ONE □ The Government of Science

At the beginning of the Kennedy Administration in 1961 there was a rather searching review of the organization of the Executive Office for the coordination of national science policy. Various proposals for a Cabinet level Department of Science were seriously debated both within the Administration and within the Congress. The following chapter is a slightly edited version of a memorandum I prepared during the summer of 1961 for the President's Science Adviser, Dr. Jerome B. Wiesner, setting forth as objectively as I could the arguments both for and against a Department of Science. In reviewing this paper in the light of the experience of the past six years I find surprisingly little reason to alter the views expressed at that time. Some of the examples and some of the general intellectual and political climate toward science and technology now appear dated, but the basic conclusions and arguments do not seem to me to have been altered by subsequent events and experience.

INTRODUCTION

The phenomenal growth of the national scientific enterprise since 1950, especially that stimulated by federal support since 1957, has led to intensified discussion of the means by which this vast effort is planned and managed. Within the last few years, there has been a realization that while federal research and development expenditures represent a very modest fraction of national economic resources, they engage a much larger fraction of one of our scarcest national resources, namely, scientific and technical manpower. Furthermore, since the points of growth in our national economy appear to follow closely research and development expenditures, to the extent that these are channeled by decisions of the federal government, the whole thrust of our economy is determined. In sum, the social and economic leverage of the 2 percent of the gross national product which is expended on research and development by the federal government is out of proportion to the actual amount of money involved, yet the extent of this leverage is only now beginning to be appreciated.

Nevertheless, concern with our national scientific and technological strength, and with the influence of government upon it, has been manifest for some time. Many of the issues involved in the discussion of the management and planning of science in the federal government find a focus in the argument concerning whether there should be a Cabinet Department of Science. The present article is devoted to setting forth some of the pros and cons of such a department, not so much because I believe the issue itself is so central as because the arguments provide a framework within which it is easy to illuminate many of the problems and issues that are of current concern in the management of the federal science effort.

WHAT IS INCLUDED IN A DEPARTMENT OF SCIENCE?

Proposals for a Department of Science range all the way from very comprehensive centralization to relatively modest consolidation of a few of the more basically oriented government scientific activities.

There are currently four federal agencies whose mission is defined largely in terms of science: the Atomic Energy Commission, the National Aeronautics and Space Administration, the National Science Foundation, and the National Institutes of Health. Three of these are independent agencies reporting directly to the President, and the fourth is a part of a Cabinet Department. In addition to these major agencies, there are a number of scientific institutions, such as the National Bureau of Standards, which have a very broad capability and a present mission that is difficult to define in operationally useful terms within the framework of the department in which they are placed. In the most ambitious proposals for a Department of Science, the four agencies listed above are those usually mentioned for consolidation into a single Cabinet Department

under a single Secretary. The various agencies in the Department of Defense are usually omitted from these considerations, despite the fact that this department was, prior to the spectacular growth of NASA, responsible for nearly 80 percent of federal expenditures for science and technology.

Indeed, the National Science Foundation, as originally envisioned in the report "Science the Endless Frontier," [1] had been expected to carry out specific research in support of health and defense missions, and it was only the long delay in the creation of NSF that resulted in the growth of independent basic research programs, first in the Navy, and later in the other military services and the Public Health Service.

In summary, a Department of Science would serve for the federal government a function analogous to that of the corporate research laboratory of a large private corporation, and the Secretary of Science would play a role analogous to that of the vice president for research of such a corporation. Creation of a Department of Science would not preclude operating departments from having their own separate laboratories rather strictly tied to the specific problems and missions of these departments, in analogy with the laboratories often associated with the manufacturing divisions of large corporations. Thus, for example, a laboratory like the Applied Physics Laboratory at Johns Hopkins or the Naval Ordnance Test Station at China Lake, California, would tend to remain an integral part of the Navy, while the Naval Research Laboratory, which is more in the nature of a corporate laboratory, would be transferred to the administration of a Department of Science.

Actually, there exists a whole spectrum of proposals of which that described in detail above is probably the most radical.

[1] Vannevar Bush, "Science the Endless Frontier, a Report to the President on a Program for Postwar Scientific Research," National Science Foundation (Washington, D.C., reprinted 1960).

A more modest proposal is for a Cabinet Department which would take over certain national laboratories having a rather broad capability, for example, the National Bureau of Standards, the Naval Research Laboratory, Lincoln Laboratory, the Brookhaven National Laboratory, and others, and would also take from existing agencies most of the contract research program in universities. Such a Cabinet Department might be similar to the National Science Foundation, enlarged to incorporate substantial inhouse capabilities and operating responsibilities over a broader spectrum of science, replacing the some seven agencies and offices which now play a significant role in the support of university science.

In almost any version of the Department of Science proposal, the new department would have responsibility for the present interagency scientific programs, such as oceanography, atmospheric sciences, high-energy nuclear physics, and so on, which are now coordinated through the Federal Council for Science and Technology. There would probably be fewer such programs because many present programs that now cut across agency lines would probably lie wholly within the assemblage of capabilities brought together under the direct management of a new department. In any case, the Department of Science would carry primary budgetary responsibility for interagency programs, and the funds for such programs would be defended by it before Congress and would be appropriated to it and allocated by it to the participating federal agencies. Through its reporting to Congress, it would take ultimate responsibility for the efficient management of such programs, and to that extent remove it from the agencies themselves.

Similarly, the Department of Science would take responsibility for certain government-wide activities in direct support of the national scientific enterprise, such as scientific information, recruitment of scientific manpower for the federal government, the support of scientific education, and so on.

ARGUMENTS FOR A DEPARTMENT OF SCIENCE

The following are some of the arguments that can be brought forward in favor of the creation of a Cabinet Department of Science:

1. It would ensure a better balanced national scientific program. With the present organizational arrangements, new and glamorous subjects, such as atomic energy and space, tend to be selected for special emphasis, often to the detriment of the balanced growth of basic science, and to the neglect of applied areas of equal or greater importance to national welfare. The accidents of congressional committee organization often tend to determine the relative allocation of resources among different fields of science without much reference to the real scientific opportunities or social needs involved. Scientific fields that can be made to appear to serve an immediately useful social or political goal receive lavish support while other fields of equal intellectual importance but less understandable to the public or to Congress receive only meager support. The generous support granted by Congress to the National Institutes of Health is contrasted with the very slow growth of the programs of the National Science Foundation, because the NIH programs are more understandable to the layman.

   In the present system there is often strong pressure to create a new agency for each new scientific discipline as its importance is recognized, and in this way to freeze into the executive branch a static organizational pattern which cannot accommodate itself readily to the dynamic reshuffling of relationships between fields which characterizes progress in science. Until relatively recently, many areas of applied science have been able to develop as somewhat isolated and self-contained disciplines without much dependence on the more fundamental sciences or on the

general advance of science as a whole. Within the last twenty years this situation has entirely changed. Each applied area has drawn on a broader and broader base of fundamental science and reached further and further beyond empiricism and experience into common scientific principles. As a result of this, each new major governmental program places increasing demands on almost every branch of science and on advanced scientific education outside its own immediate domain. Whereas agricultural science, for example, was able to develop successfully as a self-contained specialty, "space science" really comprises almost every scientific and engineering discipline, both in the life sciences and the physical sciences. Thus, a government scientific agency can no longer control or command every technical capability or skill needed to carry out its assigned mission. The creation of new agencies for each new scientific discipline tends to place serious organizational barriers in the way of one agency's taking advantage of the skills and facilities of another. Furthermore, the United States has been noticeably slow in adopting and exploiting new areas of science or technology which do not fall clearly within the mission of an existing agency, for example oceanography, radio astronomy, and until the creation of NASA, the scientific exploration of space. It is often argued that a Department of Science could move much more rapidly into new areas and could continually reorganize itself to accommodate to the changing relationships between disciplines and the appearance of new disciplines.

2. A Department of Science would provide a more congenial home for certain national laboratories that cover a wide spectrum of disciplines. The National Bureau of Standards, the Brookhaven National Laboratory, and the Naval Research Laboratory could be cited as examples. In this connection a Department of Science would facili-

tate maximum national utilization of the full capabilities of these laboratories and would permit reassignment of laboratory missions to conform with the rapidly changing needs and requirements of technology. When a new national problem such as air traffic control, urban transportation, water or air pollution came to the fore, a Department of Science, it is argued, would permit us to move into the problem with all the national resources available, unconstrained by existing roles and missions. The potential contribution of a laboratory would be assessed wholly in terms of its capabilities rather than in terms of the limited mission of the agency of which it is a part.

3. Science budgets would be defended before Congress in a more uniform, coherent, and consistent way. There would be a single focus of responsibility in the executive branch, and this would engender greater congressional confidence in the overall management of the program and in the absence of "duplication and waste." There would be a single spokesman for science and technology in the executive branch, who could speak with the authority born of vast operational responsibility and budgetary control.

   Furthermore the creation of a single spokesman for science and technology in the executive branch would naturally lead to the development of a counterpart committee in Congress. There would thus grow up within Congress a group which would make a career of defending and promoting science as a whole and would provide a channel for mobilizing the testimony of the outside scientific community on congressional issues affecting the health of U.S. science. Much of this has already happened in the area of the health sciences in relation to the National Institutes of Health.

4. The centralization of key scientific service activities such as scientific information, the support of scientific educa-

tion, and the development of the overall scientific plant of the country would be greatly facilitated by a Department of Science and would provide greater insurance of the healthy development of science as a national resource. Such a department would pay greater attention to the health of scientific institutions.

5. A Department of Science could support and plan those technical activities which are of interest and importance to the government as a whole but not of overriding importance to any one agency or department. In this way it would be possible to avoid the difficult problem of adjusting agency interest and budgets to a comprehensive national program. Individual agencies could receive funds to support their role in an interagency science program outside their normal budget ceilings by direct transfer from the Department of Science. The problem of conflict of priorities would thus be avoided, and at the same time, the Department of Science could exercise much greater control over how the money was spent. The above function in the past has been exercised mainly through the Federal Council for Science and Technology, which has only the power of persuasion but no control over agency budgets. Coordination of interagency programs in the past has been successful only in those fields that were expanding very rapidly, because it is much easier to divide a pie which is growing in size 30 percent or 40 percent each year than to divide a pie of nearly constant size.
6. A single agency for science and technology would conserve scarce manpower needed in the effective monitoring and management of science programs in the federal government. Foı example, there are now no less than seven agencies that support substantial basic reseach programs in the physical sciences in universities: the Atomic Energy Commission, the Office of Naval Research, the Office of

Scientific Research in the Air Force, the Office of Army Research, the Advanced Research Projects Agency, the National Science Foundation, and the National Aeronautics and Space Administration. The administration of these extramural programs requires a high degree of skill, experience, and judgment, and the realization of the benefits of the basic research requires a unique combination of technical understanding, with knowledge of the needs of the government. As each new basic research agency has been created, it has recruited many of its key administrators from existing agencies with a resulting general dilution of talent and lowering of standards. It is argued that this talent should be concentrated in one agency where it can achieve maximum effectiveness.

It is also argued that the proliferation of agencies with different policies and administrative practices is demoralizing to the universities and greatly complicates their internal administrative problems.

In addition to these problems, there is also the problem that the basic research people in the more mission-oriented agencies are forced to spend a great deal of time and effort in defending basic research budgets against their superiors rather than on running the program. This happens because long-range research programs having a somewhat nebulous connection with specific mission requirements are forced to compete with urgent current problems and procurement in allocation of the budget. In a Department of Science as proposed, mission-oriented agencies would expend their basic research funds through the department and would thus not only make use of a single reservoir of administrative talent but also face a much stronger and more articulate set of defenders of the needs of basic research.

7. It is also argued that a new government agency is needed

now to assure the continued healthy growth of U.S. science. Since the last war, the spectacular growth of science has resulted mainly from the creation of a series of new scientific agencies at regular intervals. New money has been brought into the program by these new agencies rather than through expansion of the older agencies, which tend to reach a static budget after their glamour has worn off during the first few years. In each case the new agency has been created to exploit public interest in a new field or a new idea. The impact of all the series of new agencies has been to dramatize the importance of science to the public and to Congress. It is argued that the time is now ripe for the creation of still another new agency, and that because of general public acceptance of the importance of science, a Department of Science would enjoy support and backing which it could not have expected a few years ago.

ARGUMENTS AGAINST A DEPARTMENT OF SCIENCE

1. Science and technology are essentially tools for the achievement of social, political, or economic ends, whose desirability is arrived at through a political process.

   Essentially nonscientific ends are embodied in the missions of various government agencies which support scientific programs. It would be unhealthy and inefficient to deprive the mission-oriented agencies of one of the principal tools needed for accomplishing their mission. Even the agencies whose mission is defined mainly in scientific terms, such as the Atomic Energy Commission, have large operating and production responsibilities in addition to their research and development responsibility. It would be illogical and inefficient to attempt to separate these operating responsibilities from the research and development which support them, and yet unless these

operating responsibilities are separated out, many of the arguments for a Department of Science lose much of their point.

The separation of research and development from operating missions would have one of two effects. Either the scientific effort financed within the Department of Science for the agencies would lose focus and purpose, and would thus become less effective in helping the agency to accomplish its mission, or else, more likely, the mission-oriented agency would "bootleg" its research in the guise of production or some other activity. Such bootleg research would be inefficient, done by the wrong kinds of people, and would lead to substantial duplication of the effort already going on in the Department of Science. We see evidence of this kind of duplication even now in connection with some of the major military and space hardware programs. It would be greatly aggravated and extended beyond the military sphere by the creation of a Department of Science.

2. Science and technology, regarded as ends in themselves, or as purely cultural activities, do not attract public support, at least on the scale which is now required. Support of science on this scale can only be sold to the public and to Congress by identifying it with specific desirable social goals such as the curing of disease, the enhancement of national security or national prestige, or the protection of public health or safety. We have seen many instances of this in the recent past. By identifying the solid-state sciences with the urgent practical materials needs of the Department of Defense, it was possible to achieve nearly a doubling of support of research in this area in some universities. The civilian nuclear power program of the Atomic Energy Commission has attracted wide public support because it was related to a simple and readily understood social goal. The program of the National In-

stitutes of Health has attracted congressional support much more readily than that of the National Science Foundation because it was easy to relate the work done, even the most basic work, to problems of health and disease, which were widely understood.

Some of the problems outlined above might be overcome by organizing the Department of Science in accordance with definite social objectives and goals rather than by scientific discipline. However, this type of organization might remove much of the advantage of flexibility which has been claimed for a Department of Science, and at the same time would not overcome the difficulty of the separation of operational from research and development functions.

3. Competition and diversity in the public support of science are important in ensuring its continued health and in the development of the most effective methods of administration and support. Historical experience suggests that conferring a functional monopoly on any agency in the federal government often leads to stagnation, inertia, and complacency. With the whole of American science now so heavily dependent on federal policies and programs, we cannot afford the risk of too much centralization of control, especially the risk of stagnation or political manipulation. Under the present system of basic research support by many federal agencies, individual agencies take great pride in the quality and productivity of the programs which they support and vie with each other in creating the conditions of administration which will attract proposals from the highest quality scientific groups. The inherent competitiveness of the scientific community has been matched by a healthy competitiveness within the government, which has led individual agencies to formulate their policies in such a way as to invite the confidence, approval, and praise

of the scientific community. Furthermore, the institutional and educational needs of science are quite diverse, and so the variation in policies which some complain about has certain advantages. Decentralized decision-making in the support of basic science certainly does create problems and results not only in some inefficiencies but also in undesirable effects on universities and research institutions. On the other hand, the decentralization of decision-making gives the scientific community a leverage on federal science policy which it would gradually lose were the policy centralized in a single agency. There is also an opposite danger that a Department of Science would become the captive of narrowly professional scientific concerns and interests and would cease to develop science in the best interests of the nation.

4. The imbalance between different scientific areas supposedly created by the present system of science support is probably not as serious in practice as it appears on paper. The missions of the Atomic Energy Commission, the Space Administration, and the Defense Department have provided a very broad stimulation to the physical sciences across the board, and there are few areas that have been seriously neglected as a result. Indeed, the glamourization of the missions of these agencies has probably resulted in more, rather than less, broad support for basic science. Many of the deficiencies noted in areas such as oceanography, geophysics, or atmospheric sciences have been due not so much to neglect as to the appearance of new opportunities opened up by massive progress in other areas of science or technology. Thus the appearance of such deficiencies should be regarded as a sign of the health of our whole scientific effort. If such deficiencies are recognized and met, little has been lost. As long as we maintain the quality of our whole scientific effort and training

at a sufficiently high level, we are in a position to make up newly identified deficiencies very rapidly, since well-trained scientists can channel their talents rapidly into entirely new areas.

The fashions in science, which often appear capricious to the layman, produce in practice a concentration of effort which leads to breakthroughs more rapidly and effectively than would a more centrally managed and less spontaneous effort. Scientific fashions and the rapid evolution and dissolution of communities of interest within science are strongly offsetting influences to the apparent high degree of institutional fragmentation in U.S. science, especially in the field of basic research.

5. The world scientific community constitutes an extremely complex social system, a subsystem within our whole society which is very little understood, least of all by scientists themselves. The present system of federal support of science has grown in an evolutionary way with relatively little conscious planning and has been the result of thousands of individual scientific and governmental decisions in response to immediately felt needs. Nobody is wise enough to foresee all of the effects of any organizational change at the federal level, especially when one factors in the unpredictable influence of individual personalities. It is more sensible for the government to make small organizational changes and arrangements in response to specific and clearly identified needs and deficiencies rather than attempt to mastermind or rationalize the whole process by setting up a radically new and apparently more logical organization whose effects would, in fact, be completely unpredictable. The creation of the Office of Special Assistant to the President, the President's Science Advisory Committee, the Federal Council for Science and Technology, and most recently, the Office of Science and

Technology are examples of evolutionary changes of the type that are most likely to meet the requirements for government planning for science. We need to create such institutions one at a time, and measure their influence on the scientific enterprise over a significant period. We also need to devise ways to make the most effective use of existing institutions.

Many deficiencies in our planning for science are the result of inadequate understanding of planning itself, of what things should be influenced by government and what things should be left to the natural responses of the scientific community. These deficiencies will not be removed by organizational changes but only by improved understanding of the relations between science and society.

It is possible that the present system for governing federal science is gradually evolving toward a Department of Science or something closely resembling it. If this is so, it will be much healthier if this evolution does not take place too rapidly or too radically.

6. The most serious management problems pertaining to government science and technology are related not to basic and applied research but rather to large development projects. The problems in this area are connected fundamentally with the choices among alternative goals rather than with specifically technical problems. Most of these choices involve economic evaluations (as in the case of civilian nuclear power) or operational cost-effectiveness studies (as in military and space systems). To an increasing degree these decisions depend as much on considerations of political, social, or military goals as on questions of technical feasibility. It is difficult to see how a Department of Science, which is further removed from these nonscientific aspects, could deal more effectively with this type of problem than the existing federal departments and

agencies. Indeed, one of the problems with which we are faced in the development of major systems is that technical feasibility tends to become confused with military or economic desirability. Technological developments tend to take on a life of their own, independent of the military, social, or economic context in which they will operate. The number of technical possibilities is rapidly exceeding the availability of resources to realize them, and more and more the problem of choice becomes a problem in resource allocation, an economic rather than a technical problem. The tendency for divorcement of technology from its political, social, or military context is likely to be aggravated rather than relieved by the creation of a Department of Science. There appears to be no good substitute for the present methods of debate and negotiation for resolving the complex interactions of technical and nontechnical considerations which are inevitably involved in all of our major decisions about priorities, whether between research fields, between hardware or operational systems, or even between research and procurement.

7. While the protection of the integrity of basic research is of the utmost importance, maintenance of a proper channel of communication from basic research to applications is also essential to the effective conduct of development. In the federal government, this channel is most effectively provided by the program officers who administer basic research for their mission-oriented agencies. It should be the duty of these program officers to understand the applied needs and requirements for their agency and to be alert to all the opportunities for filling these needs, which result not only from the basic research programs that they administer but also from related work throughout the whole body of science. It is their thorough knowledge of basic research and their contact with the

scientific community which give them the necessary communication with the scientific world to alert them to the opportunities provided by science, but they need also to understand enough of the mission of their agency to be able to match scientific opportunity to need. If all basic research programs were administered exclusively in the Department of Science, the vital channel of communication between basic and applied work would be weakened, since the program officers of the Department of Science, though highly competent in science, would not be thoroughly familiar with the needs and requirements of the various government agencies.

CONCLUSIONS

1. In the American system of government, central management of the scientific enterprise, even by scientists, cannot be an effective alternative to the complicated and often frustrating process of arriving at a national consensus. Science is an important instrument for almost all the goals of the federal government; the agencies responsible for the achievement of these goals cannot function effectively if they do not individually keep their channels of communication open to the world scientific community, which they can only do by carrying out or supporting research and development on their own.
2. Although the present diversity of support and decentralization of decision-making for science are desirable, further fractionalization of scientific support should probably be discouraged, and in general, new areas of science should be developed by existing agencies or by the interagency mechanism rather than by the creation of wholly new federal scientific agencies.
3. The creation of any new scientifically oriented federal

agency should be considered only when its service, production, or other operational functions reach an importance that is at least commensurate with its research and development function.

4. Better long-range planning for science and technology in the federal government is urgently needed, but in the last analysis, must be achieved by interagency agreement rather than by central direction. Many of the weaknesses noted in the present system for the management of science result from lack of technical competence or lack of adequate status for scientific activities within the agencies themselves rather than from deficiencies in central management and planning.
5. The function of central planning and coordination for science in the federal government is not to control the substance of the scientific activity in the nation but rather to ensure that the scientific enterprise as a whole develops in a way which is most responsive to the needs of the country and regulates itself responsibly. This function includes making sure that the needs and opportunities in science are made known and receive the proper attention in the process of arriving at a consensus on what the government should do. In the final analysis, continued and increasing support of science by the federal government will depend upon its continuing ability to demonstrate its social utility. Although the cultural and ethical aspects of science are of tremendous importance, one cannot expect that society will continue to support it on the present scale as a purely cultural activity. Therefore, in the management of science by the federal government attention must be given to the efficient utilization of science and to the realization of the opportunities it provides. Effective utilization does not automatically follow from a healthy and vigorous basic science, which is thus a necessary but not a sufficient condition.