PART I

Current Aspects of American Science

The Year in Review

All the people of the United States are stakeholders in the success of basic scientific research. From this Fifth Annual Report of the National Science Foundation comes clear evidence of the affirmative manner in which the resources of these stakeholders are being used selectively to seed promising scientific ground throughout the several States.

However modest the total amount, the nearly $8,000,000 disbursed by the Foundation across the Nation represents a timely endowment of the work of principal investigators and their research assistants and associates. To the lay reader, the following examples of the kind of grant approved by the Foundation may signify little—University of California (Berkeley), Otto Struve, *The Composition of the Stars;* University of Utah, Henry Eyring, *Theory of Reaction Rates;* Columbia University, P. Kusch, *Energy Levels and Hyperfine Structure of Helium Three and Four;* University of North Dakota, Donald E. Severson, *Mass Transfer Rates under Forced Convection;* Long Island Biological Association, Cold Spring Harbor, New York, M. Demerec, *Equipment for Virus and Bacterial Genetics Research.* But to the scientist, these grants and more than 500 others have a reassuring meaning—a chance to precipitate the known from the unknown for a better understanding of nature and man and in order that his discoveries in basic research can help his associates in applied and developmental science to produce finer electronic instruments, better vaccines, more disease resistant crops. Even today our socio-economic structure is built solidly on foundations embedded deeply in basic scientific research—breakthroughs ground out of the obstinate unknown in the recent and distant past. The objective of the National Science Foundation is to help keep the grindstone turning by a discriminate selection of men and facilities found most deserving of Federal support in order that the breakthroughs of today will sustain the Nation tomorrow.

As expressed in more detail in the section on *Support of Basic Research in Science* (page 45), such Federal support was extended through 588 grants in the biological, medical, physical, mathematical and engineering sciences to 184 institutions in 47 States, the District of Columbia, Hawaii, Puerto Rico, England, and Italy. The average research

grant for fiscal year 1955 was $13,400 to run for 2.7 years, or about $5,000 per year.

In the same selective manner, the Foundation has acted with respect to the inadequate total supply of scientists. Of those graduating from colleges each year, too many are being drained off into applied and developmental research to support the particular missions of industry and agencies of Government. Inducements to work in these latter fields are too enticing to disregard—although the compensations of accomplishment are tremendous in basic research, the work is not highly remunerative.

Although modest, the $1,850,000 representing Foundation support for graduate fellowships during the academic year 1955–56, assured about 800 pre- and post-doctoral fellows an opportunity to continue their full-time work in basic scientific research. Average annual costs for a predoctoral fellow are about $2,500; and for postdoctorals, $4,180.

To these two programs—*Support of Basic Research in Science* and *Training of Scientists and Engineers*—the Foundation dedicated last year nearly $10,000,000, or (exclusive of the International Geophysical Year) about 80 percent of the total appropriation made to it by the Congress. These figures compare with a total national expenditure for research and development during fiscal year 1954 which reached a record high estimated at over $5 billion, of which nearly one-half was contributed by the Federal Government. From this total over two-thirds represented research and development undertaken by industry, but over a third of this amount, in turn, was financed by the Federal Government. National Science Foundation surveys show that of the total 1954 industrial research and development effort only 4 percent went into basic research.

Other programs called for major attention by the Foundation during fiscal year 1955. One in particular, the International Geophysical Year, promises to capture the imagination of all peoples as it approaches a climax in 1957 and 1958. Although lay interest will be centered on the drama surrounding launching of earthbound satellites and expeditions to Antarctica, scientific interest will focus on measurable results which will come from the worldwide cooperative efforts of scientists in 40 nations who will collect and coordinate geophysical data. The National Academy of Sciences, responsible for planning and executing the United States program, has established a special United States National Committee for the International Geophysical Year to carry out actual operations of the program. Administration of overall Federal participation is entrusted to the National Science Foundation. (Page 21.)

Unsatisfactory communications among scientists challenge efforts to help establish an efficient system for exchange of scientific information. Published material in the sciences is fast reaching overwhelming proportion. Coincidentally, costs of published material are constantly climbing. Investigators in a particular field must have access to the research of their associates in the same field before unimpeded progress can be made in basic research. Modern machine methods may provide some relief. The Foundation allocated to the solution of this problem a small share of its resources during fiscal 1955. (Page 80).

The loyalty of investigators seeking Foundation grants in support of unclassified basic research received careful consideration. The Foundation enunciated a principle widely endorsed by responsible groups of scientists. The Foundation will not knowingly support anyone who is, by admission or conviction, disloyal to the United States. In the interest of science, however, the Foundation will not pass judgment on the loyalty of an individual on the basis of unsupported charges but will make grants upon the judgment of outstanding scientists in his field and persons in intimate contact with him as to his competence and integrity. (Page 18).

Incident to the direct costs of scientific research using support from the Federal Government are certain indirect costs reflected in such items as administration, plant operation and maintenance, use and depreciation of buildings and equipment, and the like. At the request of the Bureau of the Budget, the Foundation last year gave special attention to the problem and recommended a uniform Federal policy for allowing the indirect costs in Government-sponsored research. (Page 28).

In order to provide forums for the exchange of ideas among scientists working in special areas, the Foundation helped underwrite 21 conferences during fiscal 1955—largely in instances where adequate support was not available from industrial or other institutional sources. Frequently attended by scientists of other nations, these conferences served as an effective clearinghouse for the interchange of concepts relating to new or incompletely explored fields. Some of the conferences brought together scientists of inter-related disciplines, resulting in a healthy cross fertilization of ideas. (Page 35).

Meanwhile, at home and abroad, science continued to assert itself. The first International Conference on the Peaceful Uses of Atomic Energy, held at Geneva, Switzerland, in July, was the outstanding scientific event of the year for citizens of all nations. The conference, called by the United Nations, was a direct outgrowth of President Eisen-

hower's "Atoms for Peace" proposals made last year. Scientists from 74 countries participated in the presentation and discussion of hundreds of scientific papers on the physics, chemistry, metallurgy, medicine, and biology involved in the fuller exploitation of atomic energy. Observers in great numbers, including industrialists, bankers, and public officials, attended sessions and exhibits and talked informally with delegates to learn when and how the promise of atomic energy for peace would become actuality. Over 2,000 journalists sent day-by-day accounts of the meetings to millions of readers and listeners in their respective homelands.

A vast quantity of unpublished scientific information was revealed for the first time at the Geneva sessions. Although experimental methods and techniques varied from country to country, it was clear to all that the world's scientists working behind walls of national security had common aims and had achieved strikingly similar results. A leading American theorist noting this fact remarked that "it is gratifying to learn that nature is the same on both sides of the Iron Curtain!" Announcement by several nations, including the United States, of current studies on the possibility of controlled energy release by thermonuclear or fusion reactions was a highlight of the meetings.

During the year bilateral agreements were made between the United States and 28 other nations for the exchange of information, technical assistance, and in some cases, materials for the construction and operation of research reactors. This program also was inaugurated as part of the Atoms-for-Peace plan.

During the year the Food and Agricultural Organization at Rome issued a 10-year summary of world agricultural developments since World War II. The report showed great improvement in some areas of the world in the ability of nations to meet minimum requirements for food and agricultural raw materials. This in large part was attributable to scientific agriculture, but there was no cause for complacency among scientists. In many areas it was clear that growing populations continue to outpace agricultural progress.

Throughout the United States research laboratories continued to report significant findings in all fields of science. Some led almost immediately to practical developments. In most cases, however, the results were less susceptible of immediate application serving more as bricks and mortar to buttress and strengthen the structure of science.

The nationwide program of antipolio vaccination proceeded vigorously, despite problems incident to getting into large-scale vaccine production.

At the Langley Aeronautical Laboratory, research scientists reported the aerodynamic principles that led to the design of the low-drag, pinch-waisted fuselage for aircraft at supersonic speeds. This development, supported by the National Advisory Committee for Aeronautics, has been described as "the most significant military scientific breakthrough since the atomic bomb" and "the kind of breakthrough that makes fundamental research so important."

Scientists and engineers at many other Federal laboratories reported discoveries of significance in a variety of fields. Among these were research in the kinetics and dynamics of metabolic processes at Brookhaven National Laboratory and the pioneering research of the Bureau of Standards on the reflecting layers of the upper atmosphere.

Basic research received encouraging emphasis in the Nation's industrial laboratories. Among scientific developments originating in industrial laboratories were the announcements of diamond synthesis at the General Electric Research Laboratories and the synthesis of natural rubber by scientists at research centers of the Goodrich-Gulf, Firestone, and Goodyear corporations.

The biological and genetic implications of radioactive fall-out engaged the attention of biologists and medical scientists. Both in this country and abroad extensive research was under way on the prevention and control of air pollution, a by-product of the age of machines and in certain localities one of the most critical current problems in human ecology. The Department of Health, Education, and Welfare undertook a modest program of research looking toward ultimate solution of the air pollution problem.

The Commission on Organization of the Executive Branch of the Government (Hoover Commission) in its report on research and development in the Government made a strong plea for greater emphasis upon basic research. The report stated in part that "the foundation of the greatest sector of human advancement in modern times is basic research into nature's laws and materials. It is from these sources that come the raw materials of applied science. We owe to basic research the fabulous improvement in the health of the Nation; the greatest industrial productivity known to man; the weapons of defense which have protected our independence; and our knowledge of the laws which govern the Universe."

During the year more and more voices expressed concern at the existing, and even more critical future, shortages in the supply of trained scientific manpower. Leaders in education, industry, and Government

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were increasingly alarmed at the social and cultural waste of manpower resources resulting from the failure of fully half of our most talented youth to continue their education beyond secondary school. Lack of finances was seen to be only part of the problem. Lack of adequate motivation to seek advanced training and a possible decline in public acceptance of the importance of higher education seemed to be of at least equal importance.

The National Science Foundation and Science Policy

A Four-Year Review

At the heart of the determination of national science policy is the role of the Federal Government in the encouragement and support of science. The Congress of the United States, in the National Science Foundation Act, directed the Foundation to support basic research in science, and in the area of policy forming it directed the Foundation to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences. The National Science Foundation took the position that it could be an effective policy-forming agency only after it had matured with a body of experience in operating science research programs.

While its act gave the Foundation great flexibility in the manner of research support, many advantages were found in support procedures successfully used by other agencies since the war, namely, by furnishing funds in response to applications or proposals from qualified scientists on problems of their own choice. The research support program of the Foundation was built on this basis. Typically, a grant is made by the Foundation to an institution for a specified amount and time on behalf of an individual research scientist or small group of scientists. The funds enable the scientists to continue or initiate a specified piece of scientific research for which his institution has made application.

Research can be supported by aiding departments or institutions without specification as to the precise nature of the scientific work to be done. However, the Foundation believes that at present it can best aid progress in science and the development of a concerted scientific effort throughout the country by selecting for support those problems in science adjudged most meritorious in the eyes of the country's leading experts in the respective fields.

Initiation of its research support program was a long step forward for the Foundation. Individual reviewers of research proposals, advisory panels for broad evaluations of special fields, and general committees such as the statutory divisional committees helped guide policy in operations, and laid a solid foundation on which this phase of policy might be

based. After careful deliberation the Foundation reached a series of decisions for research administration on such matters as indirect costs, reimbursement of institutions for salaries, summer employment, and similar considerations. Policy decisions directed toward the resolution of immediate operating problems of the Foundation affect, as well, relationships among scientists, universities and agencies of the Federal Government.

Support by the Federal Government affects scientific progress in three important aspects, namely, science itself, institutions concerned with science, and individuals engaged in scientific activities. Foundation support programs are directed toward removing road blocks to progress in all three of these areas. Now, out of considerable experience, policy guide lines have been drawn with respect to—

(a) the paramount necessity for increased support of basic research in the sciences;
(b) considerations of loyalty in connection with grants for nonclassified basic research;
(c) the training of scientists;
(d) the stimulation of improvement in science teaching; and
(e) the provision of facilities and equipment for the support of research.

In all its efforts "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences" the Foundation has cooperated formally and informally with other Federal agencies whose programs include science. In many ways this sharing of experience is akin to the unwritten considerations which underlie the universally recognized methods by which scientists achieve progress in their own research.

Following passage of the National Science Foundation Act, certain basic decisions were reached with respect to its grant program which still stand today as the administrative frame within which the Foundation operates.

(a) Grants in support of basic research, declared meritorious following review by scientists in that scientific field, would be awarded to institutions on behalf of the principal investigator.
(b) Grants would be made for the period of time required by the research project, up to a maximum of 5 years.
(c) Grants would include a reasonable amount for indirect costs. As an interim policy, the Foundation determined that this amount may be up to 15 percent of the total direct costs in the grant

request. Now being revised, Foundation policy with respect to indirect costs is described in detail in the section of this report beginning at page 28.

(d) Grants could include, as well, allowance for publication costs anticipated, including purchase of reprints.

(e) Grants, under normal circumstances, would permit title to equipment purchased or constructed with grant funds to be vested in the grantee institution.

The Foundation soon discovered deficiencies in precise knowledge as to the state of scientific activities as a whole, and in the nature and amount of national resources expended in scientific pursuits. The Foundation concentrated its efforts primarily therefore on systematically surveying ways to remove these deficiencies. One of the most effective ways in which knowledge can be acquired in pure science lies in an approach through the disciplines or fields of science, following closely the opinions and advice of panels or committees of experts. By the same approach, knowledge can be obtained of the Federal role in the support of basic science. Close collaboration exists between Federal agencies engaged in basic research, and by tapping into this reservoir of knowledge the Foundation soon acquired an understanding of the science content of Federal agency programs on the part of all agencies similarly engaged.

Status of Science Studies

Although organized science faces many problems, each field—and often subfield—of a scientific discipline is in a unique position in terms of its particular development and current status. Long-range studies of the development and progress of fields of science are necessary underpinnings for the development of broader policy. Such studies, to be most useful, must stimulate the interest and active cooperation of working scientists. Four have been supported by the Foundation to date.

Physiology. The survey of physiological science by the American Physiological Society is under the general direction of a committee representative of the several subdisciplines of physiology. Information has been gathered and analyzed on approximately 3,500 American physiologists. As a result, definitive data are now available on the profession of physiology—the educational, social, economic and geographic backgrounds of physiologists; what activities physiologists engage in and how they divide their time among research, teaching and administration. Such personal and motivational factors as why persons enter and leave

the field and the problems encountered in practicing it have also been studied. Other areas under analysis, for which results are not yet available, include studies of the function of scientific literature in physiological science, of college course offerings in physiology and a special evaluation of the presentation of physiological science to the lay public.

Psychology. The development and status of psychology in the United States is being studied by the American Psychological Association under contract with the National Science Foundation. This study is divided into two major parts, one concerned with an evaluation of the status of psychological knowledge, the other with an analysis of occupations in psychology. This part of the study is nearing completion and will be published in book form in the spring of 1956. Preliminary data reveal important differences in values and activities between productive research psychologists and those whose research contributions are negligible.

Mathematics. As a result of a pilot study of applied mathematics, sponsored by the Foundation, a special committee of mathematicians under the auspices of the American Mathematical Society is concerned with surveying research potential and training in the field as a whole. This major study has been recently organized and preliminary planning has been concerned with methods of obtaining information relevant to the problems of increasing our national resources in mathematics.

Demography. The fourth study under way is an evaluation of the status of demography—the statistical study of populations—as a science. This survey will not touch upon the characteristics of demographers but will concentrate instead upon substantive problems. A basic objective is to determine gaps and deficiencies in the fund of knowledge of demography, its theory and methodology, and also in its resources and facilities for research and training. The basic evaluative materials will be obtained from individual scholars whose contribution to the literature indicate special competence in the areas surveyed. The staff of the Population Research and Training Center of the University of Chicago, with Foundation aid, will edit the papers for publication and prepare summarizing statements emphasizing frontiers for research in demography.

Although none is finally completed, all these studies have aroused much interest and ferment in their respective disciplines. Meetings of professional societies have been organized around study plans and preliminary results. These surveys promise to be a stimulating force in the field as well as an important guide to National Science Foundation planning. They become most meaningful as a method of developing science policy

when considered in conjunction with the Foundation-supported science conferences (page 35) convened throughout the year to bring together scientists representative of one or more disciplines in order that they may be provided workshop forums for exchanging ideas.

Fact-Finding Studies

The Foundation has made another major effort to uncover the basic information needed before certain policy decisions can be reached—the series of studies presenting data on the total national effort in science. In contrast to the surveys-of-science described above, this series has concentrated, not on the status of a particular discipline, but rather on the total picture of scientific activities in the United States.

The ascending role of the Federal Government has provided one of the focal points of study. Prior to World War II, organized scientific research received little support from the Federal Government apart from limited activity in the Government's own laboratories and installations and the program in support of agricultural research at the land-grant colleges. The demands of World War II necessitated the beginnings of contract research performed for the Government by scientists in universities, independent laboratories and industrial concerns. An assessment of the extent and impact of Federal activity in science has been long overdue.

The initiation of a basic series of reports entitled *Federal Funds for Science* has been the first step in providing detailed information on the extent of Government activity. Gross figures for all scientific expenditures, both intramural and extramural, have now been compiled for fiscal years 1952 through 1955. By establishing this series on a yearly basis, important trends in the level and direction of Federal expenditures for science may be analyzed. A historical study of Federal Government activities in science from 1789 to 1940, being done for the Foundation by the American Academy of Arts and Sciences, will add perspective and depth to current analyses. This study is in the final stages.

In addition to background-trend data, the breadth and scope of current Government operations affecting science is an important factor in establishing sound national policy. In the life sciences, psychology, and the social sciences, semiannual and annual listings have been made for the extramural unclassified research programs of all Federal agencies. These reports are valuable both to Federal officials responsible for program planning and to research workers in the field.

On a broader front, encompassing all disciplines, a large-scale review has been undertaken of current Federal research programs. This study will provide detailed data for fiscal years 1953 and 1954 on the funds spent for research, the types of research programs involved, and the scientific manpower resources of Government. A report on the organization of the Federal Government for scientific activities will be available early in 1956 showing the structure of Federal units and functions performed in science. The overall picture of Federal Government activities in science will be completed in companion reports on funds and personnel.

A large part of total scientific research is performed with the financial support of the Government by scientists working in private organizations—nonprofit research institutes, commercial laboratories, trade associations, labor unions, industry, and universities. The research and development activities of each of these organizational units have been surveyed with particular emphasis upon areas of mutual concern to Government and to the institution or organization.

A crucial area for the future of science, particularly basic research, involves Government-university relations. Educational institutions traditionally have been the home of basic research. The Federal Government has in the last few years, however, entered the campus in a major way through its sponsorship of specific research and its support of more generalized research. To inquire into the problems raised by these new relationships as they affect the universities the National Science Board appointed an Advisory Committee on Government-University Relationships.

At the same time, the Foundation staff is analyzing sources of support for research at universities and colleges, the nature of such research, and the effect of research upon the teaching programs of the institutions. The highlights of a survey of graduate-student enrollment were released in 1955. This study covered approximately 152,000 resident graduate students in the United States in 1951. (The U. S. Office of Education estimated the total number of graduate students in all fields at 223,832 during the academic year 1953–54.) Roughly one-third were enrolled in the natural and engineering sciences—31,000 in the natural, 14,250 in engineering sciences. Graduate students receiving financial assistance in the form of (1) teaching assistantships and (2) research assistantships and (3) fellowships represented about 25 percent of the 152,000 total studied. Almost two-thirds of the graduate students receiving support were paid from funds provided by academic institutions; the remaining one-third received assistance from noninstitutional sources. Over one-half of the latter group were supported from Federal sources.

State universities are a special case since they receive, in most instances, funds from both Federal and State government sources. A pilot study of six State governments and the State universities concerned indicates that the States vary widely in allotments of funds for scientific research and development. Research is done primarily by State universities and by in-service State units, concentrating for the most part on agricultural problems.

A survey of industrial research and development is obtaining estimates on a nationwide basis of the amounts spent for the conduct of research by size of companies and by industry groups; of the source of these funds by major economic sectors; and of the amount spent by companies to purchase research conducted elsewhere, as in universities and research institutes. In designing the study special attention was focused on problems of scientific and technical personnel in industry.

Private foundations are generally assumed to be a source of substantial support for scientific research. A study made for the Foundation by the Russell Sage Foundation indicates that within recent years basic scientific research has received less and less support from the 77 largest private foundations. This study covered the years 1939, 1946, and 1953. Medical sciences and social sciences were the fields of greatest interest to private foundations.

The continuing concern of the National Science Foundation with problems of scientific and technical manpower has resulted in many background studies. This information has been compiled and published in "Scientific Personnel Resources."

Special Policy Reports

When the role of the National Science Foundation in science policy was first deliberated, two types of studies were decided upon. The first was of long-range studies for the development of knowledge about the national research effort in science. This is the type of study discussed in the two sections above.

In addition to long-range studies the Foundation decided that special studies of an urgent nature should be undertaken. "These should be on topics of interest from the standpoint of the present emergency, the general welfare or significance to science itself, and should be defined within limits sufficiently narrow to permit completion without undue delay. The aim of such studies would be to determine the extent of research at present being conducted, the degree of Federal support, and the basic research needed to make maximum progress in the special area considered."

Since that decision, the Foundation has engaged in several special studies. The Secretary of Health, Education, and Welfare, requested that the Foundation undertake a review and evaluation of the medical research programs of that department. A special committee of leading scientists in the medical research area was appointed to undertake the study and make recommendations by the close of 1955.

Upon recommendation of the Rubber Producing Facilities Disposal Commission, the Foundation was asked to undertake the administration of the basic rubber research program that had been supported by the Federal Facilities Corporation at universities and institutes. As an integral part of this responsibility the Foundation appointed a Special Commission for Rubber Research to make recommendations on the future role of the Federal Government in synthetic rubber research.

The Bureau of the Budget requested the Foundation to recommend a uniform policy for indirect costs of research supported by the Federal Government at universities and colleges. Careful attention was given this problem by the staff of the Foundation and the Advisory Committee on Government-University Relationships. The National Science Board endorsed the final recommendations transmitted by the Director.

Other policy areas which have been of special concern to the National Science Foundation are minerals research—a concern arising from recommendations of the President's Materials Policy Commission; the support of research by medical students, and the role of the Foundation with respect to social science research. On the latter point, the Board approved, in August 1954, a limited program of support of selected social science areas.

A relatively new and major activity has been the systematic study of the national need for scientific installations and facilities. In this evaluation the Foundation has been assisted by various advisory bodies composed of specialists in the disciplines concerned. Acting on their recommendations the Foundation has recommended, as a national policy, the desirability of Government support of large-scale basic scientific facilities when the need is clear and it is in the national interest and when funds are not readily available from other sources. The Foundation has emphasized, however, that it regards as a primary responsibility the broad development of science through support of individual investigators. Examples of recommended installations are: a national astronomical observatory, a major radio astronomy facility, research installations of computers, accelerators and reactors, and specialized biological field-stations. The Foundation is now devoting attention to means of putting these recommendations into effect.

Summary

Stemming from its legislative and executive directives, the National Science Foundation has been concerned from its inception with problems of national science policy. It found a void in the basic data essential to sound planning. The first step toward policy formulation is necessarily the painstaking task of accumulating relevant data concerning the national effort in scientific research and development. The several studies noted above are efforts in that direction. Larger issues have been approached through study of scientific research, study of special problem areas, and lastly, through operations of the National Science Foundation itself. Although each aspect of the total program of surveys will achieve only limited impact on the resolution of national science policy, the Foundation is confident that together the individual parts will add up to a sound basis for planning long-range policies affecting the Nation's scientific efforts.

Loyalty and Security Considerations in Making Grants for Nonclassified Scientific Research

Loyalty as a consideration in Federal support of nonclassified basic scientific research has its origin in measures developed to protect the national security during and since World War II. Balancing the need for widespread research and dissemination of scientific information with the need for imposing restrictions to protect the security of the United States has posed difficult problems.

The increasing significance of science and scientific research in the defense and economic strength of the United States makes it most important that relations between the Federal Government and American scientists remain healthy and therefore conducive to maximum scientific progress. It is vital that this partnership of science and Government be strengthened in every way possible, and that elements tending to create conflict and distrust be eliminated.

As an outgrowth of World War II efforts to maintain the national security, increasing attention was paid to the reliability of individuals working on scientific or other matters involving classified information. Considerations of security and loyalty were rightly applied to the employment and performance of personnel engaged in such work. Later the applicability of similar criteria to those engaged in nonclassified basic scientific research became a matter for consideration. However, no current provisions of law or of any executive order require the withholding or termination of a Federal grant or contract in support of unclassified research on the basis of the existence of derogatory information regarding the loyalty of anyone connected with such research. Furthermore, where research does not involve classified information, no consideration of national security can be relevant. When national security is not involved, inquiry into the political thoughts and beliefs of individuals has traditionally been contrary to American principles.

National Science Foundation grants or contracts for nonclassified research are normally made to institutions intimately acquainted with the scientist directing the proposed research project. Before an award is made, the scientific competence and integrity of the scientist involved are carefully considered by panels of outside scientists who know his qualifi-

cations. In such cases, loyalty or security-type investigations are clearly undesirable and unlikely to serve any useful purpose. Present investigative facilities would be taxed beyond capacity if character inquiries were required on the many scientists currently working on unclassified research projects. A substantial proportion of the funds available for research would be drained off into costs of investigation.

Unclassified basic scientific research, whether or not supported by Federal grant or contract, poses no security problem. In supporting such research by grant or contract it is hoped that it will lead to results which will be published and disseminated as broadly as possible. There is no danger of unauthorized release of classified security information. The only reason, therefore, that the loyalty of an individual scientist working on a federally sponsored project would appear to be involved is on the principle that it would appear to be against the national interest thus to give aid and comfort to a person disloyal to the United States. The national welfare, on the other hand, requires the greatest possible encouragement to the participation of competent scientists in basic research which can contribute so much to our scientific progress, to our defense and to our well-being. While realizing, therefore, that there is no place for the disloyal person in Government-sponsored science, our policy and procedures must, at all times, take into consideration the aims we seek to attain, while supporting our basic traditions of justice and freedom.

Bearing in mind the considerations mentioned above, the policy of the National Science Foundation in processing proposals for grants in support of unclassified research, not involving considerations of security, is to assure that in appraising the merit of a proposal for unclassified research submitted by or on behalf of a scientist, his experience, competence and integrity are always taken carefully into account by scientists having a working knowledge of his qualifications. However, the Foundation does not knowingly give nor continue a grant in support of research for one who is:

1. An avowed Communist or anyone established as being a Communist by a judicial proceeding, or by an unappealed determination by the Attorney General or the Subversive Activities Control Board pursuant to the Subversive Activities Control Act of 1950, or anyone who avowedly advocates change in the U. S. Government by other than constitutional means, or

2. An individual who has been convicted of sabotage, espionage, sedition, subversive activity under the Smith Act, or a similar crime involving the Nation's security.

Furthermore, if substantial information indicates that a potential or actual researcher might be guilty of violating any law or regulation, the information would be forwarded to the Department of Justice for appropriate action.

The Foundation, therefore, will not knowingly support anyone who is, by admission or conviction, disloyal to this country. In the interest of science, however, it will not pass judgment on the loyalty of an individual on the basis of unsupported charges but will rely upon the judgment of those who best know the individual and his qualifications. This position of the Foundation has been endorsed by the American Association for the Advancement of Science in a resolution passed at its annual meeting in Berkeley last winter. We believe it to be in the best interests of the Nation.

International Geophysical Year

The International Geophysical Year (IGY) is a world-wide program of special observations of various earth sciences phenomena planned for the period July 1, 1957, through December 31, 1958. Under the auspices of the International Council of Scientific Unions 40 nations are planning a vast, joint effort to collect coordinated geophysical data on a world-wide basis in such fields as meteorology, upper atmosphere physics, including the ionosphere, aurora, geomagnetism, oceanography, glaciology, seismology and as a special additional program, redetermination of latitudes.

The planning and technical direction of the United States program is in the hands of the United States National Committee for the International Geophysical Year. The committee exists under the aegis of the National Academy of Sciences-National Research Council. Members of the committee and its technical panels include many prominent scientists in geophysics and related fields in the United States.

The National Science Foundation, at the request of the United States National Committee sought and obtained appropriations from the Congress for the United States program in the International Geophysical Year. The Foundation is responsible for administering certain aspects of the Federal program, including coordination of Government interests in the undertaking. Federal appropriations to the Foundation for support of the United States program may be made available by grant or transfer of funds to other Government agencies and private institutions engaged in the work.

The basic scientific program for the International Geophysical Year was described in Appendix VII (pp. 123–134) of the *Fourth Annual Report* of the National Science Foundation.

The Rome Meeting, September 1955

The second full meeting of the Special Committee for the International Geophysical Year of the International Council of Scientific Unions was

held in Rome, September 30 to October 4, 1954. Over a hundred delegates from some 30-odd nations were present. At this meeting a thorough review was made of all national programs for the International Geophysical Year. During the course of the meeting four principles were enunciated which had up to that time tacitly applied to the process of selecting suitable projects for the International Geophysical Year. They are as follows:

(1) Problems requiring concurrent synoptic observations at many places on the globe, involving coordinated effort by many nations;

(2) Problems, the solution of which will be aided by the availability of the results of synoptic or other concentrated geophysical work undertaken during the International Geophysical Year;

(3) Problems which can take advantage of the occupation of stations in regions of the earth at which comparatively little geophysical effort has been devoted in the past (these would include, in addition to synoptic programs, such fields as gravity and seismology);

(4) Observations of geodetic and other slowly varying geophysical phenomena for purposes of comparison with similar observations in future epochs.

During the technical review of International Geophysical Year programs, it was apparent that very few changes were required in the United States program to conform with the recommendations of the special committee as they then existed.

Earth Satellite Program

The most dramatic of the resolutions passed by the special committee at the Rome meeting was a recommendation urging that participating nations consider the feasibility of constructing small, unmanned, earth-circling satellite vehicles to be used for basic observations of extra-terrestrial phenomena.

The atmosphere of the earth acts as a huge shield against many of the types of radiation and objects that are found in outer space. It protects the earth from things which are known to be or might be harmful to human life, such as excessive ultra-violet radiation, cosmic rays, and those solid particles known as meteorites. At the same time, however, it deprives man of the opportunity to observe many of the things that could contribute to a better understanding of the universe. In order to acquire data that are presently unobtainable, it is most important that scientists be able to place instruments outside the earth's atmosphere in

such a way that they can make continuing records of the various properties about which information is desired.

Vertical rocket flights to extreme altitudes have provided some of the desired information, but such flights are limited to very short periods of time. Only by the use of a satellite can sustained observations in both space and time be achieved. Such observations will also indicate the conditions that would have to be met and the difficulties that would have to be overcome, if the day comes when man goes beyond the earth's atmosphere in his travels.

For several months following the Rome meeting the United States National Committee investigated the possibility of this country's participation in a satellite program. The feasibility of the project was discussed at length with representatives of the Foundation and the Department of Defense. In July the President announced that the United States would include the attempted launching of scientific satellites as part of its national program for the International Geophysical Year. Technical advice and assistance in the program were to be provided by scientists of the Department of Defense, who for many years had been engaged in research on the upper atmosphere. The Department of Defense will also provide the required equipment and facilities for launching the satellite.

Description of Satellite

Under the proposal the satellite itself will be the final stage of a multistage rocket launching vehicle. The development work, designated by the Department of Defense as Project Vanguard, will be carried on by a number of industrial groups, under the general direction of the Glen L. Martin Co., prime contractor and builders of the Viking rocket for the United States Navy.

Although the exact shape and size of the small scientific satellite have not been firmly established, it will be large enough to contain scientific measuring instruments and to be tracked from the ground by optical and radio telemetering devices.

As presently contemplated, the Vanguard, the first man-made satellite, will consist of three rocket stages plus the satellite itself. The first rocket will start the entire assembly vertically on the first part of its flight. When its fuel is exhausted, the first stage will drop off, and the second rocket, deflected from the vertical, will thrust the satellite upward. The third rocket carrying the satellite proper, will accelerate it to a top speed of about 18,000 miles an hour, which will establish the satellite in its

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orbit, where it will continue under its own momentum. This high velocity is required to balance the centrifugal force of the satellite against the earth's gravitational pull.

The satellite's orbit will be elliptical rather than circular, ranging from 800 miles away at its farthest point from the earth to approximately 200 miles distant at its nearest point. The satellite will continue to circle the earth for several days, making the round trip in from 60 to 120 minutes. The cumulative effect of the drag of the earth's atmosphere, thin though it is at altitudes of 200 miles or more, will be sufficient to alter the course of the satellite and make it gradually spiral in closer to the earth. The friction of the air as the satellite enters the denser atmosphere will cause it finally to disintegrate in much the fashion of a "shooting star."

Subsequent to the announcement of the United States regarding plans for the launching of a scientific satellite, the Soviet Union made a similar announcement indicating that it also intends to launch a satellite in line with the recommendations of the Rome meeting.

Other Program Activities

One of the outstanding results of the Rome meeting was the recognition that participating countries are now willing to extend their planned programs well beyond first estimates. This involved both the filling in of geographical gaps in station networks and the addition of basic programs in seismology and gravity in certain regions. Gap stations were of particular importance in the Antarctic. Here a number of additional station sites were recommended in order to achieve a station network which would provide comprehensive observational coverage of many geophysical phenomena in this region. Principal additional sites recommended on the Antarctic Continent included a location at the head of the Weddell Sea, one on the Astrid Coast, and one on the Knox Coast. Certain additional outlying island locations also were urged.

Seismic and gravity programs were recommended in areas where few observations have been made in the past, and which will be occupied during the International Geophysical Year. These include the Antarctic, subantarctic areas, and equatorial regions of the Atlantic and Pacific.

The seismic program in the Antarctic has two objectives: (1) Better control of the location of epicenters in the southern latitudes; and (2) measurements of ice thickness by seismic methods. Gravity observations, particularly those in the Antarctic where little data have been available,

will improve our knowledge of the figure of the earth in these regions and will thus improve the accuracy of maps.

The Rome meeting resulted in the initiation of a supplemental program on the part of the United States National Committee. This supplemental program deals primarily with those new projects and the additional stations in the Antarctic which had been suggested at Rome. Thus programs of gravity measurements and seismic studies are planned for the Antarctic and in certain mid-Atlantic and Pacific areas. Additional rocketry was also recommended, particularly in the Arctic and Antarctic regions. The high-altitude ceiling of weather-sounding balloons will be increased. Finally, the program includes plans for additional stations in the Antarctic to be located at gap locations on the continent.

Appropriations

Results of the Rome meeting were not available in time to be reflected in the 1956 appropriation, which amounted to $10 million. Since $2 million had been appropriated in 1955, total funds now available for the International Geophysical Year are $12 million. If the programs recommended by the United States National Committee on the basis of resolutions adopted at the Rome meeting are to be added to the United States effort, additional funds will be required.

An Office for the International Geophysical Year was established within the National Science Foundation in April, and on April 19th J. W. Joyce joined the staff of the Foundation to head this office.

Eighteen grants totaling $1,914,975 were made during fiscal year 1955 for services and equipment for the International Geophysical Year. They are listed in Appendix V, p. 155.

Synthetic Rubber Research and Development

On July 1, 1955, the National Science Foundation assumed responsibility from the Federal Facilities Corporation for administering the Federal program for basic research on synthetic rubber. This action involved transfer of title to certain government-owned buildings and facilities at Akron, Ohio, which had been used for rubber research and development. The Foundation continued for the time being the administration of basic research contracts with eight universities, the Burke Research Co., the Mellon Institute for Industrial Research, and the National Bureau of Standards. The Foundation also continued to contract with the University of Akron for the operation of the Government Laboratories in that city.

Our Government recognized at the beginning of the Federal synthetic rubber program that research would be a continuing and necessary part of the successful development of a synthetic rubber industry. The broad objective of such research, of course, was to make the United States potentially independent of natural rubber, most of which is produced in the eastern hemisphere. Although important economically, an independent source of rubber is even more important to national defense. Synthetic rubbers now being produced are for most uses equal or superior to natural rubber. However, a few uses remain for which satisfactory synthetics have not yet been developed. Results of the research program carried on over the past few years improved the quality of various types of synthetic rubber, widely extended the uses to which synthetics can be adapted and introduced many process improvements and production economies.

Many large private manufacturers of rubber and rubber products have established their own research and development programs. However, some of the specialized types of rubber designed for defense needs will be required in such small quantities that there is little profit incentive for research. This applies particularly to certain types of rubber needed by the Department of Defense for operations under extreme weather conditions of heat and cold. Research in such cases will undoubtedly continue under sponsorship by the Federal Government.

The Federal research and development program for synthetic rubber was originally established under the direction of the Office of Synthetic Rubber, a subsidiary agency of the Reconstruction Finance Corporation. When the RFC dissolved, the rubber program and facilities were transferred to the Federal Facilities Corporation, the receiver agency of the RFC. Under Public Law 205, 83d Congress, a Rubber Disposal Commission was established to make recommendations concerning the disposal of production plants and continuation of the research and development program. The Commission recommended that basic research related to synthetic rubber at universities, research institutes, and the operation of the Akron laboratory be continued at substantially its current level of operation for at least fiscal year 1956. It further recommended that the National Science Foundation undertake supervision and control of the continuing research program.

After preliminary review and evaluation of the research program, the National Science Foundation concluded that the basic research program in rubber fell within its general legislative directives in support of research. The Foundation also concluded that continuation of the work of the Akron laboratory, pending a full evaluation of its activities, was not inconsistent with the Foundation's charter. During fiscal year 1956, the Foundation plans a full evaluation of current basic research activities by a Special Commission directed to make recommendations regarding the future scale and scope of a Federal research program for synthetic rubber. The membership of the Special Commission for Rubber Research is given in Appendix I, p. 96.

During the 5-year period ending June 30, 1955, the average expenditure for contract rubber research at universities and other institutions was about $1,118,000 per year. Over this same period the average expenditure for the program at the Government laboratory at Akron was $1,094,000 per year. During fiscal 1956 the program, which will be supported by transfer of funds from the Federal Facilities Corporation to the Foundation, will be continued at a slightly reduced level. A list of current contracts carried on as part of the rubber research program is given in Appendix II, p. 125.

Indirect Costs of Research Supported by Federal Grant or Contract at Educational Institutions

The pattern of Federal support of scientific research at educational institutions, started on a large scale during World War II, seems destined to continue. Long range development of the Nation's scientific strength will depend, however, not only upon the availability of Federal funds for research but upon the success with which these funds can be administered without destroying the independence of participating institutions. The maintenance of an environment in which our colleges and universities may continue to flourish, free from undesirable controls and influences, is a matter of national concern.

Universities traditionally have carried on scientific research as a necessary part of their educational programs. In World War II, with its unprecedented national requirements for research, the Government found at these institutions the research facilities and manpower ready for immediate scientific mobilization, at relatively low cost—although cost was not a ruling consideration—and with minimal administrative problems. The colleges and universities for their part welcomed the opportunity to participate fully in the Nation's war effort.

During the post-war period the clear advantages of this cooperation between the Government and educational institutions have led to its retention. As might be expected, however, the change from a temporary to a permanent basis has led to a reappraisal of the long range implications of this arrangement by both the Government and the institutions. The Federal agencies supporting research for the successful accomplishment of their missions have been interested for the most part in the end product or results. The institutions have been interested in Federal research support as a means to pursue their function of investigating natural phenomena and to improve the extent and quality of their scientific teaching. In many cases the performance of research for the Government is viewed by the institutions as a public service.

Before the war universities undertook only that research in which members of the faculty were interested. To a large extent the project research supported by Federal agencies immediately after World War II did not seriously modify this pattern. For this reason, many university

administrators felt that to the extent they were able, institutions should participate in the cost of such research. The university contribution was made in a variety of ways—through payment of salaries of the tenured staff members working on the projects or through partial payment of normal service and overhead costs.

As the amount of Federally sponsored research has grown, however, the ability of most colleges and universities to share in its support has steadily diminished. In many institutions the point has been reached where further increase in the amount of research accepted on a participating basis will adversely affect the overall activities and programs of the institutions. It is in this context that Federal policies regarding payment or nonpayment of indirect costs become significant.

Indirect Costs

Indirect costs normally involve the following types of institutional expense: General administration and general expense, plant operations and maintenance, use and depreciation of buildings, use and depreciation of equipment, library costs, social security taxes, and in some cases retirement costs. That portion of the total expense of the institution in these areas which is considered as applying equally to instruction and research is then divided by the total salaries and wages paid for instruction and research. The resulting percentage, when applied to the salaries involved in a particular research project, allocates to that research its equitable share of the institution's indirect expenses.

Plant operation and maintenance usually represent the largest part of an institution's total indirect costs, followed by general administration and general expense. Usually these two items account for 65 to 75 percent of the total.

Experience has shown that indirect cost rates vary widely from institution to institution. To some extent this results from differences in accounting systems, but also to differing institutional policies as to salary scales paid, the extent of services rendered to students, faculty, and outside agencies. The size and nature of the physical plant, and similar factors, may also have a marked effect on the amount of indirect costs.

How Indirect Costs Have Been Met

During the war the Office of Scientific Research and Development and later the newly established Office of Naval Research attempted to negotiate indirect cost rates on individual projects with individual universities. As the Office of Naval Research program expanded this pro-

cedure proved unsatisfactory because of the endless amount of time consumed in negotiation and the problems of administering a variety of rates, often at the same institution. The Department of the Navy and the War Department solved the problem after a 2 years' study by establishing a formula whereby a single indirect cost rate could be determined for each institution. The principles and definitions of allowable costs, known as the "Blue Book," have been incorporated in summary form into section 15 of the Armed Services Procurement Regulations. At present they serve as the basis for determining direct and indirect costs on research and development contracts with colleges and universities by the three military services.

Since 1949, the Atomic Energy Commission has used similar methods for determining costs of research at institutions, although the Atomic Energy Commission does not reimburse the institution for all the costs connected with certain of its research contracts. The normal practice of the United States Public Health Service in awarding grants has been to include an allowance for indirect costs of up to 8 percent of the total amount of the grant. Recently the upper limit was raised to 15 percent. Other agencies arrived at indirect cost allowances by various methods depending upon the size of their programs and their authorizing legislation.

The question does not arise with the Department of Agriculture's statutory grants program since research funds are distributed by statute in proportion to the rural populations of the various States. The allowance for indirect costs in research contracts made by the Bureau of Standards, the Weather Bureau, the National Advisory Committee for Aeronautics, and certain other agencies is determined by negotiation.

Indirect Cost Studies by the National Science Foundation

Since its organization in 1951 the National Science Foundation has given careful study to the question of indirect costs for research supported at universities and colleges. As an interim measure the Foundation adopted the policy of paying up to 15 percent of total direct costs as an allowance toward indirect costs.

In September 1954, the Director of the Bureau of the Budget asked the Foundation to be prepared to make recommendations for a uniform Federal policy by the end of the fiscal year, June 1955. In arriving at recommendations the Foundation had the help of its Advisory Committee on Government-University Relationships, which included among its members scientists and research administrators from educational institutions, private foundations, and industry.

In presenting its recommendations, the Foundation pointed out that indirect costs for Government supported research cannot be expected to solve the critical financial problems now facing many of the Nation's institutions of higher education. On the other hand, the Foundation believes that the indirect cost policy adopted by the Government should not further complicate nor magnify such problems. It is to this end that the recommendation is addressed.

In view of these considerations the Foundation has made the following recommendation:

> The National Science Foundation recommends that in supporting research conducted in institutions of higher learning, agencies of the Federal Government, if requested, reimburse these institutions for those indirect costs of research supported.

There are, of course, many methods by which this policy might be implemented. After consideration of various alternatives, the Foundation suggested that the following recommendation might offer the most satisfactory and equitable way of policy implementation.

It recommended that:

(1) Each institution (a) request the determination of a rate in accordance with "Blue Book" principles or other equivalent methods, or (b) elect a flat rate not to exceed a maximum limit of 25 percent of salaries. Whichever option is chosen by the institution, all Federal agencies would be prepared to pay the same rate, if requested, for all research supported at the institution.

(2) At any time, an institution may request a rate determined in accordance with "Blue Book" principles to replace the flat rate, or vice versa. In the latter case, the flat rate may not exceed 25 percent of salaries or the rate determined in accordance with "Blue Book" principles.

(3) At all times the Government, to protect the public interest, reserves the right to determine a rate in accordance with "Blue Book" principles, where it becomes apparent that such a rate would be significantly lower than the flat rate.

(4) Exceptions to the general policy of a single institutional rate be made in special instances such as facility management, large scale construction, or similar enterprises. In such instances, a special rate for the specific enterprise involved may be appropriate and desirable.

The above recommendations presuppose an acceptance of the principles of cost determination set forth in the "Blue Book". Since it is generally agreed that these principles provide the best available method for determining the costs of research, both direct and indirect, at educational institutions the Foundation believes that the acceptance of these

principles offers the most practical means for implementing the recommended policy in the immediate future.

The recommended policy is not intended to preclude the possibility of cost-sharing on the part of the institution, nor the right of agencies to seek such an arrangement where deemed appropriate. It is expected that it would continue to occur in the manner and for the types of research suggested by the "Blue Book." The policy would, however, avoid mandatory participation in one particular type of cost as a feature of some Federal programs.

The financial impact of the recommended policy on the agencies is difficult to assess. Five agencies account for more than 98 percent of all funds expended on research and development contracts or grants at educational institutions. These are the Department of Defense, the Atomic Energy Commission, the United States Public Health Service, the Department of Agriculture, and the National Science Foundation. Of these, only the United States Public Health Service and the National Science Foundation would find that the proposed recommendation would add significantly to their payments for indirect costs. Estimates based on fiscal 1956 appropriations for research and development indicate that uniform adoption of the proposed policy would increase research costs of Federal agencies by no more than $8 million. This amount would represent about 2.3 percent of the total now spent by Federal agencies for research in educational institutions.