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Government Organization of Science

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This article is based upon a seminar discussion held 8 and 9 January 1960, in which the participants were Lloyd V. Berkner, president of Associated Universities, Inc.; A. Hunter Dupree, associate professor of history, University of California (Berkeley); James McCormack, vice president, Massachusetts Institute of Technology; James M. Mitchell, director, Conference Program on Public Affairs, The Brookings Institution; Emanuel R. Piore, director of research, International Business Machines Corporation; Don K. Price, dean of the Graduate School of Public Administration, Harvard University; and the author.

This group came together to discuss the recommendations that a Department of Science and Technology be established in the federal government. It was agreed in advance not to try to decide whether or not the group favored a Department of Science and Technology, but to concentrate on the reasons for considering such a department, the alternative forms it might take, and their probable consequences for science and engineering and for the ability of the federal government to carry out its responsibilities in these fields.

At the conclusion of the discussion, the participants decided not to prepare a group report but asked me to take individual responsibility for that task. The result is based directly on the group discussion and has profited from the criticisms that members of the group gave to a first draft, but it does not represent their unanimous opinion. In fact, some of them disagree with some of the statements that I have chosen to retain despite their disagreement. The participants are, however, unanimous in hoping that the article will be helpful to scientists and others who are concerned with problems of science administration and the effectiveness with which the federal government carries out its scientific and technical responsibilities.

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A Department of Science and Technology in the federal government, a department headed by a cabinet secretary and responsible for a considerable range of scientific and technological activities, has been proposed in several recent Senate bills and recommended by several science administrators. The idea is an old one. Dupree has traced it back to the Constitutional Convention (*1*). Always before, for one reason or another, the opposition has been stronger than the support, and that may be true again, for while a strong case can be made for some major changes, there are good arguments against the specific proposals that have been made. Opinion differs all the way from the assertion that a Department of Science and Technology will certainly be established within the next five years to the equally flat assertion that such a change is impossible. Whatever decisions may in time be made, the topic merits careful analysis, for involved are issues dealing with the delineation of the responsibilities of the federal government, its effectiveness in carrying them out, and the extent to which science and engineering can make their proper contribution to national objectives. It therefore seems desirable to analyze the objectives to be sought and to consider the probable consequences of various organizational arrangements.

In the years since World War II, changes in government organization have been many and sweeping. Increasing awareness of the role of science and engineering in national affairs and their increasing contribution to national security and welfare have led to the establishment of the Atomic Energy Commission, the National Science Foundation, the National Aeronautics and Space Administration, and the Department of Health, Education, and Welfare; to several major reorganizations of military research and development; to creation of the post of Special Assistant to the President for Science and Technology and the Federal Council for Science and Technology; and to a greatly enhanced status of the President's Science Advisory Committee. These are not all of the changes since World War II in federal administration of scientific and technical activities, but only those that have attracted widest attention (*2*).

Despite these changes, there still remain some major organizational and administrative problems, and there continue to be suggestions for further change, of which the most prominent is the proposal that there be established a Department of Science and Technology. Such a department has been recommended in several recent Congressional bills (*3*) and in analyses by Berkner (*4*) and Brode (*5*) of deficien-

cies in the present administrative arrangements. Arrayed in opposition to a Department of Science and Technology have been the judgment of the President's Science Advisory Committee (*6*), the Science Policy Committee of the Republican National Committee (*7*), the majority sentiment of the participants in the AAAS Parliament of Science held in 1958 (*8*), the Administration, and a substantial number of witnesses before Congressional committees.

It is not our purpose to give a simple yes or no answer to the question, Should there be a Department of Science and Technology?, but rather to examine some of the reasons for proposing such a department, and to analyze the questions that must be answered before one decides what changes are desirable.

There is a terminological difficulty in discussions of a Department of Science and Technology, because scientists and engineers distinguish *science* from *engineering,* while headline writers tend to cover the whole gamut of research, development, and engineering with the one word *science.* Because government jargon follows headline writers' usage, the title "Department of Science" does not differ in meaning from the more frequently used title "Department of Science and Technology"; under either title the department would include both science and engineering. Engineers have recommended that the word *engineering* be used in place of *technology*, but the suggestion has not been generally adopted. The title "Department of Science and Technology" is therefore used here. In discussing subject matter, *science* is used to mean pure, or basic, or fundamental science, while such terms as *science and engineering,* or *research and development* are used when the broader range of activities is meant.

In starting out to discuss a Department of Science and Technology, one really should define the term. But there is no precise definition. Different users of the title may have quite different organizations in mind. In general, they refer to a branch of government at the same organizational level as the Department of Commerce or the Department of Health, Education, and Welfare, and, like them, headed by a secretary who sits as a regular member of the President's cabinet. But ideas concerning the scope of the proposed department and the scientific and engineering activities that should be transferred to it vary widely among the advocates, and even more widely among the opponents, of such a department.

Organizational Objectives

An administrative structure can be judged in terms of the effectiveness with which it achieves its objectives. The arguments advanced in favor of a Department of Science and Technology constitute claims that certain objectives could be better attained with that form of organization than they can be under the present organization. These arguments require analysis, for one reason because they are not always explicitly stated in the advocation of such a department, and for the more important reason that the worthier of them constitute a useful set of criteria for appraising the merit and probable consequences of the several kinds of Department of Science and Technology that have been proposed and of other administrative changes that may be considered.

1) *Operational effectiveness.* A major criterion for judging an organization is its ability to get the assigned jobs done as well as possible. The jobs for which the federal government is partly responsible include basic research in all fields of science, applied research on a wide variety of practical problems, and the development of new services, instruments, weapons, power sources, remedies, agricultural products, and a host of other devices, methods, and useful end products. To accomplish these purposes, work is carried out in government laboratories and institutions, in organizations wholly supported by government funds but privately managed, and in industrial, university, and other private or public agencies that are partly supported by government funds. The purpose is partly to provide scientific and technical information or services to the nation as a whole (for example, weather forecasting), partly to support responsibilities that are peculiarly those of the government itself (such as the maintenance of national defense), and partly to strengthen research and education in science throughout the nation. It is essential that these widely varying responsibilities be kept in mind, for whatever form the organization takes, it must be able to deal effectively with every field of science and every form of application of scientific and technical knowledge.

2) *Efficient organization.* Both Congress and the President must deal with all of the scientific and engineering agencies. Thus, the number of different agencies, their interrelations, and their coordination influence not only the operating effectiveness of the agencies themselves but also the effectiveness with which Congress and the President can carry out their responsibilities of reviewing, directing, and supporting those agencies.

Eleven years ago, the Hoover Commission on Organization of the Executive Branch of the Government reported that "the executive branch is not organized into a workable number of major departments and agencies which the President can effectively direct, but is cut up into a large number of agencies which divide responsibility and which are too great in number for effective direction from the top" (*9*).

Proponents expect that the merger of a number of agencies into a single department would reduce duplication of effort and would bring about a better coordinated total program. These changes would probably result, but the changes would not be unmixed blessings. Some kinds of duplication are to be avoided, while others are sometimes to be sought. In basic research, rapid and effective interchange of information is a better means of preventing unwanted duplication than is centralized control, for at this level scientists do not knowingly duplicate the work of others, except when duplication is required for verification. In production and procurement, and in the construction of highly specialized facilities, duplication is ordinarily to be avoided. But in applied research and early prototype development, deliberate duplication of effort is frequently desirable. Competition toward a single end is a well-recognized practice in industry, and it has been useful in some government-sponsored activities. Witness a variety of examples, including alternative means of producing fissionable material under the Manhattan Project, alternative designs of power reactors, and the competition between solid and liquid propellants. Creation of a departmental organization may reduce some unnecessary duplication; to eliminate duplication entirely should never be the objective.

As for centralization and coordination, although the merger would probably accomplish only a small reduc-

tion in the total number of scientific and technical agencies, it could bring under one head several agencies that account for a substantial portion of the nonmilitary research and development budget and that occupy a considerable fraction of the time Congress devotes to scientific and technical matters. On the other hand, independent agencies have their own budgets for review by the Bureau of the Budget and by Congress. They have their own hearings before Congressional committees, and each has some congressmen who maintain a close interest in its affairs. Merging such agencies into a single department would bring about greater centralization of planning and responsibility, but both Congress and the President would lose some of the present closeness of contact with each. It is significant that Congress established the National Aeronautics and Space Administration and the Atomic Energy Commission as separate agencies rather than as parts of existing departments.

3) *Higher status.* Proponents sometimes argue that the establishment of a Department of Science and Technology would enchance the status of research and development as a government activity and would lead to larger appropriations than are possible when the same activities are widely scattered through a number of departments and agencies.

The status argument is probably sound. Public prestige attaches to a cabinet position, and a Secretary of Science and Technology would serve as a symbol of the national importance of research and development. But the status argument is not compelling. The Atomic Energy Commission and the National Aeronautics and Space Administration are probably as well known and get as much public attention as do many of the federal departments.

The argument that financial support would be increased is of doubtful validity. The argument runs that many of the scientific and engineering activities of the government are now buried fairly deeply in departments that have much wider responsibilities and that therefore do not support their research and development activities as vigorously as would a Department of Science and Technology. The argument may carry weight, but Congressional appropriations reflect interest in the purposes being supported and a sense of their national importance. One must at least ask whether the large appropriations for nuclear physics have not come because of wide popular interest in the purposes which atomic energy is expected to serve, and whether the increasing appropriations for biological sciences have not come about because of skillful marshaling of public interest in the diseases for which the National Institutes of Health have undertaken to seek cures.

4) *Sound policy development.* Scientific and technical activities constitute essential support to the operations of many federal agencies, and constitute one of the elements that must be considered in numerous aspects of broad national policy. At some point in the federal structure there should be a mechanism for bringing all the scientific and technological threads together, both from the standpoint of establishing policy for research and development agencies and from the standpoint of the contributions these agencies make to national policy.

Three general classes of policy problems are involved. One is to provide broadly for the advancement of science and its practical applications. To avoid misunderstanding, it should be pointed out that policy guidance should not mean centralized direction of the work of individual scientists. The weight of much experience warns against any such effort. But research is not wholly a matter of individual decision; it depends increasingly upon the funds and facilities that are available. As equipment and facilities become more costly (consider high-energy accelerators, radio telescopes, oceanographic vessels, and so on), it becomes more clearly a matter of general policy to decide which new facilities can be afforded, which are likely to make the greatest contributions to science and which to the attainment of other national objectives.

The second class includes the contributions that scientific and technical knowledge can make to the solution of other national problems. A widely discussed current example is the ability to detect nuclear explosions, and the influence this ability has on decisions concerning disarmament and inspection.

The third class includes the influence of national needs on science and technology. Political, military, and economic needs help to determine the emphasis to be given to different technological areas and even to different fields of research.

Whoever has responsibility for making decisions on these interrelated issues must have opportunity and authority to review the entire research and development effort of the nation and to give due consideration to other policy issues.

5) *Major improvements.* Sometimes vague in its expression, but important in its sense of urgency, is the final argument that a drastic improvement in the ability of the federal government to cope with scientific and technical problems is essential, and that a Department of Science and Technology would achieve improvement simply by being a large, prestigious, and centralized agency with major responsibility for a wide sweep of scientific and engineering problems and developments. Sometimes the feeling is expressed with frank admission that the speaker does not know what organizational details would prove most effective, but that "something ought to be done" to enable the federal government to exercise more constructive leadership in the nation's total research and development effort. Embodied here are ideas of prestige, support, policy guidance, effective coordination, ability to anticipate future requirements, and ability and imagination to focus major attention on the problems and areas that will add most effectively to national strength, welfare, and prestige.

In a sense, this argument is a summary or a synthesis of the preceding ones, but it is also more than that, for an organization might carry out its duly assigned responsibilities effectively, meet the canons of good organization, enjoy substantial prestige, and provide for proper policy coordination, yet still be so rigid and unimaginative as to be unable to anticipate and prepare for new requirements and opportunities or to cut down or close out activities of diminishing returns. Government responsibilities change, and so do scientific and engineering capabilities. If an administrative organization is too rigidly bound to currently recognized opportunities and requirements, it cannot change readily to meet new conditions. Somewhere in the organization there must be high competence to recognize and meet new requirements and opportunities. This, in the minds of many critics, is the primary objective to be sought in any plan of reorganization. They would be quite willing to support an organization that fell short on some of the preceding points if it gave hope of achieving radical improvement in this respect.

The public interest. The executive

and legislative branches of government serve and represent the general public. It is thus also necessary that the administrative arrangement contribute as fully as possible to public understanding of the scientific activities of the government. Federal expenditures for research, development, and engineering mount year after year and now account for a tenth of the federal budget (though less than 1 percent of the budget is used for basic research). The general public has both an interest in and a need to know what is going on. An additional criterion of administrative arrangements is therefore the effectiveness with which the organizational structure meets this need and the extent to which it fosters public recognition of the place and role of science and engineering in government affairs. But the criterion of public interest is only indirectly involved in selecting one or another administrative pattern, for in the long run the public interest will be best served by adopting the administrative arrangements that most adequately satisfy the other criteria. Under any form of organization there will remain a continuing obligation to keep the public informed of problems, progress, policy, and possibilities, but the form of organization that can best serve the public interest is the one that can most effectively carry out its assigned responsibilities, provide the basis for enlightened policy, help Congress and the President fulfill their responsibilities, and foresee and prepare for the future.

Organizational Alternatives

With the objectives in mind, it is possible to examine alternative organizational possibilities. It should be recognized, however, that the form of organization that best meets one criterion may not best meet another. Thus, weighting the arguments differently may lead to different judgments concerning alternative possibilities. It should also be recognized that a purely logical organization, one created *de novo,* is impossible. Compromise among different points of view and concession to past history and existing realities are inevitable.

One over-all department. Discussion of the possibility of combining *all* research and development activities of the government into a single Department of Science and Technology is largely a matter of belaboring a straw man, for no serious proposal of such an all-encompassing department has been advanced. Yet the idea must be examined, for it represents one popular concept of a Department of Science and Technology and is the concept against which the most vigorous opposition has been expressed.

Merging all scientific and technical agencies of the government into a single department would, in one dramatic step, provide for the more effective meeting of most of the criteria discussed above. Public interest in and appraisal of the role of science and engineering in government would be enhanced, for they would be placed on a par with agriculture, defense, commerce, and the concerns of other cabinet departments. There would be one cabinet officer to whom Congress could turn for information and whom the President could hold responsible for all research and development activities; over-all policy-making responsibility could obviously be his, as could responsibility for meeting new scientific responsibilities. On these grounds, one all-inclusive department looks good, but the gains would be achieved at the expense of a drastic reduction in the ability of some departments, such as Defense and Agriculture, and their research and development branches, to carry out their continuing, day-by-day responsibilities, and this loss would be so great that the idea of an all-inclusive department must be rejected.

The primary role of government-sponsored research and development is to help in carrying out other responsibilities. It is true that the federal government has adopted the wise, long-range policy of supporting and strengthening pure science and science education. But in general, scientific and technical offices and laboratories are established and supported primarily for the services they can render their respective agencies. It follows that the organization of research and development should be planned to give maximum support to the related operational responsibilities. Two principles emerge.

1) Scientific and engineering activities that are intimately related to the operating responsibilities of an agency belong in the agency. Research on military problems cannot be divorced from the Department of Defense without weakening our defense capability. Research on agricultural problems is an integral part of the activities of the Department of Agriculture. Wherever this relationship holds, wherever the operating responsibilities of an agency are firmly rooted in an active program of research and development, the research and development activity should remain as an integral part of the agency concerned.

2) Science and technological development have so much in common and benefit so much from each other that in any particular area, such as nuclear energy, the two should remain under the same administrative direction. One implication of this principle is that if existing agencies are brought together into a new department, that department must deal with both science and technology, not with pure science alone. Another implication is that applied science and the closely related pure science work of existing agencies should not be separated. Either both should be transferred or both should be left where they are. The President's Executive Order 10521 recognized this principle in stating that medical, agricultural, defense, and other agencies that have large responsibilities in applied science are expected to support and carry out fundamental research on topics closely related to their operating responsibilities.

These principles seriously challenge any plans for a Department of Science and Technology that would include all scientific and technical activities of the government and any plans that would separate research from closely related technological development or application.

Senate bills. In recent years, several bills proposing the establishment of a Department of Science and Technology have been introduced in Congress. The major current one is S. 676, introduced by Senator Humphrey and others. It proposes to combine into a single department the National Science Foundation, the Atomic Energy Commission, the National Aeronautics and Space Administration, the National Bureau of Standards, and several functions of the Smithsonian Institution. In the main, these are agencies of wide interest to Congress and the public; several might be called "glamor" agencies. The Atomic Energy Commission and the National Aeronautics and Space Administration deal with the newest and most spectacular fields of science and technology. The National Science Foundation is the one general-purpose scientific agency of the government. The National Bureau of Standards deals

directly with business and industry.

The merger of these agencies into a single department would centralize responsibility for a number of important activities in the hands of one cabinet officer who could report directly to the President and the Congress. The numerical decrease in the number of scientific and engineering agencies would be relatively small, but the ones brought together would be major ones, to which both Congress and the President must give substantial amounts of attention. There would, therefore, be some advantages in efficiency of organization, prestige, and policy-making responsibility.

There would also be disadvantages. From the standpoint of the agencies themselves, it is widely feared that some of them would lose their effectiveness under the proposed merger. The National Science Foundation and the selected portions of the Smithsonian Institution are devoted to basic research and to education in science. These responsibilities would constitute only a minor fraction of the total program of the department, and it is feared that they would suffer as a consequence. The Atomic Energy Commission has a budget several times larger than any of the others, and most of its funds are used for production rather than for research and development. The principal officers of the new department would of necessity have to give greatest attention to atomic energy activities, including the production of atomic devices. As a general principle, it seems unwise to combine agencies of diverse interest when one is so much larger than the others. In particular, it seems unwise to subjugate a number of agencies in which the major emphasis is on research and development to a much larger one in which the major emphasis is on production. There is good reason to fear that the result would be an enlarged Atomic Energy Commission responsible for a number of not very closely related other activities, that the agencies concerned would not be helped by the merger, and that the total ability to meet new needs and opportunities would not be sufficiently increased to justify adopting this proposal.

A department of environmental sciences. Berkner (*4*) used a different criterion for selecting the agencies that might be merged into a department: to increase the effectiveness of the agencies themselves. On this basis he would exclude research and development activities that constitute integral parts of the agencies in which they are now located —for example, the Departments of Agriculture and Defense. He would also exclude those agencies that are primarily responsible for supporting research carried out by others—the National Science Foundation and the Department of Health, Education, and Welfare. Finally, he would exclude the independent agencies that are already large and strong, the Atomic Energy Commission and the National Aeronautics and Space Administration.

When these three groups are excluded, there remains a number of scientific and technical bureaus that Berkner believes could be moved without seriously harming the departments in which they are now located, because they are not integrally bound to those departments. Because these bureaus have much in common, he believes that bringing them together in a single department would strengthen all of them. This department would include the Weather Bureau, the National Bureau of Standards and its Central Radio Propagation Laboratory, the Coast and Geodetic Survey, the Hydrographic Office, the Geological Survey, the Office of Scientific and Technical Information, the Antarctic Office of the Navy Department, the Antarctic program of the National Science Foundation, the Fish and Wildlife Service, and the Naval Observatory.

There is no obvious title for such a department. With the major independent agencies left out, along with the scientific activities that are functioning well in other departments, it would seem inappropriate to use such a general title as "Department of Science and Technology." The title "Department of Environmental Sciences" does not cover all of the proposed activities but does indicate the centralization of emphasis on problems of understanding, using, and controlling man's physical and biological environment.

A significant difference between this proposal and that of the Senate bill is in the organizational status of the agencies that would be combined. The Senate bill would combine whole agencies (except for parts of the Smithsonian Institution); Berkner would withdraw selected activities from the departments in which they are now located and combine them into a new department. It would therefore be necessary in each individual case to examine the activity in detail to determine whether it would seem to be better located in the present or in the proposed new location. For example, the fact that some 75 percent of the work of the National Bureau of Standards is concerned directly with industry makes its location in the Department of Commerce seem reasonable. But the fact that the Bureau of Standards receives substantially less than half of its funds from the Department of Commerce suggests that the relationship could be severed without seriously disrupting its services to the nation. One would want to avoid severing a really fundamental working relationship, for such a step would probably require the old department to establish an agency similar to the one it had lost by transfer. We would then have two agencies where before there was one.

Some of these agencies have been moved in the past. The Weather Bureau was originally established in the Department of the Army, then transferred to the Department of Agriculture, and later transferred again, to the Department of Commerce. In none of these locations was its relationship to the parent department the intimate and essential one that exists between the Department of Defense and its research and development units. Instead, the Weather Bureau is an aid to the military services, to agriculture, to commerce, and, indeed, to the nation as a whole, and will continue to be so whether it remains in the Department of Commerce or is transferred to a new department.

An advantage of a department constituted as Berkner has proposed is that the research activities for which these several laboratories and agencies are responsible could be carried out more effectively, for they have closely related scientific interests, they could profit from each other, and they could profit from being in a department in which science and technology was the central theme instead of a side issue. Bringing them together into a single department would seem likely to raise the status and improve the scientific work of all of them. The opposing argument, the weight of which would have to be determined in each individual case, is the extent to which service functions would be weakened by the transfer.

Within the wide range of the environmental sciences, a department so constituted could be given responsibility for the development of new scientific activities. When oceanography, meteorology, geophysics, or other new fields are not a major responsibility of any

agency, no agency is likely to push very hard for their development. But a department devoted wholly to scientific and technical activities would be more likely to be on the alert to identify areas that need special emphasis, and more eager to secure the facilities they require, for its reputation would depend entirely upon the effectiveness with which it carried out scientific and engineering responsibilities.

Policy responsibilities would not be changed in principle by merging this list of agencies into a new department, but there would be improvements, for one major, well-coordinated agency would replace a number of smaller and scattered ones. From the standpoint of Congress, the flow of information concerning scientific activities would be better coordinated, even though the total number of departments reporting to Congress would be increased by one. The new department would not, however, include any of the agencies in which Congress is most keenly interested.

There are additional respects in which this proposal differs from those embodied in Senate bills. No one agency is so large as to overwhelm the others. This is an advantage. Another difference is that the list does not include any of the big, glamorous agencies that in the public mind or in the headline writers' vocabulary mean science—Defense, Atomic Energy, or National Aeronautics and Space Administration. To the public, and probably also to many members of Congress, this collection of agencies does not "look like" a cabinet-level department; combining them into a single agency would appear to be a mere rearrangement of administrative structure rather than the creation of a new department to recognize their enhanced role and status.

Cabinet status would seem more reasonable if one or more of the prominent independent agencies were also included. There are three to consider: the Atomic Energy Commission, the National Science Foundation, and the National Aeronautics and Space Administration. The reasons previously given for not merging the Atomic Energy Commission with a diverse group of smaller agencies would also hold here; the AEC should not be included.

It is more difficult to decide about the National Science Foundation. This agency, with minor exceptions, has not itself operated research and development programs but has worked through grants made to others. It is devoted primarily to basic science, while the others are concerned with applications. In general, a department that has both operating and grant-making functions tends to give priority to the operating responsibilities, and one that has responsibilities for both pure and applied science tends to give priority to applications. Thus, the NSF would run a double risk if it were to be included. But there are arguments on the other side of the case that should also be considered. The Office of Naval Research, the National Institutes of Health, and some of the private foundations have demonstrated that it is possible to administer a grant program effectively while at the same time conducting excellent research in one's own laboratories. A Department of Environmental Sciences that included the National Science Foundation could follow in this tradition, but the scope of operations of the NSF would have to be broader than the scope of the rest of the department. Whether the NSF should be included or left in its present independent status is still an open question.

The National Aeronautics and Space Administration should be included. While NASA commands a much larger budget than do any of the other agencies, the disadvantage of that disparity is more than offset by the similarity of functions and the closeness of scientific relations that would obtain between NASA and the other agencies. NASA, like the others, deals with man's environment, and there would be mutual benefit in the close affiliation of NASA with the geophysical, meteorological, and other research of the agencies that would be included in a department dealing with the environmental sciences. These relationships are, in fact, likely to become closer in the future than they are at present, as increased ability to carry out space research provides more powerful support to studies of the earth and its atmosphere and the energy exchanges that shape man's physical and biological environment.

The department originally proposed by Berkner would be strengthened by inclusion of the National Aeronautics and Space Administration, and perhaps also by inclusion of the National Science Foundation. This would be a department that would strengthen its constituent parts, that would have sufficient size and range to constitute a strong element in the general policy formulation realm, and that would be both broad enough and sufficiently well balanced to serve effectively as the agency responsible for keeping the nation abreast of new developments and new opportunities.

More fundamental reorganization. Brode (*5*) has proposed a Department of Science that differs from the others not in the specific agencies to be incorporated but in its emphasis upon a major regrouping of scientific and technological functions. Brode accepts the general principle that scientific activities essential to the work of an operating agency should be left in that agency, but points out that authority to engage in basic research in fields that underlie an agency's operating responsibilities has sometimes been used as license to support an unnecessarily wide range of scientific activities. "Thus, a Department of Science, while not removing from agencies such as Defense and Agriculture, . . . the research programs specific to their missions, should include all major segments of science not specifically pertinent to those missions."

The result would be a department of very wide scope, with "separate bureaus or institutes . . . to deal with space, atomic energy, medicine, weather, patents, science information, physical science, geology, and other recognized areas of importance." Brode does not spell out the implications for existing agencies; it is a concept he offers rather than a complete set of plans. But presumably the department would incorporate a number of existing agencies, such as the Geological Survey, the Weather Bureau and the National Science Foundation. Presumably also it would incorporate entirely or would take over the "scientific" portion of the responsibilities of the Atomic Energy Commission and the National Aeronautics and Space Administration. And, as pointed out above, it would include some of the scientific activities of other departments—for example, Defense and Agriculture.

This department would have the advantages that are inherent in greater centralization of authority and responsibility. It would provide a more centralized channel for Congressional information and interest. The department would clearly be of such size and scope that it could have major responsibility for new developments and could have

an important role in the making of scientific policy.

On the debit side, there would be the difficulties, pointed out in discussing other proposals, of merging diverse independent agencies and the additional difficulties of separating from a number of other agencies a portion of their basic research activities. Each such separation would require careful analysis to determine how much of what kind of scientific work should be left with the parent agency and how much should be transferred to the new department; making these decisions would undoubtedly involve much friction. The testimony of directors of applied research laboratories supports the arguments that better scientific talent can be recruited if the scientists are offered some opportunity to engage in research of their own choice, and that some engagement in basic research enables a laboratory concerned with applications to understand better the implications of basic research for the applied work it is doing. Clearly there will be difficulties in deciding where to draw the line if the general concept is accepted that research essential to the best interests of the agency responsible for applications is to be left with that agency while other research is transferred to the new department.

A careful study, as Brode has recommended, will be required before this proposal can be fully evaluated, for here again is a case in which the recommendation that a department be established brings in its train a whole series of specific detailed questions.

Other Possibilities

None of the proposals for a Department of Science and Technology is entirely satisfactory, yet each helps to show deficiencies in the present administrative structure. Perhaps too much attention has been devoted to a specific form of organization—a cabinet department—and not enough to the objectives. It may be worth while to take the major objectives as a point of departure and to ask what organizational changes would bring about greatest improvement in ability to attain those objectives, and also to ask how well the present arrangements are likely to meet these objectives.

Meeting new needs. A fundamental issue in the administration of research is the determination of the basis on which funds and facilities should be allocated among different fields and programs. At one extreme, research workers themselves make the important decisions because the allocation of available funds is made to accord with their research plans and project requests. At the other extreme, the allocation is made by science administrators who select the areas and types of research from which they expect the greatest return of scientific knowledge or practical application. In practice, probably every agency compromises between these two extremes, but there are situations in which a reasonably close approach to one or the other extreme is appropriate. The National Science Foundation is devoted to basic research and has adopted the policy of not attempting to direct the course of science by channeling its funds into one or another field that appears to its officers as most likely to "pay off." Yet the NSF has quietly favored some areas of basic research that its officers thought needed special stimulation. Thus it has given special support to oceanography and astronomy, and more recently to meteorology, and it secured and administered the funds for U.S. participation in the International Geophysical Year.

In contrast, the applied-science agencies have typically channeled their grants into those fields of research and development that have appeared most likely to support their responsibilities. Yet many of these agencies have also supported basic research, sometimes over a wider range than their operating responsibilities made necessary.

For a large range of basic and applied research, these two methods of allocating funds effectively complement each other. They leave a gap, however, an important gap that includes those areas of research that appear to be ripe for intensive development but that are not likely to be energetically exploited by an applied-science agency because no appropriate agency exists. Even without special help, such fields will normally grow, but perhaps too slowly for the national interest. This is by no means a new problem. The National Advisory Committee on Aeronautics was established to give special support to aeronautics. More recently, the National Aeronautics and Space Administration was established to give special support to space science and exploration. The speed with which science is gaining new knowledge and the speed with which new knowledge can frequently be turned to practical use suggest the desirability of giving greater emphasis to the effort to identify other fields of research which appear ready to respond to special emphasis and support by advancing to the state on which major practical applications could be based. In this middle ground, between pure basic research, for which outcomes cannot be clearly foreseen, and research in support of applications that have already demonstrated their worth, some very hard choices would be necessary. Difficult as the choices would be—and everyone involved would have to be reconciled to the prospect of some costly mistakes—the position of the United States as a scientific leader may well depend upon our willingness to gamble that the benefits of such an effort will exceed its cost. The gamble is a good one, for despite their difficulty, choices can be made, and the penalty for not making them will be a series of expensive crash programs entered into in an effort to make up the ground we failed to cover earlier in a more orderly fashion.

No agency now has responsibility for the area of new developments, but under the special circumstances of World War II, the Office of Scientific Research and Development and the Manhattan Project had this spirit. We need now an office with the same spirit, and with the same wide-ranging authority to undertake work in whatever areas appear sufficiently promising to justify special support. This agency would of necessity work flexibly and in cooperation with other research and development agencies and would normally transfer to other appropriate agencies responsibility for continuing those programs that had demonstrated their worth.

Responsibility for new developments might be handled in any of several ways. One would be to create a special agency just for this purpose. Another would be to divide responsibility among existing agencies, giving to each a kind of free-wheeling authority to select, explore, and develop relevant new areas. (An example is the Advanced Research Projects Agency of the Department of Defense.) Still another would be to assign responsibility to an existing agency. Among those now in existence, only the National Science Foundation is

broad enough in scope, but to assume this responsibility the NSF would require additional funds and authority from Congress and a major policy decision that it should go beyond the area of basic research that has been its primary responsibility.

Of the Departments of Science and Technology that have been suggested, some could and some could not reasonably be given responsibility for new developments. An all-encompassing department could. The department proposed by Berkner could cover a considerable range of possibilities, and the one proposed by Brode an even broader range. A narrowly confined department would have neither the appropriate authority nor the staff.

Whether or not a Department of Science and Technology is established, an urgent problem is that of achieving greater competency for looking ahead to identify and develop those areas of research that are not yet the responsibility of one of the applied-science agencies but that appear likely to produce major advances and applications in return for special support and research opportunity.

Over-all scientific policy. The percentage of the nation's total scientific effort that is financed by the federal government has become so great that the government cannot escape major policy responsibility. It establishes policy anyway, whether it wills to do so or not. Under these circumstances, conscious, deliberate arrangements for policy responsibility are essential.

Individual agencies, such as the National Science Foundation, and interagency consultative bodies, such as the Federal Council for Science and Technology, can have important roles in the policy sphere, but they cannot be all-sufficient. Neither a single agency nor a consultative body nor a cabinet department can evaluate competing demands among agencies at its own organizational level. Furthermore, the final choices on major matters cannot be separated from decisions concerning the national budget, military security, economic welfare, and other national issues. It follows that the center of policy responsibility must lie close to the President. Nowhere else can general policy responsibility for research and development be placed so effectively, just as nowhere else can responsibility for budget review be adequately handled (*10*).

If the Office of the President is to have the competence to exercise the policy role wisely, the staff must include men who are highly skilled in the management of scientific affairs and who can relate scientific matters to all of the other considerations that are involved in major policy decisions. The President has a Special Assistant for Science and Technology and a Science Advisory Committee that can make suggestions, criticize policies, serve as a forum and board of review, advise the Bureau of the Budget and operating agencies, and, in general, serve as a powerful aid to the President in the making of major policy decisions.

Even though the same man has thus far served both as Special Assistant to the President for Science and Technology and as chairman of the Science Advisory Committee, the distinction between the two positions should be kept clear. The Science Advisory Committee and its chairman may very properly place first emphasis in their thinking on the scientific and technological needs of the nation and the national implications of scientific and technological developments. Thus the Science Advisory Committee should be free to criticize established or proposed policy if damage to the nation's research and development program is foreseen. In contrast, the Special Assistant to the President is part of the Presidency and must always subjugate specifically scientific or engineering considerations to the totality of all factors involved in making policy decisions. The chairman of the President's Science Advisory Committee should be able to go to the President and say, "Mr. President, this is what we as specialists in science and engineering think should be done. . . ," while the Special Assistant for Science and Technology must help the President to decide what must be done in light of all of the considerations involved. Whether the chairman and the Special Assistant are the same man or different men, the President needs the best scientific and engineering advice available, and then needs an Assistant for Science and Technology who can help him to weigh, judge, incorporate, and perhaps override that advice in establishing national policy. The present arrangements for these functions seem to be working effectively.

Congressional responsibility. Congress needs better means than it now has for making decisions concerning scientific and technical matters. Required are better channels of information and better provisions for reaching well-informed decisions. The present system is one of multiple channels of information and multiple committees to deal with the information. Traditionally, the two Houses of Congress have had essentially parallel committee structures, in which each committee deals with agriculture, defense, commerce, or some other area, and in which each committee is responsible for those matters of research and development that constitute part of its area of general responsibility.

Merging some of the scientific and engineering agencies into a single agency would consolidate some of the channels of information, but multiple channels would remain, and would continue to be desirable. In addition, Congress needs to have a good over-all view of these matters. With the establishment of the National Science Foundation, Congress acquired a source of general report concerning basic research activities, and the chairman of the Federal Council for Science and Technology has now been authorized to report to Congress on scientific and engineering matters generally. There are sound reasons for exempting the President's personal assistants from the requirement of reporting directly to Congress, but special considerations in the case of science and technology suggest the desirability of perfecting arrangements to provide Congress with the systematic, general reviews concerning research and development problems and progress that are available to the executive branch through the Federal Council and through the Science Advisory Committee.

Congressional committee structure has also been changing. When the Atomic Energy Commission was created, Congress established a Joint Committee on Atomic Energy to serve both the Senate and the House of Representatives. More recently the Senate established the Committee on Aeronautical and Space Sciences, and the House of Representatives, the Committee on Science and Astronautics. The latter has an unusually broad charter that has permitted it to study a wide variety of scientific and engineering matters.

Congress might follow any of three lines in an effort to develop a committee structure still better equipped

to cope with the wide range of scientific and technical problems. One would be to extend the scope of the House Committee on Science and Astronautics and the Senate Committee on Aeronautical and Space Sciences so that both would become general committees on science and technology. Any such extension of authority must, however, be limited, for it is altogether unlikely that the committees now responsible for agriculture, health, or defense matters—to take these as major examples—would wish to relinquish responsibility for the scientific and engineering aspects of their areas of responsibility.

The second possibility would be to establish a committee comparable to the Joint Committee on the Economic Report. This committee serves both Houses of Congress but is not directly responsible for legislation in either. It holds hearings, analyzes the annual report of the President on economic matters, keeps under review other evidence concerning the economic health of the nation, and serves as an adviser to committees that have direct legislative responsibility. A similar advisory committee on all scientific and engineering matters could be established.

The third possibility would be to establish a joint committee for science and engineering similar in function to the Joint Committee on Atomic Energy. While the Joint Committee on Atomic Energy has worked successfully within its area of responsibility, its chairman and executive director have warned that the total range of scientific and technical problems is too wide to be handled by a single committee (*11*). Nevertheless, a committee with responsibility for legislation has some advantages over a committee that can only review and advise.

How to choose among these alternatives is clearly a matter for Congress to decide, but the arrangements decided upon should be such as to encourage interested members of Congress to specialize on scientific and engineering matters and to make their legislative careers in large part dependent upon their knowledge and special interest in this field, just as other congressmen now establish their legislative reputations as specialists on foreign relations, national defense, or fiscal policy. One of the losses that results from the present highly fragmented system is that the system does not sufficiently encourage the development of a group of congressmen interested in, well informed about, and continually reviewing the scientific and technological problems of the nation.

Continuity versus Change

One of the organizational possibilities to consider is continuation of present arrangements. General policy responsibility is being effectively exercised by the Special Assistant and the Science Advisory Committee. The flow of information to Congress is being improved and could be improved still further. Responsibility for new developments is lacking and should be provided for under any organizational pattern. That leaves for special consideration the question of coordination and effective action by the existing research and development agencies. The key to improvement in this respect lies in the hands of the Federal Council for Science and Technology. The Council was created by the President because it seemed to him and the Science Advisory Committee to be more desirable than the creation of a new department.

When the President's Science Advisory Committee proposed the establishment of the Federal Council, they recommended that it include the heads of major independent research and development agencies and the Assistant Secretaries, or comparable policy-level officers, who were responsible for all research and development activities in the departments they represented. When the President issued the executive order establishing the Federal Council, the wording was changed; policy-level officers of departments are included, but they need not have responsibility for all research and development in their departments. Some departments—Agriculture and Defense—already had top-level officers responsible for research and development; they serve on the Federal Council. Other departments—Commerce and Interior—did not have such officers, have not appointed them, and are represented by members who do not have over-all responsibility for research and development in their departments. Thus the Federal Council is not as well informed a body nor one whose members all exercise as direct research and development responsibility as the President's Committee had in mind in recommending its establishment.

The original idea of having within each department an Assistant Secretary (or comparable officer) responsible for all research and development activities, and of using these officers as a strong coordinating council, is still worthy of consideration. This arrangement could solve some of the problems of interagency cooperation, could bring about greater support for important agencies that have not had top-level representation, and could provide the President and Congress with information concerning the total research and development program. Whether or not the Federal Council as now constituted will work out satisfactorily remains to be seen; its trial period has been too brief for us to be certain. But greater effectiveness could be expected if all of its members were of the kind originally intended.

The value of change. Senility affects organizations as well as men. Agencies that once were full of vigor and promise have been known to lose their best men to competitors, to promote the remaining ones to positions of seniority, and gradually to lose all youthful vigor. The problem of maintaining organizational virility is perhaps more difficult in government service than elsewhere because of the government's competitive disadvantage in securing and retaining the ablest men. It is partly to overcome this difficulty that a number of major research and development activities have been established as contract laboratories, wholly financed by federal funds but administered by a university or industry.

An organizational change may sometimes be justified not because the new pattern is inherently better than the old one but because the change provides an opportunity to bring in new blood and to accomplish the reinvigoration that in an ideal world would not be necessary. This may not be the most respectable argument in favor of a new pattern of organization, but it is nevertheless a practical argument that should be considered along with the reasons for and against a particular change and the anticipated difficulties of bringing a new organization into being. The argument also implies its corollary, that a new organizational pattern is likely to wear out, and to have to be replaced by a still newer one sometime in the future.

The Question of Status

Much of the discussion of a proposed Department of Science and Technology has involved arguments over the desirability of having a secretary in the cabinet. From the standpoint of working effectiveness, meeting new needs, and effective relationships with Congress and the President it should be pointed out that merging a number of existing research and development activities into a single agency not of cabinet status would probably be about as effective as combining the same activities into a department of cabinet rank. The chief officers of the National Science Foundation, the Atomic Energy Commission, and the National Aeronautics and Space Administration are, on appropriate occasions, invited to attend cabinet meetings. They have access to the President, can administer their own agencies, and can discuss their problems with Congress as readily as can cabinet officers. So could the head of a new independent agency. Cabinet status has symbolic value, but the cabinet is no longer as powerful a body as it once was, and cabinet rank is not an essential of better organization.

In the eyes of many scientists and engineers, cabinet status would have a real disadvantage. The cabinet is not only an arm of government but also—despite the occasional appointment of someone from the other party—an arm of the President's political party. A Secretary of Science and Technology might be well trained in science or engineering and have appropriate administrative experience in these fields—in fact there is good reason to expect that he would—but the necessary qualifications would also include interest and ability to work in the cabinet as a political arm of the President's party. The head of a noncabinet agency would also be expected to have technical and administrative qualifications, and of course he would have to be able to work effectively with the President, but he would not have to be involved in party politics.

A related status question is sometimes overlooked. There is a necessarily inverse relationship between an administrator's closeness to the center of high-policy responsibility and the single-mindedness with which he can concentrate on any particular element that goes into total policy. Top-policy control cannot be divided. Budgetary, scientific, political, defense, economic, social, and other factors must be closely intermeshed. Whoever might be appointed to head a new agency—whether of cabinet status or not—would be working at a level at which scientific and engineering matters must be geared into the mechanisms of economic, budgetary, security, and personnel management of national affairs. In order to be effective at this level, one must be much more than an able and vigorous spokesman with a wide understanding of scientific and technical matters. One must also accept the fact that these matters constitute only part of the basis for decision making.

A Study Commission

There is no answer in any of the above to the question, Should there be a Department of Science and Technology? The question is not yet ready for an answer. When considered in the abstract, without specifying what the new department would include and without examining in detail the difficulties that would be created, the idea of a Department of Science and Technology looks attractive. It is in line with the general trend toward greater centralization of responsibility. It would make sense to the general public as a constructive, forward step that would bring about better coordination, reduce unnecessary duplication, and provide higher-level responsibility for the nation's critically necessary scientific and technological progress. It would give Congress a more direct basis for coming to grips with the major problems of science and technology and would lead to the growth of informed and responsible committees in Congress. These changes in Congress would require the executive branch to organize better its presentation of scientific and technological problems.

All of this is to the good, but each specific proposal for a Department of Science and Technology has serious weaknesses and seems to create or augment about as many difficulties as it was intended to solve. Criticism of the specific proposals does not mean, however, that there is no problem, but only that the right solution has not yet been found.

A new department—or a new agency not at cabinet level—is not the only possibility. Much of the reason for advocating a cabinet department could be achieved by other changes: (i) top-level representation and support for research and development in those departments in which these matters are not now satisfactory, and insistence upon full cooperation in and through the Federal Council for Science and Technology; (ii) making more available to the Congress the information and advice of the President's Science Advisory Committee; (iii) improvements in the Congressional committee structure; and (iv) the establishment of a special agency to meet new scientific and engineering needs and opportunities or the assignment of this responsibility to an existing agency.

Which of the possible alternatives would be the best means of achieving all of the desirable improvements remains an open question. The responsible Senate committee recognizes the complexity of the problem and now recommends the adoption of a bill (S. 1851) to establish a commission on a Department of Science and Technology. The commission would consist of 16 persons, eight appointed by the President and four each by the President of the Senate and the Speaker of the House of Representatives. Four members would be from the executive branch of the government, men participating in federal scientific activities; eight would be prominent scientists from outside the government; and four would be members of Congress. Half would be from one political party and half from the other. The commission would be asked to determine "(1) the desirability of establishing within the executive branch of the Government a Department of Science and Technology in order to provide more effective and better centralized and coordinated science programs and operations within the Federal Government, and (2) if the establishment of such department is desirable, which functions now exercised by other departments or agencies of the Government should be transferred to such department and what, if any, new functions should be given to such department."

There are two difficulties with this means of seeking a solution to the problem. The first is that the question to be asked of the commission is not broad enough. At this stage we should not be restricted to the question, Is a department desirable?, but should try to an-

swer the question, What is the best solution? The other difficulty is in the composition of the proposed commission. As a bipartisan commission, half of the members would represent a political party that has already recorded its opposition to a Department of Science and Technology. This fact almost guarantees a balancing membership of persons committed to support the idea. At this stage the idea needs nonpartisan analysis rather than bipartisan compromise.

Whether the commission is appointed or not, means of improving the administrative arrangements with which the federal government carries out its scientific and technical responsibilities will continue to be discussed. The decisions that will ultimately be made will be sounder ones if scientists and government representatives have considered the alternatives objectively and have analyzed the probable consequences of various organizational patterns.

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Mathematical Evaluation of the Scientific Serial

Improved bibliographic method offers new objectivity in selecting and abstracting the research journal.

L. Miles Raisig

In the 33 years since the report in *Science* of the Gross and Gross (*1*) method of weighing the value of the serial publication in the field of chemistry, scientists, librarians, and literature specialists have sought to provide similar "objective" evaluations for serials in several other fields.

Those later studies, which lay claim to objectivity through the counting of the number of citations quoted, rest quite solidly upon the assumptions made by Gross and Gross in 1927. (i) The value of any journal in any scientific field may be measured directly and objectively by determination of the number of times the journal is cited in the literature of that field; that is, the greater the number of citations, the greater the value of the journal. (ii) Any well-used, subjectively valuable journal in the scientific field may be chosen as the source for counting citations to other journals.

In those studies it is further variously assumed that the journal selected as a source of citations is representative of the field, and that if two or more source journals are used, both or all may be weighted equally.

In a recent thorough review of the basic citation method, I found it to be neither scientifically objective nor mathematically sound, based as it is upon raw counts of citations wholly unrelated to the numbers of original articles published.

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Qualitative Measurement Possible

In this article is offered an improved citation-count method, designed to measure qualitatively the value of any scientific serial by means of a related quantitative citation count.

Unlike the method of Gross and Gross, this improved method does not (i) underrate the serial which must for a temporary period suspend publication or reduce sharply the number of original articles it customarily publishes (for example, many German journals during 1917 and 1918); (ii) overrate the serial which, by reason of a few heavily cited articles, appears to be of considerable value; or (iii) overrate the serial which publishes a large number of very short articles (for example, *Comptes rendus de l'académie des sciences*), which therefore may appear to be relatively heavily cited.

In theory the new method rests upon the following assumptions. (i) Any original (hitherto unpublished) article which appears in a serial publication has immediate and retrospective "reader impact"; that is, it may immediately or in the future be used and quoted in the preparation of another original article