number of sea-salt particles, both because of sedimentation and removal in rain. Measurements show an order-of-magnitude decrease in the number of large particles as maritime air moves from the Gulf of Mexico to the vicinity of St. Louis, during the summer months. Measurements in Arizona and New Mexico show even smaller chloride concentrations, presumably because of the long overland trajectories required in reaching these areas. The maritime particles lost in overland trajectories apparently are more than replaced by particles of land origin. The latter are usually of mixed composition and are less favorable for the formation of outsized solution droplets.

3) Ice nuclei, required for the formation of ice crystals and for droplet freezing, are rather rare at temperatures higher than about −10°C. This, of course, accounts for the fact that natural clouds undergo extensive undercooling. Because of the scarcity of suitable nuclei, precipitation through the ice phase usually is not found in clouds warmer than about −15° to −20°C. Natural cirrus clouds might provide ice nuclei for precipitation at somewhat higher temperatures, but this possibility has not been extensively studied.

4) Precipitation in tropical clouds invariably first develops through the all-water mechanism; points discussed in paragraphs 1, 2, and 3 above all work toward this end. Tropical clouds which reach to heights above about 25,000 feet also develop precipitation through snow pellets.

The data for mid-latitude clouds are conflicting. Some measurements suggest that summer clouds in the central United States and in the semiarid Southwest develop rain largely through the all-water process; existing theories support such a suggestion. However, flight measurements indicate that there is considerably more ice and snow in the clouds than can be accounted for by present theory; as a consequence, one must be careful in ruling out the ice mechanism in these areas. It appears to me, however, that the ice particles in these clouds are best accounted for through the hypothesis of freezing of drops which have grown to fairly large size through diffusion of vapor. Thus, the ice would be only incidental to the precipitation development.

Winter clouds in the central United States and almost all of the clouds of northern United States and Canada appear to precipitate largely through the ice-crystal mechanism. The relatively cold cloud bases and the continental sources of air masses in these regions appear to retard the warm-rain mechanism to the point where the ice mechanism dominates. But here again, a great deal of research must be completed before a firm conclusion can be drawn (*18*).

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Science and Public Policy

Recent actions by the Federal Government in helping science and technology help the nation are surveyed.

James R. Killian, Jr.

Those of you who planned this joint meeting of Phi Beta Kappa–Sigma Xi had a happy inspiration. You reduced the number of scheduled annual speeches by one—an act of the purest sort of humanism not easily come by—and you exemplified Laertes' observation that "a double blessing is a double grace." By joining forces tonight you doubly bless the theme of this AAAS meeting and endow with grace your proclamation that man and his world are one and that science and humanism are complementary, each dependent upon the other.

You also have placed the speaker you didn't cancel in a position of double responsibility, if not double jeopardy. That I had the temerity to accept your invitation bespeaks my sense of privilege in speaking on this occasion.

To relate my remarks to the theme of this AAAS meeting, I wish to discuss some of the ways in which the affairs of men and the affairs of science interact in the area of public policy-making. This is a subject very much in vogue today. It is a topic of conferences, and universities appropriately are beginning to establish special programs dealing with science and public policy. My approach, however, is not academic; I come to you fresh from the firing line, where I have been engaged day in and day out in marshaling scientific advice for the Federal Government. I report to you on this experience—on the work of the Office of the Special Assistant to the President for Science and Technology and of the President's Science Advisory Committee. Until November a year ago, this office never existed in its present form in the

Dr. Killian is Special Assistant to the President for Science and Technology. This article is adapted from an address delivered 30 Dec. 1958 before the 125th annual meeting of the American Association for the Advancement of Science, in Washington, D.C.

Federal Government, nor had there been, save in wartime, a Science Advisory Committee directly responsible to the President.

Before reporting on these particular activities, however, I wish to list some of the efforts which have been made since Sputnik to strengthen science and to relate it more effectively to policy-making. These efforts have been made in many places—in the Executive Branch, in Congress, in international organizations, and wherever our scientists do their work. They have been directed at multiple objectives: to enhance the excellence of our science, both basic and applied, and to add to our effort, relatively, in basic research; to extend the recognition of science as a creative activity that augments man's dignity and understanding and affords him intellectual adventure of the highest order; to recognize that outstanding accomplishments in science appeal deeply to the hopes and aspirations of men everywhere and contribute to the prestige and good will of nations; to demonstrate that the democratic environment of the free world is the best environment for achievement in science; to improve the ways in which our Government uses and supports science; to apply it more effectively to improve our environment, to strengthen our economy, to improve the health and welfare of our citizens and the peoples of the free world; to promote international understanding and good will; to insure that science and technology contribute their maximum to the defense of the United States and the free world.

I pause to recall these objectives because the campaign in which we are engaged to strengthen science and use it wisely must embrace them all if it is to achieve full success.

And now let me summarize some of the events and some of the efforts made since Sputnik to strengthen our science and its use, especially on the part of the Federal Government.

In two speeches during November a year ago, President Eisenhower called for a many-pronged effort to insure that the best resources of science and scientific manpower be mobilized in support of national security and welfare. He emphasized the importance of strengthening science education and of bringing our over-all scientific and technological effort up to peak performance. As he said later in his State of the Union message, "In both education and research redoubled exertions will be necessary on the part of all Americans if we are to rise to the demands of our times." He called for better exchange and better cooperation among the scientists of the free world. In calling for the most effective possible use of science and technology in behalf of national security he stressed at the same time the vital need for basic research and the contributions which science can make to a better life for all men. Through these messages he heightened public awareness of the need for better science and better science education and he made specific proposals for action.

In the months that followed, these proposals *were* translated into action.

Record of Progress

The program of the National Science Foundation was expanded. The funds available to it were increased from a total appropriation of $50 million in fiscal 1958 to $136 million in fiscal 1959. As a result, the Science Foundation has been able to increase its support of basic research and expand its programs for science-teacher training and other efforts contributing to the quality of science education. The National Science Foundation has really come into its own, and is now one of the Government's major means for advancing science and for supporting basic research.

The Department of Defense Reorganization Act reflected the impact of modern weapons technology and "systems engineering" on military organization, and by providing for the new office of the Director of Research and Engineering, to which a scientist, Herbert York, has just been appointed, stressed the importance of high-level formulation of research and development policy, and supervision of the over-all program of defense research and development. During the year, also, the Department of Defense brought into operation the Advanced Research Projects Agency to sponsor long-range research for defense and to undertake projects of common interest to the military services.

Last spring, upon the recommendation of the Administration, Congress passed legislation creating the National Aeronautics and Space Administration to provide a civilian-directed and civilian-oriented space science and exploration program. The new NASA continues the work of its predecessor, the National Advisory Committee on Aeronautics, and in the same manner as this latter agency, it provides research support for military aeronautics and space programs.

The Act which created the NASA also established the National Aeronautics and Space Council, a body advisory to the President and presided over by him. This council is unique in that its membership includes both government officers and members from outside of government, including civilian scientists. Those who remember the congressional debates over the organizational form of the Atomic Energy Commission and the National Science Foundation will find much of interest in the legislative provisions for the NASA and for this new council.

Altogether the year brought an impressive array of organizational innovations for the management of government programs in science and technology and for the provision of scientific advice at policy-making levels. The NASA, the National Aeronautics and Space Council, the Advanced Research Projects Agency, and the new post of Director of Research and Engineering in Defense, the Science Adviser in the State Department, the Special Assistant to the President for Science and Technology, the reconstituted President's Science Advisory Committee, and the newly authorized Federal Council for Science and Technology, which I shall discuss presently—all these taken together convey the sense of urgency to improve the management and promotion of science by the Federal Government.

In listing these organizational changes it is appropriate to recall the thoughtful comment of Don K. Price that, "in the organization of the government for the support of science we do not need to put all of science into a single agency; on the contrary, we need to see that it is infused into the program of every department and every bureau. We do not need to insulate it from executive authority; on the contrary we shall protect it best from political interference and enable it to be most effective if we give it a direct and effective relationship with the responsible executives, as well as the support of well organized groups of advisers from the leading private institutions of the nation."

Next in the record of the year's accomplishments is the National Defense Education Act. While designed to aid education generally, this act contains important provisions specifically directed at strengthening science education—as, for example, the matching grants it makes available to the states for refurbishing and re-equipping high-school science laboratories.

The State Department reestablished

the Office of Science Adviser and appointed to this office the president of the American Association for the Advancement of Science. It also authorized the appointment again of scientific attachés. About a fortnight ago, announcement was made by the Department of the appointment of seven of these attachés.

NATO has strengthened its organization for promoting the use of science, both by NATO itself and by the member countries. During the year a Science Adviser to the Secretary General of NATO was appointed, and a NATO Science Committee was established. In addition to these NATO actions, the year brought significant increases in the science program of the Organization for European Economic Cooperation.

In many ways the most striking accomplishment of the year was the program of the International Geophysical Year. This has been an unprecedentedly productive and successful international effort. While governments have helped to support the program, it has been carried out by a nongovernmental international organization, the International Congress of Scientific Unions. The success of ICSU in coordinating this worldwide program suggests the pattern for future international programs in science. During the year ICSU established international committees on Oceanographic Research, on Antarctica, and on Space Research.

In addition to the above, there have been other important advances in international cooperation, notably the second Atoms for Peace Conference in Geneva. It was at this conference that the United Kingdom and the United States joined in announcing the declassification of research in the field of fusion. At this same conference the United States staged a superb exhibit that contributed importantly to the dissemination of information about peaceful uses of the atom and, in doing so, greatly enhanced American prestige abroad.

A number of important actions were taken this past year by Congress and the Executive Branch to improve the status of scientific personnel in the service of government.

The President's Committee on Scientists and Engineers completed a successful year in their efforts to improve the utilization of scientists and engineers across the nation, to enlarge our statistical knowledge of the nation's resources in this field, and to strengthen scientific education and counseling.

The House of Representatives established a Standing Committee on Science and Astronautics, thus creating for the first time in Congress a single committee which is concerned broadly with basic science. The Senate also created a new Standing Committee on Astronautics and Space Science, but so far its scope does not encompass the broad range of science. Upon recommendation of the National Science Foundation, Congress also gave authority to government departments and agencies to make grants for scientific research as well as contracts and to vest title to research equipment procured with contract funds with the institution involved.

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In assembling here this record of progress, I do not wish to leave the impression that we have done more than make a start on the great task of realizing the full potential of science in the United States and in the free world. Much remains to be done, but the record makes it clear that we *can* make headway. It also illustrates the multiplicity and variety of the things which must be done to bring our science and technology up to peak performance. It demonstrates that we advance by "steps and not by leaps," to use Macaulay's phrase.

Science Advisory Committee

Let me turn now to another part of the year's record and describe the organization and work of the President's Science Advisory Committee since it was reconstituted at the White House level and since the appointment of the Special Assistant to the President for Science and Technology.

The committee is concerned broadly in making scientific advice and analysis available where they are needed in the formulation of national policy. It is also concerned with the effect of national policies on the nation's scientific and engineering activities.

There has been apparently a misconception abroad that my office and the Science Advisory Committee have operating responsibilities. We do not. We have no operational responsibility, for example, for the development of missiles or satellites. We have, of course, made intensive studies of various aspects of our missile and space programs for the information and use of the President. Neither do we have any responsibility to decide policy. My function and that of the committee is to provide answers to questions raised by the President, to undertake assignments for him of an advisory kind, to mobilize the best scientific advice in the country, and to make recommendations to him in regard to ways by which United States science and technology can be advanced—especially in regard to ways by which they can be advanced by the Federal Government—and recommendations on how they can best serve the nation's security and welfare. This advisory service, the President has indicated, is available also to members of the Cabinet and other officers of Government when they wish it.

One of the principal functions of the Science Advisory Committee is to provide a communications center for science in the Federal Government and thus to facilitate intercommunication among various scientific activities within government and between the civilian scientific community and the Government. It is important to note that the president of the National Academy of Sciences is ex-officio a member of the committee and that the outgoing president of ICSU has also been a member. The director of the National Science Foundation and the Science Adviser of the State Department sit with the committee, and the Director of Research and Engineering of the Department of Defense and the chairman of the Defense Science Board are members. Warren Weaver once observed that "what science needs is not a lot of planning, but a lot of convenient communication, so that controls may arise naturally from feedback." I am sure that I and the members of the Science Advisory Committee share this view.

The 18 members of the committee are representative of those fields of science and technology currently important to the Government. With the exception of certain ex-officio members, the regular members of the committee have limited terms, and thus the membership on the committee rotates. Rotation of members will bring to the committee different points of view and fields of science not hitherto represented. It will also help the committee to avoid ever becoming inbred in its point of view.

In carrying on its work for the President, the Science Advisory Committee is organized into a group of panels which include both regular committee members and other engineers and scientists selected from outside the ranks of the committee. Some of these panels have standing responsibilities; others are called together for *ad hoc* assignments. This panel structure has been a marked characteristic of the work of the committee, and the intensive studies made possible by the individual panels have enabled us to tackle problems which could not be effectively undertaken by the committee itself with its limited membership. The panels are responsible to the Science Advisory Committee, but they draw into our councils a wider range of scientific experience and expert advice than can be provided by a single committee. The committee also serves as a board of consultants to me as Special Assistant to the President. This relationship is highly important. One man should not try to represent science or to provide expert advice in a variety of fields. I draw upon the full range of advice and experience of the Science Advisory Committee and its panels. The committee has the prerogative, when it chooses, to report directly to the President. As special assistant I also have, in addition to the Advisory Committee and its panels, special consultants, task forces, and staff. At the present time the Science Advisory Committee and my office have about 75 scientists and engineers serving part time.

It is important to note that the Special Assistant for Science and Technology is invited to sit in on meetings of the National Security Council and the Cabinet and, when it is appropriate or requested, to present the views and findings of the Science Advisory Committee. The President has thus created a mechanism to bring objective scientific and engineering advice to the top levels of government in a manner that reaches across all agencies and departments and yet can serve each of them.

In creating this new post and in reconstructing the Science Advisory Committee, widening its scope and associating it with the White House, the President has given special recognition to the fact that science and technology, apart from their use in solving specific problems, have a direct and creative impact on the formulation of public policy. The reconstitution of the committee and the establishment of my office have stimulated an extraordinary array of requests within government to make scientific advice available. The problem has been to avoid being overwhelmed by the many requests for advisory services while at the same time trying to respond helpfully and promptly whenever a need exists. The President's Committee has encouraged the strengthening and full use of each department's and agency's own advisory groups.

One of the current concerns of the committee and myself is the difficulty of bringing younger talented scientists and engineers into our own panels and into other types of advisory service to the Government. So many of the scientists and engineers who now serve in advisory capacities are the same ones who held important posts during World War II. Although their wisdom and experience are invaluable, this group is overworked. We have great need for bringing to the service of the Government a new generation, and we need to find methods of doing this which will make their services, skills, and fresh ideas available without handicapping their professional development or curtailing their vital contributions to science. As we widen the net for first-rate talent, we need also to remember that this talent is to be found within the Government as well as outside and that the advisory functions at the top level of government can benefit from groups that represent activities both within and without government.

Work of the Science Advisory Committee

Turning now to the substantive work of the Science Advisory Committee and its panels, let me select the following five examples and report on their work.

First, the panel on space science took the lead last winter and spring in suggesting the elements of a "down-to-earth" program in space science and in providing a basis for proposals which were subsequently made by the Administration on the organization of a space agency. The panel prepared a statement, "Introduction to Outer Space," for purposes of public information, and this was issued by the President as a formal paper published under the imprint of the White House. This statement has had circulation running into many millions. It has had value, too, in helping the American people share, through understanding, in one of the great adventures of our time. It has also helped, I hope, in distinguishing between what is authentic and sound in space planning and what is fantasy.

Second, the panel on scientific information (the report of which was made public several weeks ago) addressed itself to the problem of how best the rapidly growing volume of foreign and domestic scientific and technical information can be mobilized to meet the critical needs of our scientists and engineers in furthering new research and of how the Federal Government should organize to assist in this mobilization.

I hardly need to point out the problems which arise from the growing volume of scientific publications. Currently there are some 55,000 journals containing articles of significance for some branch of research or engineering in the physical or life sentences. More than 60,000 books are published annually in these fields, while approximately 100,000 research reports remain outside the normal channels of publication and cataloging. The problem is further complicated by the fact that a large and important proportion of the world's scientific literature appears in languages unknown to the majority of American scientists—languages such as Russian and Japanese. Russian-language publications now account for a tenth or more of the scientific literature published in the world. A recent UNESCO report concluded that about 0.1 percent of American scientists and engineers read the Russian language, while approximately 50 percent of Russian scientists and engineers read English. We must now anticipate a growing volume of scientific and technical publication in Communist China, and this will place new requirements on our translating services.

The solution proposed by the panel was based upon the conviction that we should not follow the Soviet pattern of establishing a centralized information center but should seek instead to coordinate the many very excellent programs we already have in this field, among both government agencies and private institutions.

In the course of the panel's review of

the problem, there developed a widespread consensus, not only among the members of the panel but among many representatives of the different agencies of government and of nongovernment institutions, as to what the proper solution would be. As a consequence, much of what the panel finally recommended had already been widely accepted within and without government. This consensus reflected itself in the action of Congress in including Title 9 of the National Defense Education Act, directing the National Science Foundation to establish a Science Information Service. The panel, with the endorsement of the Science Advisory Committee, therefore, recommended to the President that the National Science Foundation expand its information activities to provide a coordinating center for the information services of the Federal Government and appropriate assistance to private information agencies. The President accepted the recommendations of the panel and directed that the National Science Foundation take the leadership in bringing about effective coordination of the various scientific information activities within the Federal Government.

Third, the Science Advisory Committee's panel on research policy has just published a report entitled, "Strengthening American Science," which deals with the role of the Federal Government in research and development. The President has directed that an executive order be prepared to carry out the recommendation of the report that a Federal Council for Science and Technology be established to advise the Cabinet on those aspects of the Government's program which require interdepartmental and Government-wide coordination and policy-making and which affect science as a whole. Membership on the council will include representatives of the departments and agencies which have substantial research activities, these representatives to be drawn from the policy-making levels of these departments and agencies. The council, made up of government officers, can call for advice from the President's Science Advisory Committee, which draws its members largely from the nation's scientific and engineering community outside of government.

While searching for ways to improve public management where it relates to science, the report devotes attention to the nurturing of important new scientific fields and the strengthening of those which are assuming new importance. Meteorology is one example of a field where additional capital funds and emphasis are necessary. Geology, geophysics, oceanography, materials research, radio-astronomy, studies of the upper atmosphere, and combustion are other examples of fields where augmented support and effort are clearly needed.

Government operations increasingly have brought growing demands for the fruits of research and more support for actual work performed. There has been no comparable provision, however, for new instruments and facilities, except in certain specialized fields. Capital deficiencies, moreover, are being further aggravated by the rapid progress occurring in the improvement and invention of the instruments of science themselves.

The panel urges the formulation of thoughtfully conceived policies for the financing and planning of the great multi-million-dollar research instruments of modern science, such as particle accelerators for nuclear physics, and of centralized research institutes which are needed or proposed in various fields. We are at a point where we need to bring together the best available judgment from the domains of government, education, and science to determine how far we should go in the establishment of research institutes and what their relations should be with the universities. Unsound planning might result in weakening the universities and, by drawing away from them too many research scholars, in reducing their capacity to nurture new scholars.

The importance of the role of private support in the nation's total scientific effort is emphasized. Private foundations are uniquely qualified to provide venture capital, to "grub-stake" new ideas, and to "support men as well as projects."

The growth of federal support of science in recent years has been marked by some hesitancy on the part of private sources of funds to maintain the level of their contributions to academic and other nonprofit institutions. It would be most unfortunate if this hesitancy were to continue or spread, for there are growing opportunities for private philanthropy to contribute to the strength and freedom of American science. It is vitally important, therefore, that government science policy should not discourage private support of science but, indeed, should take pains to encourage more of it.

In making public recently the report of the Science Advisory Committee, the President called particular attention to its conclusion that the task of further strengthening United States science is so broad that government, industry, universities, foundations, and individuals all have vital roles to play. The future growth of American science will depend upon increased participation and contributions by all of these types of institutions if we are to be equal to the full range of opportunities which lie ahead.

Fourth, we have a very active panel on science and technology in foreign affairs. It is a source of advice on the role of science and technology in supporting our foreign-policy objectives. It seeks to assist government departments and agencies in using science and engineering effectively in our foreign programs and in furthering international cooperation in science and technology.

The interaction between science and foreign affairs is similar to that between science and public policy in general—that is, there are two clear areas of emphasis. One is the impact of scientific progress or scientific activities on foreign policy, on aid to underdeveloped countries, on our military alliances; the other is the requirement placed on our international policies to further and encourage scientific development by creating the necessary climate for effective interchange of ideas and international scientific cooperation.

The panel on science and foreign affairs has been concerned with both aspects of this interaction, as has the President's Science Advisory Committee as a whole. One of the first concerns of the panel was to respond to a request from the State Department to help re-establish the post of Science Adviser in the State Department and to aid in the reestablishment of the Science Attaché program at overseas posts.

The Lacy-Zaroubin agreement negotiated with the U.S.S.R. includes provision for exchange of scientists between the United States and the U.S.S.R. The State Department Science Adviser and the president of the National Academy of Sciences, who is also chairman of our panel, visited Moscow in the fall of 1958 to establish the details of the exchange agreement between the respective academies of science which will bear the major responsibility for the exchange of scientists.

It is well to point out here the close collaboration that takes place continuously between the panel and the National Academy of Sciences. One of the best examples of this collaboration, and of the general activities of the panel, is the consideration which has been given, at the invitation of the International Cooperation Administration, to ways in which our scientific resources can be better employed in the planning and operations of the United States technical aid programs. The panel studied this question in some detail, consulting with representatives of ICA and other interested agencies. As a result of this, the ICA has sponsored a National Academy of Sciences' study of a particular area; Africa south of the Sahara was selected. This study is now being performed by a full-time staff under the auspices of a special Academy committee.

In summary, the activities of the panel on science and foreign affairs have ranged over the entire broad field of the impact of science on United States foreign affairs and the furthering of international scientific cooperation and exchange. All that has been considered or influenced by the panel cannot be recounted briefly, but it is well to point out that one of the major aids in the work of the panel is the representation on it of those whose regular responsibilities include the day-to-day integration of science and foreign affairs—for example, the president of the National Academy and its foreign secretary, the present and the past Science Adviser in the Department of State, the director of the National Science Foundation, the United States representative on the NATO Science Committee, a past president of ICSU, and a vice president of the ICSU Special Committee on Space Research.

Scientists and engineers have special advantages and opportunities to assist in achieving international cooperation and agreement. The concepts of laws of science cross all national and ideological boundaries. It is the one language understood the world around. It is a means to common understanding and joint action.

In the unrelenting competition which faces the entire free world, nothing less than the full and efficient use of the free world's scientific resources will provide the strength it needs. The full development of science and technology by the free world is essential to its economic and military strength and thus to its political and cultural stability and advance. This is why the achievement of better exchange and cooperation is so important.

Fifth, the panel on science and engineering education is now completing a study aimed at clarifying and highlighting objectives and needs of that part of our educational system which has the responsibility for preparing adequate numbers of first-rate scientists and engineers and for achieving a high degree of scientific literacy in the United States.

The panel feels deeply that some of the major challenges which face the nation today are on the intellectual front. A greater desire to learn and an increased respect for learning—for intellectual excellence—may now in the long run be essential to national survival; consequently, we need a greater devotion to learning, a greater pride in intellectual achievement, a greater determination to achieve excellence in American life. In any educational enterprise or discussion of education we need constantly to be asking ourselves what we must do to obtain these objectives.

The panel's discussions on science education foreshadow some of the following more specific conclusions.

1) We have not yet faced up adequately to the fact that in the immediate years ahead the rising number of students will outrun the supply of college teachers. While estimates are difficult to make, it is not far off the mark to predict that the number of Ph.D.'s graduating from our universities who are qualified or who elect to go into college teaching will be less than a third of the number of college teachers that will be needed. We must, therefore, find new ways to increase the effectiveness of each teacher we now have. We must increase the time he has available for actual teaching, and we must extend the result of his efforts to more students. We must make better and wider use of every effective teaching aid, and we must invent new ones. There are still unrealized possibilities for bringing the great teacher into effective contact with greatly increased numbers of students.

2) We need to give more national attention to the quality and content of courses and curricula in science, both in high schools and colleges. We need extensive, organized, national efforts to bring together in each subject field the leading scientists and scholars with groups of high-school and college teachers, for re-examining and modernizing the content of courses in the sciences. We need to bring about the preparation of better and more modern textbooks and to find ways of making available better but less expensive laboratory equipment. Taking the country as a whole, there seems to have been a serious decline in the quality of laboratory teaching in recent years. In too many places it has become routine, overmechanized, and sterile.

This combination of requirements calling for bold and large-scale efforts to enable our teachers to teach better and to modernize and improve our curricula in science is pressing upon us now. Our colleges and universities have a very grave responsibility to help, as they have never done before, in meeting these needs. Especially does it seem to be incumbent upon the administrative heads of our institutions of higher learning to give support and encouragement to faculties in assuming the responsibility of planning new courses and course material, both for high school and college, which is in line with the most modern scholarly research and the most modern insights into the science being taught.

3) The nation's responsibilities and opportunities in science have grown to the point where we find ourselves today, in the judgment of the panel, with too few first-quality institutions of higher education in science and engineering. We need more of the same quality as the best we now have. Particularly do we need more top-flight graduate schools. Of the 700 colleges and universities in the United States which offer graduate degrees, something less than 300 offer graduate degrees in scientific, medical, and engineering subjects, and not enough of these can claim real distinction in any one scientific field. The few top-quality departments are in danger of becoming overloaded, and the peak in graduate enrollment is still several years off. It is especially important that we build more first-rate graduate schools of engineering and that they be developed in close association with excellent departments of science.

In the fall of 1958 there was a significant drop in the number of students entering engineering schools. This is serious, and it comes at a time when we must enroll more able students in engineering, not fewer. There is some evidence that students are shifting into the sciences, and so they are not lost to the broad fields of science and technology. But we need to try to find all the reasons why this reduction in enrollment has occurred, so that we may take measures to counter it and guarantee our future supply of outstanding engineers.

These five examples of the panel activities of the President's Science Advisory Committee, as you will note, fall outside of the defense area and bear testimony that the committee is deeply concerned with civilian science and technology and with the strength of science apart from any applications. At the same time, the committee and my office are working hard on various problems important to defense. This will continue.

Controversy and Collaboration

We have also had to deal with the difficult problem of making technical evaluations in projects or programs on which there has been a history of technical controversy, or of differing interpretations of the technical facts by informed laymen. In dealing with these controversial problems, we have sought to recruit the most competent advisers available and to let them study these problems in an atmosphere as free as possible from past commitments or from personal or departmental positions. We have recognized that there are certain kinds of technical questions to which scientists and engineers of equivalent objectivity, competence, and complete integrity will respond differently. Here we have sought to state the facts and to list the possible alternative interpretations. It is important, as science gets involved more and more in controversial policy decisions, that the public should understand that scientific method and analysis do not always yield a single, mathematically exact, incontrovertible answer. It will help the relation of science to policy-making to have it recognized that the scientist, however objective, must sometimes be limited to dusty answers when policy-makers understandably are "hot for certainty." There are, of course, many questions, too, on which they can give positive and exact answers, the correctness of which can be demonstrated.

We have also given much thought to the problem of how the scientist and engineer may most effectively participate with military and political personnel in analyzing policy questions which must have the benefit of the joint thinking and professional competence of all these groups. The scientist and engineer have much to learn about their role under circumstances of this kind, but there have been recently heartening demonstrations of effective political-military-technical teamwork in support of the formulation of policy.

In any discussion of science and policy, we must recognize that these two areas —(i) the problem of dealing with evaluations and analyses with respect to technical matters in controversy and (ii) the way in which the scientist and engineer play their part in studies and conferences requiring joint political, military, and technical approaches—call for the objective and creative attention of all three groups and afford the scientist and engineer a new and important kind of collaborative effort that symbolizes their widened role in the area of public policy.

In this summary report covering the work of the past year that has been directed toward strengthening our national science program and improving the relationship between science and policy, I must end by reiterating that we have much yet to accomplish. There is clearly now a national will to be strong in science, but much remains to be done. If the United States is to use to their fullest all its resources in science and technology, we must not slacken our efforts to provide the conditions and the climate which will promote peak performance.

And now may I conclude with four observations which seem to me to be important to any program designed for underwriting the strength of our science and technology.

The Factor of Excellence

First, the quality of our science and our science education cannot be separated out from the quality of our intellectual life generally. What we are concerned with basically is the importance which the American people give to the factor of excellence in our society. It is basically important that we achieve a greater respect for learning, a greater pride in intellectual achievement, a willingness to assign education a higher place in our national list of priorities. This requires that we be willing to increase our investment in men as well as our investments in material resources. In considering the effect of American attitudes and values on science and education, one cannot fail to ask whether we Americans, in our drive to make and acquire things, have not been giving too little attention to developing men and ideas. If we are to maintain leadership in this century of science, we must be sure that we devote an adequate amount of our energy and resources to the cultivation of talent and quality and intellectual accomplishment. These qualities are important to our national strength in all fields, and they are vital to our strength in science.

Should we not seek so to order our society that it will someday be said of Americans, as it has been said of the ancient Greeks, that they were a people of "fine quality living in conditions which habituated them to high spiritual, mental, and physical endeavor"?

Our Tradition of Progress

My next observation relates to the motivations in our society which give vigor to our science and technology and which are important to our continuing strength. So far we have demonstrated a sustained eagerness to find better ways of doing things. We have forged ahead because we wanted things to change. We have wanted to look forward and not backward. The revolution of modern man—the revolution which has found its fullest expression here in the United States—lies essentially in this. It is a revolt against things as they are when there are ways of doing things better. It is a revolution based upon determination rather than determinism. It is a revolution against all the forces which hinder man in building a better life. Science has had a major part to play in shaping this basic American faith in creative change and improvement.

The course of our nation has been deeply affected by the tenet, very early embraced, that nature could be put to work for the benefit of man and that it is possible to wrest from nature a range of benefits to meet the needs of our people—that science and technology provide a means to advance the welfare of our people and that this has been a better way to progress than through radical social change or ideological nostrums.

I do not suggest that we have any warranty, expressed or implied, that progress is inevitable or immutable; I only describe the deep-rooted American belief that progress is an achievable and worthy goal. I reflect my own intuitive belief that man has the capacity greatly to improve himself and his society.

Today we hear voices of doubt and pessimism, decrying or questioning the concept of progress. The increased currency of such phrases as the "illusion of progress" and the "corrosive effect of materialism" reflect an array of attitudes challenging the power of reason and the actuality of progress. Technology and science are attacked as contributing only to the convenience and comfort of life and not to its quality. In mentioning this attitude of doubt and pessimism, it is not my purpose to debate the philosophical considerations on which they rest. My purpose is to express my contrasting faith that we can continue to draw the blueprints of a still greater society and that we can direct our advancing technology toward the realization of those plans. My purpose is to stress the importance of those aspects of science which enhance the quality of our society, which encourage individuality in the midst of standardization, which enhance man's excellence and dignity as well as his productivity. We must direct and expand our technology to serve man's highest capabilities, in addition to his safety and material comfort.

If research is to continue to flourish, these traditional American beliefs in the validity of progress become increasingly important. They are the wellsprings of that zest and audacity which have characterized our research and our economy in the past and, God willing, will continue to characterize them in the future.

National Responsibility

My third observation has to do with the great responsibility which rests upon science today in the light of the extraordinary opportunities to participate in the formulation of national policy which it has been given. The growing linkage of science and technology with government demands of science a new order of poise, steadiness, and statesmanship. It demands of scientists who serve in advisory capacities a deep understanding of the role and the limitation of the adviser.

The current emphasis on science, if it is not to cause reactions adverse to science, also requires of the scientific community humility and a sense of proportion. It requires of scientists a recognition that science is but one of the great disciplines vital to our society and worthy of first-rate minds—a recognition that science is a partner, sharing and shouldering equally the responsibilities which vest in the great array of professions which provide the intellectual and cultural strength of our society.

Science and Human Values

Fourth and finally, I recall the remarks which I made in giving the Sigma Xi address at the AAAS meeting three years ago. I emphasized then, as I do again, that if American science is to continue to prosper, if it is to attract to it its proper complement of creative and gifted minds, we must combat the notions that science and engineering are incompatible with the great humanities, and that they are narrowly materialistic and destructive of human values. In the face of the practical responsibilities which rest in science and engineering for our security and our material welfare, it is all too easy for people to conclude that science is inimical to the spiritual ends of life and for them to fail to understand that in reality it is one of man's most powerful and noble means for searching out truth and for augmenting man's dignity by augmenting his understanding. Scientists have an obligation to make this true character of science better understood, not by an arrogant advocacy of science and technology as the only objective means to increase our understanding and well-being, but by the balanced and tolerant practice and presentation of science as one of the powerful means by which man can increase his knowledge and understanding and still remain humble and ennobled before the wonder and the majesty of what he does not understand. When thus perceived and practiced, and when not misused for ignoble ends, science and engineering are major means for "making gentle the life of mankind." When so practiced and used, they become one of the great humanistic forces of our time.

News of Science

AAAS Council Resolutions

The Council of the AAAS passed the following resolutions on 30 December 1958, when it met in Washington, D.C., during the Association's annual meeting, 26–31 December.

Resolution on Parliament of Science. The Council commends the Board and the special committee which arranged the stimulating Parliament of Science in Washington in March, 1958, pursuant to the Council's resolution in 1957, and notes with gratification that plans for further symposia are already well advanced.

Resolution on Committees on the Social Aspects of Science. The Council commends the accomplishments of the ad hoc committees on the Social Aspects of Science. They have had significant and beneficial effects on the understanding by scientists and by the public of the inescapable problems of adapting society to the age of science.

The Council has approved the Board's proposals to create standing committees to continue work in this area and will take special interest in their activities.

In order that the Council members and the affiliated societies may be kept fully informed of the thinking of these committees, as well as of formal Board actions resulting from their recommendations, the Council requests that the President arrange for the circulation to Council members of the special report of the Committee on the Social Aspects of Science issued after their June, 1958, meeting and of future reports of the three standing committees.

Resolution on International Scientific Programs. The success of the International Geophysical Year in correlating and integrating international scientific resources and extending the areas of cooperation and communication in science stands as a challenge to all other areas of scientific and cultural endeavor. This magnificent international effort is a fitting prelude to the "space age." The time is now ripe for world-wide attacks on other major problems.

The Council of the American Association for the Advancement of Science urges its affiliated societies, the Board of Directors, and appropriate committees to participate fully in appropriate international programs, for example, in such areas as the health sciences, outer space exploration, population problems, and social consequences of science.

Resolution on Dissemination of Council Resolutions. The Council requests the President to send duplicate copies of resolutions passed at this meeting to each