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FOREIGN NUCLEAR POWER PLANS

European and American researchers have entered into an agreement to pool efforts in developing a breeder reactor, one that produces more nuclear fuel than it consumes. In the 20-year history of reactor development, marked more by nationalistic competition than international cooperation, the arrangement for trans-Atlantic cooperation is unusual. Joining in the project are 17 private utilities in the Midwest and Southwest, the General Electric Company, the Atomic Energy Commission, West Germany's Karlsruhe Research Center and the six-nation European Atomic Energy Community (Euratom).

The groups will join in building and operating an experimental fast breeder reactor near Fayetteville, Ark., in the Ozarks. The contract calls for an outlay of about $25 million, of which the AEC agrees to pay up to $12.7 million in research and development assistance. The significance of the project is likely to prove more political than technical in establishing a pattern for international cooperation. The Commission and Euratom have cooperated in reactor research but the new program marks the first direct financial participation of a European group in a reactor project in the U.S. Euratom already has entered into an arrangement for pooling fast-breeder research among its six member nations—Belgium, France, Italy, Luxembourg, the Netherlands and West Germany. (NY Times, 5/15).

U.S.-EURATOM TO EXCHANGE BREEDER INFORMATION

In the near future, Euratom and the U.S. are expected to sign a long-delayed agreement for exchange of research results and personnel in the fast-breeder reactor field. The agreement also provides for the U.S. to sell Euratom a large quantity of plutonium and to lease to the six-member agency all the uranium it will require for its breeder reactor program over the next four years. Experimental breeder reactors already are operating in the U.S., in Britain and on the continent, and more are being built. Britain, which is not a member of Euratom, is dickering with the U.S. and Euratom to arrive at some sort of breeder information exchange program too. Politically, the accord between the U.S. and Euratom is viewed by some as a symbol of unity within the Atlantic Alliance, with some significance being attached to the fact that the French, who in the past have been critical of Euratom-U.S. relations, have not opposed the breeder reactor accord. However, the French plan to announce soon a major civilian nuclear power program involving construction of five large power stations, each of which will utilize a French-developed, natural uranium, gas-cooled system. The French have been trying—without success—to sell their brand of reactor to other nations, and recently chided Euratom for following the U.S. lead and failing to develop a strictly European nuclear technology. (W. Post, 5/7 & 5/11).

BRITISH PLAN EXPANSION

The British government announced last month that it plans to double its civilian nuclear power effort during the next decade. The program calls for construction of four new power stations, of a type or types not yet decided. In recent months, General Electric and Westinghouse have been making attractive commercial offers to sell the British large water-cooled reactor stations, which would be cheaper than Britain's own gas-cooled type. British officials have said that if the American reactors are chosen and built under license, no more than 15 per cent of the components will be imported from the U.S. The best guess of officials is that the new British power stations will be a mixture of American and British types. Under its present nuclear power program, British power stations expect to generate 2000 megawatts by August; the new ten-year plan is expected to provide a

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SCIENCE AND THE GENERAL WELFARE IN A DEMOCRACY

(Dr. Glenn T. Seaborg, Chairman of the Atomic Energy Commission, delivered the Harrelson Lecture, as titled above, at North Carolina State College, Raleigh, N. C., last March 11. Most of the lecture is reprinted here.)

It is the Third Revolution of Science that concerns us today as in earlier days the Democratic Revolution called into service the architects of our national political institutions and as the Industrial Revolution engaged the best talents and energies of those who fashioned the great industrial system of America during the last century. With the advent of the Third Revolution, science has become so important to our national welfare, not only in terms of national defense but also for our economic growth and social well-being, that the relationship between science and government is for us in our day a matter of profound significance.

There was the foreshadowing of such a relationship as early as the Civil War, and a yet stronger indication during the first World War. No one, however, could fail to see at the conclusion of World War II that the contributions of science had been fundamental to national survival in our greatest crisis. Later, the shifting of alignments and the prolongation of latent hostilities in the shape of the Cold War meant that the Federal Government had perforce to become more and more heavily involved in the support of science. These factors account for much of the Government's continued role in setting national objectives in science and influencing progress toward these objectives.

But as we responded to the persisting demands of the Cold War and the needs of national security, we awakened also to a more significant realization. We found that we could not abandon the productive fusion of forces that emerged during the war years. We discovered that the powerful focusing of basic and applied science, engineering development, and industrial production which accomplished so much for us in wartime had equally profound implications for our peacetime future. The advancement of peaceful national goals, for example, economic expansion, the improvement of health, the development of adequate energy resources and assistance to other nations—all these were recognized to rest upon a continuation of the machinery of concerted scientific-technological efforts. . . .

As a general condition applicable more or less across the board, we should note first the factor of *amplification.* In every phase of modern technology, the potentiality for phenomenal degrees of amplification forces us to consider the whole planet and even its surrounding regions in space as a closely coupled system. On the terrestrial level, a devastating flood or earthquake in the remotest region of the globe can almost instantly, through modern means of communication and transportation, marshal the enormous resources of our own and other technologically advanced nations to assist the beleaguered inhabitants of that region. The effects of a drought in some part of the world resonate throughout the economies of the major grain-producing nations with an almost imperceptible time-lag. In the reaches of outer space, a scientific experiment by one nation becomes the concern of the international community of scientists even before it can be performed. Today in the strictest sense of their truth we can quote John Donne's words that "no man is an island unto himself." Certainly with the increasing unity of world science, no nation of great power can shape the future of its own scientific and technological development without profoundly affecting also the future of all mankind. . . .

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HOUSE COMMITTEE HEARINGS ON GOVERNMENT-SPONSORED RESEARCH

The Daddario Committee, or, more properly, the Subcommittee on Science, Research, and Development of the House Science and Astronautics Committee, has held hearings during the past month on "two of the more vexing problems currently associated with Federal sponsorship of scientfiic research and development": (1) geographical distribution of Federal funds for research and development, (2) indirect costs allowed on Federal grants for basic research. Witnesses have included: William J. Armstrong, Bureau of the Budget; Lee A. DuBridge, president, California Institute of Technology; Kingman Brewster, Jr., president, Yale University; Lt. Gen. William J. Ely, Department of Defense; Leland J. Haworth, director, National Science Foundation; George B. Kistiakowsky, Harvard University; Herbert E. Longenecker, president, Tulane University; Donald F. Hornig, director, Office of Science and Technology; Gerald F. Tape, commissioner, Atomic Energy Commission.

Generally, witnesses have felt (a) that the government should pay, but is not now paying, the full cost of research for which it makes grants and (b) that despite the difficulties and dangers inherent in the task, programs to develop additional excellent centers of science should be pushed. Hearings are continuing.

The Daddario Committee has also appointed a Research Management Advisory Panel "which will act as a special task group for the committee in pointing the way to improve research management." Michael Michaelis will serve as the Panel's executive director.

The National Science Foundation has agreed to conduct a study on science education in the United States for the committee. Also the National Academy of Sciences will conduct several special studies for the committee, the first of which, according to a progress report: "will involve determining the level of Federal support of basic scientific research necessary to maintain the nation in a posture of leadership in the following areas: (a) technological accomplishment; (b) economic development; and (c) national security. The study will also endeavor to identify the important phases of scientific research which are being inadequately pursued and determine whether present imbalances of money and manpower are to blame."

Two reports have already been released by the subcommittee. The first dealt with the subcommittee's purposes and described a number of social issues raised by increased technology. The second reviewed trends in Federal spending on research and development since World War II. A third report now being prepared will discuss ways in which Congress can become better informed on science.

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The FAS, founded in 1946, is a national organization of scientists and engineers concerned with the impact of science on national and world affairs.

NEWS FROM ORGANIZATIONS

Society for Social Responsibility in Science

The SSRS is holding a resident Institute on "The Scientist's Role in Peace" June 30-July 5, at Fellowship House Farm (near Philadelphia, Pa.). This informal conference is planned especially for scientists, engineers, and students who wish to explore "peaceful and constructive outlets for their abilities," and will cover questions concerning "war and peace" choices and the response of scientists. (Further information: Prof. William C. Davidon, Dept. of Physics, Haverford College, Haverford, Pa.)

Council for a Livable World

A recent report reviewed Council activities to publicize issues of war and peace and to exert pressure on Congress and the Administration. The Council has been preparing, or reprinting, a series of position and background papers, on defense issues and broader questions of foreign policy, the role of scientists etc. The Council is sponsoring public talks by several Senators; a program of seminars for Senators has been "highly successful." Plans for the immediate future stress: issues concerning a NATO multilateral force, increasing East-West trade, and further arms control steps. (May 1964 Council memorandum.)

Scientists' Institute for Public Information

SIPI aims to provide the general public with the scientific information needed for responsible judgment on public issues. At present, it will emphasize problems of environmental conservation—radiation, air and water pollution, pesticides, etc. Other problems under consideration include population control and consequences of automatic production methods. SIPI was established in April, 1963; its Chairman is Dr. Edward L. Tatum, a Nobel Prize-winning geneticist. (First issue of SIPI Newsletter, 30 E. 68 St., N.Y.C.)

Society for Psychological Study of Social Issues

SPSSI's Subcommittee on Problems of Peace and War is sponsoring a $1,000 prize for "the best essay on a researchable problem relating to a specific threat to peace likely to arise during approximately the next two decades." Criteria for the essays emphasize systematic treatment of social-psychological aspects of a specific problem. Deadline for essays is January 1, 1965; "suggested length" up to 50 pages. (Further information: SPSSI, Box 1248, Ann Arbor, Mich.)

FOREIGN NUCLEAR POWER (continued)

total of 10,000 megawatts eventually. In the U.S., the AEC reported in January that the electrical generating capacity of this country's nuclear power stations exceeds 1000 megawatts. The chief difference between the civilian power programs of the two countries is that Britain decided ten years ago to build a single type of reactor whereas the AEC pursued a shotgun research and development program to experiment with a variety of reactors. This still is the essential difference between the two efforts (W. Post, 4/16).

OTHER COUNTRIES WANT POWER REACTORS

Both Rumania and Yugoslavia have put out feelers to the U.S. about buying nuclear power plants. Rumania is interested in obtaining two 500-600 megawatt plants, a size larger than any now even under construction in the U.S. Yugoslavia, it was reported, also is considering two plants, one about 200 megawatts and the other an experimental pilot type which would involve U.S. cooperation in its research and development. Three members of the Yugoslav Federal Nuclear Energy Commission currently are touring the U.S. on U.S. leader grants. The AEC reported that the U.S. has "ample" supplies of the U-235 fuel necessary for such plants and, with Congressional approval, is prepared to make this available under the inspection safeguards of the International Atomic Energy Agency.

The United States recently agreed to provide India with a $88 million, long-term, low-interest loan to build a 380-megawatt nuclear power plant at Tarapur, near Bombay. General Electric has recently signed a contract with the Indian Government to build this station, one of the world's largest. Now Pakistan has begun negotiations for U.S. assistance on a similar reactor of 100 megawatts. Also, Spain, Japan and Sweden have put out feelers recently about the possibility of obtaining U.S.-designed nuclear power plants (W. Post, 5/17 & 5/26).

U.S.-Israeli talks are pursuing President Johnson's February offer to cooperate with Israel in using nuclear power to help solve the Middle East's chronic water shortage. A possible obstacle may be Israel's reluctance to accept international controls over atomic aid from the U.S. (N.Y. Times, 2/8, 4/19, 6/7).

SEABORG: SCIENCE AND THE GENERAL WELFARE (continued)

Not only do we have these tremendous new [nuclear] energy resources well on their way to successful exploitation, we are also rapidly mastering the revolutionary technology of high-speed computers and automation. Amplification is very much in evidence in this field: unprecedented amplification of the rate of production and equally unprecedented amplification of our thought processes, leading to the solution of problems of remarkable scope and complexity. The potential effects of this technology are of such significance that we must restudy, and perhaps may have to reshape, what we had thought were unchanging economic concepts and principles.

Equally profound changes have taken place in the life sciences, especially in their relationships to physics and biochemistry. The possibilities of transforming microorganisms, plants and animals in such a manner as to improve our ecological and economic situations are so nearly infinite as to dwarf description. There are millions of species, and the routes of artificial evolution through which any one of them may be educed into new forms are diverse, ever-branching and virtually endless. We may expect that inevitably our recently acquired knowledge of the genetic code will be applied also to the improvement of the human species which Julian Huxley said recently so badly needs to be done. He says that our species is deteriorating "thanks to the keeping alive of genetic defectives . . . and thanks to new mutation-causing agents." But once we have the ability to determine the genetic characteristics of a human infant, who will step forward with sufficient wisdom to choose those traits most beneficial to the man of the future?

These possibilities, together with the urgent problems of an exploding world population, force us to consider the fundamental question—what are people for? We will need to answer this question at the same time that we are struggling with the multitude of other problems brought about by the population explosion. Science must play the key role in the solution of these problems. We may expect, for example, that our present farm surpluses will soon disappear and we shall require all the skill of our soil scientists, agronomists and agricultural experts to raise productivity to the required levels. These difficulties are sure to be further increased by the withdrawal of appreciable acreages of our best farm lands from cultivation to be used for urban developments, freeways, military installations, factories, etc. New methods of food processing and means to reduce waste and spoilage will have to be devised so that we may more completely utilize our plant and animal crops. Our diminishing reserves of forests and minerals will force the adoption of adequate conservation policies, and the development of substitute materials will assume a new urgency. We shall find ourselves increasingly dependent on the desalting of sea water to fill urban reservoirs. The congestion of our cities will intensify present problems and create new ones in transportation, utilities, water supply, waste disposal, public health and recreation, mental health and the entire range of social behavior.

NEW ANSWERS AND NEW PROBLEMS

Fortunately we have the potent instrumentality of the new techniques in automation to help us with the solution of many of these problems. Not only does this new computer-based technology provide the means of tremendously increasing production but it also will enable us to operate the systems of great complexity which we will need for the simultaneous control and harmonizing of the many factors affecting our expanding urban civilization. The extremely great capability of the new computer technology brings with it, however, the threat of major social and economic distortions. One free-wheeling mathematician believes that the rise of automation will propel us into an entirely novel kind of world where 2% of our population, working in factory and on farm, will produce all the goods and food that the other 98% can possibly consume. Faced with this overabundance of leisure, an economist predicts that we may have to keep the unemployed portion of our population under more or less constant sedation unless we can figure out something better for them to do.

Sedation as an answer may already be old hat because of the startling development of new chemotherapeutic drugs which upon further development hold promise for the alleviation of mental suffering and perhaps also for the beneficial readjustment of personality and our more transient moods. We would hope that, valuable as these drugs may prove themselves to be, their use on any extensive scale will be no more than a passing phase in our history, giving way in due time to a finer adjustment in the relations between the individual and society. It is possible that by the combined attack of improved human genetics and the development of more sophisticated social sciences and psychology we may someday be able to empty our medicine cabinets. However this may be, we can imagine the grave political consequences, even apart from war, should these psychotherapeutic drugs be used as psychochemical weapons for coercion and control. Since self-control is essential for non-violent resistance, peaceful Gandhian methods could be rendered ineffectual by mood-altering drugs; in such a nightmare existence, brainwashing might become a specialty of chemists.

We need not accept the probability of such extreme predictions concerning our future to realize that by the most conservative estimates profound social and economic changes are in progress through the impact of science. There can be no doubt that the kinds of jobs people will be doing in the future will be very different from those being performed by the majority of us today. Indeed there has already been a great increase in the number of jobs based on providing services and recreation—a trend that is certain to be magnified with further increases in national productivity and the accompanying increase of leisure time.

The most remarkable testimony to the unsinkable buoyancy and optimism of mankind is that over the centuries with possibilities and problems of this magnitude facing him, man has nevertheless begun to feel restless within the confines of his local planet and has sent spacecraft with their human cargo beyond the atmosphere. We have now mustered and coordinated the massive resources of our whole technology in an effort to reach our moon and ultimately the neighboring planets of our solar system. The horizons of human vision have shifted from a horizontal to a vertical orientation. More and more often as we think of the future, our gaze turns toward the immense regions of outer space.

IS SCIENCE ORGANIZED?

Against this background of the impact of science on our future perhaps we are ready now to consider the question—how well are we equipped as a nation to enter upon this new age of Science, the Third Revolution? There is at this point, I think, no question but that we must face the problems of our time and must assume the responsibilities that our new knowledge and technology are forcing upon us ever more urgently. Before we become too scholarly about the question, however, I must say that some have managed to look at the lighter side of our situation. A few of the more irreverent individuals, scientists I suspect, have compared our management of science policy in recent years to a ship with a thousand helms all connected to one rudder with rubber bands. Another of these whimsical images would have Federal science and its leaders as a colony of ants riding a rolling, tossing log down a flooded stream. As each new twist of the log brings a different bunch of ants out of the water and on top of the log, the ants then able to see daylight proclaim to the others that they have the situation well in hand and know exactly which way to steer the vehicle.

As to where we presently stand with respect to a national policy toward science, there is no better way of gaining a perspective than to review briefly the genesis of science in our government. The growth of our national policy affecting science and our programs for furthering this policy have been the resultant of many forces and events over the span of our history. Looking at the course its development has followed, some have described the evolution of our national policy as the product of a struggle between factions aiming at unified control—those tending toward a monolithic system—and opposing forces striving to preserve pluralism.

One of the earliest visions of a national science, the national university as envisaged by Thomas Jefferson, Benjamin Rush and Joel Barlow, would have been both centralized and comprehensive—including many functions now performed not by universities but by research organizations within the government. But like Adams' dream of a national academy to restrict and regulate the vagaries of the American language, this plan came to naught. What has happened since bears some resemblance to a slow-motion ants-on-the-log situation. Beginning with the establishment of the Coast Survey in

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1843, the history of Federal science except for periods of crisis has been mainly the rise of a single agency predominant in one field of science, its longer or shorter period of dominance, and the relinquishment of its dominant position in the end to another agency born into the glamorous aura of another emerging field. A. Hunter Dupree says of the Geological Survey which succeeded the Coast Survey that it "gained its hegemony by creatively joining a live and developing science to the expansions of a nation's horizons in the great basin and Colorado plateau," that it was "still there when most people had ceased to get a thrill out of the problems of the trans-Mississippi West, and it was still there when the need for uranium ore brought prospecting on its classic ground back into fashion." In the line of further succession we would include the Forest Service of the Progressive Era and later the Department of Agriculture.

With the continuing crisis of recent years, the picture in terms of dominance has become a bit confused. The Department of Defense has unquestionably been the dominant agency from the standpoint of expenditures and perhaps even in the multiplicity of its interests. But it was the Atomic Energy Commission that captured and held the national imagination until the post-Sputnik era when the National Aeronautics and Space Administration quickly became the focus of all eyes. I would say that both AEC and NASA continue to engage us in our dreams of a better future. During these same years the National Institutes of Health (NIH) has entered the galaxy of dominant agencies, both in terms of funding and the scope of its programs. Lesser in budgetary stature but of growing significance, especially in its influence on the future of basic research, is the National Science Foundation.

SCIENCE IN WORLD WAR II

Nothing in this line of development, however, speaks of the events which have from time to time pushed us harder in the direction of a unitary national policy for science, for none of these agencies aspired to leadership over the whole of American science. The nearest approach in our history to completely centralized Federal science came during World War II with the establishment of the Office of Scientific Research and Development. It was both a predominant agency and a central scientific organization. It had a straight line organization within the government culminating in its director, Vannevar Bush. The director had an immediate access to the President and a relationship to Congress that resulted in hardly any limitation on money or on the timing of actions. In this great emergency, the Director and his associates worked closely with the military but could proceed, if they chose to do so, on their own initiative. They brought into the service of the government an array of laboratories undreamed of earlier by using contractural relationships to exploit existing resources in the universities. When one part of the job proved to be beyond the scale of other endeavors—I am speaking of the wartime nuclear program—they showed great administrative adaptability in assigning it as the Manhattan Project to the Army Engineers. The most remarkable aspect of the whole arrangement, however, was the assumption that when the emergency was over the OSRD would be dissolved. Implementation of this was like no other decision in all American political history.

The decision was made in good faith, and pluralism again was dominant in the American scientific community. However, the complete dominance of pluralism and the complete absence of any unified direction by the Federal government was to last only a short time. Already, as I have shown, some few had recognized that our country was caught up in the beginnings of a Third Revolution in science at the same time that we found ourselves becoming engaged in a scientific and technological struggle with the East. We began to recognize the importance of expanded scientific and engineering efforts on our economic growth and social well-being. As these realizations dawned, they motivated large-scale Federal support for research and development. Equally important, they brought about a somewhat more unified approach to the formulation and execution of a national policy for science and technology. The effect of Sputnik in October 1957 insured that there would be recognition and some guidance of this major aspect at the highest levels—the President and the Congress—to meet the challenge to both our national security and our international prestige. In a less conscious but perhaps no less effective way, we thus began to meet also the more fundamental challenge of the Third Revolution.

As in other times of crisis, the nation responded effectively and with impressive accomplishments. The history of the past year or two, I believe, reflects the result of this response in some lessening of international tensions. We have been given time to pause, the time to think at least briefly, and to reflect on what our future course should be. And as we have almost invariably done in like situations of the past, we have stopped to examine more closely our national pocketbook.

We discovered, of course, that the national expenditures for science and technology had mounted on a super-planetary trajectory with no sign of deceleration. We found that over the period of years from 1955 to 1964 the expense of Federally-sponsored research and development had grown from about $3 billion to $15 billion annually—or expressed in terms of percentage of gross national product, an increase from a little over one-and-one-half per cent to nearly three per cent. To put this more concretely, our present rate of Federal expenditure amounts to nearly $100 for every man, woman and child in the United States. For a family of four, this is equivalent to a new color television or one or two major appliances for the home each year. If our research and development expenditures were to continue to grow at the present rate, we could expect them to nearly equal the gross national product at the turn of the century in the year 2000.

Considered thus, the absurdity of such a projection becomes apparent. It is equally absurd to extrapolate the present rate of growth of Federal research and development expenditures and to determine thereby that such expenditures would be equal to the total of *all* government spending by the late 1970's. Obviously, there must be a limit. Even though our economy continues to grow at a substantial rate, we can reasonably expect that the proportion of our gross national product invested in science must taper off at some point in its expansion. We have already reached a position of having to make some hard choices and we are beginning to make them.

PROBLEMS OF DIRECTION

Thus while our system of modified pluralism with all of its imperfections has worked remarkably well during a number of crucial years in our nation's history, we have come to a point at which we must grapple with basic issues, questions both as to the management and the support of Federal science. The degree of our preparedness as a people to meet the new challenge of the Third Revolution can be measured by our ability to cope with these issues of the management of science in a democracy. For this reason I want to consider with you the pattern of the problems we are now contending with. They are not problems of the kind that one man, however capable, or one committee, however distinguished its membership, can hope to solve in the span of a few days or months. I present these questions rather so that we may consider the shape of our future as it may be implied in our present national situation in science. They are questions that are sure to be with us in one guise or another for many years to come.

I have called the national program of science as it is presently operating a form of modified pluralism. Dr. Donald F. Hornig, recently appointed Science Adviser to the President, expressed the matter very well the other day in his appearance before the Joint Committee on Atomic Energy. He made a general observation concerning the use of the words "science policy" in connection with national planning and programming. Dr. Hornig said, "It is obvious that no simple broad policy declaration can meaningfully guide the planning of science programs. There are in fact many national science policies designed to satisfy a number of national objectives."

By virtue of his position as the President's Science Adviser, no one is better able to appreciate the nature and problems of our system of modified pluralism than Dr. Hornig. The view from where he sits encompasses some half dozen Federal Agencies—the National Science Foundation, the Department of Defense, the National Aeronautics and Space Administration, the National Institutes of Health, the Office of Education, and the Atomic Energy Commission —all supporting programs of broad scope with mounting budgets and multitudes of projects competing for growing space in the financial sunlight of Federal support. In his efforts to help coordinate this diverse array of Federal programs, the Science Adviser must wear several hats. Primarily, of course, he advises the President on scientific questions of national importance, including their budgetary aspects. But in order to pull together the variety of data and considerations that support such advice, the President's Scientific Adviser is also Director of the Office of Science and Technology which provides him with staff assistance and a headquarters. He also serves as Chairman of the President's Science Advisory Committee, which represents the scientific community, especially the universities, and as Chairman of the Federal Council of Science and Technology with its representatives from all the scientific agencies of the Government. This pattern, which evolved out of the appointment of Dr. James R. Killian in November 1957 as Special Assistant to the President for science, has obviously been an influence working toward the better coordination of our national goals in science.

There continue to be stubborn difficulties, however, even in this arrangement which represents considerable progress. I believe we may with continued thought and consideration be able to achieve a more nearly optimum balance between unity and pluralism. For example, much of the present coordination of the science program is accomplished through *ad hoc* panels, and though there may be good reason for continuing to employ this approach in many phases of our activities, there is also danger in the lack of continuity and the possibility of failure to achieve an adequate integration of programs from a national standpoint. We should give serious thought to ways of improving our management of science by the Executive Branch of Government.

NEEDS OF CONGRESS

If the present form of pluralism within the Executive Branch impresses us as needing further improvement, the Legislative Branch of our Government, the Congress, is at least up to this point even less adequately equipped to regard science from the viewpoint of an overall national policy. This is not to say there has been no encouraging progress during recent years. The Joint Committee on Atomic Energy has for some time worked closely with the Atomic Energy Commission, both in reviewing program accomplishments and in developing needed legislation. The House Science and Astronautics Committee and Senate Committee on Aeronautical and Space Sciences have performed a similar function in connection with NASA programs and have lately begun to review broader questions. Perhaps the most encouraging of recent developments, however, has been the work undertaken by the Elliott Select Committee in its efforts to develop a comprehensive view of the whole range of national science programs.

It is plain that Congress is becoming sensitive to the need for a more inclusive and better informed view of science, but, though a number of proposals have been made to accomplish this by providing legislators with full-time science advisors, so far these efforts have met with little enthusiasm. One bill recently introduced calls for the establishment of a panel of three science advisors for the House and a similar staff for the Senate. Another would create a Congressional Office of Science and Technology patterned after the President's scientific office. As things now stand, whatever coordination exists is mostly of an informal kind among the various committees of the House and Senate, and the advice received by Congress is either a general variety from witnesses called before committees or else it stems from advice generated within the Executive Branch.

Thus we may conclude with regard to our present arrangements for the management of national science programs that, despite welcome progress, we may yet have a considerable distance to go before the desired balance between pluralism and a more nearly integrated viewpoint can be achieved. Though our current practices have the pluralistic advantage of great flexibility, we continue as a nation to be plagued by a persistent myopia as to our long-term national goals in science.

As we now turn to examine a number of very thorny questions concerned with the financial support of science by Government, the perspective shifts in some degree toward a distribution of problems occupying a foreshortened time scale. In talking of financial questions I believe we would do well to think in terms of strains to occur during the next few years. I make this observation because it seems to me that the next several years will witness economic and technological readjustments tending to ease the present financial strains imposed by science, readjustments brought about largely by the gains accrued through further scientific and technological developments. We nevertheless have this period of stress to be weathered, and during this period our major decisions will be concerned with the wise parceling out of available funds among competing programs. We must decide what programs to emphasize and—since emphasis is unquestionably translated into terms of financial support—with what degree of financial support we shall emphasize them.

We need especially in our present situation to develop effective and rational criteria for assigning priorities. Someone, for example, will have to make decisions between the competing claims of Big Science and little science. Would we do well to give greater heed to the support of the independent university investigator whose other job besides research is to train the next generation of scientists and engineers, or is it better to keep a few great centers growing at the rate of 15% a year? We will need to apportion funds among the different fields; weigh the relative merits of spending for research, for facilities, and for the improvement of teaching; and decide how much is justified for high-energy physics, for oceanography, for radio astronomy, and for other areas of work in which the costs for basic facilities are high. If we cannot afford to advance each major field at the optimum pace, should we stress the biological sciences and let the physical sciences lag or vice versa?

The time has passed when every competent scientist can have all the money he wants for any reasonably worthwhile project. The time has also passed when we can expect that very large and costly projects will be financially underwritten by the Executive and Congress without having the support of a consensus of the scientists working in the fields for which the projects are intended. The means by which such consensus is established may in the end have some influence on the functions and responsibilities of our scientific advisory structure in the Federal Government. Perhaps we have not yet arrived at the best means of obtaining an objective consensus from any segment of the scientific community, if such a consensus can in fact be reached. Is there a truly effective way to do this which will at the same time avoid certain predictable dangers? Are we to use some kind of measure weighted according to the prestige of the people voting? These are not trivial questions for a society whose future is so greatly predicated upon the future of its advancement in science.

It is important also, at this transitional point in the development of our technological society, that we preserve clearly in our minds the distinction between basic scientific research and applied research and development. I say at this transitional point for the reason that it is a point marked by budgetary problems and we need to keep in mind that the great bulk of our $15 billion or more in Federal expenditures for science is spent on applied research and development, especially development. I think it is fair to say that up to the present time the great majority of our citizens, including many of those most influential in government, have been able to justify expenditures for basic research only by keeping somewhere in the back of their thinking that the money spent would be returned many-fold in the form of useful applications. In almost every case this expectation is realized. The results of basic research are the raw material for the practical applications which now follow so swiftly. But as a people we should be beginning to learn what scientists have felt from the beginning, that new knowledge is vital even if its only purpose is to extend the boundaries of reality, to give us new insights into the circumstances that surround our lives. Basic research is the lifeblood of our time. We cannot neglect it, absolutely or relatively, without danger of retrogression.

THE NEED FOR EXCELLENCE

In this same vein we must recognize that for our time and the foreseeable future the encouragement of excellence merits our sustained recognition and support. The core of my own philosophy on this point coincides with the Statement by the President's Science Advisory Committee on *Scientific Progress, the Universities and the Federal Government* issued in November 1960. In this report the Panel states: "In science, the excellent is not just better than the ordinary; it is almost all that matters. It is therefore fundamental that this country should energetically sustain and strongly reinforce first-rate work where it now exists." The report states further that "It is of equal importance to increase support for rising centers of excellence." How are we to accomplish this increasing support for rising centers of excellence in the face of our increasingly difficult budget situation? The costs of excellence can be very high, both for staff and for the major items of equipment demanded by Big Science. How do we prevent the competition for establishing such new centers in the various regions of our country from degenerating into squabbles reminiscent of our saltier pioneer political eras? How can we prevent a Science pork barrel?

We must not let our national support of science and technology degenerate to the point where no state—no Congresssional district—is complete without a Post Office, a reclamation project and a new science laboratory. This does not imply a lack of merit in the considered geographical distribution of our scientific expenditures. Any such program, however, should be both soundly conceived and wisely administered if we are to build new centers of excellence in new geographical areas without tearing down or undermining other centers that have already achieved and sustained excellence. We must manage somehow to provide for the support of new centers and allocate the development of major facilities among them in such a way that we do not turn our best scientists into migratory workers. We cannot afford to have these men gravitating from one scientific mecca to another, dependent upon the fluctuating whims of Federal support.

If there are problems connected with being too poor, there are some who are now saying—though I have never personally experienced this kind of discomfort—that there are dangers accompanying extreme affluence. I refer by this seeming paradox to the impact of our large Federal expenditures for science upon the universities and industries which receive them. Government expenditures make up about two-thirds of the total amount of money spent in this country on research and development. With this we may compare industry's portion, amounting to about 30%, and the 3% from universities and other non-profit institutions, the latter going mostly for basic research. It should be abundantly clear that Federal funds constitute a large enough part of the total to have a strongly felt impact on both the business and academic sectors.

SCIENCE IN THE UNIVERSITIES

Experience shows that for the most part the impact of these funds on the universities has been beneficial. They have brought about a significant growth in science. They have increased the number of students entering scientific fields. They have been allotted in such a way as to foster a close involvement of basic research with graduate education. This latter point is of especial importance because the direction and force of the Third Revolution will depend upon new men and women, new scientists and engineers, new minds and ideas, and these can come only from the rising generations of students.

There have also, unfortunately, been drawbacks associated with Federal support of science in the universities. Because of the influx of Government funds, some universities may tend to become one-sided in their emphasis on science. The humanities may be neglected. In other schools, professors may find themselves burdened with administrative duties which preempt the time they would otherwise be able to devote to teaching. An extreme complaint occasionally heard is that a professorship may be awarded not because of an individual's scientific and educational merits, but rather because of his ability to obtain Federal support for the university's research programs.

While Government money does not necessarily subvert university freedoms, alter its structure of professional relationships, or distort the patterns of emphasis placed on different fields of study, hazards are certainly present. The Government must bear these things in mind. But an important task of the universities is to assure that their own standards of excellence and freedom are maintained in a period of growing connection with the Federal Government. The universities have an obligation—which they are generally not at all hesitant to exercise—to keep Government actions and methods reasonable and proper.

In the private sector there are problems of a similar nature. Much of the $15 billion of research and development funds spent by the Federal Government is placed in the hands of industrial contractors performing the many-faceted research and development tasks this nation pursues. This results from the fact that a major part of the total Federal funds are for developmental efforts—hardware and engineering.

In industry the one-sidedness of Federal expenditure has had a noticeable effect. The civilian technologies supported largely or solely by the private sector have suffered in comparison with those which depend on the growing and thriving fields of science of interest to the Government, such as aerospace. Young science and engineering graduates are naturally enough attracted to the newer, and more glamorous, fields of endeavor. We can imagine them asking the question, "Why improve the family refrigerator when you can play a role in man's quest for the stars?"

Nevertheless, the scientific and engineering problems sponsored by the Government primarily for the military and space programs also may have benefits for the general industrial technology. "Spin off" and "scientific fallout" are the terms often used to remind us that ideas, processes and inventions developed in one program can greatly influence new developments in other fields.

As in the case of the universities, the more indirect relationships between Government and industry are also beset with problems and questions. The unique patent position held by the Government as a result of its massive support of science is an area of recurring problems. Where the Government supports the work, the Government understandably also often retains patent rights to the inventions resulting from this work. With the continuation of large-scale Federal involvement, one can see the possibility that the Government would eventually come to hold a singular and somewhat monopolistic position. There are complexities enough here to challenge our best legal talent in industry and Government for a long time to come.

What is apparent in looking at Government-university and Government-industry relationships is that over a period of many years, a period that began with the widespread operation of the Office of Scientific Research and Development during World War II, a generally fruitful and beneficial pattern has evolved. This flexible and somewhat ingenious interpenetration of Government, industry and the academic world is a distinctively American invention which has cut several Gordian knots in the past and will continue to make worthwhile contributions to our way of life. . . .

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