Government Sponsorship of Scientific Research

A cabinet-level department of science could serve to develop support for neglected areas of research.

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In the second year of the space age a radical change in American attitudes toward science and education has become noticeable. The Russian success, in a field where America should easily have led, has forced a reappraisal of American attitudes and actions—a reappraisal that is not yet completed.

Today I would ask, first, what new has happened since sputnik? Have we really devised and initiated actions designed to check the deterioration in our national scientific stature? The answer is yes, and we can cite some striking measures that have been undertaken. Then I shall inquire whether the measures to date are adequate. Here the answer is no, and a number of examples of deficiencies will be noted. Finally, I will inquire into the adequacy of certain aspects of our present federal organization in science and consider some alternative measures that seem imperative if serious deficiencies are to be corrected.

Let us turn first, then, to the positive side of the ledger: What have we done as a consequence of sputnik?

Measures Initiated since Sputnik

The appointment of the science adviser to the President and the instatement of the President's Science Advisory Committee directly at White House level have been a major accomplishment. Certainly this step has profoundly influenced all that has followed, for the needs of science, scientific research, and science education can now be understood and discussed at top governmental levels. Scientists finally have a definitive access to the Government. Although this step is not a cure-all, it is certainly an immense step forward that makes consideration of corrective actions more likely.

Second, serious cuts in funds for science and technology made by the Department of Defense a little more than a year ago have been largely restored over the subsequent months. Few people outside the graduate schools have realized the devastating effects of those so-called "economy measures." Over the years since World War II, the Department of Defense had increased its support of work under direction of the universities to about $300 million, of which some $30 million was for research involving graduate students. Having created this university dependence on government, the Department of Defense, in issuing its orders to cut, appeared to be ignoring completely the consequences of such action on the growth of our scientific and engineering manpower. Certainly sputnik saved us from the serious consequences that would otherwise have been inevitable.

Third, the National Science Foundation finally seems to be coming into its own. Established by Congress in 1950, it struggled through its first few years with appropriations far below even its fixed ceiling of $15 million. When the ceiling was lifted by legislative action, the situation improved somewhat. Until the current year, however, its peak appropriation had been $40 million. And of this amount, less than half went for the actual support of science; the remainder went for science education, fellowships, and other activities specified by law. Yet Vannevar Bush, in his report to the President, *Science, the Endless Frontier,* had, as early as 1944, visualized the foundation as growing to a level of $125 million in 5 years. As a direct result of sputnik, its 1959 appropriations total $130 million—certainly a radical recognition of the neglected importance of science and technology. Moreover, in response to recommendations by the National Science Foundation, Congress has authorized all departments to utilize grants as instruments for research support.

Fourth, the 6-year $1 billion student loan bill was passed. For the first time the Government has recognized the gifted student as an asset worth capitalizing. Now the way is clear for all gifted students to realize, more nearly, their optimum capabilities. This is a large entry on the positive side of the ledger.

Fifth, the National Aeronautics and Space Administration was created under civilian auspices and under a law with which few would seriously quarrel. Moreover, substantial appropriations and transfers of funds appear to have initiated this agency on an impressive scale of $250 million. This bodes well for the future of our space research and of a whole assortment of related scientific activities.

Sixth, substantial reorganization of our military research activities has led to direction of research effort into more useful and urgent channels. The creation of the Advanced Research Projects Agency by executive authority is a major step forward. Likewise, the reorganization of the Department of Defense itself is influencing our military effectiveness in a way that will soon be felt. The reorganization seems certain to lead to a more intelligent treatment of some of our most urgent and difficult defense problems.

Seventh, I would mention appropriations made for many facilities that had been knocked out of the budget, to be restored in the shadow of sputnik. The appropriation for our first large precision radio telescope is a case in point. Likewise, research facilities in the field of atomic energy, restored by the Congress over the head of the executive branch, will help to repair the deficiencies that had been for 5 years accumulating in this field, though the facilities in the American research establishment generally still remain grossly inadequate.

Eighth, the post of the Science Adviser to the Secretary of State was filled again after a lapse of nearly 5 years, and a plan to restaff the offices of the science attachés abroad was accepted and funded.

Ninth, Congress has taken action to

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make the federal service more attractive to scientific and technical personnel. Departments can now grant leaves-with-pay for advanced studies, similar to sabbatical leaves granted by universities. Other attractions, such as payment of moving expenses, can now be granted, as has been customary in nongovernmental employment. In adopting these measures, Congress has shown realization of the need for nurturing first-rate men of scientific and technical skill in government.

Likewise, the House of Representatives has created a Standing Committee on Science and Astronautics to review the needs and activities of such agencies as the National Aeronautics and Space Administration, the National Bureau of Standards, the National Science Foundation, and the Smithsonian Institution. For the first time science has been given full stature in the deliberations of a house of Congress. The corresponding new standing committee in the Senate recognizes only astronautics, and an extension of its responsibilities must be awaited.

Finally, people themselves, through committees and school boards, have undertaken revision of the curricula for secondary education. The recent books of Conant, Rickover, and others provide guides and stimulate discussion. The "pipe" electives are being reconsidered, and mathematics and science are coming back into the high school on a substantial scale. Citizens are reexamining the responsibilities involved in education. Likewise, the universities, with the National Science Foundation, are helping to bring textbook and teaching methods up to date. The work at Massachusetts Institute of Technology on physics teaching and the Yale revision of the mathematics curriculum in the high schools are having widespread impact. Communities are reconsidering tax structures to increase the attraction of the teaching profession. The attitude that high schools should be institutions that teach the disciplines of thought and learning, rather than kindergartens for play, is again becoming respectable.

I submit that this is an impressive list of accomplishments. It certainly does not justify the oft-heard comment that "nothing has happened since sputnik." Quite to the contrary, really major measures have been initiated in a little more than a year through genuine effort of the executive branch of our government, of the Congress, and of the people. I must add that I believe that a very great influence in this change has been the science adviser to the President, James R. Killian, and the President's Science Advisory Committee. For the first time, the President and his administration have had direct access to knowledge of the interaction of science on government, an interaction that now influences government more than any other single factor.

Deficiencies

But impressive as this progress has been, it falls far short of meeting the entire intellectual challenge of our time. The drastic nature of the remedies serves to emphasize the depth of our intellectual deterioration as an advanced nation in the presputnik days.

The sputnik has demonstrated that we are engaged in more than a military contest; it is a total contest in which intellectual leadership plays a major role. The contest requires that the victor demonstrate the ability of his system to provide opportunity to accomplish easily those things that men *want* and *admire*. Promise of individual freedom and dignity, and mere material welfare, are not enough. In addition to these essential ingredients, peoples expect a nation that would be great to provide added opportunities to challenge the frontiers of mind and nature—opportunities of the kind that man has treasured in his rise to civilization. The world's recognition of the challenge of space is but a symbol of this need. We can now see more clearly that national superiority comes from positive measures providing sound and widespread education, adequate laboratories, a spirit of daring to embark on new and challenging ventures—in short, all those measures that together spell the intellectual stature that emerges in our citizens from creative opportunity. In this perspective, we can see that the actions taken in the past few months have been interim and urgent measures to check our fall; they are by no means the sole elements of a complete policy to ensure our leadership in the future. But before we discuss some of the major elements of such a policy, we would benefit by looking at some remaining deficiencies that may serve as guides to future action. I shall select some examples from the earth sciences, with which I am most familiar.

We have heard a great deal of talk in recent years about weather control. Certainly, if weather modification on a large scale could be achieved, it would have most profound social, military, and economic consequences. A nation that developed a capability in this field would control, moreover, a powerful potentiality. One would suppose, in view of this potential, that as a matter of minimum common sense we would hasten to exhaust every promising avenue of research on such a problem. Nothing could be further from the fact. Two high-level committees have studied the matter, one established by the National Academy of Sciences and the other composed of the heads of the 14 American departments of meteorology offering graduate degrees in the subject. Both committees have reported, and their reports are in substantial agreement. What is urgently needed to supplement university effort is a major laboratory to provide facilities to attack the meteorological problem on a global scale—large and complex facilities that would extend the opportunity already available to university faculties. The laboratory should provide a giant computer capable of solving problems faster than nature solves them in the atmosphere; a squadron of specially instrumented aircraft to range into areas where special phenomena such as hurricanes, tornadoes, and global atmospheric circulation can be observed and measured; rain towers for observing the physics of rain formation; wind tunnels for studying atmospheric circulation; and laboratories for instrumentation of satellites and analysis of their data. Such a laboratory would cost about $15 million a year for operations. Yet our meteorological research sputters along on $3 million a year, working on insignificant problems while competent scientists sit on their hands awaiting facilities adequate for attacking the really significant problems at hand. All that happens is sympathetic talk.

This is in the face of the fact that the petroleum industry indicates that $100 million would be saved annually if the accuracy of seasonal forecasting could be improved by 10 percent, since it would know where to ship its fuel. Even small advances in meteorological knowledge would yield billions of dollars in the fields of transportation, agriculture, and business. Quite aside from national military and social potentials that can be acquired from meteorological progress, the tax from those billions might well offset some part of our present federal deficit.

The same story can be told for oceanography. The oceans cover three-quarters of the earth's surface. Untold riches are doubtless contained in them and covered by them. During the International Geophysical Year explorations, a submerged continent was explored, from Tahiti almost to South America. That a whole continent of this kind should remain unexamined until this day is an indictment of our imagination and initiative. Reason dictates that the potential resources of the oceans should be explored and studied by every means. The Soviet Union now has 22 oceanographic vessels, led by the superbly-fitted *Ob* of more than 12,000 tons. Contrast this with the half-dozen yachts of our three or four half-starved oceanographic institutions.

As a third example, the means for thorough survey, in depth, of geological resources and continental structure are at hand. The Soviet Union is reported to be coring its continental strata at the rate of 200 deep holes each year. With such coring and simultaneous survey of geomagnetism, rock magnetism, and gravity, with natural and artificial seismology, geochemistry, radiochemistry, geochronology, and other available geophysical tools, and with the supplementary activities of our oil industry, it would be reasonable to expect that we could map our continent in three dimensions and assess our continental resources in a reasonable length of time. In the face of such a program, the meagerly supported efforts of our competent Geological Survey seem pitiful.

As a further example, one might mention seismology. This powerful phenomenon not only provides the means of characterizing the nature and origin of earth shocks but also supplies the major tool for exploring the earth's interior. With a piddling half million dollars a year, seismology has been unable to grasp the opportunities that science could provide. Detailed knowledge of transformation of earth-shock energy into waves, of phase equalization for intervening wave distortion, of methods of noise reduction, and of instrumentation designed in the light of current techniques of electronics remains but a gleam in the seismologist's eye. Now that such knowledge is urgently needed for our Geneva negotiations, we can only deplore our ignorance and the complacency that has perpetuated it.

One could go on to mention the deficiencies in our antarctic program, where we have fallen far behind the Russians. Yet to the world, Antarctica represents the last great geographic frontier; its scientific exploration remains a symbol of skill and foresight, of courage and endurance that characterizes a nation that would lead.

Scientific deficiencies such as these have one common characteristic. They require integrated planning and support for the science in question on the scale of the problems concerned. They have not yielded, and will not yield, through support of a variety of independent and disconnected research projects on a small scale. Global meteorology can be understood only when it is studied on a global scale. The recording of earthquake phenomena that emerge from an earth shock requires a chain of intimately interconnected instrumentation. Oceanography requires real ships, not yachts. A critical antarctic traverse embraces many sciences and requires years of intimate planning. Scientific problems such as these require a kind of "package" support such as that demonstrated during the International Geophysical Year.

This does not mean that I advocate this form of support for all science. The individual project is ideal for many researchers. But in other fields of science there can be no opportunity for the individual unless the problems can be organized in an integrated package on an adequate scale. The successes of the great nuclear laboratories sponsored by the Atomic Energy Commission, with their specialized and expensive nuclear tools, have been made possible by offering *the individual* opportunity to carry on research on the scale required.

But there is now no adequate organizational machinery in government to initiate or even to conceive of corrective measures for such obvious deficiencies as I have described. What little oceanography the Government does undertake is split between the Hydrographic Office in the Navy and the Coast and Geodetic Survey in the Department of Commerce; both agencies are effectively buried in their departments and are regarded only as something of a nuisance. The research support that is available for oceanographic activities from the Office of Naval Research and the National Science Foundation is distributed among minute and unrelated projects. The Weather Bureau is lost in the Department of Commerce (and incidentally is separated from the ground-water half of the meteorological job because this is a function of the Geological Survey over in the Department of Interior). The Geological Survey is likewise thoroughly subordinated to Interior's major interests—grazing, Indians, and territorial affairs. And so on through the list.

Scientific Activities in Government

What, then, must be done? To analyze this problem, I would tentatively divide scientific activities in government into three parts.

First comes the science and scientific research that is an integral part of the program and objectives of certain government departments and agencies. Such research is directly related to the mission of the departments and hence is essential to their growth and evolution. Thus, the Department of Defense *must* have its supporting research for defense and must, furthermore, sponsor pure research in order to experience the revitalization that science can provide. To cut off the Department of Defense from access to the ideas that renew its vitality would be to damage our defense irrevocably. Likewise, the very lifeblood of the Department of Agriculture is scientific research in agriculture, biochemistry, plant and animal biology, soil chemistry, and so on. Similarly, in many departments one finds activities in scientific research, conducted or sponsored by the department concerned, that are necessary for its intelligent and healthy growth.

The second major government scientific activity is research support. The Government supports a variety of scientific programs in many fields for the sole reason that such support helps to maintain the vitality of American science and technology itself. These are primarily the programs of grants and contracts of the National Science Foundation and the Department of Health, Education, and Welfare. They are frequently described as "extramural" programs of government, because their purpose is to help assure the continuation of free, uncommitted research in colleges, universities, and research institutions. These agencies support graduate students and the individual pure research studies of professors. They contract for the basic laboratory facilities that are necessary to a balanced American scientific activity. These agencies are not "operating" agencies in the usual sense but, rather, have certain broad responsibilities with respect to the general welfare, including not only the encouragement of scientific research but the support of science education to the extent needed to keep America intellectually strong.

The third federal scientific function is represented by those federal services that cut across state boundaries and departmental interests and must, therefore, be performed by the Federal Government. There are a variety of such agencies that must provide very general technical services, based on science, that have no special relation to any single department of government but are applicable to all departments and to the country and its business as a whole. Among the agencies performing such services are the Weather Bureau, the National Bureau of Standards, the National Bureau of Standards' Central Radio Propagation Laboratory, the Coast and Geodetic Survey, the Hydrographic Office, the Geological Survey, the Office of Scientific and Technical Information, the Antarctic Offices of the Navy Department and the National Science Foundation, the Fish and Wildlife Service, and the Naval Observatory. These agencies provide those technical and scientific services that are the normal functions of government with respect to its citizens everywhere. They have no real organic relation to the departments with which they are individually associated but find themselves assigned to one department or another largely through historical accident.

Let me summarize, then, the three parts into which I have divided federal responsibility for science for purposes of this analysis: (i) the organic research activities of the departments that are integral and vital to the achievement of department objectives; (ii) external federal support of scientific research and education, conducted by nongovernmental organizations, universities, and laboratories and unrelated to any direct organic responsibility of the supporting agency; (iii) governmental scientific and technical services not principally involved in attaining existing department objectives or strongly related in the organic sense to the functions of a single federal department but of the utmost importance to the Government and the people as a whole.

This third responsibility is not now well discharged by the Government, nor can it be, for a number of obvious reasons. (i) Since the agencies concerned do not vitally participate in striving to attain the organic objectives of the departments concerned, they are "stepchildren" and something of a nuisance to their individual departments. (ii) The organizational distribution of interrelated scientific responsibilities among a variety of departments prevents the close collaboration that is imperative to the success of these services on matters of overlapping scientific and technical interest. (iii) These agencies are at a vital disadvantage in obtaining budget support in competition with other bureaus more closely related to individual departmental objectives. (iv) Since these agencies are minor departmental responsibilities, departmental heads have little knowledge of their real importance. Therefore, appeals for corrective action are not adequately understood or interpreted by departmental administrators.

Department of Science and Technology

The present organization of these vital activities has grown haphazardly over the past century. The time has come when organizational change is imperative. I submit, therefore, that a new federal Department of Science and Technology should be organized to bring the agencies of this third category together, with the objective of adequately developing the broad scientific and technical services of government to meet the needs of today.

Such a department might well include the following divisions, among others: Division of Physical Sciences and Standards; Division of Oceanography; Division of Meteorology, Climatology, and Water Resources; Division of Continental Structure and Resources; Office of Scientific and Technical Information; Government Map Service; Office of Time, Geodesy, and Astronomy; Division of Continental Fish, Wildlife, and (perhaps) Conservation; Division of Radio and Outer Atmospheric Research; and Office of Polar Activities.

The creation of such a department would centralize government responsibility for vital scientific functions that are now performed to an extent that is most inadequate in the light of current needs of science and technology. It would bring together closely related scientific responsibilities so that their natural relations could be exploited. Above all, it would provide the means of extending our leadership to scientific areas where we are now surpassed by other nations.

In advocating such a department, I do not propose that it should try to set up government laboratories to do the job at hand. This would defeat the very objectives of broadening the base of American science and providing opportunity to men of great skill wherever they may be. Rather, the department should be a focus for the now neglected responsibilities in American science. In sponsoring scientific research, a Department of Science and Technology might well emulate the successful pattern of the Atomic Energy Commission in contracting to sponsor national laboratories or institutes in fields of meteorology, theoretical geophysics, polar research, and the like. Certainly I would not preclude government operation and expansion of such essential agencies as the National Bureau of Standards and the Naval Observatory. But, wherever possible, research facilities should be organized as a supplement to university and institutional activities and should be easily accessible to the faculties of such institutions.

One may ask why I have not included the National Science Foundation in such a proposed Department of Science and Technology. I believe that the objectives of the National Science Foundation are radically different from those of a Department of Science and Technology. Such a department is designed to provide government services in science and technology that are essential and must be provided on a nationwide basis. It *must* be closely related to operations at every turn. Its research activities are focused by those responsibilities. On the other hand, since the National Science Foundation functions solely in the area of extramural research, it is and should continue to be nonoperational. Its funds for grants and contracts should not be in competition with funds for internal government responsibilities.

Likewise, I would not disturb the Department of Health, Education, and Welfare, which is now functioning successfully in the life sciences. Although the National Astronautics and Space Agency and the Atomic Energy Commission are operating agencies in the same sense as the agencies in category (iii), their size and specialized functions are such as to justify their independence. It would seem unwise to upset their successful operations for the doubtful advantage of operational symmetry. If combined into a new department, these two agencies would bury the very functions that the new department should be designed to expand and develop. The purpose of the new department should be to correct deficiencies and not simply to engage in organizational exercises.

The most impelling argument that has been advanced against such reorganization of science in government is that Congress is in no mood to stop with the kind of measures that I have proposed. There is real fear that in organizing a Department of Science and Technology Congress would end up by dumping all the scientific activity of the departments and agencies into such a department. An indiscriminate lumping together of all categories of government activity in science would, of course, be little short of catastrophic. The damage so done would doubtless outweigh, by far, the advantages to be achieved. Because of this very fear, I believe, scientists generally have not advocated, or have even opposed, the creation of a Department of Science and Technology.

Executive Responsibility

Consequently, any initiative for corrective action should originate in the executive branch of our government, where a carefully prepared and well-reasoned plan can be presented to Congress. Failure of the executive branch to review broad deficiencies in federal scientific and technological activity has arisen from lack, until recently, of any workable mechanism for examining and formulating technological and scientific policy at the top governmental level. Of course, such a charge was assigned by Congress to the National Science Foundation. But from my earlier analysis of government responsibilities in science it may be readily seen that, organizationally, it is quite impossible for the foundation to assume or to discharge this responsibility successfully. Since the foundation discharges one of the three coequal functions of federal science and technology, it cannot coordinate all three without endangering that function for which it is principally responsible.

For this reason, the President's science adviser and the Science Advisory Committee have a major role in the examination and formulation of over-all broad policy for federal science and technology. I visualize their duties along the following lines: (i) to assess the impact of science on government, in all its aspects, military, economic, and social; (ii) to evaluate the balance of the United States program of science and research in order to insure adequate support for all areas of scientific research; (iii) to be especially sensitive to new potentialities for scientific research and development, and to find means to open up, and to recommend support for, new areas of activity; (iv) to review adequacy of support for reconstruction and extension of facilities for scientific research to keep America's research plant up to date, with the objective of creating a plant capable of investigating the clues that nature provides, to the full extent possible with the tools that can be provided by our technology (our research plant is now seriously obsolescent); (v) to review constantly the character of the opportunity offered scientists and engineers and the administration of scientists and engineers within government, looking to the improvement of government personnel practices with respect to such men; (vi) to insure suitable and adequate federal practices in support of scientific information; (vii) to monitor federal policies on international collaboration in science; and (viii) to review, from time to time, the effectiveness of broad federal policies with respect to the general health of scientific research.

In these tasks the President's Science Advisory Committee might well lean heavily on the National Academy of Sciences. The academy is representative of our most skilled scientific workers. In its statutory function of advising government the academy should be an especially valuable source of advice on explicit questions that the committee may properly ask it.

But, of course, neither the committee nor the academy has the facilities for the detailed planning and preparation of data that are prerequisite to discharge of their policy responsibilities. Moreover, there are subfunctions of policy planning that are intimately associated with departmental functions which can never be carried adequately by any external committee. Consequently, the new Federal Council for Science and Technology, chaired by the President's science adviser, assumes a major role in policy planning.

With the President's Science Advisory Committee for broad policy function and with the federal research council for policy planning, the President's science adviser should find adequate means of formulating both broad and detailed policy. These are the policy tools needed by the executive branch to plan a Department of Science and Technology and to guide it through congressional debate in suitable form. I believe that with these tools, the nation can safely undertake the corrective action required by the present grave deficiencies in federal science and technology through organization of a Department of Science and Technology, without danger of creating a governmental monstrosity that would wreck the direction of federal scientific effort. We can now regroup related federal responsibilities in science and technology from haphazard into workable form.

To achieve these ends demands that a sobering and challenging measure of responsibility be assumed at every level of social and political action.