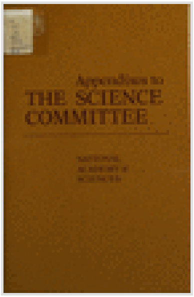

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Appendixes to THE SCIENCE COMMITTEE

A Report by the Committee on the Utilization of Young Scientists and Engineers in Advisory Services to Government
NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY OF SCIENCES Washington, D.C. 1972

NOTICE: The study reported herein was undertaken under the aegis of the National Research Council with the express approval of the Governing Board of the NRC. Such approval indicated that the Board considered that the problem was of national significance; that elucidation of the problem required scientific or technical competence; and that the resources of NRC were particularly suitable to the conduct of the project. The institutional responsibilities of the NRC were then discharged in the following manner:

The members of the study committee were selected for their individual scholarly competence and judgment with due consideration for the balance and breadth of disciplines. Responsibility for all aspects of this report rests with the study committee, to whom sincere appreciation is hereby expressed.

Although the reports of our study committees are not submitted for approval to the Academy membership nor to the Council, each report is reviewed by a second group of appropriately qualified individuals according to procedures established and monitored by the Academy's Report Review Committee. Such reviews are intended to determine, *inter alia,* whether the major questions and relevant points of view have been addressed and whether the reported findings, conclusions and recommendations arose from the available data and information. Distribution of the report is approved, by the President, only after satisfactory completion of this review process.

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APPENDIX **A**

A Brief History of Science Committees in the United States

Science committees advisory to the federal government have a history going back to the first years of the republic. The remarkable proliferation of the present day, however, when nearly every major federal agency has its conjoint structure of committees, can be said to have its origins in the creation of the National Advisory Committee for Aeronautics in 1915 and the National Research Council in 1916, reflecting the urgent needs of the nation during World War I.

Prior to that time, men of science and engineering were called upon from time to time as specific needs arose. But these were usually needs of limited duration, and the committees were short-lived. Their use is evidence, nevertheless, of a historical recognition in our government that scientific knowledge and technical expertise have something to contribute to public affairs. Thus these occasional committees constitute an interesting forerunner of the permanent, sometimes statutory, advisory committees that exist today at every administrative level, from that of the President downward, many of them with constellations of subordinate committees and panels.

The following brief history cannot claim to be a balanced account of the evolution of the use of science advisory committees by government so much as an introductory guide to some of the more prominent committees that have played a part in that development. It is a story of some of the taller trees rather than of the whole forest.

As early as 1791, Thomas Jefferson, then Secretary of State, took the advice of a committee of scientists in deciding whether a certain Mr. Isaacs should have a patent for a process of distilling fresh water from seawater.[1] The law at that time required that a device to be patentable had to be effective as well as novel. It was recognized in Congress that the best judges of a patent application would be "men of science," although no provision was made for obtaining their advice.[2] Jefferson suggested a meeting of his committee to decide the case of Isaacs any time "from five in the morning to twelve at night, all being equal to me."[3]

Other matters calling for scientific judgment were referred to *ad hoc* committees of scientists during the following decades. In 1807, for example, Albert Gallatin as Secretary of the Treasury invited scientists to submit plans for the coast survey that his fellow Swiss, Ferdinand Rudolph Hassler, had persuaded the government to undertake. The committee chose Hassler's plan and recommended him as the best man to carry it out.[4] This, the beginning of the U.S. Coast and Geodetic Survey, is the earliest instance of scientific advisers being consulted on the shape of a technical government program.

In the 1830's the Treasury Department asked a committee of scientists at the Franklin Institute in Philadelphia to study the causes of steam boiler explosions. An anxious public wanted protective legislation, but lack of scientific information made sensible legislation hard to write. Although funds were provided to pay the committee's expenses, which included the construction of a test boiler, the members themselves were unpaid.[5]

But science was still a young profession in the United States and there was confusion as to what constituted professional scientific knowledge and understanding. When in 1838 the proceeds of James Smithson's bequest were received in the United States, willed for the founding of "an Establishment for the increase and diffusion of knowledge among men," President Van Buren instructed his Secretary of State to "apply to persons versed in science and familiar with the subject of publication" for their views on the best way to accomplish this end. However, the Secretary's list of correspondents was characterized not by professional scientists but by scientific amateurs like Gallatin and literary scholars like President Wayland of Brown University.[6]

TOWARD SYSTEMATIC PROFESSIONAL ACCREDITATION

Alexander Dallas Bache, second superintendent of the Coast Survey, an able scientist who knew how to get things done in Washington, was convinced of the need of "an institution of science supplementary to existing ones . . . to guide public action in reference to scientific matters." Addressing the recently founded American Association for the Advancement of Science as its president in 1851, he spoke of the "absence of accredited tribunals" to "try" the claims of pretended science, and pointed to the danger of a "modified charlatanism, which makes merit in one subject an excuse for asking authority in others, or in all, and, because it has made real progress in one branch of science, claims to be an arbiter in others." He proposed a national institute, composed of scientists drawn from the several states, which would engage in researches "self-directed, or desired by the body, called for by Congress or by the Executive." The government would "furnish the means for the inquiries." He suggested that "the public treasury would be saved many times the support of such a council, by the sound advice which it would give in regard to the various projects which are constantly forced upon their notice, and in regard to which they are now compelled to decide without the knowledge which alone can ensure a wise conclusion."[7]

The Civil War, coming as new technologies in propulsion and armament were forcing themselves on the nation's attention, underscored the need for expert advice that Bache had cited a decade before. Perhaps the real harbinger of the modern advisory systems was the Permanent Commission formed in the Navy Department in 1863 by Secretary Gideon Welles, "to which all subjects of a scientific character on which the Government may require information" might be referred.[8] The Commission had been proposed by the forward-looking Commander Charles Henry Davis, Chief of the Bureau of Navigation. Its membership of three consisted of Davis, Bache, and Joseph Henry, probably the most respected scientist in the country. It was small, unpretentious, and effective. Meeting frequently during the war, it issued more than two hundred reports on proposals that had been referred to it. It showed the practicality of a government agency turning to scientists for advice in a systematic way.[9]

In the same year a more permanent result of Bache's vision emerged with the creation of the National Academy of Sciences.[10] Appropriately enough, Bache became its first president. Amid the rich variety of administrative and organizational patterns exhibited by the abundance of advisory mechanisms today, the Academy is unique. It was established by

Act of Congress, but as an independent corporation; it was authorized to organize itself, to effect its own perpetuation, and to provide for all "matters needful or usual in such institutions." The Academy was instructed to "investigate, examine, experiment, and report upon" any subject of science or technology whenever called upon by any department of the government. Thus a private institution was created, independent of governmental administrative control, but required by law to assist the government in appropriate matters. No funds were provided. Indeed, although the Act states that the government is to pay the actual expenses of the Academy in responding to governmental requests, it specifies that the Academy "shall receive no compensation whatever for any services to the Government of the United States."[11]

This is the legal framework within which many thousands of scientists and engineers, coming together under the Academy's aegis, have provided advice to federal agencies for more than a hundred years.

THE INTERIM YEARS

In the half century following the Civil War, the Academy's services were used only sparingly by the government. Few specific issues or tasks were referred to it.[12] On the other hand, it exerted a substantial influence on the evolution of scientific bureaus within the executive branch. It provided the mechanism by which the advice of leading scientists and engineers was brought to bear on matters affecting the internal structure or relocation of older agencies like the Coast and Geodetic Survey, the Weather Bureau, and the Patent Office, and the creation of new agencies such as the Geological Survey, the Forest Service, and the National Bureau of Standards.

Quite apart from the Academy, however, the use of science committees was growing gradually through those years, along with the mounting impact of technical and scientific questions on public policy and on the substantive responsibilities of the executive agencies.

In 1878, Congress gave the Marine Hospital Service, which maintained hospitals at the points where the great epidemic diseases entered the country, limited authority to enforce a quarantine. But the yellow fever epidemic of that year, coupled with concern on the part of the American Public Health Association regarding the effectiveness of the quarantine laws, prompted Congress in the following year to establish the National Board of Health to enforce the federal quarantine laws and to "obtain information on all matters of public health." The Board consisted of seven members chosen by the President with the advice and consent of the

Senate, and representatives of the Army, the Navy, the Department of Justice, and the Marine Hospital Service. It was an expert group—for example, the distinguished medical scholar John Shaw Billings was the Army's representative—but it was not established as a permanent body, and in four years the quarantine power reverted to the Marine Hospital Service.

The concept of the advisory committee was more permanently established in the public health field in 1902, when Congress provided for an advisory board for the Hygienic Laboratory of what had by then become the Public Health and Marine Hospital Service. This board was composed, by statute, of three experts detailed by the Army, Navy, and Department of Agriculture, and five "not in the regular employment of the Government." The original membership included the great William H. Welch of Johns Hopkins, who was later President of the National Academy of Sciences, Simon Flexner of the Rockefeller Institute, later elected to the Academy, and W. T. Sedgwick, chairman of the department of biology and public health at MIT.[13] They were the forerunners of the multitude of scientists who since that day have served as advisers to the Public Health Service.

Meanwhile, the National Bureau of Standards had been established in 1901, with a statutory provision for "a visiting committee of five members, to be appointed by the Secretary of Commerce, to consist of men prominent in the various interests involved, and not in the employ of the Government." The first membership, like that of the board advisory to the Hygienic Laboratory, set a worthy precedent of distinction. It included Ira Remsen, later President of the National Academy of Sciences, Henry S. Pritchett, President of MIT, and Edward L. Nichols and Elihu Thomson, both later elected to the Academy.[14]

In 1908, controversy over food-and-drug legislation prompted the appointment of the Department of Agriculture's first significant advisory committee. To scrutinize the judgment of the Department's Division of Chemistry in administering the new food-and-drug act, President Theodore Roosevelt appointed Ira Remsen, by now President of both the Academy and Johns Hopkins, and four other chemists to constitute a referee board for final determinations on questions "concerning which there exists a serious difference of opinion among eminent authorities." Roosevelt hoped that its answer on a question would be "the final word on the subject so far as the United States is concerned."[15] Then as now, the question of the safety of foods and drugs touched on powerful interests, and Remsen, who did his job well, disliked the responsibility. The board ceased to be active after Harvey N. Wiley, chief of the Division of Chemistry, left the Department in 1912.

WORLD WAR I

The committees described thus far were for the most part called into existence by problems of the moment, usually limited in both scope and duration, although a new precedent was being set by the statutory committees like the advisory board of the Hygienic Laboratory and the visiting committee of the National Bureau of Standards. But up to 1915 nothing had appeared to compare with the pervasive and extensive advisory committee structures that are a commonplace in government today.

Under the spur of European war in 1914 and the rapid advance of aviation in the European countries, Charles Doolittle Walcott, Secretary of the Smithsonian Institution, and Alexander Graham Bell, a member of the Smithsonian's board of regents, informed Congress of "the need for a National Advisory Committee for Aeronautics" in the United States. Congress was responsive. The legislative device selected was a rider added to a naval appropriation bill. This provided for a committee of twelve members to be appointed by the President, two each from the Army and Navy, one each from the Weather Bureau, National Bureau of Standards, and Smithsonian Institution, and five others "acquainted with the needs of aeronautical engineering or its allied sciences." The members were to serve without pay. The Committee was to "supervise and direct the scientific study of the problems of flight, with a view to their practical solution." The Committee was specifically empowered to direct and conduct laboratory research "in the event of a laboratory, or laboratories, . . . being placed under [their] direction. . . ."[16]

By 1958, when the National Advisory Committee for Aeronautics (NACA) was succeeded by the National Aeronautics and Space Administration, it had five major laboratories, 8,000 paid personnel, and some 450 individuals serving on five technical committees and 23 subcommittees.[17]

Thus the NACA was a committee that was itself a major research and development agency of the government. It came into being because of the conviction of Congress that in the national interest the government must be a leading partner with industry in developing the science and technology of heavier-than-air flight. It operated through its own very large professional staff. And by means of its system of continuing technical committees and panels, it sought systematic advice across a broad field from experts both in the government and in industry and the universities.

The National Research Council came into being and developed in a very different way.

George Ellery Hale, the distinguished astronomer, had, upon his election in 1902 at the unusually early age of 35, found the National Academy of Sciences (in the words of a friend), "a small, exclusive, relatively uninfluential body which was apparently more interested in keeping young men out of its membership than in acting as a vital force in the scientific development of the United States."[18] He was eager to see the Academy play a greater role.

His opportunity came in the concern for "preparedness" preceding American entry into World War I. He persuaded the Academy at its annual meeting in the spring of 1916 "to offer its services to the President of the United States in the interest of national preparedness." Upon President Wilson's acceptance, a small organizing committee was appointed, composed of Hale as chairman, the medical scientist Simon Flexner, the zoologist Edwin G. Conklin, the chemist Arthur A. Noyes, and the physicist R. A. Millikan. The committee quickly agreed with Hale "that true preparedness would result from the encouragement of every form of investigation, whether for military and industrial application or for the advancement of knowledge without regard to its immediate practical bearing." They further agreed that "the scheme of organization must be broad enough to secure the cooperation of all important agencies in accomplishing this result."

With this in mind, the committee proposed the formation of a National Research Council (NRC) "composed of leading American investigators and engineers, representing the Army, Navy, Smithsonian Institution, various scientific Bureaus of the Government; educational institutions and research endowments; and the research divisions of industrial and manufacturing establishments." The committee recommended that the nongovernmental Council members be chosen in consultation with the presidents of the American Association for the Advancement of Science, the American Philosophical Society, the American Academy of Arts and Sciences, the American Association of University Professors, the Association of American Universities, and the leading engineering societies.[19]

The Academy accepted its committee's recommendations, and the National Research Council, with thirty-seven members, came into being before the year ended. Hale was chairman, elected by the Council, and Millikan served as its full-time executive officer in Washington through 1917 and 1918. Through appointments to its many committees, it involved large numbers of researchers in its efforts, far beyond its own membership.[20]

The Council's effectiveness during the war was evidence that it was an institution that should be maintained. In the spring of 1918, Hale drafted an executive order designed to give the government's blessing to the NRC as a permanent agency of the Academy.[21] President Wilson signed such an order in May, along the lines of Hale's draft. It requested the Academy "to perpetuate the National Research Council" with a broad range of duties in stimulating research and its applications, developing effective means of utilizing the country's scientific and technical resources, promoting cooperation in research at home and abroad, bringing American and foreign investigators into cooperation with government scientific and technical services, mobilizing investigators to aid in the military and industrial problems of the war then still in progress, and gathering, organizing, and disseminating scientific and technical information.

BETWEEN WORLD WARS

Reorganized in 1919 as a peacetime institution, both the NACA and the NRC served the government and American science during the next two decades in a number of useful ways.

Both the NACA, which was a statutory committee with operating authority, and the NRC, which was a strictly advisory council created by the National Academy of Sciences and perpetuated in response to the presidential request, developed extensive committee structures to deal with the wide variety of scientific and technical matters within their purview. These committee systems in both cases brought together for their purposes scientists and engineers from the universities and industry and from within the federal agencies as well. They furnish excellent examples of institutions designed to mobilize experts and marshal knowledge on a broad basis for the consideration of scientific and technological matters of national import.

But the 1920's and the depression years of the 1930's saw little further development of the use of scientific committees.

The NACA went ahead steadily and effectively, building a mass of achievements. As one account put it, "There is no doubt that scores of aircraft improvements should be credited to NACA research. NACA is usually given credit for the over-all superiority of conventional Allied fighter planes in World War II. . . ."[23]

The NRC meanwhile addressed itself to a number of important problems in the evolution of American science. Perhaps its most far-reaching achievement in the years between the two world wars was the establishment, with Rockefeller Foundation financing, of the National Research Fellowships, a program to support the research of young investigators of promise in the first year or two after receiving their doctorates. These fellowships gave aid and encouragement, at a critical point in their careers, to many men and women who later achieved great eminence. The fellows, in turn, were a stimulating influence at the institutions at which they pursued their research. In 1950, R. A. Millikan "had no hesitation in expressing the conviction" that the program had been "the most effective agency in the scientific development of American life and civilization in my lifetime."[24] The National Research Council continues today to administer postdoctoral and other fellowship programs. Thousands of scientists have now served as members of selection panels, working out of the limelight but in a tradition of service that goes back fifty years to the first Fellowship Board.

But apart from a few important highlights like the National Research Fellowships, the period following World War I was not a favorable one for an organization like the NRC, for the government had not yet learned to make systematic use, except in emergencies, of external scientific and engineering advice on a significant scale. For that, the overwhelming demands of World War II and the perils and challenges that followed in its wake were necessary.

An effort was made in the doldrums of the 1930's. With the onset of the Great Depression, the budgets of the scientific agencies of the government were deeply cut.[25] Concerned about the loss of strength of these agencies and ultimately about the effect on the scientific development of the country generally, the National Research Council proposed the appointment, by executive order, of a Science Advisory Board to deal with specific problems in the various departments, acting "through the machinery and under the jurisdiction" of the Academy and the Research Council.[26] The idea was a promising one, but it got off to an unfortunate start that led to a serious division of scientific opinion with regard to its merits.[27] In 1933, the proposal was accepted by President Franklin D. Roosevelt, the order was issued, and the Board was appointed. But to the White House it appeared that the naming of members was a presidential prerogative, while a substantial number of leading scientists feared that too much governmental influence would result unless the authority to name members resided firmly with the Academy and Research Council.[28]

Karl T. Compton, chairman of the Science Advisory Board, had high hopes for the Board's usefulness, including the possibility that it might be able to elicit funds from the government for the support of research at nonprofit institutions, a concept as novel at that time as it is commonplace today. But the fundamental divisions of view were too deep, and the Board was discontinued in 1935, after expiration of its original two-year appointment.

WORLD WAR II AND THE POSTWAR DECADE

Following such a period as the 1930's, the coming of World War II found the country without administrative or organizational machinery to do the job that the National Academy of Sciences, through the timely organization of the National Research Council, had done in World War I. In any case, the situation was quantitatively very different; the job this time was immensely greater, and the sums of money involved were fantastically large by World War I standards. Nevertheless, the task was begun by a committee, the National Defense Research Committee (NDRC), under the chairmanship of Vannevar Bush, which began to mobilize the scientific effort. The Committee was formed in June 1940, immediately after the fall of France, by an executive order issued by President Roosevelt at Bush's urging.

The Committee was, by its terms of reference, to "correlate and support scientific research on the mechanisms and devices of warfare" except those in the field of activities of the NACA. It was empowered to supplement the experimental and research activities of the Army and Navy, to conduct research on its own, and to utilize the laboratories, equipment, and services of government institutions. And it was empowered to make contracts and agreements with individuals, educational or scientific institutions, and industrial organizations for studies, experimental investigations, and reports.[29]

In July 1940, the Bureau of the Budget provided $6.4 million for NDRC. By August, Bush had placed contracts with nineteen institutions. Two hundred contracts were signed during the first twelve months.[30] And this was only the beginning.

In the spring of 1941, a similarly organized Committee on Medical Research (CMR) was established. In May the President decided that all three bodies, NDRC, CMR, and NACA, should come under Bush's direction, and in June the wartime organization reached its final form with the establishment, by executive order, of the Office of Scientific Research and Development (OSRD) in the Executive Office of the President. Bush became the Director of OSRD, and NDRC and CMR became advisory committees within OSRD.[31]

The expenditures of OSRD dwarfed anything that had gone before. Bush records that "approximately 30,000 men were engaged in the innumerable teams of scientists and engineers who were working on new weapons and new medicine.... We spent half a billion dollars."[32] In World War I, the National Research Council had spent less than half a million dollars.

More significant than this thousandfold increase in fiscal magnitude was the change described by Bush when he wrote, ". . . for the first time in history the decision was taken to recognize scientists as more than mere consultants to fighting men. . . . In the National Defense Research Committee and the Office of Scientific Research and Development, in the Second World War, scientists became full and responsible partners for the first time in the conduct of war."[33] Wartime emergencies of overwhelming magnitude set the stage for a new level of scientific and technical participation in the whole business of government.

President Roosevelt wrote to Bush late in 1944, "The Office of Scientific Research and Development . . . represents a unique experiment of teamwork and cooperation in coordinating scientific research and in applying existing knowledge to the solution of the technical problems paramount to war. . . . There is . . . no reason why the lessons to be found in this experiment cannot be profitably employed in times of peace. The information, the techniques, and the research experience developed by the Office of Scientific Research and Development and by the thousands of scientists in the universities and in private industry, should be used, in the days of peace ahead, for the improvement of the national health, the creation of new enterprises bringing new jobs, and the betterment of the national standard of living."[34] He asked Bush to suggest how this should be done.

Bush's response was his report, *Science, The Endless Frontier,* published in 1945.[35] It resulted—five years later, after Congress had considered a number of bills and had passed one that was vetoed by President Truman—in the establishment of the National Science Foundation. Besides supporting scientific research and training, the Foundation was directed "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences."[36] Thus the government was itself now in the business of encouraging and supporting basic scientific research as such and of promoting scientific training. In discharging these very fundamental responsibilities, the Foundation has always made extensive use of advisory committees. Its successive directors have emphasized the primary role of the leaders of the scientific community in determining the course that science and science education should take. In 1969, upwards of 360 scientists sat on approximately 40 advisory councils, committees, and panels of the National Science Foundation.[37]

In 1946, after much legislative and executive debate, the Atomic Energy Commission was also established and given specific responsibilities for scientific and technical developments. The Commission was equipped by law with a General Advisory Committee of nine members, appointed by the President, to "advise the Commission on scientific and technical matters relating to materials, production, and research and development."[38] President Truman's first nine appointments included four distinguished physicists (Lee A. DuBridge, Enrico Fermi, J. Robert Oppenheimer, I. I. Rabi), two equally distinguished chemists (James B. Conant, Glenn T. Seaborg), a prominent metallurgist (Cyril S. Smith), and two leading industrial scientists (Hartley Rowe, Hood Worthington).[39]

In the older agencies as well, the tradition of scientific advisory committees was becoming established. In the military departments particularly, fresh from the experience of enormously fruitful cooperation with civilian scientists and engineers in World War II, extensive networks of advisory committees were developing. Today, the Army Science Advisory Panel, the Naval Research Advisory Council, and the Air Force Scientific Advisory Board provide technical advice at the level of the Chiefs of Staff of their respective services. The Defense Science Board, with a membership that includes the chairmen of the senior advisory bodies of the three services, advises the Secretary of Defense.

The Scientific Advisory Board of the Air Force may be taken as an example of these advisory committees. It was established in 1946 as one result of an elaborate series of technical studies, oriented toward the future, which had been started in 1944 by a large group of advisers under the leadership of Theodore von Karman, at the instigation of General H. H. Arnold, wartime chief of the Army Air Forces.[40] The Board consists largely of applied scientists and engineers. Its purpose is to provide the Air Force with the best technical advice available, whether in the universities, in industry, or elsewhere. The chairman and members are appointed by the Chief of Staff of the Air Force. Between 1946 and 1964, a total of 243 individuals served on the Board.[41] It works mostly through panels, but the whole Board meets twice a year for briefings and discussion. An executive committee and a staff provide the necessary liaison with the Air Force. Sometimes swamped with problems, the Board in recent years has had to take special care to avoid tasks that could be handled as well by other organizations and to select the problems to which the Board could devote its energies with the greatest effect.

In the health field, the National Institutes of Health have followed the early precedent of the Hygienic Laboratory. The act of 1937 that established the first of the present Institutes, the National Cancer Institute, provided for the appointment by the Surgeon General of a six-member National Advisory Cancer Council. Each of the Institutes established since has a similar council. In 1968, there were 16 National Advisory Councils and more than 150 other advisory committees, boards, and study sections, with a total membership of more than 2,000.[42]

In 1946, a National Agricultural Research Advisory Committee of eleven members was established in the Department of Agriculture by Act of Congress "to aid in implementing the research and service work" of the

Department and "to assist in obtaining the fullest cooperation among Federal and State agencies, producers, farm organizations, and private industry."[43] In addition to the national committee, there are a dozen committees concerned with research on particular agricultural commodities. A Committee on Agricultural Science, composed of scientists, was established in 1962 to provide a technical review of the Department's research program.[44]

There are numerous other scientific advisory committees in the National Aeronautics and Space Administration, the Department of Commerce, and other agencies. All are part of an enormous web of advisory committees in Washington, by no means all concerned with science and technology. In the late 1950's estimates placed the total number of advisory committees, task forces, boards, and panels in the federal government at between 1,700 and 1,800.[45]

AT THE PRESIDENTIAL LEVEL

With the development of scientific advisory committees at senior levels in the several executive departments, the ultimate formation of such a committee to advise the President became inevitable. Scientific and technical questions enter more and more into the largest questions of policy, national and international. Growing strength in the executive agencies in dealing with such matters, and the spreading practice of enlisting the advice of leaders of science and engineering outside of government, meant that in the White House itself a corresponding mechanism became necessary to focus the issues for the President's consideration and to elucidate matters relating to many departments or, at least at the outset, to none.

The first move in this direction was the appointment by President Truman in 1951 of a Science Advisory Committee, located in the Office of Defense Mobilization. Without a well-established place in the scheme of things, however, and with duties and powers that were not clearly defined, the committee found it difficult to be effective. In late 1957, impelled by the success of the first Sputnik and the failure of the first efforts of the United States to launch an artificial earth satellite, President Eisenhower drastically altered the situation by transferring the committee to the White House as the President's Science Advisory Committee (PSAC). At the same time, he named James R. Killian as the President's Special Assistant for Science and Technology. Although the committee reports directly to the President, and can do so independently of the Special Assistant, the

Special Assistant has in fact served as chairman of the committee from the beginning.

The President's Science Advisory Committee appoints *ad hoc* panels to consider particular topics, and these panels and their membership are continually changing. "The panel system of PSAC," Dr. Killian has commented, "has enabled the policy-making agencies of government to have deep roots in the creative non-government community of science."[46] George B. Kistiakowsky, the committee's second chairman and Special Assistant to President Eisenhower, stated in 1960 that there were more than 100 scientists serving on PSAC panels.[47]

THE LAST FIFTEEN YEARS

Thus the systematic and widespread use of advisory committees, spreading throughout the executive branch of the government from its beginnings with the NACA and the NRC forty years earlier, reached the top level nearly fifteen years ago when PSAC was taken into the White House as a full partner in the work of the Executive Office of the President. Shortly afterward, NACA, which had been a unique and highly successful experiment in public administration, vanished from the scene when it was supplanted by NASA.

What of the National Academy of Sciences and its Research Council? In the whirlwind pace of World War II, they had served as part of a highly effective team under the governmental scientific leadership provided by Dr. Bush and the Office of Scientific Research and Development. After the war, with the creation of more and more committees that brought outside scientists and engineers directly into the administrative structures of the executive agencies, the role of the Academy and Research Council might have been greatly diminished. But Frank Jewett, the wartime President of the Academy, was a man of vision who saw the importance of a continuing independent institution, close to the government but not within it, in bringing a fresh and dispassionate approach to questions, in being able to keep the scientific and technical entirely apart from the political, and in being able to take time to look penetratingly at long-range problems. His successors, A. Newton Richards, Detlev W. Bronk, Frederick Seitz, and Philip Handler, have retained and expanded that vision, and have found the Academy and Research Council actually called upon more and more, until their operation today is on a scale that could not possibly have been envisioned when World War II came to a close. For fiscal year 1970, the total expenditures of the Academy, with the National Research Council and the National Academy of Engineering (formed in 1964 under the basic congressional charter of the National Academy of Sciences), were more than $30 million. Its staff numbered some 800 in that year, and more than 6,000 individuals, mostly scientists and engineers, were serving on its hundreds of committees, boards, institutes, and panels.[48]

The relationship of the Academy to PSAC has been an interesting one. As has already been noted, PSAC has made use of *ad hoc* panels of its own to consider the many facets of the questions and issues that arise in its two great areas of concern: science as an ingredient in many areas of decision making and policy formulation at the presidential level; and governmental policy and programs as determinants of the scale, direction, and quality of our national scientific development. But as the roles of PSAC and the Special Assistant to the President for Science and Technology have developed, situations have developed in which it has been better to seek outside advice through nongovernmental channels. An example is the question of what governmental support should be given to a field of science in which new research opportunities have developed but in which advance is dependent on very expensive facilities beyond the means of any private foundation or group of universities. Another is the very broad question of whether, for lack of support, perhaps resulting from lack of awareness of research opportunities, an entire field of science may be stunted in its development and the attendant question of whether, if that is the case, there is reason for the government to provide a significant financial stimulus.

Confronted with cases of this sort, the Special Assistant to the President has found it desirable on a number of occasions to call upon the Academy to consider the purely scientific aspects of the questions and to make a report, which could then receive in his office in the White House the necessary review in the light of budgetary and other policy considerations of a nonscientific nature.

In 1961, against the background of his previous experiences with such questions when he served as Special Assistant to President Eisenhower, George B. Kistiakowsky, as a result of extended consultation with Detlev W. Bronk, President of the Academy, proposed that the Academy establish a standing committee to study the scientific aspects of policy matters of national and international interest related to science and its applications. The Academy created the Committee on Science and Public Policy (COSPUP) the following year. Composed entirely of Academy members, this committee has addressed itself to a series of important questions of broad scope. Its first study was of the problem of the uncontrolled growth of human population. The resulting report, *The Growth of World Population,* published in 1963, is credited with paving the way for the Kennedy administration to support programs at home and abroad in the controversial field of birth control. It was followed two years later by another report, *The Growth of U.S. Population.*

Illustrative of COSPUP's concern with broad issues of public policy was the publication in 1964 of *Federal Support of Basic Research in Institutions of Higher Learning,* a report that had considerable influence on later Bureau of the Budget studies on the administration of research grants.

In another area of its principal activities, COSPUP has reviewed the state of progress and assessed future research opportunities in a number of broad fields. It has done so with the help of many scientists throughout the country, working in a number of instances through appropriate divisions of the National Research Council. Beginning in 1964 with *Ground Based Astronomy: A Ten-Year Program,* the resulting NAS reports were *Digital Computer Needs in Colleges and Universities* (1966); *Chemistry: Opportunities and Needs* (1966); *Physics: Survey and Outlook* (1966); *The Plant Sciences: Now and in the Coming Decade* (1966); a series of three reports in 1968 by the Committee on Support of Research in the Mathematical Sciences; *Biology and the Future of Man* (1969); and, with the collaboration of the Social Science Research Council, *The Behavioral and Social Sciences: Outlook and Needs* (1969).

Generally unprecedented in their range and thoroughness and in the breadth of their distinguished authorship, these reports have been widely acclaimed. For example, 175 scientists contributed through 22 subpanels to *Biology and the Future of Man.* In order to reach the largest public, the report was put in the hands of an international publishing house, the Oxford University Press. C. H. Waddington, the noted British biologist, called it "by far the best single volume on the whole of biology that is now available anywhere."[49]

The Committee continues this process of taking stock and looking into the future in various fields. A committee to survey materials science and engineering is at work, and further studies in astronomy and in physics are also in progress.

Through COSPUP, the relationship of the Academy with Congress also advanced in a new way. In 1964 COSPUP was given the task of framing the Academy's response to two "extremely broad questions of fundamental importance to the Federal Government" that had been placed before the Academy by the Committee on Science and Astronautics of the U.S. House of Representatives:

I. What level of federal support is needed to maintain for the United States a position of leadership through basic research in the advancement of science and technology and their economic, cultural, and military applications?

II. What judgment can be reached on the balance of support now being given by the Federal Government to various fields of scientific endeavor and on adjustments that should be considered, either within existing levels of overall support or under conditions of increased or decreased overall support?[50]

The Committee invited papers from fifteen distinguished individuals, eight of them COSPUP members. After discussion and revision, the papers were submitted with an introductory summary as the Academy's report. Published in 1965 under the title *Basic Research and National Goals*, the report urged the importance of basic research as a long-range economic investment and as a vital part of our modern culture, and generally argued "that, starting with the present situation, which has given us leadership, every really good [research] man, especially if he helps the educational process, should be supported." It suggested that during the next decade this would require annual increases of 15 percent in federal funding for basic research.[51]

A second report, in 1967, responded to a series of questions from the House Committee on Science and Astronautics relating to requirements for successful applications of scientific knowledge. COSPUP organized an *ad hoc* committee for this purpose, and the resulting 17 essays were published by the House Committee under the title, *Applied Science and Technological Progress.*

Still a third report for the same House Committee was prepared in 1969 by another *ad hoc* group under COSPUP, *Technology: Process of Assessment and Choice.* It is noteworthy that although half of those who prepared this report were scientists in the usual "hard science" sense, the other half included historians, economists, political scientists, two lawyers, and a clergyman.

Whether a fruitful relationship with respect to the broadest questions of science in the nation will continue between the Academy on the one hand and the White House and Congress on the other remains to be seen as the policies and concerns of succeeding administrations and Congresses change and evolve.

Because of its particular location in the national scientific picture and because of the nature of its responsibilities and structure, the Academy, with its National Research Council, has been in the last two years the focus of concern about another question raised by the evolution of the relationship of science to government and public policy. Not only has COSPUP in the past decade developed a mechanism for using the Academy's resources to look at whole major areas of science, but to a greater and greater extent the several divisions and other units of the National Research Council also have become involved in studies of wide scope and in questions having more or less direct economic and social implications. In an earlier time, reports were issued on the authority of the duly appointed groups preparing them, almost entirely without any review other than editorial scrutiny. Yet such reports inevitably carried with them the implication of institutional approval by the Academy.

To bring a greater degree of overall review to these reports, to add further assurance of quality, to seek a desirable consistency of approach, to avoid unresolved or unexplained contradictions among reporting groups, and, in short, to introduce a new feeling and a new reality of institutional responsibility, the Report Review Committee came into existence in March 1970. Composed of members of the Academy under the chairmanship of George B. Kistiakowsky, the Academy's vice president, the Report Review Committee was charged with providing for the review, either by themselves or by other Academy members or properly constituted groups selected by them, of all reports or other documents with significant policy implications or with recommendations regarding the expenditure of public funds.

The fundamental principle laid down was that every such document must be reviewed by a group not directly involved in preparing it. At the same time, it was made clear that the purpose was not to second-guess expert authors and that in matters of substance the reviewers were to be only advisers and not final arbiters. Rather, the central purpose of the review was to add a disinterested judgment as to whether the report was fully responsive to the questions before the preparing body, whether its conclusions followed logically from the material it presented, whether it was clear, concise, and convincing, and whether there were conflict-of-interest issues that could depreciate its credibility.

Simultaneously, review procedures for all other kinds of report of Academy and Research Council bodies were clearly defined and tightened.

The Report Review Committee and the related measures that attended its establishment represented a major evolutionary departure in the *modus operandi* of the Academy as the principal "outside" scientific institution advisory to government. It is manifestly impossible to arrange any meaningful review by the Academy's whole membership, nearly 900 in number, of the reports prepared by the hundreds of committees appointed under its aegis. But through the Report Review Committee and the panels it names, every report having policy and fund implications is effectively reviewed by a group that is representative of those members who have knowledge in the particular field in question. The new procedure appears thus far to have been a demanding but rewarding and effective exercise of institutional responsibility.

THE FUTURE

Whatever happens, the whole scheme of advisory committees, with its vast expansion since World War II, is likely to come more and more under both executive and legislative review. This brief history can perhaps best be concluded with a statement made by Representative John S. Monagan, chairman of a Special Studies Subcommittee of the House Committee on Government Operations, as he opened hearings in March 1970 on the role of advisory committees: "The role of the council, committee, or commission as a governmental advisory function in the operation of the executive branch of the U.S. Government has never been fully reviewed. The theory underlying the use of advisory committees appears to be fundamentally sound. However, a review is warranted to assure that advisory committees are efficiently utilized and their activities are directed to legitimate objectives."[52]

APPENDIX **B**

The Role of the Science Advisory Committee in Government

Advisory committees are a means of enlisting in the service of government the best scientific and engineering talent in the country. They give the government access to the experts on given problems, whether or not they happen to work in government laboratories. American science is supported in a multitude of institutions. Less than 15 percent of all scientists are employed by the government. The government can point with pride to the scientists in its employ, but for every distinguished man in government service there are many more outside. Since we believe in diversity, this is as it should be. The government should have its share of scientific talent, but it would be a mistake if it had a monopoly. The committee system allows the government to have the best of both worlds—to benefit from the skills of its own scientists and to tap the wisdom of able scientists working elsewhere.

Science advisory committees play many roles in various circumstances. Following is a summary of the principal kinds of service they may perform, directly or indirectly.

SOLUTIONS OF PROBLEMS AND GENERATION OF IDEAS

New ideas for fruitful research or the solution of technical problems usually have their genesis in the minds of individuals, not in the deliberations of groups. Nevertheless, committee discussions of a problem or of a field of endeavor can provide the stimulus for individual ideas and fresh insights. This is probably especially true in the realm of applied science; certainly the committees of OSRD in World War II were an important source for a revolution in military technology.

The growth of government science and the proliferation of in-house laboratories has lessened the likelihood that a committee will come up with new ideas, but a committee still has some advantages. It has the flexibility of relative freedom from administrative channels and pressures. It can draw on new talent and give it a voice. Because it comes from outside, it can view the work of a department from a new perspective. Even when the work of a department is excellent, the questioning of a committee can produce new ideas.

In general, however, as the capabilities of in-house government science have grown in magnitude and quality, it has become more and more difficult for part-time committees, meeting periodically for short periods, to produce significant new ideas. For that purpose, the newer technique of the "summer study" has come into use. Usually, a core group, which may number from a dozen to fifty, is brought together in comfortable surroundings at a relatively isolated location, often with their families, to devote from one to eight weeks of sustained effort to a broad problem. Experts may be invited to join the group for shorter periods when particular facets of the problem are discussed. The group can be briefed intensively by governmental personnel and others on the nature and background of the problem. There is enough time for the chemistry of interaction among individuals to work. Such studies in difficult fields like that of antisubmarine warfare have produced important new concepts and technical advances. Summer studies are often organized by committees that have a much longer life, because they offer a powerful tool for advancing the work of the committee.

CRITICAL EVALUATION OF TECHNICAL PROPOSALS

The flow of new ideas has imposed another function on science committees—reviewing proposals. The greater the implications of a proposal, the greater the need for careful review. The classic case was the suggestion in 1941 that the nation commit major resources to work on an atomic bomb. Vannevar Bush, who had to recommend to the President whether to proceed or not, asked the President of the National Academy of Sciences to appoint a committee of physicists—"men who are not now deeply involved in the subject, but rather men who have sufficient knowledge to understand and sufficient judgment to cold-bloodedly evaluate [the subject]"—to advise on the chances of success. The committee—W. D. Coolidge, E. O. Lawrence, J. C. Slater, J. H. Van Vleck, and Arthur H. Compton—urged "a strongly intensified effort." Their advice was followed.[53]

The review of questions with such far-reaching implications, involving broad policy and program issues, is perhaps the key service performed by such bodies as the Defense Science Board and the General Advisory Committee of the Atomic Energy Commission. Each advises an agency that constantly has to make decisions on highly complex technical matters. Some of the ultimate decision makers—the Chiefs of Staff, the Secretary of Defense, some of the Atomic Energy Commissioners—hold their positions by virtue of qualifications other than scientific expertise. For the most part, they are not scientists. They cannot judge soundly the merits of the often competing proposals submitted to them. In part, of course, they use their own in-house procedures to make the necessary evaluation, but they find advantages in asking the advice of outsiders whose careers do not depend on the agency, and who stand apart somewhat from agency prejudices and enthusiasms. The outsiders' judgment can be sharper.

On the negative side, the possibility of conflict of interest arises when some members of committees reviewing technical proposals represent institutions or companies whose operations may be affected by the proposed actions. Organizations that sponsor committees must be acutely sensitive to this issue and weigh carefully both the composition of the committee and its terms of reference. In addition, the question of the proper mix of "insiders"—those who are close to the problem—and "outsiders" deserves far more consideration than it has received.

At the highest level of government, the members of the President's Science Advisory Committee review for the President the work of agency reviewers. It is here that the final judgment is sought on the merits of the most difficult, far-reaching proposals—proposals on the goals the nation should set for itself in space, measures for the protection of the environment, the choice of an ICBM system, the development or abandonment of an aircraft nuclear propulsion program.[54] Technical considerations are not the only considerations that govern the final decision on proposals such as these—political and budgetary factors are also vastly important—but the technical side must be properly weighed. Philip Handler, writing as a member of PSAC, lists this as PSAC's first function: It should serve, in his view, "as critical adversary of agency planners, to be convinced by them, so that it may provide, to the President, objective, unbiased advice with respect to the quality and magnitude of ongoing programs and the plans of the science-using agencies."[55] The President has not far to reach for advice on the political and budgetary implications of proposals; PSAC brings science talent as well to the decision-making process in the White House.

VALIDATION OF THE SCIENTIFIC COMPONENT IN DECISION MAKING

A committee's value lies at times in its judgment of the validity of other scientists' opinion on a question. The members of the committee confirm a scientific consensus. This may be important when the question is controversial on other grounds. The value of the 1963 report of the National Academy of Sciences on the growth of world population was not only that it reviewed the evidence competently, but that it lent the Academy's respectability and reputation to the proposition that if we wished to avoid worldwide famine, we had to learn to control human fertility. A week after the report appeared, President Kennedy told the press that he favored an expansion of fertility research. A month later, the Agency for International Development (AID) notified embassies abroad that the "problem [had] entered the focus of public attention" since the United States had supported a resolution the previous year to provide birth-control assistance through the United Nations, and that AID would be willing to consider requests for assistance from foreign governments in the area of research and planning.[56] A report by PSAC in the same year on the use of pesticides performed the similar function of confirming that Rachel Carson was in large measure justified in raising the spectre of the *Silent Spring*.[57]

A committee report may also be useful in confirming a negative. Harvey Brooks has suggested that PSAC's verdict on the controversial aircraft nuclear propulsion issue was largely a confirmation of the doubts of others. "The responsibility for that decision," he writes, "was shared by many administrators and advisers; the voice of the PSAC was only one among many voices, and this voice was probably not decisive. Such decisions within the executive branch are seldom reached through the advice of a single group or individual but are the result of a gradually evolving consensus among many advisers."[58] To have any value, of course, the confirming opinion must be an independent one. It should come from men who can be expected to look at the question impartially and critically. A committee of outside experts can often perform this role best.

QUALITY OF GOVERNMENT SCIENCE AND SCIENCE SUPPORT

Two early committees concerned with the quality of government science have been noted in Appendix A—the visiting committee of the National Bureau of Standards, established in 1901, and the advisory board of the Hygienic Laboratory, established in 1902. Both these committees survive, the latter under the name of the National Health Advisory Council of NIH.

As long as the government spent relatively little on science, the roles of these and similar committees were modest ones. But the picture has changed radically. The government spends millions of dollars each year on research in its own laboratories and still larger sums on research conducted elsewhere. Whereas it was formerly only one among many patrons of research, it has become the largest supporter of research in the nation. In 1968, federal expenditures for research and development amounted to 60 percent of the total national expenditures for that purpose. Following and extending the precedent of such committees as the Hygienic Laboratory's advisory board and, still more, the precedent of NACA, the government has taken the advice of scientists on how its increased funding for research should be spent. A multitude of committees have been established to advise on the work of the federal laboratories, to suggest research areas that deserve special emphasis, to choose the recipients of research grants, to name research fellows, and to give critical scrutiny to programs of contracted research.

INDIRECT CONTRIBUTIONS TO GOVERNMENT AND SCIENCE

The solution of problems and the contribution of new ideas, the critical evaluation of proposals submitted by others, the validation of the scientific component in decision making, the scrutiny of government science, and the overseeing of government science support are ways in which members of advisory committees serve the government directly. But they provide indirect benefits as well. One is the influence of the committees on the climate of government science. They can help to keep government scientists in contact with the rest of their profession. They can bring to the in-house laboratories something of the intellectual give and take and coming and going that are characteristic of the university. They are a partial substitute in the laboratories for the quickening influence of students and visiting professors. They help, in short, to make government laboratories more stimulating places to work.

The committee's presence may also be useful in giving new ideas an alternate route to the point of decision. If the in-house hierarchy is slow to accept an idea, a committee may decide to carry it over their heads.

Beyond these specific contributions of advisory committees, there are certain general characteristics and consequences of the large-scale use of such committees that should be mentioned.

The use of science committees to help plan and administer the nation's research program seems to some observers to accord with the nature of scientific research. In their view, science flourishes best when it is allowed to take its own course. If there must be direction, it is best that it come from scientists. Asa Gray used to despair that the United States government, as a democracy, could ever be an effective patron of science. It would be too impatient for results, its support too heavy-handed.[59] The device of the science committee has helped to give the government a sensitivity to the needs of science that Gray did not foresee.

The growth of the committee system has established new connections between the scientific community and government. Scientists and science administrators in government and members of the scientific community at large have become better known to each other. The bureaucrat has become a colleague. To the scientist outside of government, Washington is less of a mystery. Committee service may give scientists opportunity for constructive expression of their citizenship. Many committee members have subsequently accepted full-time government appointments. James R. Killian, for example, was a member of PSAC's predecessor, the Science Advisory Committee in the Office of Defense Mobilization, before he became President Eisenhower's Science Adviser and Special Assistant for Science and Technology. Four of his successors have come from PSAC. William D. McElroy was a member of the same committee before he became director of the National Science Foundation, and Glenn T. Seaborg was a member of the General Advisory Committee of the Atomic Energy Commission before he became chairman of the Commission itself. Numerous members of the Air Force Scientific Advisory Board have served a term as Chief Scientist of the Air Force. Many more instances might be cited.

The advisory committee system has also established new connections between different parts of the scientific community. The committees bring together scientists from industry, nonprofit laboratories, and universities, and scientists from different disciplines. There is opportunity in this for fruitful cross-fertilization. Committees have often directed attention to new lines of research. A good example is an interdisciplinary PSAC panel on environmental pollution, which reported in 1965. The panel included a mathematician, a soil scientist, an entomologist, authorities on public health, and the president of a public utility company—men from government, the universities, and industry. In addition to numerous recommendations in other areas, the panel made nineteen research proposals. One of its recommendations was for the establishment by the National Academy of Sciences and National Academy of Engineering of an advisory body to oversee NAS–NAE environmental quality studies. In response to this recommendation, the NAS–NAE Environmental Studies Board was formed and is now active.

At their best, committees serve an educational purpose. A major benefit of committees is the education received by the members themselves. Since the marshalling of talent for the demands of World War II in 1941, large numbers of American scientists have been given a first-hand familiarity with some of the most critical questions before the nation. Professors, university presidents, and scientific administrators have become experts on major public questions. Service on such bodies as the Scientific Advisory Board of the Air Force, the General Advisory Committee of the AEC, and PSAC continued an education started by the war, and the process is still going on. As a result, a new class of men has joined the ranks of those who can speak with knowledge on matters of policy. To this extent, the inner councils of government have been enlarged, and more voices are heard in the debate.

Even in a more limited and technical sense, participation in advisory services can be an educational experience for scientists. Committee members educate each other—about new areas of science and about the work of one another's laboratories and research programs.

The participation of scientists in committees has been especially valuable in the public discussion of questions of national policy, especially those related to national defense, when the need for secrecy limits participation by the general public. In the 1950's, scientists who had served on defense-related committees played a large part in stating the arguments for and against a continental air defense system.[60] Recently, scientists have helped to give the public the arguments on the two sides of the ABM issue. The scientists who have participated in these and other discussions have freely taken sides on the issues, and they have often spoken vehemently, but they have spoken as individuals and have been careful not to reveal information that must remain secret. Their participation has contributed vitally to public understanding without compromising security.

In a sense, the advisory structure constitutes a superuniversity, one in which experts are called upon to teach and learn as they advise on topics on which the nation seeks understanding. The "professor" whose advice is requested—whether he comes from academia, industry, or a government laboratory—finds among his students cabinet officers and congressmen, generals and White House aides. The nation has learned much from the professors, and the professors also have been educated and stimulated. But we still have much to learn about the curriculum and teaching methods of this nationwide university.

APPENDIX C

Types of Committee

One obvious distinction among committees is between those concerned with the scientific or technological aspects of a broader policy or program and those concerned with a policy or program in science or technology. An example of the first kind would be a committee to advise the Secretary of the Interior on the ways in which scientific research should be employed by the National Park Service to further its purposes or a committee to analyze the biological effects of nuclear radiation as a basis for protective standards. An example of the second kind would be a committee to examine the scientific quality of the work of a division of the Naval Research Laboratory or a committee to advise the President or the Director of the National Science Foundation on whether basic research in high-energy physics is being adequately supported or on what new national facilities are needed in radio astronomy. The distinction is between committees concerned with *science in policy* and committees concerned with *policy for science.*

But leaving that useful distinction aside, one can readily identify six types of committee, any of which may include committees of both the above kinds.

THE TECHNICAL COMMITTEE

This committee is concerned with a topic that is unambiguously technical or scientific. The committee may be appointed to make a study, after which it disbands, or it may be appointed to give continuing attention to a technical matter. A notable example of a short-term technical committee was the Advisory Committee on Smoking and Health appointed by Surgeon General Luther L. Terry in 1962 to assess the evidence linking smoking and disease. The committee's work was finished when it presented its report in 1964.[61]

A large part of the National Research Council's service to government and to the nation consists in making available technical advice on a continuing basis. For example, a short-term technical committee recently reported on the effects on human health of chronic exposure to low levels of carbon monoxide. An NRC standing committee, with panels on flight dynamics and reconnaissance, among others, advises the Air Force Systems Command; a National Materials Advisory Board, with panels on bismuth, cadmium, columbium, and chromium, for example, advises government agencies on the technical aspects of critical and strategic materials; and a Food and Nutrition Board, with standing committees on a wide variety of subjects, including dietary allowances, food protection, and maternal nutrition, advises a number of federal agencies, principally the Department of Health, Education, and Welfare and the Department of Agriculture.

Besides the technical committee whose function is to bring technical expertise to bear on a public problem, there is the committee that is concerned with a technical problem in science itself. An example is the NRC Committee on Radio Frequency Requirements for Scientific and Engineering Research, which coordinates the views of U.S. scientists and engineers and represents their needs on the Inter-Union Committee on Frequency Allocations for Radio Astronomy and Space Science of the International Council of Scientific Unions. Another is the Committee on Nomenclature of Organic Chemistry in the NRC Division of Chemistry and Chemical Technology.

The technical committee, more than any other, puts its members to work as specialists and professionals. Like other committees, it calls for judgment in its members, but it is largely the judgment of the scientist—the ability to weigh all the evidence, to find the nub of a problem, and to sense directions of fruitful research. A competent young scientist may be in as good a position to contribute effectively as an older man. Indeed, he may be in a better position to do so if his youth means that he is still fresh with creative ideas. He may find service on a technical committee a stimulus to his creative work, rather than an interruption. A technical committee has the merit that it is usually concerned with a concrete problem and that its advice is genuinely desired. It is seldom appointed as a delaying tactic. A member can feel that his service is useful. Younger scientists respond especially well to invitations to serve on such committees.

THE SURVEY COMMITTEE

The survey committee undertakes to take stock of a whole field or program in a comprehensive way and to make recommendations on what it finds. Its approach is inclusive. It must often make judgments that are not purely scientific. It may attempt to project the growth of a field. The committee's topic may be a question of science in policy or a question of policy for science, or both.

A good example of a science-in-policy topic—although not a type of question that is limited to survey committees—was the question that the Space Science and Space Technology panels of PSAC were asked to consider in 1966: Where should the United States space program go after completion of the Apollo missions? The panels had to consider the full range of foreseeable space activity, from a manned earth-orbiting laboratory to planetary exploration. The focus of the panels was scientific, but, as their report pointed out, they had to take account of important questions lying outside of science: What does the nation expect from its multibillion-dollar space program? How emphatically do we wish to be leaders in space? How does space exploration rank with other national goals?[62]

For a survey committee with a less fashionable assignment, but one concerned nevertheless with a broad-gauge problem, one may turn to a committee on weeds appointed by the National Academy of Sciences in 1964. The committee was one of a series appointed to consider aspects of plant and animal pest control and to write a set of volumes summarizing their findings. A committee on plant and animal pests directed the enterprise as a whole. The work of the committee on weeds resulted in a handbook of nearly 400 pages summarizing the state of knowledge and practice in the field of weed control and suggesting lines of new research.[63] "If we knew as much about weeds as we know about crops," the report pointed out, "vastly improved weed-control methods could be developed." The book was aimed at "administrators of science programs, scientists in weed-control and related fields, advanced students in weed science, and weed-control technologists seeking to broaden their understanding of control principles." Unlike the PSAC space panels, the committee was not concerned with national goals or programs, and its work was straightforwardly scientific. The chief challenge to the committee lay in the breadth of its topic, not in the need to make difficult nonscientific judgments.

For a survey committee with an assignment lying clearly in the area of policy for science one may take one of the recent committees appointed by the National Academy of Sciences, under the auspices of the Committee on Science and Public Policy, to survey the state of a discipline and assess its needs and its opportunities for progress. An example is the Committee for the Survey of Chemistry, which reported in 1965. The committee consisted of fifteen members. Seventy others served on fifteen panels on such topics as chemical synthesis, the chemistry of condensed states, nuclear chemistry, and chemistry and education. The committee used questionnaires extensively and made a detailed statistical study of recent chemical literature. The resulting report has been given the credit for obtaining larger federal funds for chemistry.[64]

A survey committee does not use the research competence of its members so much as what one might call their scientific scholarship. It calls for broad scientific knowledgeability. One can conjecture that the young man sharply focused on his chosen field is likely to be less effective as a member of a survey committee than the older man who has done and seen more science. The work of a survey committee frequently requires a large commitment of time, time that an active man may consider as time lost professionally. On the other hand, the younger man's interest may be keen and his motivation to serve high if he sees that the committee's recommendations will affect a public policy in which he is deeply interested or will set the conditions of growth of his field.

THE AWARDS COMMITTEE

The selection committee is concerned with the evaluation and selection of individuals for specified purposes.

An obvious case is the committee that chooses persons to be honored with special awards. Many professional societies and similar organizations have established medals that are awarded periodically, usually upon selection by a committee, to recognize distinguished achievement. Ordinarily, the committee's choice is final, although it may be submitted to the chief officers of the society or other organization for *pro forma* ratification.

Quite different in character is the task, sometimes entrusted to a committee, of assessing possible candidates for important administrative, executive, or advisory posts, and providing the appointing authority with names or slates of names. Such an assessment must usually include not only scientific eminence and achievements but entirely unrelated qualifications such as administrative ability and experience, personal characteristics, state of health, stage of career development, and often the delicate question of whether the individual would be likely to accept if invited. Strictly speaking, such a committee can be no more than advisory to the responsible agency official. Yet this kind of selection task should not be given to a committee unless the responsible official fully intends to accept the committee's judgment. At the same time, the usual practice of requesting the committee to furnish a slate rather than a single name not only provides alternatives in case the appointment is declined but also gives necessary flexibility to the appointing official to weigh qualifications that relate to special internal or nonprofessional matters outside the committee's competence.

A third and by far the most common kind of selection committee is that charged with choosing among candidates for fellowships or research grants. The committee may have a share in setting the criteria on which the selection is made, but often the criteria are predetermined and the committee's only function is to apply the criteria to the candidates and to make the selection. There are two reasons for appointing a committee to do this: to provide impartiality and to put the choice in the hands of people who will be as sensitive as possible to the claims of candidates. In the case of awards committees for research grants, the members are characteristically appointed from the professional group from which the candidates come. The applicant is judged by his peers. Familiar examples of peer-group committees are the Study Sections of NIH and the Advisory Panels of NSF.

In 1963 NIH awarded over 15,000 research grants on the recommendation of the Study Sections. There were more than 50 Study Sections, each composed of 13 to 15 scientists. The members were drawn mainly from universities, but members also came from hospitals, research institutions, and government agencies.

For other examples of awards committees, one may take the numerous evaluation panels in the NRC Office of Scientific Personnel. These panels nominate recipients of NATO and NSF postdoctoral fellowships, of NSF graduate fellowships, and of postdoctoral research associateships in federal laboratories. At present, there are over 30 panels doing this work, with about 400 members.

As noted before, the recommendations of awards committees are ordinarily decisive. An agency turns to an awards committee expecting to follow its recommendations. The fruit of the committee's deliberations is not a report that can be judged on its content, but a list of names—ranked or grouped in some fashion—that the agency concerned must accept on trust unless it is willing to do the committee's work over again. Given the fundamental uncertainty in any judgment of scholarly promise—whether of a research proposal or of a fellowship candidate—there is usually no way to know whether a second review would or would not produce a better list. If a second committee were to produce a somewhat different list, and this list were to be accepted in place of the first, its acceptance would again be a matter of trust. The National Advisory Councils of NIH depart from the recommendations of the Study Sections when the Councils judge some proposals to be more relevant than others to the programs of the Institutes, but "almost never does [a] Council override a Study Section purely on a question of scientific merit."[65]

Grants committees and fellowship committees require somewhat different qualifications in their members. The member of a grants committee is selected because he is highly competent in his field and has a good sense of feasible lines of research. He is expected to be broadly knowledgeable about a wide variety of scientific styles and approaches and to be sympathetic to them. The fellowship committee member is not required to bring so much specialized expertise to his work even though he may in fact possess it. The Office of Scientific Personnel, which has experimented with interdisciplinary panels, has found "that most of the evaluational process [does] not require special knowledge of a particular field."[66] The recommendations of an interdisciplinary panel agree "very well" with the recommendations of panels of specialists in the candidates' own fields. In light of these findings, the Office of Scientific Personnel uses only two biology panels to evaluate fellowship candidates at the predoctoral and postdoctoral levels in all of the life sciences. One works under the rubric "biological sciences" (or "biological and medical sciences"), and the other under the rubric "biochemistry and biophysics." More than scientific expertise, membership on a fellowship committee requires a feeling for people and a sense of the human qualities that matter in science.

All these bodies, NIH, NSF, and NRC, rotate the membership of their awards committees to ensure that new opinions are heard and to avoid the development of a committee "establishment." NIH, as a part of the Department of Health, Education, and Welfare (HEW), has a 4-year limit on the terms of committee members, not allowing a member to continue beyond this time even on another committee.[67] NSF rotates the members of its Advisory Panels as much as possible. No one who was on its chemistry panel in 1966, for example, was still a member in 1969. Only one member of its physics panel in 1966 was still a member three years later. The turnover on NSF panels concerned with less popular fields is slower—three members of the Panel for Antarctic Programs in 1966 were still members in 1969—but in the case of these panels, too, there is change. In the NRC, the Office of Scientific Personnel replaces a third of its panel members every year.

Service on a grants committee is taxing work, but many committee members find it stimulating. The White House committee on the administration of NIH found that "participants in the reviewing process are far from regarding the time spent as a net loss to their own research careers. On the contrary, most of them welcome the opportunity to acquaint themselves with the work going on in other laboratories and regard the study sections as a particularly lively and informative sort of scientific seminar or symposium."[68] While little science is to be learned from reading fellowship applications, service on a fellowship committee gives a faculty member an opportunity to compare his students and his objectives as a teacher with those of colleagues elsewhere. This can be illuminating, especially for one who is still developing his own approach and style as a teacher.

THE GENERAL ADVISORY COMMITTEE

This committee differs from the preceding committees in that it is intended to serve the government, or a particular arm of government, in a variety of ways. It is ordinarily a continuing committee, and its charge is often quite open-ended.

Most of the prominent committees discussed in Appendix A, on the history of committees, belong in the general advisory category, from the advisory board of the Hygienic Laboratory and the National Advisory Councils of NIH to the General Advisory Committee of the AEC. The National Academy of Sciences, the National Academy of Engineering, and the National Research Council, considered as advisory bodies, may be put into this category also.

The demands on a general advisory committee are potentially very large. Its job is to be constantly pointing the way, constantly warning against false leads. The statutory provisions behind many general advisory committees reflect these large expectations. Both the agencies and the scientific community depend on their work. The National Bureau of Standards came into existence in response to pressure from the scientific community, and its visiting committee expresses this interest. The National Advisory Councils of NIH reflect the interest of the medical profession and of academic medicine in the creation over the years of the National Institutes of Health. The General Advisory Committee of the AEC was created at a time of intense discussion in the scientific community regarding the uses of atomic energy.

An agency appoints to a general advisory committee people whose judgment it has learned to trust and respect, and the scientific community wants to see people there in whom it has faith. The two sides may differ on the candidates they would most prefer, but both sides want men and women of distinction. Hence, in an earlier era, such men as Elihu Thomson and Ira Remsen were chosen for the visiting committee of the National Bureau of Standards; the advisory board of the Hygienic Laboratory included such figures as Simon Flexner and William H. Welch; the first members of the National Cancer Council included James B. Conant and Arthur H. Compton; and J. Robert Oppenheimer and Enrico Fermi were among the first members of the General Advisory Committee of the AEC.

As a general advisory committee becomes established and acquires a reputation of its own, it may not be felt so necessary to pick distinguished names, but the open-endedness of a general advisory committee's responsibilities requires that members be chosen with care. Often the members have already proved themselves on other committees.

THE POLICY COMMITTEE

Its role is the formulation of policy, typically policy for science. Such a role is reserved for few committees, but it is an important role and should be noted here. Leading examples of policy committees are the Committee on Science and Public Policy of the National Academy of Sciences and the Committee on Public Engineering Policy (COPEP) of the National Academy of Engineering. The two committees study and report on public policy matters involving science and engineering. They also review the work of some of the other committees of the Academies and of the National Research Council in the light of public policy content. Important reports touching on policy are submitted to them before publication. The two committees are concerned chiefly with policy for science and engineering, but not entirely. COSPUP's first report, for example, *The Growth of World Population*, dealt with a science-in-policy question.

Perhaps the most important examples of committees with responsibility for formulating policy are the President's Science Advisory Committee and the National Science Board. PSAC, which has no charter, has developed, with the approval of the President, its own practices and guidelines. Philip Handler, writing as a PSAC member, ascribes to PSAC two main roles. First, it serves as the President's own general advisory committee in science; second, it assists the President in making policy in areas involving science. "PSAC," he believes, "should engage in a continuing appraisal of our society with respect to the manner in which our national goals may be furthered by technological means. When, hopefully, a politically stable and peaceful world permits a reduction in the effort to perfect our arsenal, this second and already prominent activity should become the dominant activity of PSAC."[55] The National Science Board's role as a policy committee, which has been given to it by statute, is "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences."[69]

THE ADMINISTRATIVE COMMITTEE

The administrative committee is not properly an advisory committee at all. Its role is not advice giving, but administration. Two of the most distinguished scientific committees in this class no longer exist—the misnamed National Advisory Committee for Aeronautics and the National Defense Research Committee. NACA organized and operated the major part of the nation's research effort in aeronautics for forty years, and NDRC mobilized civilian science in World War II.

Below this august level, there are a good number of science committees with administrative functions. One group contains the committees in the divisions of the National Research Council that administer the details of United States participation in international scientific organizations. They act for the National Academy of Sciences in its capacity as the participating organization representing U.S. science. These U.S. National Committees, as they are called, include such committees as the U.S. National Committee for the International Union of Biological Sciences, the U.S. National Committee for the International Union of Pure and Applied Physics, and the U.S. National Committee for the International Union of Pure and Applied Chemistry. The committees nominate delegates to attend meetings of the unions and generally speak for the United States in the disposition of matters pertaining to the unions.

The national committees must be sensitive to a wide range of considerations, from the needs of U.S. scientists in their field to questions of international reciprocity. It may happen, for instance, that a country providing the facilities for an international congress denies a visa to a duly appointed delegate from another country. In this situation, the cognizant U.S. national committee must consider the appropriate U.S. response—

what action it should recommend to the international union, whether the United States delegation should attend, and so on. The members of the national committees must be diplomats as well as scientists.

Another group of administrative committees are the many executive committees in the advisory structure. The executive committees of the divisions of the National Research Council, the executive committee of the National Science Board, and the executive committee of the Air Force Scientific Advisory Board are examples.

APPENDIX D

Membership Characteristics of Two Advisory Structures

We estimate that in fiscal year 1970, the total unduplicated number of individuals serving on scientific and engineering advisory committees at the national level was in the neighborhood of 11,000. Table D-1 shows the several estimates used in compiling the total.

In order to study the characteristics of the membership of the science advisory system at present, we have assembled statistics on two of the advisory structures in Table D-1, the National Research Council and the Department of Defense. Advisers serving through the NRC represent more than half the total shown in Table D-1. We have limited our analysis of NRC, however, to the 5,828 appointments exclusive of the technical panels of the Highway Research Board. So limited, these still represent more than one third of the total in Table D-1, and they include members of every type of committee described in Appendix C of this report, serving in every role discussed in Appendix B, and advising at every administrative level of the requesting agencies.

In the Department of Defense, on the other hand, the 272 appointments listed in Table D-1 are a small part of the total and include no committees serving below the "headquarters" level. They therefore represent a system with a certain kind of homogeneity that contrasts with the wide diversification of the NRC system. We selected for analysis five groups with a total membership of 228.

THE NATIONAL RESEARCH COUNCIL

For the purposes of this report, we have made no distinction between advisory services provided through the mechanisms of the National Research Council and those provided more directly by its parent organizations, the National Academy of Sciences and the National Academy of Engineering. The services are entirely similar, and all come under the same ultimate responsibility, that of the National Academy of Sciences. Thus, references to NRC herein are to be taken as including the total advisory role of NAS–NAE–NRC.

In fulfilling its role as an adviser on scientific and technical matters, the NRC seeks to identify and recruit for committee service people who are up to date and, indeed, actively involved in research areas pertinent to the questions at hand. Typical assignments for NRC committees include obtaining a consensus on some single scientific question, assessing the feasibility of a proposed technical program, assisting an agency in preparing a new program of research or a program in a new area of

TABLE D-1 Estimated Numbers of Science Advisers, Fiscal Year 1970

Organization	Number of Advisory Appointments	Estimated Number[a] of Individuals (Unduplicated Numbers)
National Science Foundation	326	240
Atomic Energy Commission	241	180
NASA	440	330
National Institutes of Health	2,389	1,790
U.S. Department of Agriculture	2,256	1,690
U.S. Department of Defense	272	200
Other federal agencies with *scientist* advisers	500	380
National Research Council[b]	5,828	4,385
NRC Highway Research Board	2,500	1,880
Total	14,752	11,075

[a]Assumed to be 75 percent of the number of appointments, based on NRC data concerning multiple appointments of individuals.
[b]Not including the technical panels of the Highway Research Board.

TABLE D-2 Age of NRC Advisers, 1969-1970

Division	Number	Median Age, 1969 (yr)	Chairmen Number	Chairmen Median Age (yr)
Behavioral Sciences	526	47.4	34	48.7
Biology and Agriculture	599	51.2	89	53.5
Chemistry and Chemical Technology	282	51.5	45	54.7
Earth Sciences	378	50.1	75	51.1
Engineering	826	51.0	132	53.5
Mathematical Sciences	73	48.2	14	52.5
Medical Sciences	380	51.1	47	52.0
Physical Sciences	726	49.2	129	52.2
Office of the Foreign Secretary	58	56.7	15	57.0
Office of Scientific Personnel	385	48.1	46	50.9
NAS-NAE committees	540	53.5	113	55.6
Unduplicated Total	4,385	50.0	577	52.4

research, evaluating research proposals for their scientific merit, screening fellowship applications, providing mature judgment on a question that requires input from a variety of scientific or technical fields, and formulating research objectives as related to the missions of an agency or subagency. The purposes of NRC committees range from providing specific technical or scientific expertise to providing overall value judgments where experienced scientific intuition must be brought to bear in the absence of precise answers.

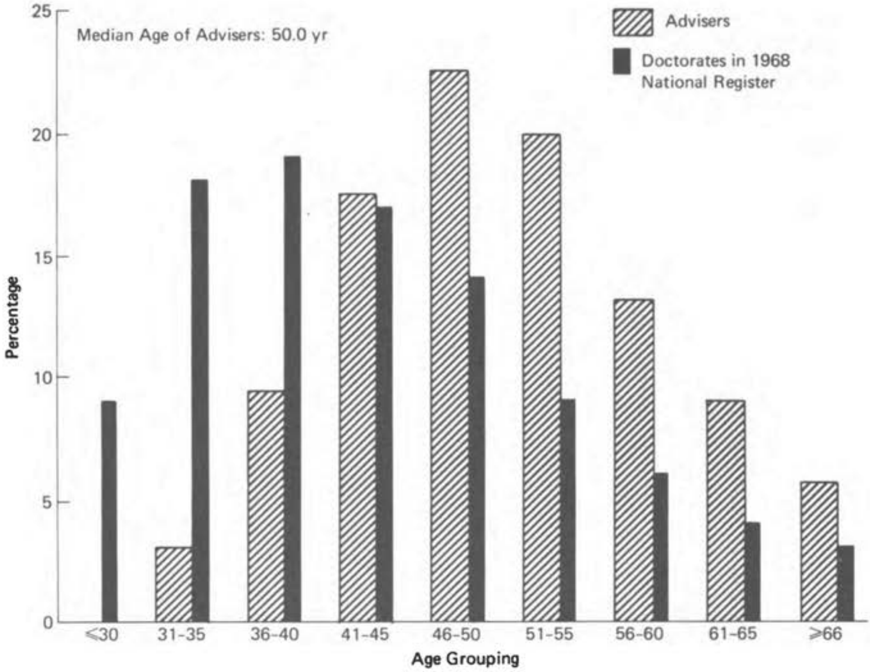
Table D-2 presents data on the median ages of the 4,385 advisers serving on 698 committees and panels within the NAS-NAE-NRC in 1969-1970. It will be noted that the median age of the entire group was 50.0 years, based on 89 percent reporting, while for the chairmen, the median age of the 577 reporting was 52.4 years.

Figure D-1 shows the distribution of NRC advisers by age in 1969. Also shown is the age grouping of doctorates as recorded in the 1968 National Register of Scientific and Technical Personnel. It is safe to say that most NRC advisers are holders of doctorates.

Figure D-2 shows the distribution of NRC advisers by type of employer in 1969, compared with the distribution of doctorates in 1968.

Table D-3 and Figure D-3 show the geographic distribution of NRC advisers in 1969, Table D-3 also including the geographic distribution of doctorates in the 1968 National Register.

The number of NRC advisers 35 years old or younger in 1969 was only 128, or 3 percent of the total. Table D-4 divides this number between those



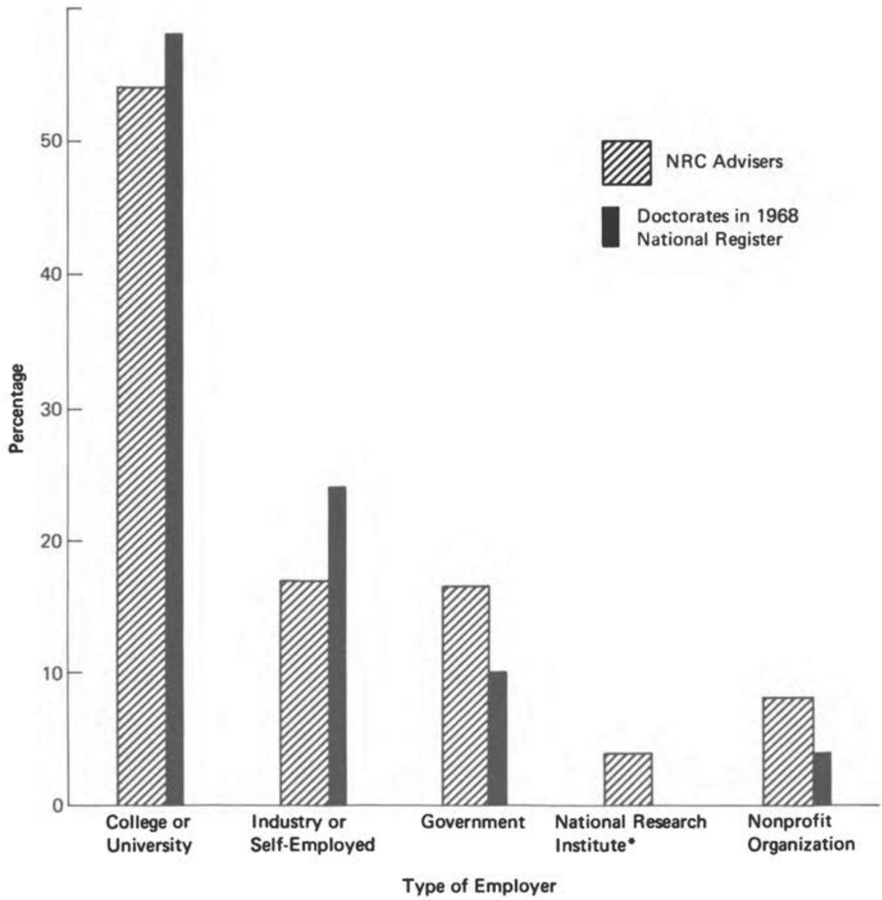
NOTE: The age groupings of doctorates in the National Register differ from the age groupings of advisers. The Register data, plotted above, were combined as follows: ≤30 yr, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, and ≥65.

FIGURE D-1 Distribution of NRC advisers by age, 1969.

under 31 years old (15) and those in the range of 31 to 35 years old (113), and shows the distribution among the several divisions. The last two columns compare each division's share of all young NRC advisers with its share of the total number of NRC advisers of all ages. Thus, for instance, the Divisions of Behavioral Sciences and of Earth Sciences show the largest proportional use of young advisers, while the Division of Medical Sciences shows by far the smallest.

Table D-5 breaks down the young advisers and the whole population of advisers by field of employment, type of employer, and number of NRC committees served. Here it is interesting that the proportion of advisers employed in colleges and universities is substantially higher for the young group than for the total group. Few young advisers are in other categories of private employment, and fewest of all are in government. The proportion of advisers serving on only one committee is larger for the younger group than for the total, which is to be expected because the younger individuals are at an earlier point in their advisory careers and are therefore less well known, less experienced, and in less demand.

To throw additional light on the matter of utilization of young scientists and engineers, we analyzed the memberships of a subset of 35 NRC committees having special advisory or policy-determining responsibilities. Some were concerned with the governance of the National Research



*Federally funded R&D centers are not a separate type of employer category in the National Register tabulations. Scientists employed by these centers are included with the type of organization that manages the center.

FIGURE D-2 Distribution of NRC advisers by type of employer, 1969

TABLE D-3 Geographic Distribution of NRC Advisers (Employment Region), 1969

Geographic Region of Employment	NRC Advisers		Doctoral Scientists in 1968 National Register	
	Number	Percent	Number	Percent
New England	425	10	8,617	8
Middle Atlantic	889	21	23,838	21
East North Central	696	16	19,337	17
West North Central	190	4	7,440	7
South Atlantic	944	22	17,395	16
East South Central	93	2	3,911	4
West South Central	192	5	6,833	6
Mountain	150	4	5,609	5
Pacific	656	15	16,120	15
Foreign, U.S. Territories, and unknown location	150	1	2,106	1
Total	4,385	100	111,206	100

TABLE D-4 Distribution of NRC Advisers 35 Years Old or Less in 1969, by Division

Division	Number (years)			Percent of Total		
	<31	31–35	Total	In Division	All NRC Advisers, Age < 35	All NRC Advisers, All Ages
Behavioral Sciences	5	20	25	4.8	19.5	12.0
Biology and Agriculture	1	7	8	1.3	6.2	13.7
Chemistry and Chemical Technology	—	7	7	2.5	5.5	6.4
Earth Sciences	2	14	16	4.2	12.5	8.6
Engineering	4	25	29	3.5	22.6	18.8
Mathematical Sciences	—	3	3	4.1	2.3	1.7
Medical Sciences	—	2	2	0.5	1.6	8.7
Physical Sciences	2	18	20	2.8	15.6	16.6
Office of Foreign Secretary	—	—	—	—	—	1.3
Office of Scientific Personnel	1	13	14	3.6	10.9	8.8
NAS-NAE committees	—	8	8	1.5	6.2	12.3
Total	15	113[a]	128[a]	2.9	[a]	[a]

[a]Unduplicated total. There are advisers who serve on committees of more than one division. The percentage of the total number of advisers therefore sums to more than 100.

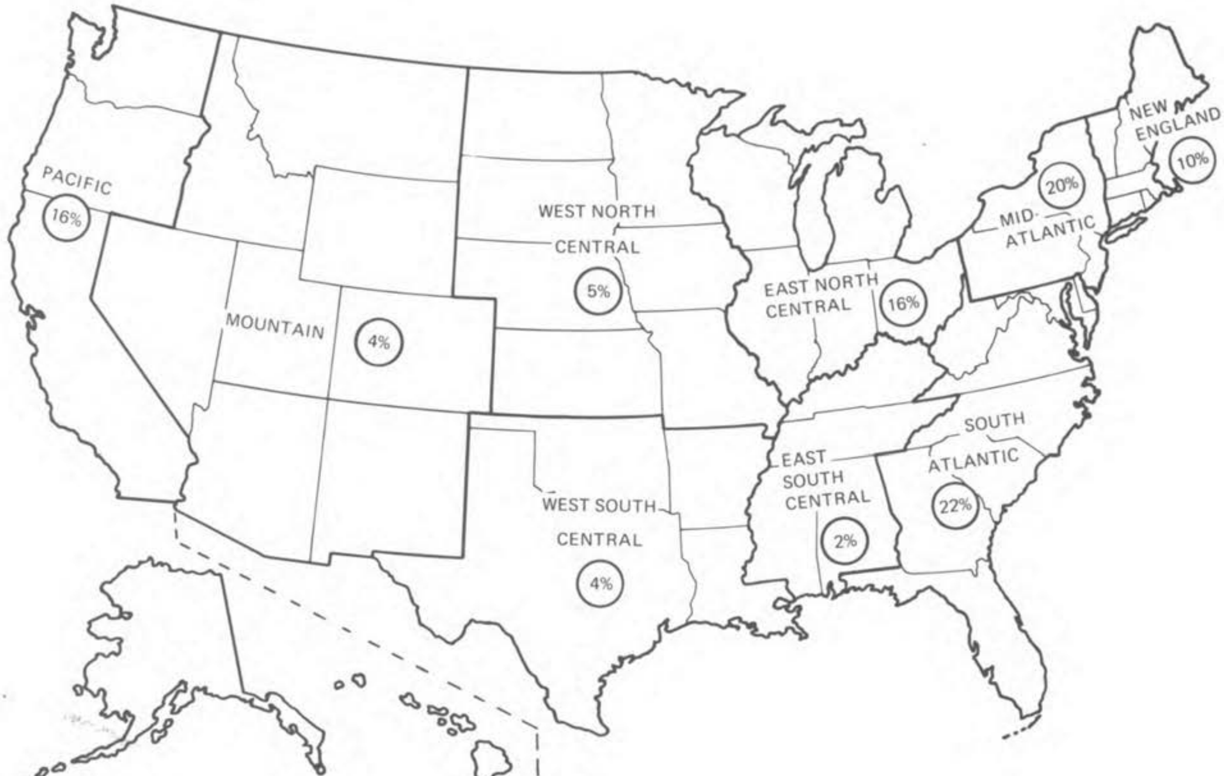


FIGURE D-3 Geographic distribution of NRC advisers (employment region), 1969.

TABLE D-5 Selected Characteristics of NRC Advisers 35 Years Old or Less

Characteristic	NRC Advisers Age 35 Years or Less		Percent of All Advisers, All Ages
	Number	Percent	
Field of Employment			
Mathematics	5	3.9	3.3
Astronomy	5	3.9	1.4
Physics	14	10.9	11.1
Chemistry	16	12.5	9.7
Biochemistry	3	2.3	4.4
Earth sciences	15	11.7	8.3
Engineering	20	15.6	15.3
Agricultural sciences	2	1.6	2.6
Medical sciences	6	4.7	8.2
Biological sciences	12	9.4	14.0
Psychology	7	5.5	4.1
Social sciences	11	8.6	6.9
Other fields	9	7.0	4.2
Unknown	3	2.3	6.4
Total	128	99.9	99.9
Type of Employer			
College or university	84	65.6	52.7
Industry, self-employed	18	14.1	16.7
Government	15	11.7	16.1
National research institutes	3	2.3	3.9
Nonprofit organizations	6	4.7	7.9
Unknown	2	1.6	2.7
Total	128	100.0	100.0
Number of Committees Served			
One	115	89.8	79.6
Two	10	7.8	14.2
Three	3	2.3	3.4
Four or more	—	—	2.8
Total	128	99.9	100.0

Council itself, others with giving advice that had large public policy implications, and others with the conduct of major national or international programs. The selection was made somewhat arbitrarily, but nevertheless with knowledge of the functions of these and other com-

TABLE D-6 Data Profile of NRC Committee Members, 1969–1970[a]

	Advisers on 35 Selected Committees	Advisers on All Other Committees
Number of persons	372	4,013
Median age (in 1969)	54.4 yr	49.5 yr
Scientific fields		
Physical sciences	33.2%	36.5%
Biological, medical, agricultural sciences	31.9	31.1
Social sciences	17.1	11.2
Engineering	15.4	16.4
Other	2.2	4.7
Professional affiliation		
College or university	64.2%	53.3%
Industry, self-employed	16.2	17.2
Government	9.8	21.5
Nonprofit organization	9.8	8.0
Number of NRC committees served		
One	41.7%	82.8%
Two	28.8	13.0
Three or more	29.5	4.2
NAS or NAE members	36.8%	5.2%
Region of employment		
New England	15.3%	9.4%
Mid-Atlantic	24.2	20.2
East North Central	16.4	16.2
West North Central	3.3	4.5
South Atlantic	11.7	22.9
East South Central	1.1	2.3
West South Central	3.1	4.6
Mountain	2.5	3.6
Pacific	20.9	14.8
Foreign	1.4	1.2

mittees. The 35 selected committees included 372 members, compared with 655 other committees having 4,013 members.

The median age of the members of what might be called the "policy-related" committees selected in this way proved to be 54.4 years, while the median was 49.5 years for all other NRC committees. Their membership was more likely to include social scientists, academic members, and residents of New England, the mid-Atlantic region, and the West Coast than were those of the other committees. Members of the National Academy of Sciences or the National Academy of Engineering comprised 36.8 percent of the memberships of the 35 committees as compared with 5.2 percent of all other committees. Multiple membership on committees

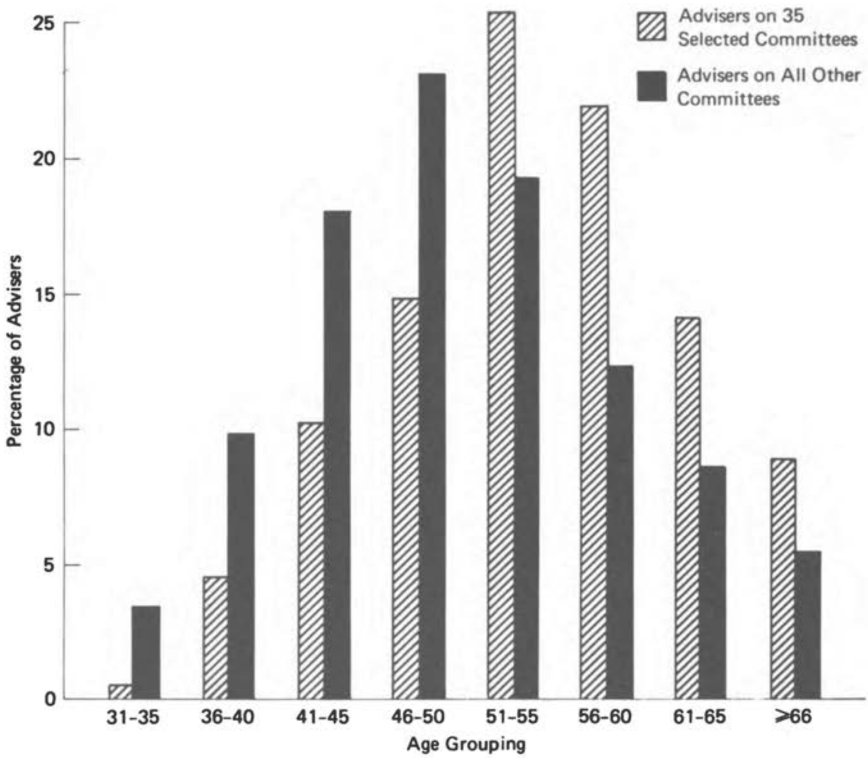


FIGURE D-4 Distribution of NRC advisers by age, 1969-1970.

was more prevalent among members of the 35 committees: 58.3 percent of them served on more than one NRC committee as compared with 17.2 percent of the members of other committees. These and other characteristics of the two groups of committees are summarized in Table D-6 and Figure D-4.

The question of the utilization of women and of ethnic minorities in the advisory system has also been of concern to us. A portion of this question is of course included in that of the utilization of young scientists, but the whole question is broader. The number of women serving on NRC committees in 1970 was 57, about 1 percent of all NRC advisers. Yet there were 8,305 women with doctorates in the sciences included in the 1968 National Register, 7 percent of all doctorate-holding scientists. Data about members of ethnic minorities are more difficult to obtain, but an informal count indicated that 80 members of minority groups* were

*Black Americans, Spanish-speaking Americans, and American Indians.

serving on NRC committees in 1970, about 2 percent of all NRC advisers. Evidently, more women and more members of ethnic minorities should be involved in advisory work, both to give them a voice when decisions are made that will affect them and to give the highly competent people among them an opportunity to contribute to the solution of important problems.

THE DEPARTMENT OF DEFENSE

Scientific and technical advisers serve at many points within the Department of Defense and the Departments of the Army, Navy, and Air Force. As of January 1, 1969, the five senior advisory groups had a total membership of 228, involving 204 persons. The total membership was divided as follows: Defense Science Board, 26; consultants to the Advanced Research Projects Agency, 35; Army Scientific Advisory Panel, 69; Naval Research Advisory Committee, 23; and USAF Scientific Advisory Board, 75. The first of these advises the Secretary of Defense, the second the Director of Defense Research and Engineering, and the other three the secretaries and military chiefs of their respective departments.

An analysis of available biographical data concerning 183 of the 204 advisers revealed a number of characteristics. Figure D-5 shows the distribution of ages at which the *present* members began their service as advisers on *any* significant committee. The criterion was the earliest indication of committee or other advisory service in the biographical record. Since it is probable that earlier and less noteworthy service was not reported by the individual, the ages indicated here are presumptive and probably represent upper limits. With this limitation noted, the results are a median age at entrance of 37 years, a lower quartile of 32.5 years, and an upper quartile of 42 years. The average age was 38.4 years. Of the 183 cases analyzed, two began their participation in advisory functions at or before age 24, and 19 between the ages of 25 and 29.

Figure D-6a gives the age distribution of the present members as of January 1, 1969. Their median age was 50, and their average age was 51.4 years. None was under 30, and 22 were 65 or over.

Figure D-6b indicates that 49 percent of the present members were employed by universities, 31 percent by industry, 11 percent by government (including the armed services), and 9 percent by nonprofit organizations.

Figure D-6c shows that 49 percent of the present members were in the physical sciences, 37 percent in engineering, 9 percent in the life sciences, and 5 percent in other fields, including the behavioral sciences.

Figures D-7 and D-8 give the age distributions separately for the

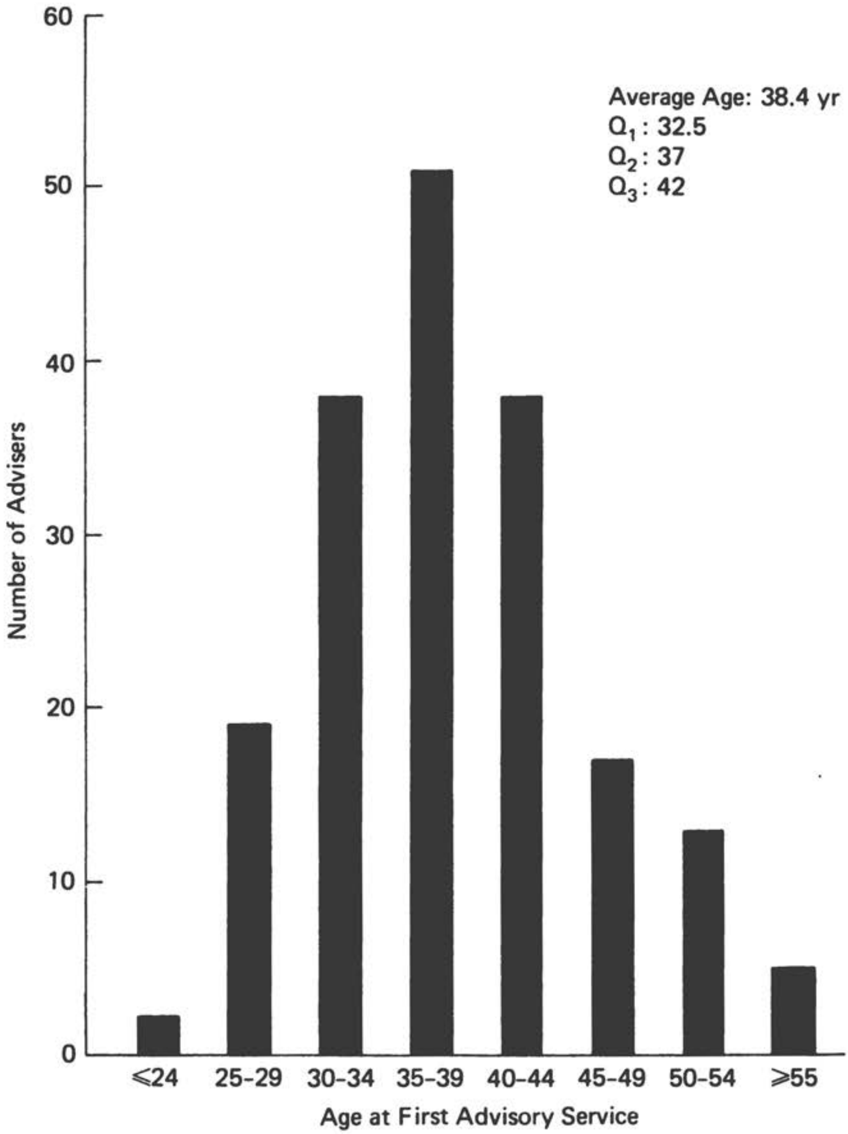


FIGURE D-5 Age of DOD advisers at time of first service on any advisory committee.

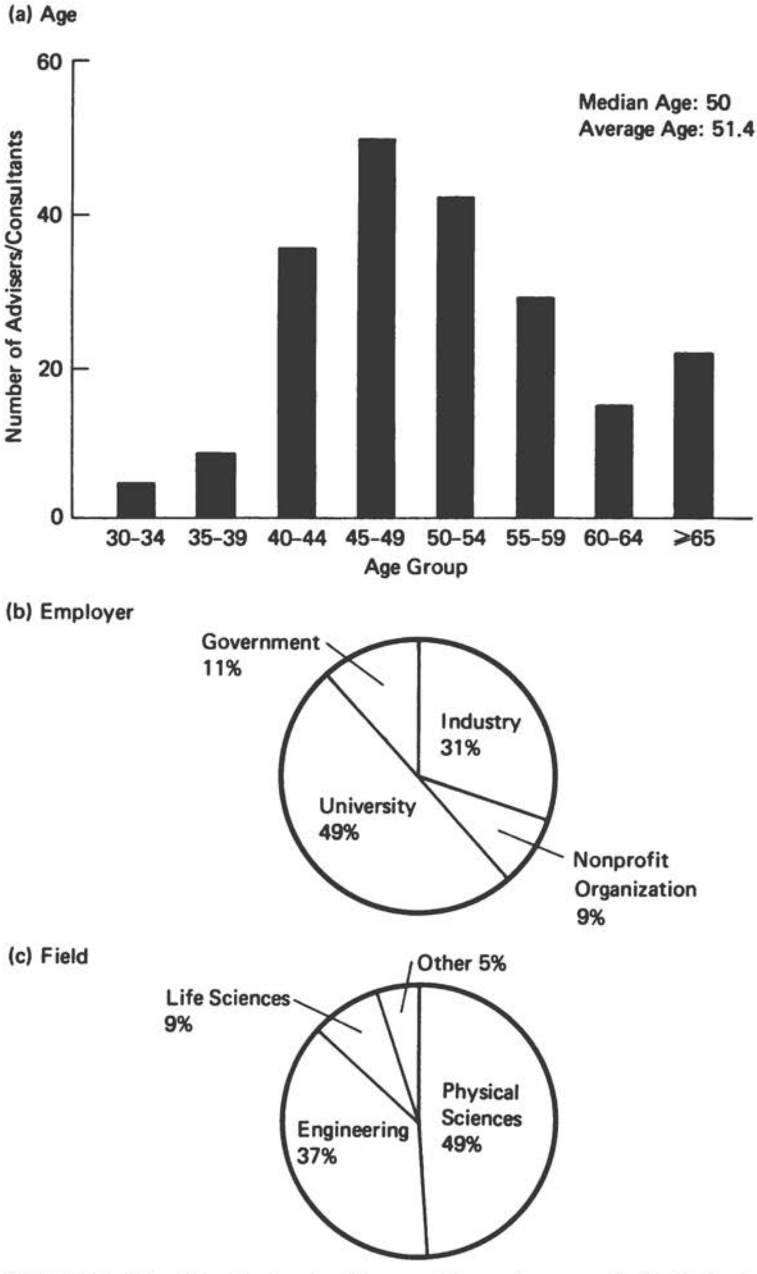


FIGURE D-6 Distribution by (a) age, (b) employer, and (c) field of the 204 technical advisers and consultants within DOD (no duplications).

Defense Science Board, the consultants to ARPA, and the three senior advisory bodies of the military departments.

It is interesting to note that the median age for these senior advisory bodies of the Department of Defense is no greater than that for the far larger, highly diversified group of NRC advisers. But apart from the consultants to ARPA, with the low median age of 47.6 shown in Figure D-7, one notes that the senior advisory committees to the Department of

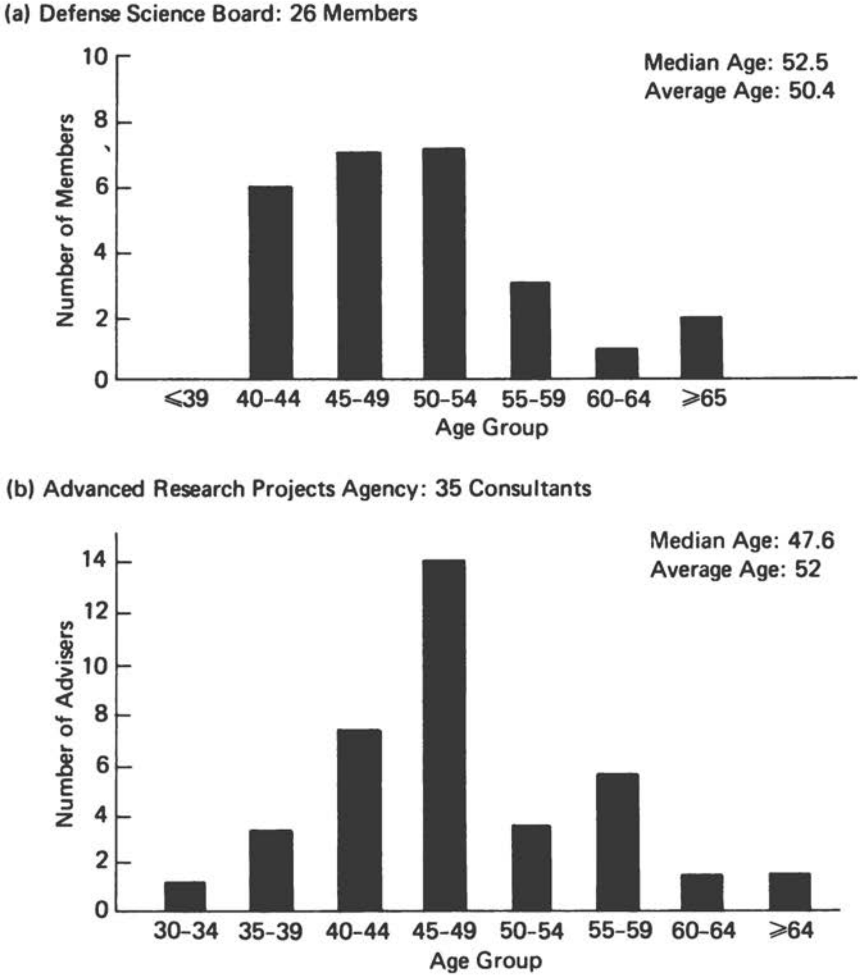


FIGURE D-7 Distribution by age: (a) Defense Science Board, 26 members; (b) Advanced Research Projects Agency, 35 consultants.

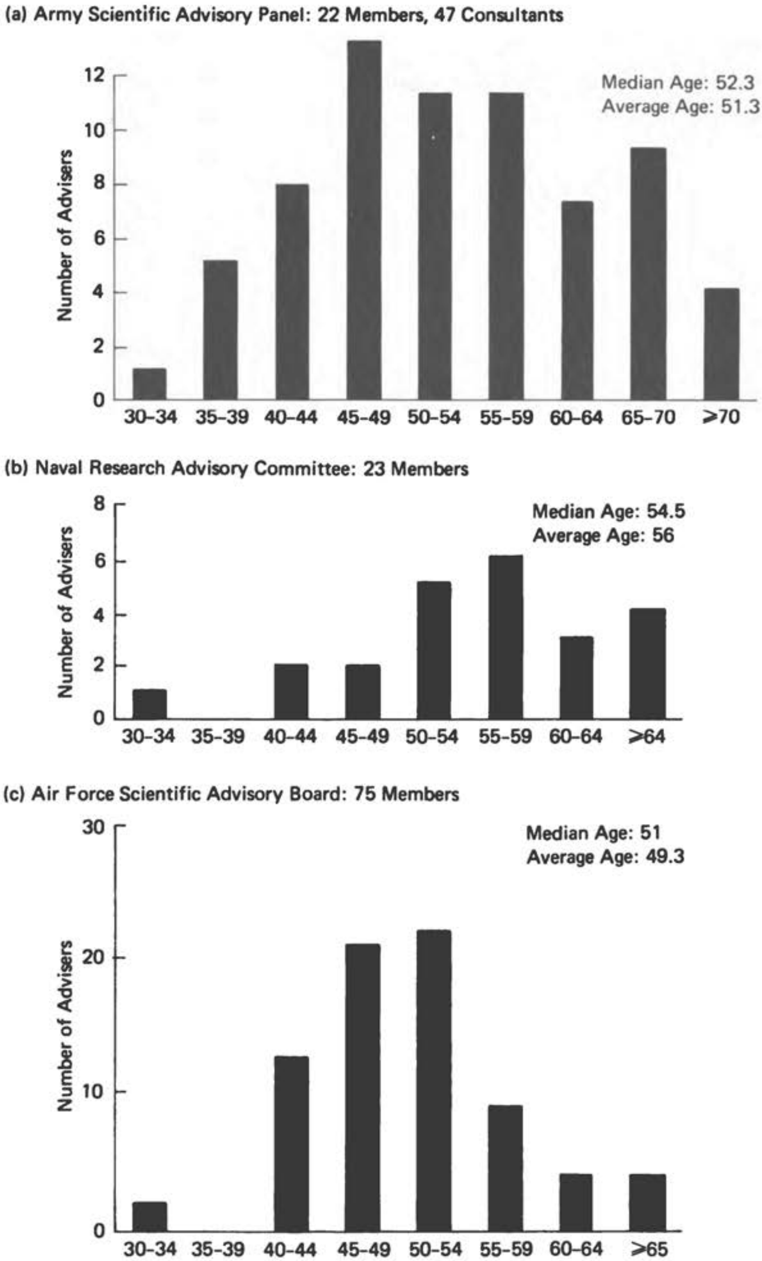


FIGURE D-8 Distribution by age: (a) Army Scientific Advisory Panel, 22 members, 47 consultants; (b) Naval Research Advisory Committee, 23 members; (c) Air Force Scientific Advisory Board, 75 members.

Defense and the three military departments have median ages of 52.5, 52.3, 54.5, and 51, more in line with the figure of 54.5 found for the 35 "policy-related" committees of NRC.

Figure D-6 shows that the utilization of advisers 35 years old and younger in these Department of Defense groups is in about the same range as in the NRC, although the difference in age groupings prevents a precise comparison.

AGE DISTRIBUTION

Figure D-1 indicates that NRC advisers in 1969 were drawn most heavily from age groups about ten years older than the groups containing the largest numbers of doctorate holders. The age-distribution curves for the two populations cross in the 41–45-year range. That bracket included about the same proportion (17 percent) of all NRC advisers and all doctorate holders. But the next older bracket, 46–50, included 22.5 percent of NRC advisers and only 14 percent of doctorate holders, while the next younger bracket, 36–40, reversed this situation, with 19 percent of doctorate holders and fewer than 10 percent of NRC advisers.

Only 3 percent of NRC advisers were 35 years old or younger, when scientific productivity is often at its peak, while 27 percent of all doctorate holders were in that age range. In these terms, therefore, the available "young" scientists were grossly "underutilized." At the same time, "old" scientists were heavily "overutilized," 50 percent of the advisers being older than 50 years, a range that included only 22 percent of the doctorate holders.

Two influences are at work, in our opinion, in the matter of underutilization of the young and overutilization of the old. First is the fact that appointment processes, which are discussed in Appendix E, depend heavily on multiple chains of personal acquaintanceship. The better known the individual becomes in his field, the more likely he is to come under consideration for an advisory appointment; and the more favorably he becomes known professionally, the more likely he is to be actually appointed.

Second, there is unquestionably a preference among appointing authorities for appointees who have matured and become seasoned in their fields. It is probably a sound preference, based on the feeling that if a person is to be depended upon to judge larger affairs, he should be expected to have demonstrated sound judgment for a period of years in his own career as it has developed and broadened. An individual's professional and personal reputation among his colleagues takes time to build; and the circle widens with the years, especially the early years.

Thus the question of whether the underutilization and overutilization mentioned above are truly inadequate and excessive utilization remains difficult to resolve. We know of no way to determine any "right" relationship between the proportion of advisers and the proportion of doctorate holders in a given age bracket.

Nevertheless, we are convinced that in the advisory system there is grossly inadequate utilization of men and women in their thirties and that the system will benefit by widespread efforts to make greater use of such individuals.

The finding that the chairmen of NRC committees tend to be one to four years older than the members undoubtedly reflects the same kind of selection process described above, which more or less automatically correlates qualities of judgment with age, at least in the age ranges pertinent here. Also, of course, appointing authorities seeking an effective chairman are inclined to judge heavily by the earlier performance of an individual, either as a chairman or as a committee member. Again, it takes time to build a reputation.

Similar points apply to the finding, summarized in Table D-6 and Figure D-4, that the median age of 372 NRC advisers on 35 "policy-related" committees was 5 years greater than the median age of 4,013 NRC advisers on all other committees. The tendency noted above to regard some years of seasoning as desirable for all advisory appointments is more marked when the committee is to deal with policy-related issues calling especially for maturity and experience.

The evidence from Figure D-5 of a phenomenon of "rising through the ranks" in the advisory system is heartening to us. The sample is relatively small—183 individuals. For this group, at least, comprising most of the members of five senior advisory bodies of the Department of Defense, with a median age of 50 in 1969, the individuals were first tapped for advisory service—not necessarily in the Department of Defense—at the relatively early median age of 37. In general, this must have been advisory service on other bodies, since the median age of the senior bodies of the Department of Defense has not changed much in the last 15 years.

No similar study of age at first advisory service has been made for the NRC advisers. In other respects, the age analysis of the Department of Defense committees does not reveal features significantly different from those of the NRC committees.

GEOGRAPHIC DISTRIBUTION

Table D-3 shows no large difference between the geographic distribution of all NRC advisers and that of doctoral scientists in the 1968 National

Register. The New England and South Atlantic regions appear to be somewhat over-represented in those terms, while the West North Central and East South Central regions are somewhat under-represented. When it comes to the 35 "policy-related" committees, however, the relative representations from the New England, Pacific, and Mid-Atlantic regions rises markedly at the expense of most of the others, especially the South Atlantic region. Figure D-3 shows how the several regions are demarcated.

INSTITUTIONAL DISTRIBUTION

Data on institutional representation on committees are incomplete. There are preliminary indications of a high concentration of the doctoral graduates of a relatively few particularly prominent universities. This is not surprising in a system that seeks excellence as the first criterion of selection and is therefore inclined to turn especially to the institutions recognized as having first-rank standing. It can be a pernicious situation, however, if it means that individuals of high quality in less well-known institutions are therefore more likely to be overlooked. We feel that this danger must be guarded against.

DISTRIBUTION BY TYPE OF PROFESSIONAL AFFILIATION

Figure D-2 indicates that among NRC advisers, government agencies and nonprofit organizations are over-represented by comparison with the distribution of doctorates, while the colleges and universities, industry, and self-employed persons are under-represented. Again, however, the departures are not such as to raise serious questions of unbalance. It is noteworthy that in the senior committees of the Department of Defense, as shown in Figure D-6, the colleges and universities and the government have relatively less representation and industry has relatively greater representation than among NRC advisers.

APPENDIX E

Selection, Recruitment, and Motivation

Here we are concerned with the selection of individual members of committees—with how they are brought into advisory service.

The total number of science advisory appointments in fiscal year 1970 at the national level was about 15,000, as shown in Table D-1 of Appendix D. If we assume that the terms of appointment to the average continuing committee are three years, and that the life of the average *ad hoc* committee is three years, then one third of the appointments, or 5,000, would be made each year. We estimate that 2,000 of these may be filled by reappointment of the incumbent on a continuing committee. If so, then perhaps as many as 3,000 new advisers are appointed each year. This assumes that new committees established and existing committees terminated are equal in numbers of members, so that there is zero growth in the total number of advisers in the entire system.

We have no statistical data on present practices to compare with this very rough estimate. It appears reasonable to us—if only as a desideratum—and not discordant with present policies.

AVAILABILITY OF ADVISERS

Manpower estimates indicate that, in general, advisory services are not likely to be manpower-limited except in a few special areas. Studies made by Lindsey R. Harmon of the NRC Office of Scientific Personnel at the request of this committee indicate that in the age bracket under 40 years—to take just part of the potential supply—the supply of potential doctoral-level advisers seems adequate.[70] In gross numbers, about 124,000 men and women earned doctoral degrees at U.S. universities in the physical and life sciences, engineering, mathematics, and the social sciences during the period 1958–1969. Of these, about 20,000 were citizens of other countries. By field of specialization, the number of doctorate recipients under 40 also seems adequate, with one possible exception. Econometrics, with only 142 U.S.-citizen graduates in the 12-year span, and a slow growth rate, is about the only field in which it might be relatively difficult to find a not already overloaded person with the qualifications desired for government advisory service. Thus, identification, selection, and motivation seem at first glance to be more important problems than any shortages of advisory talent.

On closer scrutiny, however, certain kinds of manpower limitations appear. Many of the national problems now coming to the fore are in interdisciplinary or transdisciplinary areas in which the number of experienced people is still relatively limited. Even in the traditional fields, the imposition of a series of distribution requirements or other special requirements—geographic location, experience, age, sex, ethnicity, sector of employment, proprietary or nonproprietary employment, and so on—could diminish the effective populations to the point where manpower limitations became important. Application of the usual subjective criteria for selection of committee members would further attenuate the supply. With the possible exception of technical committees operating in highly specialized fields, however, we believe that science committees are likely to have ample numbers of qualified persons to draw on.

From time to time, we have encountered statements that qualified younger scientists and engineers were increasingly unwilling to serve on committees. Discussions with young scientists and some informal and limited inquiries among sponsoring organizations have convinced us that the problem is less severe than we had thought. We believe that many young people are highly motivated to serve, but that they are more selective than before in accepting assignments. Thus the problem of locating good people and matching them to advisory assignments is more demanding than that of interesting them in serving.

CRITERIA OF SELECTION

Objective criteria, requiring information about individuals that is usually in the public domain, include such things as level of education (institutions attended, degrees), scientific specialties, and work experience in areas relevant to the advisory role. In principle, information pertinent to such criteria could, if desired, be collected from available sources and used in the selection process—possibly even in large-scale identification projects.

Subjective criteria. Subjective personal information about nominees for advisory service is also important, of course. The personal traits most often mentioned include such things as judgment, effectiveness of performance on committees, integrity, breadth of view, articulateness, imagination, and interest in the committee's task. The opinions of colleagues and others in the relevant peer group are influenced by the traits mentioned, and it seems well established that such opinions are the most valuable information for predicting the nominee's probable success as an adviser. Such opinions have to be collected from nominators or evaluators about whom favorable subjective judgments have been made. They must, of course, be held in confidence.

Compositional criteria. By this term we mean the distribution of the committee membership by scientific specialty, age, sex, ethnicity, geographic location, sector of employment, and other pertinent criteria. It is our impression that in the great majority of cases in present practice, the controlling compositional criterion is scientific specialty. This is necessary to assure adequate knowledge of all aspects of the question before the committee. Geographic location is often a factor, although a lesser one, usually invoked only when it is desirable to have no more than one member from any one institution or when there might be an undue number from one part of the country. Sector of employment is ordinarily considered only when the subject dealt with is such that, for example, the commercial disinterestedness of a university appointment is desirable or the administrative constraints of government employment are to be avoided. Age has, for the most part, we believe, been considered explicitly only when a proposed membership list turned out to contain "all old men" or, more rarely, "all young Turks." Sex and ethnicity have, in our experience, hardly been considered at all.

Conflict of interest. Sponsoring organizations avoid knowingly appointing a person to a committee if his interests, or those of his employer, will be affected by actions that may be recommended by the committee. Awards committees, for example, should not include scientists whose academic departments are applicants for awards in the programs being considered. Industrial scientists should not sit as members of committees that will recommend actions likely to affect the fortunes of their companies. Other forms of conflict of interest—involving ownership of equities in a company, industrial consultancies, and the like—also must be considered.

The problem becomes especially difficult when a field is so highly specialized that only a few advisers of top quality can be found, and also when the activities of the agency requesting advice are so pervasive in a field of expertise that almost all advisers with the technical competence required are related to the agency in some way. They may have received research grants or fellowship support from the agency, made application for such grants, served as consultants to the agency, or been employed by industrial contractors. This is especially true of the most competent in any field. As examples, one thinks of the relationship of the Atomic Energy Commission to nuclear reactor development, of the National Institutes of Health to policies for the support of biomedical education, and of the National Aeronautics and Space Administration to exobiology.

Where, for any reason, conflicts of interest must be accepted in order to obtain adequate expertise, it is important that they be known to all members of the committee, and to the sponsoring and requesting agencies. This is not only to ensure that the possible biases are in the open but also to assist the members who have such conflicts to make necessary compensations in their own thinking and judgment.

Clear statements of the task assigned the committee, and of any possible conflicts of interest among its members, can do much to assure the likelihood of public confidence in its conclusions.

PREFORMED JUDGMENTS

When a committee is expected to clarify an issue by reviewing facts and arriving at judgments, it is of course desirable to avoid the selection of members who have already made up their minds, especially any who may have taken such strong positions as to be fairly presumed to have lost some degree of openness to other views. With regard to controversial questions that have come under wide discussion among scientists, it may be difficult to find individuals immersed in the subject who have not already, and often publicly, formed strong judgments on the points at issue. In such cases, the best procedure, sometimes the only adequate one, may be to select a committee that is carefully balanced among divergent preformed judgments, and to name as its chairman a tactful individual of widely recognized distinction who is not an expert in the field but who is equipped to understand the issues and to sharpen them for discussion. The result may not be any substantial consensus among the experts, but may be valuable in clarifying issues and the reasons for disagreement among highly qualified judgments.

An example was the question, in the 1950's, of the genetic effects of atomic radiation. Leading geneticists were in deep disagreement, and many had taken strong public positions. Confronted with the task of appointing a National Academy of Sciences committee to seek sound judgments, Detlev W. Bronk, President of the Academy, named individuals on all sides of the matter, and selected as chairman Warren Weaver, a mathematician and biologist, not a geneticist. The committee, under Weaver's leadership, succeeded in clarifying and agreeing on what was known, what was unknown or only partially understood and therefore subject to differing judgments, and what needed to be done to explore the most crucial questions further.

Another risk in committee consideration of controversial issues arises when far-reaching political or national policy decisions hinge on them. It may then be nearly impossible to select a committee that will be widely acceptable, inside or outside the scientific community, as capable of rendering a finding that is both expert and impartial. The stage may then be set for an agency of government to name a committee of individuals who are undoubted experts but whose views are known to favor the current government policy or point of view. Appendix B mentions the useful contributions of scientists to public discussion of the ABM issue. One potentially negative and perhaps unavoidable result is that it would now be extremely difficult, should the need arise, for anyone to select an expert committee on that issue that would enjoy wide credibility. Certainly, any committee selected by an agency of government would be suspected by many of having been chosen to confirm the current policy.

APPLICATION OF CRITERIA OF SELECTION

The selection of members of a committee is the duty of the organization that accepts responsibility for the reliability of its report rather than that of the organization that requests the advice. Suggestions about qualified persons, especially when the task requires a high degree of specialization, are always in order, but final decisions about the membership must be made by the responsible organization. Where a continuing committee is concerned, the committee itself should participate in the evaluation of qualifications of new members because those who have already served are in a good position to apply the subjective criteria for selection. Staff members of long experience in working with committees can be extremely helpful.

A committee should be sufficiently broadly based that all reasonable ways of looking at a topic will be given consideration. One cannot set out categorical rules for this because the requirement is different with different committees. The personal biases that may be a hazard on a committee called upon to assess current problems and needs in physics will not be the same as those that may influence the judgment of members of a committee on urban planning. Great sensitivity is required in the appointment of committees to identify the perspectives that should be represented, and the biases that should be guarded against. Indeed, those who appoint committees must recognize their own biases.

The uniqueness of committee tasks requires that selection criteria be applied with understanding of the special circumstances within which the committee will work. These vary widely. It is understandable then that the approach to selection would be almost completely empirical and that the record would show not a few mismatches between people and committees.

A few generalizations can be made. Some individuals like to work on very sharply focused problems; others prefer unstructured problems. The former are of greatest value on technical committees, where the problems are well defined and the scientific content high. The latter are most effective on committees that must work at or beyond current frontiers of scientific knowledge or in policy areas in which new problems are being tackled.

Experience suggests the value of peer judgment in determining qualifications for certain assignments. Over a wide range of kinds of selection, peers who know the candidate well are the best qualified to evaluate him. At the same time, the candidate knows his own interests; this argues for letters of invitation that contain reasonably complete descriptions of what a committee is being asked to do, so that the recipient of the invitation can judge soundly whether he is qualified and willing to give time to the task.

The question of age as a qualifier in the selection of committee members has been much discussed within the National Research Council and elsewhere. Sagacity does not seem to be age dependent: Some persons are ready at age 25 to be wise and effective advisers; others will never be. Experience and the quality we have referred to as "connectedness"—knowing the ways of the world—are, of course, related to age, but the ability to profit from experience is not. Imagination and capacity for innovativeness are qualities that appear early and are retained by some into advanced age.

Finally, we must mention the quality of individual "visibility." The age and career stage at which a person becomes prominent in the special way that makes him a likely candidate for advisory service varies from field to field, from sector to sector, and from individual to individual. Engineers apparently reach this stage later than physical scientists; academic people, earlier than industrial people. All, of course, are less easily identified in the early stages of their careers. Special effort has to be invested, therefore, in identifying younger nominees, more in some cases than in others.

PRESENT METHODS OF SELECTION AND RECRUITMENT

The method of selection now generally preferred begins with an analysis of the committee's task, consultation with knowledgeable people in relevant fields of scholarship or experience, and a search for the names of candidates who seem to have the qualifications needed. The "telephone method" or "buddy system" is used. Staff members, members of an executive committee, or others assigned to this activity in the responsible organization call professional colleagues or write to them, describing the committee's task and soliciting suggestions of candidates. Those usually asked to make nominations are people with established reputations in the field, who often have served as members or chairmen of committees. Their judgment is respected by the sponsoring organization. Cross-checking and collection of further information about nominees follow. The list of names of nominees is screened repeatedly as the requirements become better established, until a group of persons who meet the dominant criteria has been selected.

Some organizations determine the willingness of candidates to serve before extending formal invitations; others simply issue the invitation. The selection process may cover six months in the establishment of a new policy committee; it may last only a few days when a technical committee is urgently needed. A list of 30 nominees for a 12-member committee is common; occasionally, the list runs to more than 100.

The advantage of the personal-contact method is that it enables close personal evaluation by people who know the nominee. The disadvantages are that it can be quite time-consuming, it permits consideration of only a limited field of candidates, and it tends to call upon "the same old faces" repeatedly.

Again, we take the National Research Council as an example for the description of specific selection procedures. The NRC appoints more than half of the estimated 1,500 science committees currently advising at the national level.

As a general rule, the largest role in the identification of individuals for appointment to NRC committees is played by the chairman, staff officers, and members of the NRC division concerned. (The members of divisions are nominated by the scientific societies in the relevant field and, in a relatively few cases, by governmental agencies.) The process usually involves two or three layers of personal consultation with those who are actively engaged in the pertinent fields. Typically, the division chairman or executive secretary may approach someone in academia or industry that he believes is well informed in the field concerned and solicit his help in identifying persons who would be well qualified to serve on the committee or panel. On the basis of suggestions thus received, the division chairman selects a balanced membership and recommends it to the President of the National Academy of Sciences for his approval. The president's office examines the nomination list with two criteria in mind: first, balance and apparent qualifications; and second, present commitments of the nominees to other committees and panels of the Academy and Research Council. Although a number of persons serve on two or even more NRC committees at a time, it is a general practice to limit the assignments so that no individual is overburdened.

NRC committee members are, in general, chosen for their technical qualifications, recognized communication skills, and judgmental qualities, but other more subjective factors such as motivation and temperament are not overlooked. The identification of possible members and the final selection are often preceded by an extensive analysis of the various competences needed to deal with the subject and the issues to be placed before the committee.

The appointing function is thus carried out at two levels: at the division level, where there is professional expertise on the scientific fields and the specific problems; and in the Executive Office of the Academy, where the above-mentioned screening procedure takes place. The Executive Office maintains a complete file of all current task appointments for all activities of the National Academy of Sciences and the National Research Council.

As mentioned above, nominations for committee participation are usually obtained by what is called the "telephone method" or "buddy system": referral for committee membership by peers who are canvassed privately and informally by those responsible for gathering a list of candidates. While the deficiencies of this approach are apparent—especially the narrow range of the search—it has the virtue of being based on close personal knowledge of the nominees.

The composition of the committee is regarded as extremely important. Geographical and institutional representation is sought over a fairly broad range, although, as indicated earlier, this is more to avoid undue distortion than to achieve any designated norm. In any event, each member is expected to serve as an individual and not as a representative of any institution or organization.

There is a general tendency within the NRC to call repeatedly on unusually effective people. This, however, is not done on a consciously planned or prescribed regimen whereby participants progress in an orderly fashion from panel to committee to board to chairmanship. Committee service gives a person visibility, and new or young talent expressing itself through active committee participation and accomplishment is recognized; the individuals involved are asked to assume more responsibilities as they gain wider experience.

There seems to be widespread recognition that among the very large population of scientists and engineers, a great many potential advisers of the highest quality are overlooked because of the inherent difficulties in identifying them. The gravity of the situation is almost impossible to measure, but it is probably getting worse. The total number of scientists and engineers in the United States has doubled in the last 20 years, from 790,000 in 1950 to about 1,600,000 in 1970. In that period, while the individuals have changed, the circle consulted for nominations has probably not widened very much, and the numbers of people well known to them are probably about the same. Thus it seems inevitable that under this method of selection, the proportion of the whole scientific population that is considered for appointment has shrunk.

From time to time, attempts are made to throw the net more widely. One way to do this is to take advantage of various centralized rosters. The National Register of Scientific and Technical Personnel, maintained by the National Science Foundation, contains information about those scientists—and a sample of engineers—who are deemed by their professional societies to be eligible for inclusion in the Register and who are willing to fill out a questionnaire. In cooperation with the major professional societies, the National Science Foundation updates the Register every two years. The information provided by each respondent—biographical, educational, professional—is coded and computerized. The 1968 Register contains information about some 297,000 scientists, an estimated 60 percent of those eligible. The number of doctoral scientists in the Register at any one time has been estimated to be around 75 percent of all doctoral scientists.[71] Evidently, useful current information exists in the Register, and, on occasion, it has provided the names of people who might be asked to take on certain advisory tasks. In practice, however, the Register has not proved effective as a means of locating advisers. For one thing, it contains none of the information needed for the application of subjective criteria—no quality information, in other words, except for what can be inferred by reading between the lines. One is defeated by the sheer numbers in the Register. Second, it has proven difficult to obtain the needed information within a reasonable time. With limited financial resources, the Foundation has not been able to set up an information system that permits immediate access to the file except in extremely rare circumstances. Finally, the Foundation has taken the position that the information is privileged, because it contains such things as salary data, and has not been willing to release any of it except under carefully controlled conditions. The result has been to limit the usefulness of the Register in providing statistical data about the scientific population.

Some organizations have files of their own to which they resort when names of advisers are wanted—as a supplement to the "telephone method." The NRC Office of Scientific Personnel, for example, maintains a roster of persons who can be invited to serve on awards committees for fellowships and associateships. Every five years or so, the chairmen of doctorate-granting university departments in the sciences, engineering, and mathematics are invited to nominate those of their Ph.D. graduates in the last few years whom they deem unusually well qualified for committee service.

At the same time, members of the various NRC divisions are invited to nominate colleagues for the same purpose. The names submitted are then screened by the NRC divisions, and a roster is drawn up by field of specialization. In the compilation of 1966, for example, the names of 3,869 persons who had received their doctorates between 1945 and 1955 were added to the roster. Copies of the roster were made available to the various NRC divisions. The roster has been exceedingly helpful to the Office of Scientific Personnel and helpful to some extent to NRC divisions. It has the expected shortcoming that nominees in some of the newer fields are less numerous than those in traditional fields. An additional difficulty is that for most kinds of committee, the subjective criteria enumerated above are regarded as being especially important for selection, and, as pointed out with regard to the National Register, mere lists of people with objective information about each are difficult to use in the normal selection process.

In 1969, as part of the Study of the Utilization of Young Scientists and Engineers in Advisory Services to Government, the NRC divisions screened nominations of 494 scientists and engineers who had been nominated by their doctoral department chairmen and who were 36 years of age or less. The divisions were able to second the nominations of 170 of the nominees, and information about these people was included in a roster that was made available to all divisions. The roster was transmitted to the divisions with a letter from Philip Handler, President of the National Academy of Sciences, asking that these nominees be given consideration when new committees were appointed. The divisions were asked to report any actions taken as a result of this experimental project to involve younger people in NRC committees to a greater extent. Early reactions to the list pointed to the following needs: (a) more precise identification of scientific specialties—"physical chemistry," for example, was not sufficient, (b) a way of entering additional quality indicators and indicators of the nominee's interests, and (c) a greater number of names of people now employed in industry or government as compared to those in academia.

Our interviews and the data that we have been able to gather suggest that agencies are prepared to appoint younger advisers when they can identify them and evaluate them. Some 14 percent of NRC committee members are 40 or under, and a little more than 4 percent are 35 or under (Figure D-1, Appendix D). More to the point, the typical DOD adviser was 37 when he was first appointed to a committee in DOD or elsewhere of sufficient importance to be listed in his *curriculum vitae* (Figure D-5, Appendix D). A quarter of DOD committee members were under 33 when they were first recruited to committee service. The difficulty seems to be not that the talents of younger scientists are discounted, but that once a younger man is found, he is called upon again and again during the next 20 years or so while other younger men of talent are passed over. Agencies need to tap more regularly the bright young men coming along.

PROPOSED ADDITIONAL METHODS OF SELECTION

Several additional methods that seem worthy of trial have been suggested to us. The "snowball technique" would start with nominations solicited from a relatively few trusted nominators. The nominees themselves would then be asked to suggest other colleagues in specified categories for advisory service, and so on, in chain-letter fashion. The process might begin with 20 carefully picked nominators, and a multiplying factor of five might be used. Two or three successive stages would yield perhaps 1,000–2,000 unduplicated nominations. This could be done in various sectors of special interest: e.g., industry, younger people, emerging fields. Such a method would take full advantage of peer judgments and might well turn up advisory talent that would escape more conventional searches. It would not obviate the need for boldness on the part of sponsoring organizations in appointing a few relatively unknown people.

Another suggestion is a combination of the "old boy" technique and the centralized roster. Instead of a list of potential advisers, a roster of nominators would be compiled for use in identifying advisers when they were needed. The nominators, as always, would have to be knowledgeable people with reliable and responsible judgment. They would be distributed throughout the various disciplines and sectors of interest. Upon telephoned request, they would nominate members of their organizations relatively promptly when the specific committee assignments were described to them. This method would have the advantage of producing nominations to specification as contrasted with the storing of information about potential advisers in a large pool.

Perhaps the most innovative suggestion that has come to us is for a process of open nominations or for self-nominated committees. In the first of these, a proposed committee assignment would be described in a professional journal or in a circular letter, the qualifications of members specified, and people invited to nominate themselves, if they believed they were qualified, or to nominate colleagues. The qualifications of nominees would then be screened in the usual way. Self-nominated committees would enable entire groups to come forward and work on a problem, with the assurance that their reports would be read, even though the groups would not possess delegated authority. Both of these procedures might indeed draw forth hidden talent and would certainly identify the strongly motivated. Obviously, any organization that considered such a procedure would have to recognize the hazard of receiving far more nominees than could be effectively utilized and of often being subjected to pressure from those who had not given adequate thought to the requirements for advisory service.

It has also been suggested that files containing information about research awards or fellowship awards made by agencies and foundations might be used to locate persons with the scientific abilities needed for advisory service. This method might be useful as a supplement to some of the foregoing methods that rely more on subjective criteria.

RECRUITMENT

The problem of recruitment is important for two reasons. The first is axiomatic. If a topic is worth a committee's time, the advice given should be the best available. And second, many committees are concerned with matters pertaining to the organization and welfare of science itself. They are asked to consider the needs of a discipline, to select investigators for research grants, to award fellowships. It is not enough that the members of such committees be well qualified; if they are acting on matters affecting the profession, they should represent the profession fairly. The committees are reporting to agencies that are answerable to the nation at large, and the committees should be subject to the same democratic principle. It will not do to choose only people whose names happen to be known. The committees should be representative of more than one section of the country, of more than one group of institutions, of more than one age group. At a time when women and members of ethnic minorities are joining the ranks of the profession in increasing numbers, it is appropriate to add that the committees should include them.

Even where, as may usually be the case, such differences in background make no difference in a member's contribution to the work of a committee, his membership adds another dimension to his professional life. The college teacher or industrial researcher is thrown together with new colleagues in a new setting, performing new tasks. He is identified with his profession in a new way. Not all scientists want this exposure. For some, committee work is a distraction from work they consider more important. But many scientists are pleased to serve. They welcome the chance to meet new people, to apply their expertise to problems at the national level. The personal rewards—committee members are seldom paid—are to them worth the work and time involved.

Equally important, service on a committee, if it has been appointed for a genuinely useful purpose and if its work can be demonstrably effective, is likely to give all its members a feeling of satisfaction in being able to play a meaningful role, even though modest, in the affairs of the nation. Few can actually exert leadership at the top; many can and should, through the advisory system, play their part in shaping the countless programs, goals, evaluations, and decisions that together constitute the business of government.

A number of attempts have been made—some of them quite succesful—to stimulate interest in the work of advisory bodies and to prepare people for advisory service. For example, the Defense Science Seminars were sponsored by the Advanced Research Projects Agency of the Department of Defense in the summers of 1964, 1965, and 1966, in an effort to interest younger scientists and engineers in the broad range of technical problems involved in defense-related research and development. The procedure followed was to invite about 30 scientists and engineers, mainly in the 30–35 age bracket, each summer to spend four weeks in briefing sessions, site visits, and discussion groups, learning about the nation's defense problems and the ways in which science and engineering were contributing to their solution. The participants were selected from among holders of various prestigious fellowships and the nominees of various DOD consultants. Forty-four people from universities and 71 from federal laboratories, nonprofit and industrial establishments, and the armed services took part during the three years, comprising a total of 115 alumni of the seminars. The fields represented were predominantly physics, chemistry, and engineering, with some representation from mathematics, earth sciences, and life sciences. The seminars were generally recognized as giving a high degree of motivation to many of the participants. As of 1970, some 40 of their alumni reported that they had taken part in at least one advisory activity of the Department of Defense subsequent to their seminar experience. Only one indicated a lessened interest in participating in DOD advisory functions.

Another example is JASON, an organization of university scientists, 35 to 40 in number, formed by the Institute for Defense Analysis (IDA). Here too, the primary activity is an annual summer study of six or seven weeks' duration during which JASON members devote themselves to significant technical problems related to the national interest. In addition, through the remainder of the year, members gather occasionally for weekend meetings designed to help them keep abreast of scientific problems of interest to the government. They often also serve in advisory capacities to other agencies. JASON members are generally drawn from among the young faculty members of universities. Besides their direct usefulness in the matters to which they address themselves in JASON, they gain the kind of exposure to governmental problems that often is a major factor in securing younger members for advisory committees.

Another example is furnished by the workshops conducted by the National Academy of Engineering. In 1969, the Academy sponsored a workshop on "Systems Approaches to the City—A Challenge to the University" to provide an introduction to team attacks on urban problems. One hundred and seventy-three persons participated, including a number of younger people.

In addition to these methods, it has been suggested that special means be provided to involve younger people in advisory roles of a productive variety. For example, they might be asked to serve as consultants to committees and to prepare background papers for the committees. Internship programs, in which younger people would serve for a period of time as temporary staff members, have also been suggested.

Finally, the suggestion has been made that sponsoring organizations give highly visible evidence that they want more representatives of minorities to serve on advisory committees. A sharp break with past practice is needed, not a gradualistic approach, if the energies and interest of these presently underutilized groups are to be captured.

MOTIVATION

Throughout our history, scientists have responded positively to their government's request for advice. We believe that most scientists are prepared today to serve as advisers if called upon to do so. And yet we cannot in good conscience fail to examine the reasons that motivate scientists to serve or to ask whether useful steps could be taken to increase incentives and minimize the effect of disincentives.

We are concerned, of course, not just with inviting people to "sit on committees," but with asking them to provide advisory service—to take an active role, to contribute to the solution of a significant national problem. Effective performance on a committee is much more than a matter of possessing technical competence. The highest scientific competence will not avail if its possessor is not moved to put his energies into the task. Committment is important. A calling—that of national adviser—is involved to a considerable degree.

In this regard, it is necessary to consider the relation of advisory roles—especially their requirement of time and effort—to the life style of the scientist. Traditionally, in the early stages of a scientist's career, his commitment has set a life style that precludes distraction. These are usually the years of greatest accomplishment, and the young scientist devotes himself wholeheartedly to his research. If he is at a university, he also teaches, but the line between research and teaching is almost invisible. Into the middle thirties of his life, he is interested primarily in his own field and in his contribution to its intellectual development. Most of his friends and colleagues are in the same field, and he knows very little about the national problems of science. He travels to scientific meetings and specialized research conferences and subscribes to the leading research journals in his field. He gladly gives time to refereeing papers that his colleagues have submitted for publication, but that is so much a *quid pro quo* and so close to his own interest in keeping up with his field that he seldom regards it as a service. He guards his time and critically examines requests to give time to activities outside his research interest. If he ever does so, the activities are likely to be those closely related to research—departmental selection of graduate students, the graduate curriculum at his university, obtaining funds to support his research, standards in his field. Service on a committee, however important its task, ranks low on his scale of priorities.

As the scientist grows older, his interests usually broaden. He gains in reputation and is likely to receive invitations to take part in activities outside his own field, including committee assignments. He will probably accept some of them because he views his responsibilities now in a different light. If he is truly distinguished, however, he maintains his interest in research. He is still jealous of his time and still critical of the poorly defined advisory task. He may be willing to serve on a committee, but he approaches the task with some distaste.

Or so it went until recently. Now the attitudes of scientists toward helping to solve social problems seem to be changing. Criticism of the isolation of the scientist and realization by scientists themselves that critical problems will not be solved without their participation are having their effect. As in the depression days of the 1930's and the World War II period, social problems—as contrasted with those of pure science—have become so important that scientists, including, and perhaps especially, young scientists, are looking beyond their fields to see where they can make their contributions. To the extent that advisory service seems to be a productive way to attack the ills that beset society, scientists will make time available for it if asked to do so. However, they are not entirely confident that advisory service *is* productive.

For one thing, there is the problem of alienation. The scientific enterprise within government and outside it has become so large and so impersonal that many scientists feel left out and frustrated in their desire to help. Regardless of the cliches repeated by some popular writers, science has always had a highly personal style. Scientists—as much as other people—work closely with their colleagues, are encouraged and stimulated by them, look to them for help, and feud bitterly with them. They are put off by the sheer size of the scientific enterprise now, by the large numbers of people in it—very few of whom they can know—and by the growing bureaucratization of government science. The relatively small numbers of advisers reinforce this feeling of exclusion: The probability is shrinking that an individual scientist or his immediate colleagues will be asked to come to Washington to serve. Other scientists have been alienated by what they feel is the improper use of science and technology. The Vietnam war has intensified many of these concerns.

Another problem is that of fear of co-option—the belief of some scientists, especially those who are most outspokenly critical, that they are being invited to serve on a committee in order to silence them. The situation in science is not unique. Whenever an institution is opened from the top of the authority structure and dissidents are invited in, the newcomers ask themselves whether they are being co-opted. Situations of this kind occurred in the labor movement of the 1930's and exist today in the minority-group movements and the efforts to involve students in university government.

To understand motivation, it is necessary to examine the attitudes of the institutions that employ the prospective science advisers—the universities, colleges, and industrial and government laboratories. What opinions do they hold about service on national committees? Do they encourage such service? During the period immediately following World War II, universities and industrial companies differed in the extent to which they encouraged members of their science faculties or scientific staffs to serve as advisers. Some universities were deeply involved; others—quite as prestigious—were not. Some companies participated; others did not. During the 1950's and most of the 1960's, however, advisory service came to be in good repute almost everywhere. Indeed, the number of faculty members who were absent from their campuses at any time because of advisory duties in Washington became a matter of embarrassment to many universities. Near the end of the 1960's, attitudes began to change again—away from encouragement and toward tolerance. The complaints of students that their teachers were away too much was a factor. Another was the attack launched by campus militants against defense-related associations and, by extension, against all associations with the federal government. On a few campuses, invective has been aimed at national advisers. Although the number of such incidents connected with advisory service *per se* is still small, this opposition may become a factor to be reckoned with in the future.

Occasionally, employers may urge scientists to perform advisory functions that the scientists themselves regard as unproductive and would prefer not to accept. The reason usually given by the employing organization is that representation on national committees carries prestige value. If the disinclination of the scientist to serve is based on reliable judgment, however, the insistence of the employer does not serve the cause of effective advisory service.

Finally, perceptions of the pathology of the advisory system, as discussed in Appendix F, may heavily influence the prospective committee member's decision whether or not to serve. Such perceptions constitute a strong disincentive when they come into conflict with idealism, loyalties to other causes, or simply the wish to invest one's time as wisely as possible.

REWARDS OF ADVISORY SERVICE

The major satisfaction that most science advisers seek to gain from their service is a sense of achievement in contributing to significant work. Without the prospect of such achievement, they are unlikely to accept advisory assignments. By such achievement, they feel amply repaid. The implication for this report is that improvements in the effectiveness of committees can increase accomplishment and enhance the rewards. A special point is that efforts should be made by the organization sponsoring a committee to let the members of the committee know what was accomplished after the report was submitted. Follow-up activities, with occasional reports to the committee members, seem highly desirable.

Committee members receive recognition for their work and gain kudos of various kinds: some publicity, their names on the report, occasionally attribution of sections of the report to the authorship of individual members, and—rarely—special citations for their work.

All of this could appropriately be enhanced. Public announcement of the appointment of the committee, including a statement of the committee's task, should be made nationally and also through committee members' hometown newspapers. Interim news releases where appropriate, and especially a news release about the final report of the committee, should be provided. Letters of thanks at the conclusion of the advisory assignment might go not only to the committee members, but also to officials of their institutions. The latter should be told rather explicitly what the task of the committee was.

We pointed out earlier that committee work can be educational for advisers—sometimes highly so. Such opportunities are probably most effective when they are informal and unforced. Occasionally, it may be possible to enhance them by special arrangements. One chairman did this successfully by including in the plan for each committee meeting a discussion of some scientifically interesting and relevant topic.

We considered whether financial rewards should be given to science advisers. Several of the federal agencies pay their advisers a modest honorarium in addition to reimbursing them for their expenses. Other federal agencies and the National Research Council pay only the travel expenses—seemingly without encountering difficulties in obtaining able advisers. Participants in sustained working groups—for example, summer studies—are usually paid. But for normal committee service, pay seems to be regarded as secondary in importance to other rewards. When honoraria are offered, they are not large in comparison with consulting fees and are probably not decisive in determining whether a scientist will accept an advisory assignment. We do not recommend that payment of honoraria be made a general practice, but it is a legitimate question to raise. Financial reward is a form of recognition that society employs. Scientists are paid to give talks at colloquia, to consult in industry, and to write articles. Should they not be paid for time spent in advising the government? A few people would take their advisory responsibilities more seriously if they were paid for them. Some advisory tasks—the writing of position papers, for example, or the drafting of lengthy sections of the report—take time away from the scientist's other activities and constitute more than the normal advisory load.

In the National Academy of Sciences and National Research Council, where, as noted in Appendix A, the founding Act of 1863 prohibits compensation for advice, the position is taken that the no-compensation provision lends important strength to the independence of the advisory service. Advisors have nothing to gain except the satisfaction of service and the possibility of an enhanced reputation for wisdom. Also, most of the advisors are on salaries from their own employers that do not stop while they are doing committee service. Still, such service may and often does cost them extra income that they might otherwise have obtained through their consulting activities. Nevertheless, in actual practice, few objections to the no-compensation policy are heard, and few individuals are known to have declined to serve because of it.

APPENDIX F

Desiderata and Pitfalls

That the science advisory committee as an auxiliary of government holds an honored place on the American scene is undeniable. The brief history contained in Appendix A and the general account of the role of such committees given in Appendix B by their nature tend to emphasize the positive aspects of the system that has developed. Such an emphasis is justified by the overwhelming evidence that by and large the system has succeeded in bringing a high quality of scientific and technical talent to the assistance of the government, much of it contributed without material compensation, on myriad issues, including some of the most difficult and portentous that the country has faced.

Of course, the record is far from stainless. Some committees have been highly successful, and some have become bitterly frustrated or have failed totally to accomplish their objectives; most fall somewhere between these extremes.

We enumerate here some of the conditions to be sought and pitfalls to be avoided.

THE NEED FOR A COMMITTEE

It is relatively easy to establish a committee. It is not so easy to ensure that a committee will be effective. Indeed, if an agency wants merely to defer action on a question, it may appoint a committee. A former assistant director of the Bureau of the Budget recently had this to say: "In my experience, nothing was simpler than to set up an advisory group. It started wheels turning, it bought time, it was a surrogate for action, and it produced a kind of structural grandeur. It implied that somebody was taking charge of a problem, and perhaps things would work out. This is the way of governments." He added, "The advisory committee system has its own laws of inertia and there exists no satisfactory mechanism for insuring its productivity or its accountability."[72]

Before a committee is established or a task is assigned to a committee, a number of questions should be asked and answered to the satisfaction of the proposed sponsoring organization. They are of highly legitimate interest to the committee membership as well. The first question should always be whether the task could be performed as well another way. If it appears that an individual could do the job as well, an individual should probably be asked to do it. After Abraham Flexner had started his landmark study of American medical schools for the Carnegie Foundation for the Advancement of Teaching, Henry S. Pritchett, the foundation president, asked whether he should not have an advisory committee to direct him. Flexner was able to stave off the idea, and he finished the study single-handed.[73] His report remains one of the most comprehensive, incisive, readable, and influential ever written in the realm of policy for science.

On the other hand, there are cases in which even though the report of an individual could be expected to be fully as competent as that resulting from the deliberations of a committee, the use of a committee is still preferable. A report gains weight from the evidence of agreement among a number of known and respected persons. The award of grants and fellowships is a case in point. One wise and perceptive individual might select as successfully as any committee most of the time, but action by a group gives confidence to sponsor and successful and unsuccessful applicant alike that the selection has been fair and well judged.

CAN THE COMMITTEE PERFORM?

If the need for a committee is clear, the question remains whether the conditions are such that a committee can perform satisfactorily. This involves the subsidiary questions of whether the problem or issue placed before the committee is properly defined, whether the information necessary for its adequate consideration will be available, and whether conditions are such that the committee can expect its report to be effective.

Appendix B discusses the roles that are played by science advisory committees in government, while Appendix C outlines in more specific terms the types of committee that have become familiar in the advisory system. It is clear that these committees are called upon for a very wide variety of tasks involving very different qualifications in matters such as detailed technical knowledge, broad judgment, sensitivity to nonscientific factors, and the ability to place scientific questions in a larger perspective.

While examples can be cited of both good and bad performance in each of the roles described, it is important to avoid placing in the hands of a committee a task that can be better handled in another way. An example of a task in which committees find it especially difficult to be effective is that of advising on the division of limited resources among projects or fields. Ideally, recommendations for "cutting the pie," especially when the total size of the pie is specified, might be regarded as best done by a wise and knowledgeable group of "outsiders" who can be expected to know what balance will be best. But in practice, the members of such a group are likely to experience a difficult conflict between adequate representation of their several fields and the necessary detachment from their special interests to serve as a panel of dispassionate judges. They can more easily define a "maximum reasonable program," but this may not be helpful. It may be that the allocation of limited resources is simply not an appropriate task for a committee.

In general, this question of the appropriateness of various kinds of task for committee consideration seems to have been little studied from the behavioral and group-dynamics points of view. Studies along such lines might prove very enlightening.

DEFINITION OF TASK

The definition of the committee's task calls for careful consideration. Is it a task that can be accomplished within the time that committee members can reasonably be expected to give? Is it defined in such a way as to be clear and to set necessary limits, but not to put arbitrary constraints on the committee's deliberations? Has an effort been made to generalize the task so that the committee's response can have the widest possible usefulness? John S. Coleman, Executive Officer of the National Academy of Sciences has said, "It might be noted that among the more difficult questions which new committees must face in responding to an agency request for assistance is that of formulating the question or the set of questions to which the committee should direct its attention. In this situation, assistance from the Academy's professional staff is often invaluable and, indeed, in many of the Academy operations a very considerable amount of time is spent by the Academy staff with representatives of the requesting agency in sharpening such questions before the Academy accepts the responsibility of responding to the request and subsequently identifying and recruiting people to serve on the advisory committee, panel or board, which may be asked to carry out the task of providing the solicited advice."[74]

The problem of adequate information varies greatly from committee to committee. In addressing strictly technical questions, the members of a committee often bring with them most of the data required. On the other hand, for advisory reviews of governmental programs, and for matters involving the missions or operating problems of government agencies, extensive briefings of the committee, or even extended site visits, may be necessary before the members can be expected to grasp all aspects of the job to be done. Top-quality staff work is necessary in such cases to make sure that the committee is adequately served and the time of its members is not wasted.

Finally, the question of whether its report is likely to be effective is important to a committee's morale. The true receptivity of the agency requesting the advice, the administrative level at which the committee will report, the timing of the request relative to other developments, and the general milieu in which the report will find itself, all are important. At the same time, if the task before it is adequately explained, a committee will usually understand the limits within which it can speak and will realize that legitimate nontechnical considerations, budgets, national policies and priorities, and public attitudes are all matters that can restrict the effect of its report. What should not, but sometimes does, restrict it is bureaucratic interference within the agency.

MEMBERSHIP CONSIDERATIONS

The selection of the membership of a committee is obviously crucial, but it is far more crucial in some cases than in others. For a purely technical task, balance is not ordinarily of special importance except in the sense of inclusion of all the necessary general competences. Deficiencies in detailed knowledge need not be crippling, for the members of such a committee have informal access to colleagues, usually well known to them, who can readily fill the gaps. But in policy and judgmental matters, committee balance is a prime consideration. Will all reasonable viewpoints be represented? Is there among the members a strong element of flexibility and openmindedness, a readiness to weigh opposing views, a readiness to express unusual views and to question the "accepted" views, an inclination toward independent judgments, but at the same time a sense of judicious restraint? The desirable qualities are practically never found in a single individual; they must be sought in some kind of balance among the members.

The perspective of the individual often needs to be considered before he is appointed, either because a particular perspective is needed for its own sake or because it is needed to balance other perspectives in the membership. The perspective of the expert is often a point in question; expertness is usually desirable, but breadth at some expense to expertness may be more so. Arthur Kantrowitz, in an article on the problems of committee objectivity, has written: "The selection of scientific committees has always been beset by the dilemma that one must choose between those who have gone deeply into the subjects under discussion, and, accordingly will have preconceived ideas about what the outcome should be, and those who are perhaps unprejudiced but relatively uninformed."[75] There are also the perspectives of institution and of discipline. Apart from differences of broad research philosophy, for example, that may exist between the university scientist and his industry colleague, either one is likely also to see the scientific community from the narrower point of view of his own institution. He may consider the strengths and weaknesses of different disciplines as he sees them represented there; he is likely to evaluate students in terms of his own students; and he may judge the competence of scientists elsewhere in fields other than his by comparing them with scientists at his own institution who are in these fields. He is almost sure to have strong disciplinary ties and, at least to some extent, to view the problems of science as being the problems of his discipline.

And there is also the perspective of age. Committees on long-range questions of far-reaching importance, whether they are dealing with the advancement of science or technology as such or with the scientific components of larger questions, seem, understandably, to be composed principally of senior people of wide reputation and well-established judgment. But it is precisely such long-range questions that have greater implications for the younger men and women who are more likely to have to live with the answers that are given. This particular manifestation of the age-balance problem is, of course, common in other connections as well, for example, in the governance of universities and in the issue of minimum voting age.

The members of a committee, whatever their intellectual qualities, must be people who will apply themselves to the committee's work. To take an elementary point first, a person should not be appointed if he is not likely to be able to attend most of the committee's meetings. If a member finds that he will not be able to attend often, he should step down. Usually in the choosing of a committee there are more good candidates than there are places to fill. A member who does not attend meetings has kept out someone else who might have made a contribution. When a committee reports, the name of an absentee appears on the document beside his colleagues' names as if he had participated in the committee's work. It is an understandable fiction, but it does not enhance the credibility of the committee as an institution. The chairman might well state this requirement of attendance and participation at the outset.

But participation at meetings is only part of a committee member's job. He must also be prepared to read and digest written material circulated to the committee, which, if the committee's assignment is a large one and its staff energetic, may run to hundreds of pages, and he must be prepared to help write the committee's report. It is easy for a committee whose work will issue in a report to forget that the report may well be their only permanently recorded and visible product. They may look upon the report as a necessary nuisance. Many committee members are not prepared for the labor of writing and, if they write anything at all, may write it hurriedly and poorly. If so, it falls to others, even perhaps to the staff, to pull a satisfactory report together.

The most critical single choice in the appointment of a committee is usually the choice of the chairman. The qualities of the chairman to a large extent determine the success of the committee. He must give firm leadership, keeping the committee to its task while encouraging free discussion, giving the committee a sense that it is progressing, making sure that every reasonable point of view has opportunity for expression, that no pertinent points are overlooked. He must make sure that the committee's task is clear, that an effective *modus operandi* is followed, that questions of purview and procedure are answered, that access to all necessary information is arranged, that necessary staff assistance is provided. Ordinarily, it is he who speaks for the committee in interim discussions of progress or problems with the sponsoring or requesting agency and in intra-agency or public discussions of the report.

These qualities of leadership in a chairman usually mean that he is also a man of firmly held and intelligent views on the subject with which the committee is dealing. He must add to his other qualities the grace and sensitivity to permit his own views to be presented and considered on the same basis as any other.

In difficult and controversial situations, with a committee having the desirable balance among its members, there is danger that the deliberations may end in agreement only on trivial points, with no useful conclusions on the major issues, unless the committee has a chairman with the imagination and resourcefulness to find alternative approaches to the task, or fresh ways of clarifying the issues and defining both the area and the essence of any unresolved disagreement.

PROBLEMS OF THE REPORT

Committee reports can all too easily become bland. The discussion process and the editing process, in the search for consensus, can take the bite out of the committee's findings and lead to recommendations that are only slightly different from the *status quo*. Minority reports are sometimes discouraged and even made impossible unless the dissenting members wish to lose their effectiveness as advisers. Interviews with those who have had much experience in working with committees indicate that the desire to achieve consensus and to avoid minority reports is strong. Resifting of evidence and prolonged discussion are resorted to in order to reach a consensus. This is understandable and desirable—the aim of the committee is to reach one answer if possible, not ten. In the gray areas that lie beyond scientific evidence, however, answers are not clear-cut and value systems come into play, sometimes covertly, sometimes quite openly. Also, what one man may view as the suppression of a valid finding, another may regard as an excision of a questionable extrapolation.

In these situations, the leadership of the chairman and the strength of individual members are crucial elements. After a reasonable struggle for agreement or consensus, a "maximum area of common agreement" solution must not be accepted if the problem is larger than that. Far better to define the areas of agreement and disagreement clearly, either by a statement acceptable to all or by means of majority and minority reports.

PRIVILEGED RELATIONSHIP

The confidential nature of the relationship between committees and sponsoring agencies can give rise to a series of special problems. First, it is generally accepted that the recommendations of a committee should remain privileged until they are released by the sponsoring agency. Otherwise, the advisory system would degenerate rapidly. On the other hand, the sponsoring agency must accept responsibility for the release of committee findings, and particularly for clear and public statement of the reasons if the findings are not released within a reasonable time. Such action can minimize the suspicion that, in their relations with the public or the Congress, executive agencies sometimes use advisory committees to enhance the appearance of widespread support for agency decisions or programs, but without disclosing the full content of the recommendations, which may present a somewhat different picture.

A particularly vexing question is that of restrictions imposed on the individuals of a committee, limiting their freedom to express their views in public or before the Congress on matters considered by the committee. Any official requirements of national security should be fully understood and accepted by the committee in advance. But many controversial subjects do not involve such requirements. Executive agencies should be able to count on a privileged relationship with advisors up to a point, but they cannot expect to keep the members of a committee silent indefinitely because they have rendered a privileged report. Yet if individual members of a committee begin to discuss in a public forum the controversial issues on which the committee has reported, the result can easily be confusion and some perhaps quite unmerited discrediting of the report. The deliberations in committee meetings, where experts on an equal footing can both defend and deeply question each other's views, usually bring some tempering to the views of each, with benefit to balance and wisdom of the final result. But this hard-won and often delicate adjustment may be lost again by individuals in the heat of public pronouncement or debate, where the tempering effect is no longer present.

No easy solution of this problem presents itself, although the suggestion of some kind of statute of limitations has been made. No one can be enjoined from changing his mind, but members of a committee might ordinarily be expected individually to "stick with" their collective judgments in discreet silence for at least a certain length of time, in the absence of new facts or unforeseen developments.

PUBLIC RELATIONS

Another kind of problem may arise because the different roles of committees are sometimes poorly understood by the public, by the agency the committee serves, and by committee members themselves. Something has been said earlier about the various kinds of role committees may be called upon to play. In addition, whether or not this is publicly stated at the time of their appointment, committees are sometimes expected to provide reassurance to the public, defend budgets, strike moral postures, and so on. Confusion of these roles, especially in areas that impinge strongly on public policy, undermines the affected committee's report and in some degree erodes confidence in the whole advisory structure.

Examples of such confusion are not hard to find. A commission that was asked to examine the scientific basis for legislation about pornography was accused of advocating immorality. A committee charged with evaluating various technical factors in order to provide a basis for choice among alternative methods of disposal of chemical munitions was thought to be careless of the environment. To make clear public statements, at the time of appointment, of what the committee will and will not be concerned with, and to seek further means of making the committee's assignment known and the committee process more visible, are obvious antidotes, but ones that are often ineffective once the report is out and the public and the news media are free to make of it what they will. More serious difficulties in this regard probably lie ahead in the present era in which the separability of roles is increasingly being questioned in our society, especially by some of its younger members.

THE CAPTIVE COMMITTEE

The freedom of the committee to do its work and present its findings without outside interference is crucial to the success of the advisory process. This is not to say that a variety of kinds of interactions with individuals or groups outside the committee are not possible and desirable. But at all the vital points of investigation and decision, the committee must be free. Difficulties arise when the requesting agency takes an excessively proprietary view of the committee and its actions. Continuing committees in particular run the danger of becoming captives of the agencies to which they are most closely related.

Such captivity may be the fault of the committee as much as of the agency. Active and interested committees in existence for a long time are likely to develop a strong sense of sympathetic identification with the problems and purposes of the agency they serve. This is a situation ordinarily conducive to high morale in the committee and to devoted and effective work. But it brings with it the danger of blunted critical faculties and reduced readiness to probe, to be skeptical, and to break new ground or take a strong stand for major change.

An agency may seek to avoid the risk of captivity-induced anemia in its advisory structure by asking one of the National Academies to provide an advisory committee, or a group of committees, usually through the National Research Council. This inserts an added layer of vigilance, for the Academies and the Research Council are ultimately responsible for the quality of their committees. But the danger remains, and vigilance at every level, including the committee itself, is the only real safeguard.

Rotation of membership, including the chairman, on a fixed schedule is usually a wise policy for a long-standing committee, not only to bring fresh viewpoints and different personalities to the committee's work, but also as one measure to lessen the chance of the committee's falling into a captive mentality. Rotation, of course, involves the extra time and trouble to inform and "break in" new members. Rotation is especially difficult when a committee has hit its stride, and has the twin blessings of an effective, smoothly working membership and a first-class chairman.

EVALUATION OF THE EFFECTIVENESS OF COMMITTEES

The act of appointing a committee does not absolve the appointing organization or the requesting agency of the responsibility for periodically evaluating the committee's effectiveness. A new committee, perhaps appointed under the most auspicious conditions, may make little progress. A continuing committee that was once successful may become ineffective. The sponsoring organizations should not attribute the difficulties to some incurable defect in committees—"committees are like that"—but must diagnose the difficulties and try to correct them. To do so, the sponsors must know that such difficulties exist.

Danger signals of many kinds may show themselves: failure of members to participate, assignments left incomplete, a slackening pace, dearth of new ideas, staff dominance, and criticism either covert or openly expressed by members or by critics outside the committee. The sponsors should watch for such danger signals and also institute periodic evaluation of the effectiveness of a committee, especially of a continuing committee.

There can be many parties to the evaluation: the appointing organization, the agency or other organization to which recommendations were or will be directed (if this is not the appointing organization), the committee itself, and one or more of the publics or constituencies to which the committee addresses itself. The appointing organization and the agency receiving the advice will usually base their evaluations on a comparison of the achievements of the committee with the charge given to it. Is the (technical) committee making satisfactory progress toward its solution of the problem? Is the (policy) committee addressing itself to the significant questions? Are the recommendations of the committee making an impact on the problems, policies, and practices it was asked to consider? The reviewing body may find that the committee has been faithful to its charge, but that conditions have changed, requiring a redefinition of the committee's mission. A continuing committee can often be transformed and given new vitality by redefining its goals and bringing in new people. When the NRC Committee Advisory to the Weather Bureau (later the Committee on Meteorology) was transformed into the Committee on Atmospheric Sciences in 1960, it showed vigorous new activity. The various constituencies can contribute usefully to the evaluation of the work of committees—for example, by means of articles or letters to the editors of journals or by letters to the sponsoring organizations or the committee itself—if they understand what the committee's assignment was. Occasionally, criticism of committees is misdirected because it is based on a false conception of what the committee was asked to do. The reception given to the report of the Commission on Pornography and Obscenity provides an illustration. For this reason, it is urgent that committee work be made more visible and the committee process better known by means of interim reports, news stories, reports at meetings, and other communications directed toward the various constituencies, not overlooking the public at large.

WEAKNESS OF THE EXPERT

Finally, we come to perhaps the most fundamental consideration of all, a danger that must be recognized and cautioned against.

A committee that is consulted on the scientific component in a policy decision is expected to be scientific. It is expected to respond objectively to the facts. In some cases, this is not difficult because the facts are conclusive. One cannot have two views about them. In other cases, however, the facts are so complicated or so uncertain that the best answer is a probable one. In these cases, the scientific adviser stands on much the same footing as the diplomat who is asked to advise on the best approach in negotiation or the attorney who is asked to predict the outcome of a lawsuit. It is probably impossible for him not to be influenced by personal biases in making his judgment. The public is used to such biases in other advisers, and it takes their advice with appropriate caution, but it associates the scientist with objectivity. It is inclined to regard his advice as authoritative. The scientist himself, because he is used to forming increasingly firm conceptions in his professional work, may not realize how much room for bias there is in his advice on policy questions. He may claim for his advice more authority than he should. Committees should be careful to recognize the uncertainty in their deliberations and should make it clear to the public that their judgment may be off the mark. The public should be taught not to look for a scientific certainty that is not there. A committee should report important disagreements and should endeavor to make clear their significance to the decisionmaker. A committee is not helpful if it does not aim at a consensus, but the consensus should not suggest that the issues are simpler than they really are.

If there is room for innocent bias in the deliberation of science-in-policy questions, there is of course still more room for it in the discussion of policy for science. There is no lack of men in science who are devoted to its advancement and who can be trusted to work hard to study and promote its best interests. They can be expected to put the case for such interests as compellingly as possible, but they should not be expected to be able to be objective in weighing them against other interests.

Associated with the automatic, or innocent, bias of the expert is the corollary and even more important question of his credibility in the broadest political context. This centers around the growing concern of the ordinary citizen today that he is being left out of the decision-making process. He may agree that there are many problems of government that are too complicated for him to understand and that he must go for advice to experts, but the worry remains: How can the citizen be sure that the expert understands his real needs, that the decision to which he assents on the expert's advice is the decision he would make himself if he understood the situation? What control does the citizen still have over his government? In a Fabian Tract on the limitations of the expert, Harold J. Laski[76] wrote in 1931:

> The day of the plain man has passed. No criticism of democracy is more fashionable in our time than that which lays emphasis upon his incompetence. This is, we are told, a big and complex world, about which we have to find our way at our peril. Either we must trust the making of fundamental decisions to experts, or there will be a breakdown in the machinery of government.
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> But it is one thing to urge the need for expert consultation at every stage in making policy; it is another thing, and a very different thing, to insist that the expert's judgment must be final. For special knowledge and the highly trained mind produce their own limitations which, in the realm of statesmanship, are of decisive importance. Expertise, it may be argued, sacrifices the insight of common sense to intensity of experience. It breeds an inability to accept new views from the very depth of its preoccupation with its own conclusions. It too often fails to see round its subject. It sees its results out of perspective by making them the centre of relevance to which all other results must be related. Too often, also, it lacks humility; and this breeds in its possessors a failure in proportion which makes them fail to see the obvious which is before their very noses. It has, also, a certain caste-spirit about it, so that experts tend to neglect all evidence which does not come from those who belong to their own ranks. Above all, perhaps, and this most urgently where human problems are concerned, the expert fails to see that every judgment he makes not purely factual in nature brings with it a scheme of values

which has no special validity about it. He tends to confuse the importance of his facts with the importance of what he proposes to do about them.

Government by experts would, however ardent their original zeal for the public welfare, mean after a time government in the interest of experts. . . . Our business, in the years which lie ahead, is clearly to safeguard ourselves against this prospect. We must ceaselessly remember that no body of experts is wise enough, or good enough, to be charged with the destiny of mankind. Just because they are experts, the whole of life is, for them, in constant danger of being sacrificed to a part; and they are saved from disaster only by the need of deference to the plain man's common sense.

Laski quoted approvingly the dictum of a nineteenth century British cabinet officer: "Political heads of departments are necessary to tell the civil service what the public will not stand." He urged this as the statesman's basic task: "He represents, at his best, supreme common sense in relation to expertise."

In President Eisenhower's farewell address, these warnings are heard again. He cautions against proposals for action that are too narrowly conceived: "Crises there will continue to be. In meeting them, whether foreign or domestic, great or small, there is a recurring temptation to feel that some spectacular and costly action could become the miraculous solution to all current difficulties. A huge increase in newer elements of our defense; development of unrealistic programs to cure every ill in agriculture; a dramatic expansion in basic and applied research . . . each proposal must be weighed in the light of a broader consideration." There is the famous warning against the excessive influence of scientific advisers: "in holding scientific research and discovery in respect, as we should, we must also be alert to the . . . danger that public policy could . . . become the captive of a scientific–technological elite." And there is the call for statesmanship to maintain the necessary balance: "It is the task of statesmanship to mold, to balance, and to integrate these and other forces, new and old, within the principles of our democratic system."[77]

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