The Welfare of Science in an Era of Change

Or, can Humpty Dumpty get it all together?

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How can enlightened support for basic scientific work be ensured at a time when such research is increasingly classed among the indulgences of a society that is no longer inclined to be indulgent?

This problem can only be understood, I think, in the context of questions concerning the health of our entire scientific undertaking as a social enterprise in the decade ahead. To be preoccupied with the primacy of pure, as contrasted to applied, science is to reify a specious distinction, for science is, in its most fundamental sense, only an approach to solving problems—an approach based on logic tempered by experience—and its goals may be both specific and general, concrete and abstract, practical and theoretical, and immediate and long-range. Indeed, history has taught that fundamental knowledge often emerges in the course of attempting to solve practical problems. By way of example, one need only note the impact of the transistor and the laser upon the recent expansion of knowledge in physics. By way of an object lesson, one need only speculate about the relation of such technological innovations to the unprecedented affluence enjoyed by virtually all of us in the scientific community during the past 20 years.

I approach the question of the current welfare of science by first asking how it is that scientists suddenly find themselves confronted by a crisis of confidence on the part of the public and then by suggesting several courses of remedial action: political strategies, broadly defined; educational programs, both short- and long-range; and the stimulation of a more clearly articulated national science policy than the one now held by our government.

Why the Crisis of Confidence?

People ultimately resent being excluded from judgments or even information about scientific and technical developments that may change their lives and their world in major ways which they are powerless to anticipate or affect—CARYL P. HASKINS (*1*, p. 246).

This statement tells us a lot about the bases of society's present estrangement from science. We Americans have always regarded ourselves as essentially unique in our commitment to a bright tomorrow. We have steadfastly believed that we can, with appropriate effort, achieve whatever we wish, and over the years science has been seen as a handmaiden to that achievement. In this tradition and flushed by its successes during World War II, the American scientific community turned to the problems of a world at peace and assured their countrymen that, with sufficient funding, anything was possible.

Funding was indeed provided—and in unprecedented amounts. By the mid-1960's, the annual total had in a dozen years grown from $2.8 to $12.6 billion and was continuing to grow at the rate of 12 percent per year; meanwhile, the leaders of the scientific community were asserting that 15 percent per year was closer to the necessary rate. Then the troubles began. Scientists had based their justification for the large-scale support of science by public resources on the criterion of utility, but had failed to take into account the principle of public accountability and thus had failed to reconcile the traditional laissez-faire philosophy of research with a need for strategies that relate basic studies to socially useful outcomes. More than this, the scientific community had built a closed world of grants and contracts, publications, professional meetings, and committee business that inevitably excluded such matters as public concern and welfare. Thus, when their hand was called on specific national problems—curing cancer, curbing the physical deterioration of the environment, reducing crime rates—they were caught by surprise.

This failure to perceive fully the implications of public support of science has meant many things. Among other things, it has meant that scientists simply have failed to understand the importance of making clear to the nonscientific public the long time lag that usually occurs between the formulation of a scientific concept and its practical application (*2*). The average scientist, let alone the average layman, does not readily recall that 100 years separated Babbage's idea of a computing engine and the modern electronic computer, that 40 years were required to get from Oberth's analysis of space propulsion to Sputnik, or that a similar period elapsed between Einstein's paper on stimulated emission and the first laser.

Given the role of science and technology in World War II, it was easy for scientist and layman alike to assume that national prestige and power were linked to scientific supremacy. This became another justification for continued escalation of science funding, particularly by the military establishment. But if there is anything that has been learned about the geopolitics of science, it is that science is fundamentally international in character. Indeed, this was a lesson the war itself should have taught: Great Britain and Germany developed both radar and jet aircraft at about the same time, and the United States and Russia developed atomic weapons (and, subsequently, ballistic missiles) and orbital satellites at approximately comparable rates. Breaches in security undoubtedly made their contribution to these parallel developments, but I cannot believe they were totally responsible for them. The way in which scientific interests evolve, the nature of scientific communication, and the whole manner in which the scientific enterprise operates all militate against national advantage for any

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length of time. Joseph Ben-David (*3*, p. 179) advances the compelling view that the two greatest spurts in scientific production in the past (that in Germany during the late 19th century and that in the United States after World War II) were both impaired by sudden increases in governmental support motivated by concerns for military superiority and national prestige.

Its prevalent laissez-faire philosophy of research, in addition to a preference for problems that are manageable in the laboratory of the individual scientist, has inevitably meant that the scientific community has given little or no attention to problems that are—or should be—of overriding concern to the larger society. John Platt (*4*, pp. 160–178) has recently catalogued these problems in order of their urgency and has made estimates of the time still available for solving them before they reach crisis proportions. He describes eight grades of crisis intensity and a time scale extending to 50 years, although 20 years in most cases marks his estimates of the outer limits of tolerance. Platt's ordering of problems ranges from the danger of annihilation by nuclear, chemical, or biological means, through the disturbance of our ecological balance and the problems of the cities, to those problems with which scientists are currently preoccupied. These last he characterizes as sets of exaggerated or overstudied problems associated with military research, certain kinds of medical research (for example, heart transplants), and space research. He also states that thousands of studies are simply minor variations on well-known themes. In every case, Platt says, the number of scientists involved exceeds the number of significant questions.

The essence of the scientist's philosophy of conduct is that he refuses to assign priorities to the importance of his work. Yet, as Marcus Goodall (*5*) points out, priorities are, for the most part, what politics is about. When it acquired large-scale government funding, science also inevitably acquired a political dimension. Platt summarizes the situation pungently (*4*, p. 172): "When we see the scale and urgency of our worldwide problems today, the idea of 'science as usual' is so irrelevant and wasteful of tens of thousands of our best minds that it approaches frivolity." This failure of science to confront Platt's urgent problems Ben-David (*3*, pp. 169–185) perceives in terms of Durkheim's concept of anomie. He points to the fact that many scientists have experienced a feeling of loss of purpose and satisfaction in their work. This, he suggests, may be the result of a too easy material success, with little or no substantial contribution to science and society. And now, as Edward E. David (*6*) observes, society is no longer content to allow scientists simply to do what they will, or even to pick and choose their projects from a long list of societal needs. Rather, it will increasingly insist that scientists do what society as a whole demands.

The Elitism of Scientists

Certainly, a factor in the public's disaffection for science has been a matter of the style or posture adopted by scientists. The scientific community's traditional preoccupation with individual excellence has produced a psychology of elitism that has excluded the layman, often unnecessarily, from both the intellectual and social company of scientists.

On questions of research funding, elitism has meant for many scientists an expectation of support by virtue of some special position in society, without a commitment to accountability in the sense that men of public affairs understand this phrase. This attitude is epitomized by Vannevar Bush's widely quoted 1946 statement on the strategy for supporting research (*7*).

> Select scientific men of great power—men who are thus regarded by their colleagues —and see to it that they get every bit of support which they can utilize effectively, in their own undertaking, and in accordance with their own plans. Such an effort should cover every contributory field, and hence the entire science of man's physical and chemical constitution and growth.

Such selections are difficult to make, and over the past several decades of rapidly expanded funding many scientists have come to equate membership in the scientific fraternity with qualification for support.

Furthermore, implicit in the philosophy of elitism, I suspect, is the assumption that intellectual superiority means moral superiority. History, however, has demonstrated that the scientific community is like any other community of men: it contains both sages and fools, men of integrity and selfless commitment and men whose purposes are less admirable. The individual scientist must have the right to make the technical decisions necessary to the course of his scientific work without interference. But to insist that scientific freedom also means that only scientists shall participate in decisions that relate to the purposes of scientific funding or otherwise concern public policy in areas related to science is quite another matter. The correctness of scientific statements is, of course, independent of value judgments; but, as Ben-David (*3*, p. 181) has observed, decisions to spend money for research involve a choice between alternatives and are an expression of values. Most scientists, I am sure, would be quick to question the wisdom of leaving matters of defense policy exclusively to the professional military community or questions of the economy exclusively to the leaders of the corporate community. Thus they should not be too surprised if the layman insists that science is, in an extension of Clemenceau's thesis, too serious a matter to be left only to scientists.

A clear mark of the Zeitgeist of the late 1960's and the 1970's is the increased demand for participation in decision-making by those affected by it. The voting down of the supersonic transport was, I suspect, as much a reaction against an earlier, narrowly taken decision by a small special-interest group as it was a reflection of concern for environmental pollution. There is, says Daniel Moynihan (*8*, p. 8), "a fairly steady evolution toward direct citizen participation in the actual workings of government, a movement that has somewhat lagged but otherwise paralleled the increasing professionalization of government service." Twenty-five years ago, Bush's great—and undoubtedly justified—fear, following the spectacular technological accomplishments of the World War II period, was that there would be an overemphasis on applied science, to the detriment of both basic science and national interest. For the past several years, the concerns of many, both scientists and laymen alike, have taken the opposite turn.

Science Is Knowing; Technology Is Doing

Now that I have sermonized on the sin of irrelevance, I must also caution against the excessive enthusiasms of the saved. At present, scores of scientists—particularly many of the younger ones —responsive to social pressures from a number of quarters, sensitive to emerging patterns of funding, troubled that science may have missed an important turn in the onward movement of society's institutions, have rushed pell-mell to attack what they have heard variously are society's critical problems. This is reassuring and commendable. But even as scientists engage themselves, they must ask themselves just what their qualifications for such a task are. Certainly, they bring to the situation better than average intelligence, experience in framing questions for empirical analysis, and certain relevant information. However, science is not in itself technology. A distinguished engineer, in a recent conversation about these matters, commented to me, "There are too many scientists mucking up the practical. They should leave this to the engineer. We still need basic science. The shoemaker should stick to his last." Modern scientists and modern technologists, however, are, as John Ziman (*9*) has pointed out, extremely difficult to distinguish from one another. Certainly, the distinction cannot be made simply in terms of differences in substantive interests or available skills. Rather, it is more appropriate to differentiate in terms of goals, motivation, and professional life-style. I am indebted to Dr. Newman Hall (*10*) for a succinct way of putting it: knowing versus doing.

The goal of the scientist is to understand nature, and his ambition is to provide information useful to his professional peers and thereby to secure and maintain their respect and attention. His preference is for restricted problems that are easily adapted to the style of the individual investigator in the laboratory setting, and his commitment to precision is absolute. In contrast, the technologist's goal is to create socially useful things; his aim typically is to bring to bear all available means on achieving an acceptable solution of some immediate practical problem. He therefore must consider a wide range of questions outside his specific sphere of technical competence. His approach is usually the team approach. And his concern for precision is limited to that required for dependable operation.

When the scientist has acquired information related to the meeting of a societal need or has uncovered a principle significant for the solution of a societal problem, he has still made only the important first step. There follows the complicated and usually laborious task of developing the reliable production model or operational system [it has been estimated (*11*) that for every dollar spent on basic research, $10 is needed for development and $100 for the introduction of a new product]. These last steps are ones that the scientist typically is not prepared, by temperament or training, to take.

Relevance or Significance?

Yet the difference between science and technology is not simply a matter of understanding for its own sake versus understanding for application. Melvin Kranzberg (*12*, p. 31) says it is both, "singly and together in whatever combinations are necessary for the problems we wish to solve." Thus, it strikes me that the *fundamental* question for the scientist is not "How can I be relevant?" but "Is my work significant?" Furthermore, significance must be defined as broadly as possible: significance not simply for a handful of colleagues who engage themselves on some narrow piece of intellectual turf, but for the broader reaches of science and beyond, and for purposes beyond those of basic understanding. Only if he is willing to face this question honestly and often is the scientist justified in asking society to be tolerant of the risks inherent in basic science and to understand its value in the long haul.

Scientists in a democracy have a responsibility to their lay peers to explain clearly both the nature of science and the potential significance of their scientific achievements for the larger society. It is increasingly in the scientist's interest to understand more clearly what the layman thinks and feels about science. What approaches may the scientist take in order to bring about this mutual understanding? What can he do to restore a climate of favorable opinion toward science and technology so that the value of his contributions may be adequately appreciated?

Scientists and the Politics of Enlightened Social Involvement

Conflicts (of human values) must be settled ultimately by the political process, but experts may nevertheless have a great deal to say about the differing relevance of various kinds of values to the problem at hand. Some systems of values may be far more appropriate to the situation than others—MURRAY GELL-MANN (*13*, p. 24).

As a field of activity acquires the status of a profession, this evolution is marked by certain signs: members of the profession concern themselves with the quality of education that leads to admission into the profession; with procedures for certifying the competence of members already admitted; with means for ensuring the personal welfare of individual members, including protection from attack by persons or groups outside the profession; and with mechanisms for protecting the essential values upon which the profession bases its existence. Furthermore, as a field of interest achieves a more prominent place in society, it increasingly strives for the acceptance of its dominant values by the society at large. At least some fraction of the methods available to achieve these ends are political.

Scientists in a variety of fields have, with differing degrees of enterprise, busied themselves with the accreditation of their educational programs, certification and licensing, codes of ethics, and such things as insurance and pension plans. But their traditional elitism and its attendant self-preoccupation have meant that almost all of them have been essentially blind to the inherently political component of their enterprise.

In general, scientists publicly show ambivalence toward politics—even pronounce it corrupting—with the consequence that, when scientists have participated in public affairs, their performance, judged in political terms, has usually been poor. They have depended on powers of personal persuasion; they have usually been unwilling to take risks; and, above all, as I briefly noted earlier, they have not yet fully understood the meaning of public accountability.

The individual scientist typically has assumed that, as long as he was not profiting financially from the award of public funds, he was meeting his responsibility to the public agency that awarded them. He has failed to appreciate the literal nature of his obligation as an awardee, its implications for the goals of his work, and his commitment to the constant evaluation of what he is doing and to proper reporting. But whatever the depth of his appreciation of the notion of accountability, it has never been for him more than a rule of personal conduct. Accountability as an obligation acquired by a social institution by virtue of its growth and institutionalization (especially when that growth and institutionalization have resulted from the evolution of public policy and funding) is something that has not yet occurred to him. In this age of "participatory democracy," the public is demanding that all segments of society be accountable, and science and technology are not exempt. In this period of a troubled national economy, accountability, both individual and institutional, is inevitable. Ivan Bennett, speaking from his post as deputy science adviser to the President during the Johnson Administration, put the matter squarely a full 5 years ago: "Science . . . can no longer hope to exist, among all human enterprises, through some mystique, without constraint or scrutiny in terms of national goals, and isolated from the competition for allocation of resources which are finite" (*14*).

In his 1968 AAAS presidential address, Don Price identified the political role of American science as one of helping to "clarify our public values, define our policy options, and assist responsible political leaders in the guidance and control of the powerful forces which have been let loose on this troubled planet" (*15*, p. 31). Not every individual scientist may be qualified to participate directly in such activities. But all share equally in the responsibility to see that they are carried out, and carried out well.

To date, scientists have failed to develop mechanisms for effectively expressing the views of the scientific community or for engaging it responsibly in matters of social concern. In recent years, groups of scientists have expressed themselves on specific issues, but they have not created the impression that they are more than one voice among many. The institutions of science —the faculties, the laboratories, and, above all, the professional associations —have done little more than utter pious platitudes.

I propose some starting points for responsible public involvement. First of all, scientific associations must take greater initiative in arranging public forums for the airing of issues to which scientists can effectively contribute. A good example is the persistence of the AAAS Council, over a period of 4 years, in concerning itself with the use of herbicides in Vietnam, its consequent adoption of resolutions, and, ultimately, the work of the AAAS's Herbicide Assessment Commission, which played a major role in the Department of Defense's changing its policy in this matter.

Second, scientific associations must move to commission more in-depth studies of problems that have policy implications. In 1964, well before the general apprehension about air pollution, the AAAS established its Air Conservation Commission. This group, after 2 years of intensive work, issued a report entitled *Air Conservation*, which has over the years greatly influenced thinking on this matter and continues to be among the best-sellers in the AAAS monograph series.

Third, the scientific community must vigorously seek dialogue with persons involved in establishing public policy on those public issues with which science is appropriately involved. This includes presenting testimony to legislative committees as well as arranging for more informal opportunities for an exchange of views. For the past 12 years, the AAAS, in collaboration with the Brookings Institution, has each spring conducted a series of seminars on topics of current interest to congressmen and members of their professional staffs. Last year the program was expanded to include a fall series.

Fourth, opportunities for involvement with decision makers must be sought not only at the national level, but also at the state and local levels. It is gratifying to note that governors as well as state legislators now regard it as desirable to include persons with scientific and technical backgrounds as members of their staffs. Individual scientists are to be urged to enter volunteer roles as consultants to schools, departments of public works, mayors' offices, and other public agencies, particularly in small communities where budgetary limitations prevent the employment of full-time, professional scientific staff. A notion that is very attractive to the AAAS is that of the regional center. These centers are conceived of as strategically placed offices containing a small professional staff that serves as broker in the relationship between the scientific and the public-service communities.

Fifth, young scientists must be encouraged to enter careers of public service. At present, only a very small number have done so. For example, a solid state physicist now serves as science consultant to the Committee on Science and Astronautics of the House of Representatives. The AAAS board of directors has recently approved the development of an internship program that would recruit young scientists and arrange for their preparation to assume such posts.

Sixth, scientists must be encouraged to seek elective office. While Congress includes members of the legal profession in large numbers, and physicians and business executives are not unheard of in those halls, there is, to my knowledge, only one scientist, Representative Mike McCormack of Washington, in Congress today.

You will note that I have stopped short of advocating outright lobbying. I believe that our traditional commitment to what Ziman (*9*) calls the "principle of consensus," as well as to the requirements of an enlightened self-interest, prompt us to give attention to more than our own parochial concerns. We have already seen the frequently unfortunate consequences of a narrow rationality ["facts and figures marshalled in huge arrays that have failed somehow to include inputs from common sense or from human values" (*13*, p. 23)].

In an interview in the National Science Foundation's *Mosaic*, Presidential Science Adviser David lamented the absence of "a credible group which can lay out in terms understandable to the public, Congress, and the Executive Branch too, what the scientific and technological facts are and to do it in an unbiased and credible way" (*16*, p. 14). I feel compelled to gently chide David for what I can only assume to be a momentary lapse of memory. The AAAS is such an organization. It has been doing the things that David calls for and, indeed, has launched a significantly more ambitious program for the future.

On the Essential Role of Education

In the conditions of modern life the rule is absolute, the race which does not value trained intelligence is doomed—ALFRED NORTH WHITEHEAD (*17*).

If those of us who have experienced concern about what has happened to both science and society in the last decade share one conviction, I suppose it is that education constitutes an essential means for ensuring the future welfare of both. I am thinking of education in two senses: first, as the acquisition of both the skills and the enlightened perspective required of people to be effective members of the society of the future and, second, as a strategy for restoring the climate of respect and acceptance science needs now if it is to realize its potential to contribute to society in the years ahead.

The situation is already reassuring for education in the first sense. Young people, I believe, have again turned to education as a prerequisite for the social change they wish to bring about. I recently had occasion to visit one of the nation's leading universities in connection with a research-training grant proposal. In the course of a discussion with a group of graduate students, I pressed them on why funding should be continued for research training when there were such great and immediate physical needs in communities all over the country. Their response was polite but firm: "We have taken part in protest; we have spent long hours in the ghetto; and we know that society's problems are not going to be solved by rhetoric or by the declaration of good intentions. They are only to be solved by knowledge and skill." Others are speaking in the same way.

U.S. News and World Report (*18*), in a story entitled "Turn from campus violence," reports that at the University of California at Berkeley, where the U.S. student protest movement started back in 1964, large numbers of freshmen are enrolling in chemistry, and big gains are taking place in the physical and biological sciences, and in engineering as well. The writer quotes John Hensill, dean of the school of natural sciences at San Francisco State College, as saying that students are pushing the faculty to get all they can from their courses, and Douglas Davis, associate dean of undergraduate studies at Stanford, to the effect that students now recognize the importance of science and the law as instruments of social change. Donna Clark, vice-president of the student body at Kent State, is quoted as saying, "Students are realizing that in order to create change you have to renovate the system, and for that, you need book learning."

My primary concern at present is for education in the second sense. An effective program of education for understanding requires both a full awareness of the concerns, fears, and aspirations shared by people in all walks of life and a precise perception of how science can—and cannot—function as an instrument for improving the human condition in the context of these concerns, fears, and aspirations. The strategies must be both short- and long-range. I have on another occasion (*19*) described some of the latter. Suffice it to say here that we need a vigorous and imaginative program, and that, without minimizing the responsibility of science and technology for many of today's urgent problems, we must more effectively demonstrate specific ways in which science and technology have advanced the interests of society. More important, we must clearly communicate their essential roles for the future.

A general program of education for public understanding is a multimedia program. Because today's 18-year-old has spent some 18,000 hours before the television set, in contrast to 14,000 hours in the classroom (*20*), television must constitute an important element in such a program. For television, I think the goals should be threefold: first, to produce a large number of programs of the general documentary sort for both public and commercial outlets; second, to create a means for ensuring that information on or about science and scientists is competently presented in general entertainment programming (if science is to be included in soap operas, it ought to be good science); and third, to encourage the production, on a regular basis, of programs that treat scientists, both real and fictional, as people. To date, there have been no scientist or engineer counterparts of "Marcus Welby, M.D." or "Mr. District Attorney."

The AAAS produces five 1-hour, color programs in prime time to present the major themes of the annual meeting over the nationwide network of the Public Broadcasting Corporation. It is now examining the feasibility of a widely expanded program that will further exploit the medium in a great variety of ways.

Radio was used by the AAAS for the first time at the Philadelphia meeting last December, and a proposed program of activities in radio to complement the proposed activities in television is now under review. Planning is already under way for a series of vignettes presenting basic concepts in science and technology, to be narrated by well-known radio or television personalities. Later, these vignettes may be expanded and organized in the form of study kits for use in educational programs of clubs and community-interest groups.

Possibilities are also being studied for the expansion of the AAAS's book publication program, which is now essentially limited to symposium volumes, to include paperbacks and other materials directed toward various lay groups. Finally, the communications office of the AAAS has ambitions for establishing more effective information services, as well as a program of workshop conferences for professionals in the communications media.

Education and the Zeitgeist

Science first emerged as an avocation of men of learning and affluence. Much has been written in recent years concerning the management of leisure in a world in which work routines are increasingly being performed by machines. The expansion of higher education, accompanied by the condition of relative affluence experienced in the United States since World War II, has resulted in a marked upsurge of interest on the part of the wider public in the graphic arts, music, the theater, and books. We in the AAAS believe that imaginative measures must now be taken to stimulate increased interest in science-oriented hobbies and in participation in amateur science of all sorts.

I deeply believe that in this cybernetic age, to borrow Glenn Seaborg's phrase (*21*), science must be viewed not simply as a beneficent instrument of society, but, more important, as an essential part of the intellectual infrastructure of society. It must not only be understood, but assimilated to a significant degree by all members of society, in the way that politics was incorporated into the life of ancient Greece, religion into the life of the Middle Ages, and commerce into the life of the 19th century. For this to occur, science must be understood not simply as a collection of facts, nor even as an integrated system of information, but rather as a way of looking at the world.

In the past decade or more, the loss of interest in science on the part of many students has come about, I believe, through the disembodiment of science as a result of its parochial concerns. The scientific community's educational predilections, particularly in higher education, have been largely oriented toward the training of professionals, and in this pursuit they have been so preoccupied with communicating the theoretical basis of a particular science that they have ignored the importance of discovering its exciting facts. Young people need to know again more of the pleasure of observing the phenomena of nature. The demonstration lecture, a dying art, merits a renascence. Professors, through the mechanism of a sabbatical in industry or public service, need to see science in the context of the problems of the real world.

Just as important, young people need to become familiar in a first-hand way with the scientist's approach to solving problems, both pure and applied. This understanding is best acquired not through the medium of the cookbook laboratory exercise, but through the individual design and execution of experiments. The AAAS program "Science—A Process Approach" does just this for youngsters in kindergarten through the sixth grade. The child is led to understand science by dealing with the world in the way that the scientist does. Beginning with very simple situations, he observes, classifies, uses numbers, measures, communicates, infers, and ultimately formulates hypotheses and does simple experiments. In the process of these activities, he incidentally acquires an impressive body of information that is functionally meaningful for him. Thus the categorical mode of thinking that compartmentalizes pure and applied science is, hopefully, avoided.

The Need for a National Science Policy

In the affairs of science there are two sets of forces acting; the external representing the aims of society and the internal forces representing the natural development of science; and there must be some balance between them, or the system collapses.—Sir Brian Flowers (*22*, p. 26).

When, in the 1950's and early 1960's, financial support for the scientific enterprise (mainly from government sources) was expanding at a more rapid rate than scientists could effectively use it, the question of a coherent science policy was not of overriding national concern. The national strategy was, rather, to respond with more money to needs and pressures as they appeared, a characteristically American mode of response, as Haskins (*1*) has noted. But now, in a period of financial stringency marked by an acute sense of urgency in many areas of our nation's life, science has to compete with activities of higher priority for its share of government appropriations. Under such circumstances, its funding must inevitably be justified in terms of clearly specified national interests, and the creation of an explicit policy becomes an essential instrument to this end. Certainly, the need for such a policy has been increasingly recognized in the past several years. In February 1970, the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics called for hearings on the matter. In April 1970, the President's Task Force on Science Policy issued its report, *Science and Technology: Tools for Progress* (*23*). A report of hearings held by the subcommittee in the summer of 1970 was issued in October 1970 under the title "Toward a Science Policy for the United States" (*24*).

It is important, I think, that the scientific community also now exercise its own initiatives toward a national science policy. Recognizing the great range of responsibilities of government, and its inherent promiscuity of interests, the scientific community could, through a carefully planned series of study groups and conferences, identify the essential dimensions of such a policy. While I would not presume to state what the substantive provisions of the policy should be, I can suggest certain important considerations that I believe should be included.

First, it should be what Haskins (*1*) calls a coherent policy. That is, it should be flexible and should treat the funding of basic research and technology together, not in isolation from each other. It should reconcile needs and priorities with available resources and encompass the range of relevant considerations, such as the limitations of present knowledge and questions of manpower.

Second, it should include some rational basis for maintaining, over time and all circumstances, a reliable floor in research—particularly basic research—appropriations. As an example of this floor, the President's task force (*23*) has recommended for the National Science Foundation an annual budget equal to 0.1 percent of the gross national product.

Third, the funding of science should remain the responsibility of multiple agencies, for balance and institutional control are advantages of a pluralistic system. At the same time, areas and scope of responsibility should be defined with sufficient clarity to minimize wasteful duplication of effort.

Fourth, questions of manpower, both present and future, should be related to national priorities and program goals. Provision should be made for a continuous assessment and management of the supply of scientists and engineers in the light of these needs and goals.

Fifth, attention should be given both to the technological requirements reflected in the formulation of national priorities and to the physical and social costs of these technologies. Active interest, both governmental and nongovernmental, in technology assessment over the past several years has been reassuring. However, one would hope that the nation could afford the luxury, in areas other than national defense, of developing comprehensive sets of alternative technologies from which a final selection might be made. Such a policy would not, in the long run, be wasteful (*13*).

Sixth, the policy should clearly acknowledge the relations between government, the private sector, and what Greenough (*25*) calls the independent sector—the universities, foundations, and other nonprofit, service-oriented institutions—in the pursuit of national goals. The independent sector has increasingly been the vehicle for creative social innovation and discovery (witness the plant-breeding studies that have led to the green revolution or the history of the civil rights movement), and the formal recognition of its role in policy is essential.

Seventh, special attention should be given, for at least the next decade or so, to the development and utilization of the behavioral and social sciences, since societal problems, whatever their nature, ultimately include important human dimensions.

And there is, finally, a consideration that must apply regardless of the nature of the policy. Quality in American science must not be sacrificed. Regardless of the institutional character of science in this country and the organizational mechanisms that are devised for its pursuit, the nation must, without exception, insist upon having first-rate science, with all that this phrase implies.

Closing the Two-Cultures Gap

Last spring, officials of the Chicago and Southern Airways of Peoria, Illinois, broadcast a call for stewardesses no taller than four feet, ten inches. Reason: Cabin ceilings in their commuter craft are only five feet high. This long overdue recognition of the need for new people to fit new machines opens exciting vistas of a Brave Little World of Tomorrow.—Harland Manchester (*26*).

This amusing anecdote should bring us up short, for it demonstrates that somewhere along the line we have exchanged roles with the machine. It is master and we are servants. And this, of course, is what the two-cultures gap is all about. The point of C. P. Snow's (*27*) essays was not simply that there were two cultures (that of the scientist and that of the literary intellectual) and that these were marked by two contrasting approaches to understanding the world (the rational, analytical, investigative method versus that of intuition and the creative imagination), but that they were alien to each other—unable to communicate across the cultural gap—and hostile.

The two-cultures gap is nothing new. Early in the 18th century, Swift and Pope defended traditional learning and attacked science for its effect on the area of the spirit. Blake, and later Keats, saw science as something that destroyed creative imagination. And Wordsworth, who truly admired science, had a great and abiding fear of its companion, technology. In the sooty industrial towns of England and the 19th-century industrial society that created them, he saw both physical damage to Nature and a dwarfing of the spirit on which so much of civilization as he conceived it was based.

Snow judged neither culture, in itself, to be adequate as a world view. Humane rhetoric alone cannot meet the demands of our complex modern world. Sophisticated technology, without a humane dimension, cannot ensure survival. Snow foresaw a third culture, and those who are in the behavioral and social sciences share it. They find themselves between the natural sciences and the humanities; they incorporate elements of both traditions and can speak both languages. They therefore have a special obligation to the future—they can close the two-cultures gap, if only they will.

The future of science and of the larger society are inextricably linked (indeed, they probably always have been), but this does not imply a relation in which scientists may participate on their own terms. Rather, they must recognize that the relation is one in which the fundamental knowledge and outlook of science must join the other great intellectual and ideological traditions to enrich, in the fullest sense, the lives of all citizens.

As the United States faced the reality of involvement in World War II, Walter Lippmann admonished his Harvard classmates in words that seem especially appropriate for the scientific community at now another moment of national crisis (*28*, p. 39): "You took the good things for granted. Now you must earn them again. . . . For every right you cherish, you have a duty which you must fulfill. For every hope that you entertain, you have a task you must perform. For every good that you wish to preserve, you will have to sacrifice your comfort and your ease. There is nothing for nothing any longer."

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