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ABSTRACT

The public's perception of science and technology and of the National Science Foundation (NSF) is addressed and discussed in this report in terms of the social contract that exists between the scientific community and the public. A social contract is defined as the set of mutual expectations and obligations of the public, government, and science. The origins and evolution of this social contract of science and the present strains on it are examined. The discipline-driven model and the goal-driven model of the social contract are analyzed and a new pluralistic model is offered. The pluralistic model is favored because it allows scientists to determine what is good science and the public to determine for what science is good. Recommendations are presented for the implementation of the pluralistic model and suggestions are offered on how the National Science Foundation can function in this matter. The roles that the National Science Foundation performs under the pluralistic model are also specified. (ML)

Report of the National Science Foundation Advisory Council

Executive Summary

PREFACE

The National Science Foundation Advisory Council is an advisory group to the Director of the National Science Foundation which was established to advise him on issues which require the expertise of the many disciplines and program interests represented in the Foundation. Issues for the Council to address are identified by the Director after consultation with the Council. The members and the Chairman are appointed by the Director. The current members of the Council are:

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INTRODUCTION

In October 1984, Erich Bloch, the Director of NSF charged the National Science Foundation Advisory Council with the task of reviewing the public perception of science and technology, and advising him on the what the NSF should do to inform the public about its own role. A copy of the charge is appended to this report.

The members of the Council met in December 1984 to discuss the charge and to organize to accomplish the task. There was much concern expressed about explaining the importance of science and mathematics education at the precollege level and to the general public through informal means such as museums and television. Also several suggested that NSF's role should include educating the science community on how public policy is made, and improving its understanding of the social/political process. Likewise, many agreed that the scientific community should have a better appreciation os the public's need to know more about the process and results of science.

Hence the group made several recommendations for improving the two-way street between the scientific community and the public--this was translated into the shorthand phrase of building "bridges" between scientists and the public. Given the importance of science and technology to society, the group asked what is the role of the public in influencing priorities for science? This led to the proposition that we should develop more compelling indices of the status of U.S. science which would elicit greater interest in and concern for the health of science in our country.

The members also suggested that the NSF should sponsor the development of better tools to understand how pulic perceptions of science and technology are formed, and how public input can be factored into goal setting for the Foundation and the wider scientific community. Another point was raised about the scientist's own perceptions of what he or she gives society and what he or she gets from it.

The group also commented on the question of whether NSF should speak out on technical issues. Strong disagreement was voiced, ranging from the opinion that it would be "institutional suicide" to the assertion that it could be an important service. In the latter case, analogies were made to the Congressional Budget Office, which informs debate by laying out options and interpretations in an apolitical fashion.

Throughout the discussion the Council came back to the concept of redefining the "social contract" between scientists and society. And ultimately, the exploration of issues in the charge led the group to focus on very fundamental questions concerning the "social contract" between the scientific community and the public, and the nature of NSF's role in this relationship. For the sake of communicating the rich and diverse exchange of ideas, we have organized the material in the report into descriptions of two different models for NSF, accompanied by comments elicited by the two models, and recommendations flowing from both of these for the Director of NSF.

The members of the Council contributed generously of their time and it is hoped that the report communicates to the reader the vitality and excellence of the deliberations.

Report of the National Science Foundation Advisory Council

Executive Summary

To provide a base for discussion of the public perception of science and technology and of the National Science Foundation, the NSF Advisory Council examined the "social contract" for science, its origin and evolution, and the present strains on it.

The Council found that two separate and competing models of the social contract -- a discipline-driven model and a goal-driven model -- currently coexist without reconciliation under the mask of a monolithic system. Since each model involves a distinct array of mutual obligations and expectations among parties to the social contract, the hybrid system which now exists generates tension, misunderstanding, and confusion.

To sharpen the study team's understanding of the sources of conflict in the system and to aid its search for design criteria for a more fruitful model, the Council analyzed the two models in terms of their driving forces, the locus and type of performers, the public's role, and the agency's roles.

The study team concluded that a renegotiation of the existing bargain between science, government, and the public is needed and that a pluralistic model, rather than a hybrid of competing models, seems promising. In the pluralistic model, discipline-driven and goal-driven approaches to science and technology are applied <u>explicitly</u> to different tasks and in different arenas within the overall system. The pluralistic contract includes a clear delineation of the public role as one of setting broad goals and priorities, while science pursues the publicly-set agenda in a discipline-driven framework. The government assumes the new roles of protector of the base of discipline-driven science, coordinator of the parts of the system, and liaison between science and the public in order to assure both progress toward national objectives and health and vigor of the

scientific enterprise.

The Council recognized that the implementation of a pluralistic system would require some new or differently focused mechanisms for public, government, and science activities and linkages, and offers some specific suggestions for change, including:

-- Improvement in understanding and implementation of the support structure of U.S. science and technology.

-- Recognition that the support structure of science and technology must evolve or become dysfunctional.

-- Investment in research on innovative organizational arrangements for the funding and performance of science and technology.

-- Changes within performing organizations, especially realignment of reward structures.

-- A more coherent rationale and broader participation in the basic priority-setting decisions for explicit treatment of the allocation of resources among the conduct of science, science education, and public understanding of science.

-- Development of better indicators of national scientific achievement to enhance public understanding and support.

-- Increased education and participation of the public in the public-policy aspects of science and increased scientific participation in public decision-making.

-- More widespread recognition by scientists of their role as citizens.

Although there is not consensus within the Council on how far the agency should pursue the pluralistic model, there is absolute agreement that NSF must, in the process, sustain the work of scientists in the universities acknowledged to be the "science-technology base."

THE PROBLEM

The National Science Foundation finds itself in the vortex of conflicting demands. National policy for science and technology is undergoing reassessment. Public support of science and technology is linked to a social contract, i.e., a set of mutual expectations and obligations of the public, government, and science. That social contract is faltering for a number of reasons, including:

-- Recognition that the United States' world role and position are closely linked to its scientific and technological leadership;

-- The increased size and complexity of the science and technology enterprise; and

-- Public anxiety about the uses of scientific and technological advances.

Public understanding of science and technology, however, centers on visible economic and social benefits and often incorrectly assumes a monolithic system for decision-making for the direction and support of science and for the control of its uses.

To provide a base for the discussion of the several questions posed by the NSF Director [has regarding] on the public perception of science and technology and the NSF, the Council examined the social contract for science, its origins and evolution, and the present strains in it. The Council found it useful to distinguish two competing models for the contract — a discipline-driven model and a goal-driven model —

and then to conceptualize a pluralistic model. The results of the Council review follow.

Strain on the Social Contract

The notion of contract implies a bilateral relationship benefiting both society and science. The contract established by Vannevar Bush in Science -- The Endless Frontier certified that science had a right to a large measure of independence and that this independence was in the long-range interest of society (Atkinson, 1978). The identification of the "original compact" as science best serving the long-range needs of society by serving its own internal needs is arguable, however, since the Morrill Acts and the Hatch Act, which long predated the Bush scheme, invigorated agricultural research.

Even if the original contract of the Bush-model did call for substantial independence of science from outside control, the convergence of heightened sensitivity to the environmental and social implications of science and technology and a changing view of expertise is forcing renegotiation. While the public remains very supportive of science in general, ih has a set of growing concerns:

- -- The public is more aware of potential harm and sees fewer ways to influence decisions (Nelkin, 1980). Technology has outpaced the social systems for the guidance of its uses. The public has become aware of the disparity between the sophistication of our science and the relatively primitive state of our social and political relationships (Yankelovich, 1984). Nowhere is this more evident than in the public unease about arms technology. Citizens fear threats to their safety as a result of perceived failure by scientists to assess and control risks adequately. They also fear that the ethics of professionals in the scientific establishment have decayed. Not only does the public feel that scientists are remiss in not taking moral responsibility for the uses of research; it also feels that technology has removed the citizenry's autonomy and control through the "tyranny of the expert." The public thus feels it can no longer make crucial decisions on policy and control.

-- The central economic importance of science increasingly gives it a political significance beyond debates over applications to socially desirable or undesirable ends. The size of the public investment in the scientific enterprise and the key role of science in national economic competitiveness and defense now make science a visible competitor for scarce resources. The related the public concern involves accountability, or demonstrable return on public investment. The public regards the diminishing of the nation's technological edge in the global arena as an instance of the failure of science and technology to deliver on their promises.

-- Science, in our culture closely entwined with both freedom and promise, is important in the public's widespread concern about society's fundamental beliefs and goals (Haskins, 1972). The determination of overall national priorities in science and technology may be a mask for a deeper demand for a more general reordering of social and political life. The citizenry seems, in any case, to be unwilling to award untrammeled funds to science simply in exchange for long-term benefits as it no longer trusts in the beneficence and social relevance of the results of science.

The public has been largely a silent partner in the tripartite relations of government, science, and the public (Reagan, 1969). Science receives support because the public does not object -- not because the public demands it. Nonscientists easily see the value and necessity of research in defense, health, space exploration, and agriculture, based on previously visible breakthroughs and on the need for exploration into large areas of the unknown. The need for research in the social sciences, on the other hand, is less obvious and comprehensible to the public. An understanding by the public of why basic research is important and merits large-scale support remains shaky and incomplete (Reagan). Dramatic breakthroughs in science and technology capture the imagination and spur the support of the public but do not represent the normal process of science in which progress is made in painstaking and modest steps -- "on hands and knees, not by leaps and bounds" (Carey, 1985).

In summary, the public understands the results rather than the process of science. "I think to the extent that basic research and development commitments can be oriented towards things that improve the quality of our people's lives and enhance the security of our Nation, contribute to our position in world leadership, to that extent these allocations of funds and interests will be more readily acceptable and supported by the American people." (Presidential remarks, Medal of Science awards ceremony, November 22, 1977.) Having gained public funding on the basis of arguments that science yields useful knowledge, the scientific community finds itself driven by a utilitarianism which may cripple the foundation upon which rests science and its results.

The dilemma of the goal-driven pursuit of scientific utility versus the disinterested pursuit of scientific truth may be clarified by the presentation of two conceptually distinct models of science and technology: a discipline-driven model and a goal-driven model. Neither of these models constitutes a historical or current reality, or a desirable or practical system. Rather, the presentation of the extreme models serves to sharpen the issues and to provide a framework for clarifying entangled entities. The public (as well as many members of the government and scientific establishments) experiences great confusion in understanding distinctions between science and technology; the scientific process and the process of using scientific knowledge; scientific or technical and political or value issues; the role of the scientist in the public arena and the role of the public in science-policy formulation; and the role of government as purchaser and as supporter of research.

These "extreme" models, then, can serve to disentangle polar concepts which coexist in the current debates. Each model represents a different driving force for science, calls for a different locus and different types of research performers, and ascribes different roles to the public and to the NSF and mission agencies.

DISCIPLINE-DRIVEN MODEL

Driving Force

The discipline-driven model of research is the scientist's view of science, which calls for systematic study directed primarily toward greater knowledge or understanding of the subject studied. Discipline-driven research follows the logic of the discipline and investigates problems which are generated from progress within the discipline. This model assumes that curiosity-driven efforts are necessary in the long term for identifying and solving practical problems of benefit to society at large.

Locus and Performers

Because of the unique environment of universities for fostering these efforts, academic researchers are the dominant performers of science in this model. They fulfill a unique social role of questioning, investigating, and understanding in an environment which is relatively free from ideological bias or vested interest. The brilliant individuals already in universities foster a vigorous stream of scientific stimulation and creativity through their free communication with colleagues and students. The close nexus of research and teaching provides a unique, ideal institutional arrangement for the training of the next generations of scientists. The universities, as institutions, remain healthy to the extent that they can pursue knowledge for its own sake, with external stimulus but without external, nonscientific controls. Universities, therefore, require institutional support to ensure their health, particularly the venture capital to launch young investigators on their own curiosity-impelled projects.

The Public's Role

In this model the public role is the setting of overall amounts of resources for science. The scientific community makes decisions about what projects and methods to use on the basis of scientific criteria and the peer evaluation of scientists. Decisions rest on intrinsic criteria. The freedom of the investigator, in both direction and approach, is ideally limited by no authority alien to the absolute authority of science and the moral authority of peers through shared values.

The Agency's Roles

In the discipline-driven model, the National Science Foundation is seen as the "keeper of the flame" of science, as the enabler of advancement of knowledge. Its selection of the best university science, represents the optimal arrangement for deploying support to achieve long-term practical benefits to society. Other government agencies attend to other parts of the enterprise, such as technological development and its commercialization.

GOAL-DRIVEN MODEL

This model identifies as the best performers and locations for science those which guarantee the most effective and efficient results within a time frame which allows accountability for evaluating the return on public investment. Goals must be specified precisely enough that this link between investment and outcome may be relatively directly established and evaluated.

The Public's Role

The public and scientists should jointly participate to the greatest possible extent in the mobilization of resources in support of publicly determined national goals. In this model extrinsic, nonscientific criteria are on a par with intrinsic, disciplinary considerations in determining priorities for science funding and projects. One reason for the importance of extrinsic criteria for decisions on science and technology is that national problems with the commercialization of knowledge are inextricably linked with public understanding of science. Their separation poses an insuperable political, if not conceptual, problem.

The Agency's Roles

In the goal-driven model, the National Science Foundation serves in the role of provider of the basic research which is needed to meet the strategic goals of the nation. NSF, in this role, sets priorities among scientific fields and performers, in terms of their relevance to publicly determined goals, and itself calls for targeted research which is absent elsewhere in the Federal Government. The mission agencies, in this model, mobilize effort in terms of their own goals and follow funding arrangements which maximize the effectiveness, efficiency, and accountability of science in meeting these goals.

THE ARGUMENTS

It is not difficult to discount both the extreme "science for science's sake" and the "science for utility" models. The first argument, that the public should fund science without strings in the expectation of eventual social benefits, cannot be an exclusive model primarily because it requires an "act of faith" by the public in which citizens relinquish all control over a publicly funded activity which fundamentally affects them. Political goals involving values issues and competing priorities are set in this model by elites, who assure the public (but fail to convince them) that their decisions are in the public interest. The two-part rationale -- that scientific matters are incomprehensible to the public and that "disinterested" scientists are capable of good scientific decisions -- obscures the distinction between the process of science and the uses of science and between technical and political issues. The scientist is especially capable of determining the feasibility of a project, but has no special expertise in determining its relative value for the public. Scientists determine what is good science. In a political process involving the authoritative allocation based on values the scientist is no more expert than the layperson in deciding what science is good for (Broudy, 1982). Finally, the discipline-driven approach may not be the most efficient means of solving national and international problems, even if its long-term benefits are great.

The discipline-driven model can be supported, however, by pointing to the enormous benefits which university-based basic research has provided. In this sense, discipline-driven science has proven itself over and over. It has an established constituency, its own ideology and procedures. Discipline-driven research benefits from its close association with the university, which holds a unique position as social critic and trainer of the next generation of researchers. This model is familiar, and accords well with the values and basic insularity of much of the scientific community.

Whether desirable or not, whether originally contracted or not, the reaffirmation of a purely discipline-driven system of science poses an insuperable political problem. The public resists the removal of fundamental decisions on the directions of the nation's scientific enterprise from the domain of active public decision-making. "For much of its history the pure research community has been relatively free from direct outside intervention. It has also been widely regarded as the main source of reliable knowledge and has experienced little difficulty in attracting new members. In recent years, however, all this has changed. There has been a fall in recruitment. Many scientists and laymen have come to regard certain aspects of the scientific endeavor as pernicious. And there has been a pronounced move towards regulating scientific development in accordance with non-scientific criteria" (Mulkay, 1977, p. 134).

The goal-driven approach also has severe drawbacks. These problems include the lack of qualifications of the public to understand complex technical issues in order to make informed decisions and the danger to the integrity of science by decision-making based on nonscientific criteria. An extremely serious drawback of the goal-driven approach is the problem of short-term, specific goals undermining the interdependent "base" of the science system by skewing support among fields and sub-fields. The base consists of "basic science and engineering research, plus science and engineering education, plus the facilities and equipment required to perform that research and education" (Schmitt, 1984). Schmitt provides a critique of direct mobilization of science and technology to solve urgent national problems by noting that the result of an era of goal-driven support to science was a period of serious neglect of the base. Furthermore, the inability to relate science support directly with desired outcomes led to a degree of disenchantment with the support of science and engineering, because the complex problems proved far more difficult than anticipated.

While the goal-driven model allows the public to participate in science and technology policy-making, this approach also demonstrates serious flaws. Both discipline-driven and goal-driven approaches to science and technology suffer from the inability to account directly for the relationship between inputs (funding) and outcomes (achievement of goals). In discipline-driven science, the public cannot participate in the policy process, and citizens feel that priorities which affect them are set outside their control. In goal-driven science, the public loses faith when its goals are not demonstrably achieved. The discipline-driven model provides no mechanism for determining priorities in terms of public concerns; the goal-driven model provides no mechanism for assuring the viability of the science base.

A PLURALISTIC MODEL

A possible reconciliation of these models calls for a pluralistic approach in which the two extreme models -- discipline-driven and goal-driven -- represent clear approaches to different tasks within the science and technology continuum. The pluralistic model, first, stresses care for the science and engineering base in terms of the close relationship between the base and meeting national priorities. The public's difficulties with the support of the science base for the sake of science dissolve in the face of an understanding that any useful results of science depend on a healthy base. In this pluralistic system, the public determines broad policy decisions on national goals, resource allocation among competing demands, and priority setting in general terms, between such goals as health, education, defense, and economic competitiveness. Scientists, working in universities and in other institutions, make decisions on how to reach broad publicly-generated goals on the basis of discipline-driven criteria.

Just as managerial styles have evolved from the industrial mass-production era in which efficiency was highly valued, so must a contemporary system of science and technology policy and performance change to accommodate current conditions and needs. New arrangements for public participation and the formation of public judgments can evolve and be designed after evaluation of innovative institutional arrangements. Similar evaluation can yield new institutions and organizational arrangements for the funding and performance of science.

In this pluralistic model, the National Science Foundation protects the base through two methods. First, NSF supports discipline-driven research. Second, NSF supports goal-driven research which is being neglected by the mission agencies or which involves very long-term goals. The mission agencies address their missions and invest some of their resources in basic research and in care of the science and engineering base.

The pluralistic model affords several advantages. First, it explicitly involves the public in decision-making on broad goals and relative priorities. These decisions include values elements and direct public implications which properly place them in the political realm in which the scientist is no more expert than the layperson. The role of the scientist in making specific decisions on projects, methodologies, and peer evaluation remains properly ensconced in the scientific community. The pluralistic model stresses the importance of the relationship between national goals and the research base in order to assure that neither is neglected. The model, in short, allows scientists to determine what is good science and the public to determine what science is good for.

RULES FOR NSF

The National Science Foundation performs several roles under the pluralistic model:

- Explains the importance of the complete array of discipline- and goal-driven tasks;
- Surveys goals of mission agencies with attention to: need for realignment; danger to the base by heavy concentrations of support; impact of technology; and maintenance of the national technological edge;
- Acts as the guardian of the best science;
- Addresses goals which are appropriate for a federal agency but are not covered by other agencies and goals which are very long-term;
- Encourages research, by an array of methods, on science performance and public participation in innovative organizations, on science indicators, and on the effects of organizational mechanisms on the conduct of science and the achievement of national goals; and
- Resolves the relative distribution of resources allocated to

science, science education, and the public understanding of science.

IMPLEMENTATION

The implementation of a pluralistic system such as the model described in this analysis will require some new or differently focused mechanisms for public, government, and science activities and linkages.

First, the support structure for science and technology must be more widely understood and better implemented. The National Science Foundation, other federal agencies, and performing organizations must also learn more about managing science and technology and become better at organizing institutions and support mechanisms to achieve stated objectives. Symptoms indicating that current mechanisms are faulty include the following:

-- Remarkably few participants, decision-makers, and members of the public have even a rudimentary knowledge of the design of the U.S. science and technology support structure and underlying rationale. Given the importance of this system to the nation, remedies for this information deficit should be addressed by the Federal Government and by research performers, especially universities.

-- There are inadequacies in the facilities and equipment which comprise the science and technology infrastructure.

-- There are difficulties in attracting and launching young investigators in some fields.

-- The present system strains rather than reinforces the integrity of the performers.

-- Funds for research facilities are sometimes awarded by direct political action through legislative channels without review of technical merit.

Second, some changes within performing organizations are needed. For example, a realignment of the reward structure in universities is needed to accommodate goal-directed research, science education, fostering public understanding of science, and the formation of linkages between science and the public and between science and government.

Third, the allocation of human and financial resources among the conduct of science, science education, and public understanding of science needs to be more explicitly addressed with input from a broader array of concerned parties. The three functions are interrelated, and their interdependence is increasing. A more coherent rationale and approach for resource allocation among them seems necessary.

Fourth, better indicators of scientific and national achievement need to be developed. The public understands science in terms of its visible results. These results, both individually and in the aggregate, need to be communicated regularly.

Finally, public participation in the science and technology process must become viable. The existing public-comment model of participation is unsatisfactory. It fails to yield a sense of ownership and control over national goals. In order to participate effectively the public must possess required information and expertise, as well as effective mechanisms for involvement in policy decisions. Such information and expertise derive from strengthened scientific literacy and from both science education and general education. In view of the abysmal lack of scientifically aware and informed citizens (Miller, 1983) as well as the changing ethnic and age distribution of the population, continued automatic public support for science cannot be assumed.

The education and participation of the public will require an immense amount of effort by scientists, educators, citizens, and public representatives. One under used means of exposing a large cross section of the population to science is the community college. The scientist needs mechanisms and incentives to share his or her expertise with the public. A process of telling the public about science and listening to public concerns will initiate the "working through" process which precedes judgment (Yankelovich, 1985).

People want to share in decisions which affect their lives. Furthermore, they have come to mistrust the promises of science and the beneficence of scientific outcomes. Sharply targeted research for national goals, however, has violated the expectations of scientists and universities by interfering with their disinterested pursuit of knowledge. And, practically, targeted research has also failed to meet the public expectation of seeing goals achieved.

The discipline-driven and goal-driven models constitute separate entities which coexist under the mask of a monolithic system. Since each model involves a distinct array of mutual obligations and expectations among parties to the social contract, the hybrid system which now exists generates tension and misunderstanding.

Science does maintain its creative vigor through free, curiousity-driven activity. The public does have the right to participate in decisions which significantly affect citizens' lives. A reconciliation of these apparently conflicting needs requires a renegotiation of the existing bargain between science, government, and the public. Such a renegotiation involves a pluralistic system, rather than a hybrid one, in which discipline-driven and goal-driven approaches to science and technology are applied explicitly to different tasks and in different arenas within the overall system. The new contract clearly outlines the public role as one of setting broad goals and priorities, while science investigates publicly-set agendas in a discipline-driven framework. The government takes on the role of protector of the base of discipline-driven science, coordinator of the parts of the system, and liaison between science and the public in order to assure both progress towards national objectives and the health and vigor of the scientific enterprise.

COMMENTS ELICITED BY THE PLURALISTIC MODEL

At the time of the legislation of the National Science Foundation, J. B. Conant wrote:

> ". . . 'science' is the sum total of the potential findings of the workers in the laboratories; it is their plans, hopes, ambitions in the process of realization, week after week, year after year, that is the essence of modern science."

In the same operational, empirical vein Warren Weaver then also responded to the question "What is science?"

> ". . . science is what scientists do. And in the present scene . . . when pleasant temptations and unpleasant pressures divert scientists to 'practical' researches, it would be still more meaningful to declare: What science ought to be is what the ablest scientists really want to do."

In sum, science is a human activity. To finance and otherwise foster this activity in its manifold relation to society -- this is the mission of the National Science Foundation.

Whatever the 81st Congress had in mind, we who are charged with couselling the Director on the future of the National Science Foundation have the duty to assert the crucial function of that human activity in a self-governing society. Science is not a public utility nor an instrument of national purpose to be steered and exploited for this objective today and some other goal tomorrow. It is the activity of the best qualified citizens -- so designated by standards, customs and institutions not delegated by the citizens to the authority of their government -- doing the work these carefully chosen citizens choose to do. Along with enquiry into other realms of human concern, this activity is the supreme exercise of the sovereignty of the citizen.

As Warren Weaver went on to say:

> "The sober record of human experience shows that the trained human mind, if you give it free play and a congenial climate, turns to deep and significant purposes. The rational approach to life is a successful and productive approach. The most imaginative and powerful movements in the history of science have arisen not from plan, not from compulsion, but from the spontaneous enthusiasm of capable individuals who had the freedom to think about things they considered interesting."

The objective knowledge -- knowledge rooted in experiments and observations that can be repeated and so verified by other people at other times and other places -- sought by this activity proves invariably to be useful knowledge. It works. Every process in technology is an operation first performed in a laboratory and then scaled up to industrial dimensions to be repeated over and over or run continuously. The brief history of this enterprise in our country has seen it transform a rural republic into an industrial world power. That transformation has been attended by radical redistribution of economic and political power in our social order. It has made possible the extension of the sovereignty of citizenship to the entire adult population.

The work of the scientist supported by the National Science Foundation is bound, therefore, to make obsolete first this and then that special interest in established ways of doing and making things. Because this enterprise yields science -- new understanding of nature and of ourselves -- even before it yields technology, this activity challenges authority and receives opinion at every hand. The freedom to conduct the supreme public business of this kind of enquiry must be hedged about, therefore, with defenses against private interests and governmental power as strong as self-governing citizens can muster.

This operational definition of science is buttressed by an institutional definition. The locus of science is primarily our universities. It is in these institutions that the educational process fosters and selects the most able members of the next generation to carry forward the expansion of objective knowledge. There, in community with scholars in other lines of enquiry, scientists and their students seek better understanding of the identity of man, frame human values and shape the ends to which the next generation will direct the authority of their government.

It was never contemplated -- and it is explicitly forbidden by the Bill of Rights -- that the government should have any say about what citizens think and teach. To the universities, by written and unwritten authority, the citizenry long ago delegated the duty to secure the freedom of enquiry. For scientists this is the freedom to choose and pursue their own objectives and hence to set the goals and priorities of science. For this function they are the best qualified; the consensus of the community of science should prevail in these matters on practical grounds as well as in principle.

The National Science Foundation was created to sustain the independence of this sovereign enterprise by public funding and public policy. Now that the Foundation has appropriations more in scale with its mission, it must resist the temptation and compulsions from elsewhere to make policy or set goals for science and to use its funding to induce or compel compliance.

The "pluralistic model" has its validity, therefore, if it be understood that the National Science Foundation is chartered to sustain the work of scientists in the universities acknowledged to be the "science-technology base" -- leaving it to the other, "mission-oriented" agencies to support the "goal-driven" enterprises of the Federal Government. Those goals may be pressed upon university science providing its autonomy be secured by the National Science Foundation.

* * *

On the other hand, there are different ways of organizing and managing knowledge and these ways differ according to preference and style; in the science and technology enterprise, just as in other endeavors, there is an evolution in effective management styles. When most of what the country was doing was mass production of medium quality goods, a hierarchial management structure was efficient and effective, but now the nature of the tasks and the necessary management is changing -- the different values and different styles --that are necessary to get results. For science, we have had a tried and true model, the discipline-driven model, with a lot of the work being performed in universities, i.e., the science end of the whole science-technology spectrum. But it seems clear that this could not be an exclusive model. We considered some alternative modes for different tasks; that is, we tried to derive a pluralistic conception rather than a unified entity that was broken into sects, as in the basic research, applied research and development system. Here, our understanding of the relationship of science and technology, that is the relationship of basic knowledge to innovation and technical change, is evolving and maturing, and this in itself should le[illegible] to consider whether a social contract needs renegotiation or adjust[illegible]

We also must consider the discipline diversity in the relation of science and the social contract. That is, how does this play itself out uniformly among the disciplines. In many other arenas that we are struggling with in the science and technology enterprise, we fail to understand the differences among the disciplines and the stringency of their needs; it is very difficult to get consensus towards solutions.

For the social contract to operate effectively, there need to be indicators as to whether the benefits of science are flowing properly. We also need indicators as to whether new investigators are coming into the pipeline, and are maturing in the system, i.e., whether the pipeline is working effectively. We need indicators that will help us deal with competing claims for resources and we need measures of some kind for the health of the science and engineering base. We also felt that the public is entitled to expect that managers of the science and technology enterprise will have effective ways to measure those things. If we are in charge of managing the scientific and technological enterprise, and we have not done those things, then we are irresponsible. In a sense our enterprise has been in a somewhat adolescent stage in that we haven't really matured to realize quite what all those responsibilities are. Furthermore, without better indicators, we cannot act more responsibly.

However, the public will judge our efforts on the basis of what they perceive, which may or may not be valid. The public will probably never understand what scientists do in their laboratories, or at least will only dimly catch a glimpse of that from time to time. They will never support science at the level really needed to accomplish all that this country needs in terms of its position in the world. So the support of science is inevitably linked to all of its uses, not only to the benefits. In the absence of good indicators and communication of those indicators, the public is judging our efforts in terms of what they see. It is much easier for them to see nuclear power, the bomb, and the environmental pollution as ways in which science impinges on their lives.

In the course of our discussion, we noted that not only NSF is affected by the faltering of the social contract. For example, we realize that the universities are being drastically effected by the faltering of the contract in that they are rapidly losing their autonomy. NSF's role -- the connection -- is very strong because NSF is a protector of the science and engineering base. We also reminded ourselves that NSF cannot isolate itself and simply support science as a discipline-driven enterprise. It must arrange for the better indicators and the better linkages -- the linkages being not only connections between institutions, NSF, and the mission agencies, but also connections that are in the form of information.

We looked at NSF's primary role as supporter of the discipline-driven research, its original role and the role that many scientists have perceived it to have as its sole role. To contrast that with a role that is more complex involves supporting discipline-driven research, as well as supporting some neglected mission-oriented research, some of which is very long-term, which other mission agencies will not do. The system must evolve or it will become dysfunctional and we must be astute to distinguish when something is not working right in accordance with the design -- when it is simply evolving.

* * *

In discussing aspects of the present system, we covered several miscellaneous ideas such as devoting some thought to the potential for community colleges to develop the public capacity to participate in goal setting and to communicate what science is and how it works. Another miscellaneous idea was to develop a cadre of professional peer reviewers, as opposed to the kind of reviewers we now have, since the system is so important to us and yet it is faltering. The decisions are getting so much more complex and they are still working on an old set of assumptions. It may be necessary to provide more training for the people who perform these roles.

We also talked about the differences between the elite 10 percent of the leaders in science, particularly in the university, who are very creative people; and the 40 percent who are very good, but are not breakthrough leaders, who could perform a number of valuable functions in the science and technology enterprise. However, the only path in the universities now is to strive to be one of those leaders. Inadequate value and attention is given to other important roles people might play. Reward structures could be adjusted to give us a more comprehensive understanding and acceptance of roles.

What is missing now is a real understanding that there is a whole portfolio that includes science research, science education, and the public understanding of science, and that resources have to be distrubuted among those three sections. At the moment, this is not done very explicitly and the public has very little participation in the allocation of resources. For there to be adequate support for science, we are going to have to spend more resources in public education and public participation in the goal-setting if it isn't all going to fall apart. NSF must play a very key role in the task of developing understanding of the explicit allocation of these resources. What is really missing in the current scheme of things is the participation of the public in the public policy aspect of science and the effective participation of the scientists in that process as citizens.

* * *

When all is analyzed, the real point is that NSF must attend to how the public responds to science and what we should do about their perceptions. It is not just a matter of spots on the TV and NOVA programs, and museums; it is a matter of the scientists themselves participating actively as citizens and not as experts. That is where the most effective work could be done. We recognize that this is not going to be easy to do. We are not looking for a program to get this done, but a change in mind-set.

How does this new interaction with the public fit with the fact that the community of science is a remarkably self-governing democracy? Science is at once an intentionally private enterprise in that innovations occur in a single mind. The question -- what is the truth and what is significant? -- is an intensely personal judgment which at the same time is a highly public one because the only test of that personal judgment is its submission to the consensus of the community. The greatest movement in science has come in those times and places when able people had the time and the resources to work at what they thought were important. There is little real public understanding of the process and of the institution. Consequently, there would be great public reluctance to support an enterprise that was conducted for its own sake -- in satisfaction of the aesthetic, moral, and other driving motivations of the scientist; politically, it would be more difficult to sustain.

What happened to the social contract since NSF did not receive the funding to carry on the support of science in the scale required? The universities had to go to the mission-oriented agencies. The argument for utility was the principal motivation, but not the justification, for the support of science. In consequence, mission-oriented agencies took over and all kinds of things happened to the health of the enterprise. Essentially, the enterprise depends upon the support of able people in their life work, not of financing projects from year to year. There is a serious conflict with both the practical and principal aspects of that commitment when support has to be on a short-term, project basis, justified for its utility.

There is evidence that the 360 degree horizon around us invites exploration by science; our natural enterprise is narrowed to segments of that horizon by the interests of the mission-oriented agencies. In this sense there is a distortion in the funding which has confined and narrowed the motivation that it is supposed to be eliciting. Just take the example that biology depends upon the health agencies. This means that the plant sciences, for example, have been neglected in our country and the enormous power that microbiology can bring to the understanding of plant biology is only just beginning.

If we are going to have pluralism, we need a strong National Science Foundation, committed to the mission of the patronage and support of the freely motivated initiative of the scientific community within the universities.

* * *

The rules for running a discipline-driven model are very different -- the values, the people, the questions -- and we have gone back and forth on the question of public participation. It is very clear that in a discipline-driven model, the public participation is different and more nominal. In a goal-driven model the public participation is essential. Now the value of the distinction is shown by just that one factor. If you are not clear about the two, there is misunderstanding because people who are thinking about the discipline-driven model do not know that you are talking about when you mention public input. Why should the public be involved? They have nothing to do with the matter. On the other hand, in the goal-driven model, they are the central mechanism.

There is no disagreement that NSf has a primary responsibility to be the "keeper of the flame." The difference has to do with the degree of emphasis on the other side. This emphasis is grounded on NSF involvement with long-term research, doing things that the mission agencies cannot do which is critical in its importance. The discipline-driven model is not the only way to achieve these results. The second reason is a political one, when you come to the point of needing performance indicators for measurement of support, you need to turn to the goal-driven model. You can tell wonderful success stories from the discipline-driven side, wonderful ancedotes, and that may be the mystique, but systematic monitoring of results is going to come from the goal-driven side. In other words, you are going to get the support to keep the flame alive partly by the proficiency with which the goal-driven side is accomplished.

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A very significant part of this enterprise is the integrity of the university and the community of scholars; there has been a weakening of these institutions because they do not have adequate resources to meet the commitments they have undertaken to their faculty. I think a critical element here is the need for institutional support to disengage from the individual project mode of support. Putting such an "apple of discord" in the middle of the faculty is a good way to bring the community back together again -- to stop chasing the centrifugal course and give them centripetal concerns.

* * *

Let's take another position, that the system in effect is working very well insofar as it concerns the rewards for teaching and research and has, in fact, generated an extraordinary body of talent and a maximum number of innovation. Our problem is really the quality of these components and not the economic distribution. At the marketplace, in a certain broad sense, it is working. Entrepreneurial scientists have always hustled for money for their activities, whether they genuflected to the prince in Renaissance Italy, or to the King in France, or here and there in other forms of mutual interaction. Again, we understand the process, measure it, get the indicators to tell us what has happened, put real value judgments on what the outcomes are, argue for the democratic recruitment into the class of the scientific community for the base, if possible, and share a number of other virtues. I think the protection of discipline training, discipline research, discipline orientation, discipline driving is central to the NSF. No other agency of the government does that. It is unique and its very name tells us that it is a foundation, given that name, I believe, in part to distinguish it from an agency.

The public gets captured by basic science seen through astronomy, or as seen through big accelerators, by the romance of the large enterprises as they once were captured by the voyages of exploration and romance to distant geographic lands. I think we have an opportunity to recast that familiar historical story in the present mode, which is one of the most profound revolutionary shifts we have had in a long time. The public can be made to understand this and, I think, take some special joy in it.

How we deliver basic knowledge more rapidly to function in society without killing the golden goose is, I think, the problem of our times. And the distance between basic science and its application is shorter than ever in history.

Recommendations

The implementation of the pluralistic system would require some new or differently focused mechanisms for the public, the Federal Government, and the scientific community activities and linkages. Some specific suggestions are:

1. The U.S. science and technology support structure must be more widely understood and better implemented. The National Science Foundation, other federal agencies, and performing organizations must learn more about managing science and technology, and become better at organizing institutions and support mechanisms to achieve stated objectives.

2. Recognize that the science and technology support structure must evolve or become dysfunctional.

3. Invest in research on innovative organizational arrangements for the funding and performance of science.

4. Changes within performing organizations, especially realignment of reward structure in universities, are needed to accommodate activity in goal-directed research, in science education, in fostering public understanding of science, and in the formation of linkages between science and the public and between science and government.

5. The allocation of human and financial resources among the conduct of science, science education, and public understanding of science need to be more explicitly addressed with a more coherent rationale and broader participation in the basic priority-setting decisions.

6. Develop better indicators of national scientific achievement to enhance public understanding and support; the results of science need to be communicated regularly to the public.

7. Public participation in the policy aspects of science and technology must become viable; the existing situation is unsatisfactory because it fails to yield a sense of ownership and control over national goals. The necessary information and expertise derive from strenthened science literacy and both scientific and general education. In view of the lack of awareness as well as the changing ethnic and age distribution of the population, continued automatic public support for science cannot be assumed.

8. Scientists and engineers should be encouraged to participate more in the public policy-making process.

The National Science Foundation should serve as a bridge -- a two-way bridge -- between the public and the scientific community. Some particular suggestions are:

1. Concentrate on improvements in elementary and secondary science and mathematics education, especially for those who might not go on to science careers.

2. Adult education programs should be expanded in conjunction with other federal agencies to explore new ways to present science information to the public as well as to explore humanities issues such as ethics, social responsibility, and the necessity for making choices.

3. NSF should take an aggressive role in putting specific, major science policy issues to the public. For example:

   -- The annual report should be modified to convey something of the excitement and pleasure of science and engineering, as well as to inform the lay reader of recent research results, and thereby enhance public appreciation for the activity and the agency.

   -- The Director should establish an annual cycle for presenting important issues to the public and reporting on results associated with the previous year's effort. This presentation could be combined with the new annual report. Here again indicators are of utmost importance.

   -- The Director should initiate several scheduled press briefings a year to point up key happenings in U.S. science and engineering; the Director should not merely recite new events or findings but should put such events into the broad perspective of their likely effect on the evolution of science and technology. These briefings would set the precedent that the NSF and its Director were principal describers/interpreters/ integrators of major new scientific happenings for the U.S. public.

   -- The NSF should consider publishing a "Science/Technology Issues" newletter on perhaps a quarterly basis. This would point out, in a format suitable for the generalist, significant happenings in science and technology and discuss arising issues. The newsletter would serve as an amplified continuation of some of the issues described in the periodic press briefings.

4. NSF should experiment with mechanisms for getting advice from the public in its planning and priority setting.

5. The Director should regularly remind the scientific community of the importance of public input to and public understanding of science, both for its own sake and to ensure continued public support for basic research.

6. While doing all of the above, the NSF must remain apolitical.

The National Science Foundation performs several roles under the pluralistic model. In this approach, the NSF performs the following functions:

1. Articulates the importance of the complete array of discipline- and goal-driven tasks.

2. Surveys goals of the mission agencies with attention to: need for realignment; danger to the base by heavy concentrations of support; impact of technology; and maintenance of the national technological edge.

3. Acts as the guardian of the best science.

4. Addresses goals which are appropriate for a federal role but are not covered by other agencies and goals which are very long-term.

5. Encourages research by an array of methods on science performance and public participation in innovative organizations, on science indicators, and on the effects of organizational mechanisms on the conduct of science and the achievement of national goals.

6. Resolves the relative distribution of resources allocated to science, science education, and the public understanding of science.

7. Sustains the work of scientists in universities acknowledged to be the "science-technology base."

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NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

nsf

OFFICE OF THE
DIRECTOR

MEMORANDUM October 16, 1984

FROM : Director, National Science Foundation

TO : Members of the National Science Foundation Advisory Council

SUBJECT: Public Perception of the National Science Foundation

1. Background

The public perception of science and technology in the United States has undergone many changes and swings in the last 35 years. From a very positive viewpoint at the end of World War II, it went through a negative period in the late 60's and the beginning of the 70's and is now changing to a more positive stance. Much of this public view of science and technology is stimulated in part by events outside of the science and technology areas and is influenced by opinion makers outside of this segment of the population.

In fact, it has been said many times that the science, technology and engineering community is inept at putting its case forward on a consistent and positive basis, and therefore, exerts little influence on the public.

Another problem keenly expressed at times is the fact that science and engineering do not speak with one voice. In fact, there are many activities that seem to be in contradiction to each other. Many times this fact detracts from what otherwise would be positive accomplishments.

Many prestigious spokesmen and organizations influential within science, technology and engineering are not well known to the general public. This is certainly true of the accomplishments of the National Research Council and the National Academy of Engineering. Even the American Association for the Advancement of Science and the National Academy of Sciences are not as visible as they could be.

With regard to the National Science Foundation, a similar point must be made. While its work influences both the internal workings of science and engineering and the approaches, functions and activities pursued, its role is less obvious to the general public. Furthermore, it does not speak out on major technical issues in the public forum and does not affect public opinion and attitudes with respect to the sciences and engineering.

2. Charge

I am asking the National Science Foundation Advisory Council to review the public perception of U.S. science and technology and form its own conclusions as to the veracity of the above statements. The Council should put forward a short and comprehensive statement of its own view with regard to this matter.

The Council should then consider what could be done to convey information on the nature, processes and results of science and technology so as to better inform the public; and, in particular, what perception one would want the public to have of science and technology and what action is required to achieve this result.

A third question is the one that is central to the mission of the Advisory Council: what should the National Science Foundation strive for in informing the public about its own role and how should it accomplish the goals that the council outlines?

Last but not least, how will the public's view of the National Science Foundation affect the perception of science and technology.

3. Approach

At its first meeting, the Advisory Council should discuss the charge and outline a scope of work for its activities. Prior to the meeting, the National Science Foundation will submit a series of background materials that speak to the above subject.

The broad aspect of the question that the Council is asked to pursue makes it necessary to limit the time for this study. I tentatively suggest that the Council complete the work in six months.

Erich Bloch

END

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