy as well as ad hoc solutions for immediate issues, and to resolve conflicting claims on scientific and technical resources.

Whether advice from these technical experts should be presented directly to the President or should be filtered through a group of generalists in the White House will depend on the President's own needs and style. Some presidents will want completed staff work in which scientific and technical factors are weighed against economic, political, and social ones in the alternatives presented to them for decision. Others will prefer to judge for themselves among the clash of opinions and to formulate their own options.

Political Directions for Science and Technology

The giving and receiving of advice is only one aspect of the need for new relationships between technology and politics. Dean Harvey Brooks of Harvard University recently gave a speech in which he asked the rhetorical question, "Are scientists obsolete?" He immediately answered in the negative by describing 11 major problem areas for future research and development.

Most of these problems have arisen in part from the legislative or administrative actions of politicians or will depend for their solution on cooperation among politicians, scientists, and technologists; for example, energy supply and conservation; pollution control; technology assessment, that is, the side effects and secondary effects of new technologies; efficient, humane, and cost-effective health services; world food supplies and nutrition; the communications revolution as it will be affected by the breakdown of the traditional monopoly of communications by common carriers; problems of increasing the productivity of the public sector, particularly at state and municipal levels, and the productivity of the service industries in general; and the attempt to regain a comparative advantage for the United States in international trade, particularly in capital goods technology. To these I would add the stopping and reversal of the arms race, the highly inequitable distribution of income in the world's poor countries, which probably lies at the root of population problems, and the social and economic transformations being brought about by multinational corporations, which may no longer be responsive to the traditional economic laws of supply and demand.

Beside their political nature, these problems have three common characteristics. (i) They involve the study of complex systems—the ecology of the natural world and of human societies, and systems of information, communication, transportation, and control—that cannot be studied by the conventional reductionist methods of the natural sciences but demand instead a synthetic approach. (ii) They require intimate collaboration between social and natural scientists—consider, for example, the relationships between population distribution and the impact of environmental changes, and communal responses to risks created by environmental hazards. (iii) The responsibility for solutions must be broadly shared among the people who will be affected. To exercise this responsibility the public needs much more understanding of the issues, including the technical and scientific aspects. One of the major tasks of all concerned must be to increase public understanding of the potentialities and limitations of science and technology and the socioeconomic changes they both create and require.

Two Case Studies

To understand the difficulties of joining scientific knowledge with political action, let us take two case studies: our national failure to anticipate the energy crisis and the slow progress of the "green revolution" in India.

The energy crisis. Although scientists concerned with natural resources knew and publicly stated for many years that the potential oil reserves in the United States are limited, and at least an order of magnitude smaller than our coal reserves, the energy crisis in the special form it has taken during the last 2 years was not and could not have been predicted from geological considerations, because, in its immediate aspects, it is economic and political. Nor would it have occurred to traditional economists that the Arab countries and the other oil producers could organize an effective cartel. The actual costs of oil production in the Middle East, both tangible and intangible, are about 20¢ a barrel, a fiftieth of the present price, and the production potential is so much greater than world demand that the principal worry of the international oil companies before 1973 was the possibility of a break in prices due to oversupply.

Development of our own energy resources and a reduction of our profligate use of energy seemed to conflict with other social and economic goals, although from a long-range point of view this conflict was more apparent than real. In the short range, however, the new awareness of the environmental damage caused by energy production, transportation, and use delayed construction of the Alaska pipeline, virtually prevented the burning of high-sulfur coal and oil, inhibited exploration and production of off-shore oil, and mandated energy-consuming antipollution measures. The national fixation on economic growth and the political pressures of vested interests determined government pricing and import policies which exacerbated the crisis of supply and prevented the adoption of energy conservation programs. High interest rates and a shortage of capital, together with the opposition of environmentalists, slowed the construction of nuclear reactors which could have taken some of the load off fossil fuels. The automobile manufacturers stubbornly clung to making monstrous gas guzzlers because of their high profit margins rather than smaller cars that would economize on fuel.

There were sharp disagreements among scientists and technologists on the size of U.S. reserves of petroleum, natural gas, and uranium and on the feasibility and timing of new energy sources. Since 1920 some petroleum geologists have been predicting that our oil reserves were about to run out. These cries of wolf, in the face of increased oil supplies that resulted from new technologies for petroleum exploration and recovery, lulled the public and the politicians into complacency. Optimistic estimates of uranium resources by the Atomic Energy Commission led to a weak program of research and development for breeder reactors. Scientists and engineers differed widely on the likely time scales or even the feasibility of development of thermonuclear fusion and other new energy sources.

Political action was inhibited by public disinterest. The average American, like his political representatives, has a high discount rate concerning the future. Public opinion about long-range problems rarely crystallizes into a sense of urgency. The newspapers, popular magazines, and television reflect this lack of interest by giving little coverage, particularly when the problems concern such hard-to-understand subjects as energy and fossil fuels which are full of numbers. Scientists and engineers have contributed to the lack of public interest by cultivating, or at least not abjuring, the public's faith that science and technology will always come up with a miracle in time to avert a problem. John Sawhill, formerly the Federal Energy Administrator, said in a recent interview, "We can't move too fast on science and technology. The President can't introduce a program until the people are ready to support it, and the people won't be ready until they are in a crisis situation. Once we are in a crisis we can shape a crash program to deal with it. I believe in the efficacy of crash programs. It's only when you marshall all your talents and resources on a crash basis that you get good hard results." In the light of the record in the energy crisis, this viewpoint can be most charitably described as trying to produce a baby in 1 month by putting nine men on the job.

Finally, there were structural difficulties in the federal government and the energy industry that grossly retarded effective federal action. More than a dozen federal agencies were charged with regulation of the energy industry or with energy research and development. The economic structure of the industry itself, as a partially regulated free enterprise, makes government intervention difficult and a cause for resentment. The industry raises formidable obstacles to government action and its structure makes it hard to predict the effects of federal intervention.

We can't go home again. The energy crisis will not go away. Indeed, it is likely to persist for the rest of our lives and perhaps that of our children. It could be the immediate cause of the collapse of Western civilization as we know it. A considerable degree of energy conservation is both possible and desirable, but it is mindless to suppose that we can reverse our dependence on nonhuman energy. We have gone too far in raising life expectancy, and hence the numbers of people, and in lifting the burden of physical labor from the backs of farmers and city dwellers. Without mechanical energy our cities would be uninhabitable and many people would starve.

An old saying has it that "slavery will persist until the loom weaves itself." All ancient civilizations, no matter how enlightened or creative, rested on some form of slavery, because human and animal muscle power was the principal energy available for mechanical work. It is not because we are enlightened that we have abolished slavery but because we have discovered a cheaper source of energy. A man can produce in a day about a kilowatt-hour of mechanical work; to keep him working on the meagerest of diets costs 15¢. Even at present oil prices, a kilowatt-hour of electrical power, or the equivalent in gasoline, costs only about 2¢. By its discovery of less expensive energy than human muscles, Western civilization, unlike all others, has been able to make men free.

Put in other terms, once a society has climbed onto the treadmill of technology, it can never get off again. No solution of the energy problem is possible without far-reaching technological advances in both the production and the conservation of energy. But the lesson up to now is that such technological advances will not occur in time, or may not take place at all, without enlightened, far-seeing political action, courageous political leadership, and clear public understanding of the issues and possibilities. Our future welfare and perhaps our survival will depend on the closest kind of cooperation between politicians, technologists, and natural and social scientists. This, in turn, will depend both on an enlightened public support and on the politician's sensitivity in recognizing what the people would want if they had a chance to want it, that is, the choices they would make if those choices were actually available. Social scientists have a special role to play in defining and appraising the possible range of public choices.

How to stop a revolution. Why has the "green revolution" progressed so slowly in India? When the new high-yielding varieties of wheat were first introduced in the middle 1960's they caught hold with great rapidity. From a few demonstration farms the new varieties spread to millions of acres within 5 years and the results were spectacular. India's wheat harvest doubled from 1967 to 1971. In 1971, India produced a large surplus of food grains, more than enough to feed the millions of refugees who poured over the borders from what is now Bangladesh. But from 1972 onward, food production has hardly increased at all, nor has the area planted to high-yielding varieties of wheat and rice.

A drought in 1972 and poor weather conditions over large regions during the 1974 monsoon, combined with the worldwide rise in petroleum and fertilizer prices, are partly responsible, but a major share of responsibility must be assigned to governmental actions and inactions. Farm prices of cereals have been kept low in order to placate the urban masses while fertilizer prices have steadily risen. It takes two or three times as much wheat or rice to buy a pound of fertilizer in India as in Japan and considerably more in India than in Pakistan.

To buy fertilizers the farmers must have credit on reasonable terms and this has not been available. Most small farmers are still in the grip of the traditional village moneylenders. Many of these farmers are sharecropping tenants with little or no security of tenure; they do not have much to gain from planting new high-yielding seeds which require expensive inputs of fertilizer, irrigation water, and plant protection. Land reform has been virtually nonexistent even though many larger landowners have failed to intensify their farming practices. The state governments, which are mainly responsible for agricultural development, have been dominated by the richer farmers and they have neglected the interest of the small farmers and the incentives they need to increase their production.

Insufficient resources have been allocated to the agricultural sector, with the result that development of irrigation has been very slow even though in most regions irrigation is required for the new varieties. Because of the great uncertainties in rainfall, farmers are reluctant to invest in fertilizers in unirrigated areas, and consequently the growth in the use of fertilizers has lagged far behind the expectations of the Planning Commission. Extension services, which could provide instruction to the farmers on proper techniques of fertilizer application, and soil testing services, which could indicate the required mix of fertilizer and needed soil amendments, are completely inadequate, and consequently crop responses to fertilizers are much lower than they should be. At the same time there have been short falls in fertilizer supply because of the slow rate of development of domestic fertilizer production.

Because the central and state governments have neglected the development of seed multiplication farms, the seeds of the new varieties have been in short supply. Many of the seeds, supposedly of high-yielding varieties, purchased by the farmers are adulterated with seeds of the older varieties or even with weed seeds. The agricultural research establishment has been sufficiently remote from the realities of farming that new rice varieties adapted to the special situations in many regions of the vast country have not been developed.

The future of the green revolution. An enormous increase in agricultural productivity based on new agricultural technology is still possible in India, but it can occur only if social and economic reforms are carried through by vigorous government action and if the government can find the will to divert greater resources from other sectors to agriculture. Here we find another clear-cut example of the issues I have tried to stress: biological and physical science and technology can be usefully applied on a large scale only in the context of changes in social and economic institutions, illuminated by the insights of the social sciences, and carried out by politicians who are able to mobilize an effective public support.

A National Policy for Science and Technology

What can we do to improve the effectiveness of cooperation between politicians and scientists and technologists? One step would be the formulation and adoption by Congress of a National Policy for Science and Technology as a guide to legislative and executive action, just as 25 years ago the Congress adopted a national economic policy. Such a policy would have three clearly expressed goals: (i) to maintain the health and effectiveness of scientific research and technological development in the United States; (ii) to assure the maximum usefulness of scientific and technological advances in serving the people's interests; and (iii) to provide for evaluation and assessment of unforeseen or undesirable effects of new technology and advances in applied science.

Dealing with long-range problems. The policy would recognize that government support is essential to deal with long-range problems at an adequate level of effort. It would emphasize the development of ways to recognize and define problems that will arise in the future and to improve the government's capacity to deal with them. Only the federal government can maintain a sufficiently low "social discount rate" to give a significant "present value" to problems that may take decades to solve.

Maintaining the health of the scientific enterprise. The National Policy for Science and Technology should ensure a continuing flow of highly educated, dedicated, and promising young people into the nation's scientific and technical effort. It should aim at the widest possible base for identifying and educating these young people without regard to sex, ethnic origin, geographical regions, or socioeconomic status. At the same time, the policy should state the national intent to maintain a full range of research and development facilities which will ensure that the nation's scientific and technological community can perform at high effectiveness.

Because experience shows that science and technology form a seamless web, a national policy established by Congress should state the nation's intent to support both pure and applied science, both free research and mission-oriented research and development, both "big science" requiring expensive installations, and "little science" requiring modest equipment, and science in all its disciplines. Science and technology depend on a variety of institutions —universities, government laboratories, industry, and nonprofit institutions— and the National Policy should encompass all of them.

Scientific freedom and responsibility. A National Policy for Science and Technology should provide for a broader public understanding of the nature of the scientific enterprise and the possibilities and limitations of technological development. To further such understanding, scientists and engineers should be guaranteed the freedom to express their ideas about the probable consequences for society of their discoveries, and their sense of responsibility for the potential social effects of their research should be encouraged.

Uses, priorities, and impacts. A National Policy for Science and Technology should aim to ensure that new or prospective technological developments are taken fully into account in the budgeting and programs of federal agencies. At the same time, it should encompass mechanisms to ensure that priorities for scientific and technological research and development set by different federal agencies make sense in terms of national goals, and are realistic in terms of feasibility, scientific and technical manpower requirements, timing of expected results, and available funds. It should recognize governmental responsibility for evaluating the probable impact of new products on human health and welfare and the natural environment.

Science, technology, and foreign policy. Finally, one aim of a National Policy for Science and Technology should be that the best scientific and technical information is fully utilized in making and implementing the nation's foreign policy, and that our unique scientific and technical capabilities are both an instrument and an object of foreign policy. Attention should be paid to means of increasing imports and exports of technology and to the "balance of trade" in technical exchange with other countries. International cooperation and cost-sharing in scientific research and technical development should be encouraged and technology transfer as a major element of assistance programs for less-developed countries should be facilitated. International constraints on oceanic, atmospheric, and space research should be avoided.

What room does this talk of the applications of science and technology leave for the strength and integrity of science itself? These do not lie in the impressive products or the powerful instruments of science but in the minds of the scientists and the system of discourse they have developed to seek a more perfect understanding. The strength and integrity of science can be protected by its uses in education, its international character, and its uniquely human quality.

Scientific research in its broadest sense is the solving of problems to which no one knows the answers. This is the essence of higher education and it is why teaching and research should be inseparable. Scientific education must include the learning of facts and unifying principles, but it is far more important that students learn how to discover, recognize, and use the truth.

It is a truism to say that neither the work nor the results of science can be confined within national boundaries. Many people in many nations can contribute to it. All human beings everywhere may benefit or be harmed by its application. Science unifies men.

The search for an ever-growing but never complete understanding is that uniquely human activity which distinguishes human beings from all other living things. Indeed, I would claim that man is the first step in the evolution of a new form of matter—new because it can understand the world and itself. We look at the stars with awe and wonder. The stars do not look at us at all because they have no eyes to see with and no minds to be struck with wonder.

Understanding can be sought for and obtained in different ways. But one of the most powerful, because it builds on the past and combines the efforts of many individuals, is the method of science—that method of free inquiry, theoretical construction and empirical testing which is the special heritage of Western civilization. Science is more than the handmaiden of technology or the abstract possession of a few. It does more than allay men's fears and inform their hopes. It helps to give them their true dignity as men. Aristotle said it in simple words more than two millennia ago:

> The search for Truth is in one way hard and another easy. For it is evident that no one can master it fully, nor miss it wholly. But each adds a little to our knowledge of Nature, and from all the facts assembled there arises a certain grandeur.

Science

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