NATIONAL SCIENCE FOUNDATION

Program Activities

of the

National Science Foundation

SUPPORT OF BASIC RESEARCH IN THE SCIENCES

Research Programs

In fiscal year 1959, support for basic research programs increased two and a half times from approximately $25 million in 1958 to almost $65 million. Responsibility for these Foundation programs lies with the Division of Biological and Medical Sciences; the Division of Mathematical, Physical, and Engineering Sciences; the Office of Social Sciences; and, in the case of Antarctic research, with the Office of Special International Programs. Projects described here in brief are to be considered illustrative of the research being supported.

DIVISION OF BIOLOGICAL AND MEDICAL SCIENCES

Current Research Support

The *Developmental Biology* program supported projects on the structure and physiology of reproductive organs; the physiology of reproductive cells and fertilization; the mechanism of cell division; descriptive embryology (plant and animal); plant morphogenesis (apical activity of roots and shoots, stem elongation, genesis and control of plant form); chemistry of development (molecular basis of differentiation, metabolic patterns during development, chemical induction of new structures, and growth-stimulating substances); regeneration of lost parts; development genetics (analysis of mutant gene effects in development); tissue and organ culture (plant and animal); histology; cytochemistry; fine structure of plant and animal tissues as revealed through electron microscopy; gross and microscopic plant and animal anatomy; and cell and tissue changes in old age.

The program in *Environmental Biology* provided grants for research in plant and animal ecology; ecological physiology; paleoecology; various projects in parasitology; biological oceanography; animal behavior and other areas in which the major immediate emphasis concerned the interrelationships between physical, biological, or sociological factors and one or more organisms. In addition, support was given for the purchase of specialized equipment, and for the design and development of research equipment. The distribution of grants changed somewhat in fiscal year 1959 with studies of the dynamics and structure of animal populations, biological oceanography, life history investigations, and projects involving quantitative community ecology comprising nearly half of the grants made. The remainder were rather evenly distributed in number in the general areas of plant and animal physiological ecology, vegetation development, paleoecology, behavioral studies, productivity analyses, limnology, various aspects of mycology and parasitology, and microclimatology.

The *Genetic Biology* program continued to support research directed toward elucidating the nature—both structurally and chemically—of genetic material, the laws governing the transmission of hereditary traits from one generation to another, and the mechanisms by which genetic material controls and determines the expression of hereditary characters. Within this framework, grants made by the program supported studies on cytogenetics; genetic fine structure and gene action; investigations of evolutionary mechanisms; quantitative and population genetics; and the genetics of specific traits. Experimental approaches to the problems include cytogenetic and recombinational analyses; breeding and selection experiments; and biophysical, biochemical, and mathematical methods. Much of the genetic program research was directed, at the molecular and cellular level, toward the fundamental problems of defining the gene and elucidating the mechanisms by which it acts, reduplicates, and mutates.

Since the inception of the *Metabolic Biology* program 2 years ago, there has been considerable clarification of the content of the program; grants made during the past year have dealt almost exclusively with intermediary metabolism, and comprise an area concerned with metabolic pathways and the interrelationships between enzyme reactions and metabolic pools. The areas of investigation ranged from the mechanism of protein synthesis and growth to specific metabolic factors which inhibit growth. Within this wide area were problems dealing with nearly all metabolic processes of animal and plant tissues; mechanisms of cellular respiration; and effects of hormones and inorganic ions on the metabolism of plants and animals. A number of grants dealt with various phases of photosynthesis and the mechanism of action of antibiotics.

Grants made by the *Molecular Biology* program encompassed studies of the physical and chemical properties of substances of biological origin; studies of RNA- and DNA-type macromolecules and of individual enzymes—isolation, purification, synthesis, reactivity, kinetics, and mechanisms of action; and aspects of physical and quantitative biology, such as molecular genetics, molecular morphology, virus structure and organization, membrane and bioelectric phenomena, model systems, photobiology, and bioenergetics. The research supported showed a continuing and relatively large effort in investigating peptide and protein structure, synthesis, and reactivity. There has been a relatively large increase in research dealing with virus structure and organization, primary light and energy processes, membrane phenomena, and the organization and replication of RNA and DNA. Fiscal year 1959 grants also showed a marked increase in research on immunochemistry, molecular genetics, molecular morphology, bioenergetics, and investigations into the active sites on enzyme molecules. Nuclear and electron spin resonance technology is becoming more prominent in biological research; several grants were made this year whereby instruments were purchased or adapted to biological problems.

Grants awarded in the *Psychobiology* program continued to stress physiological and experimental psychology, with some emphasis upon the support of quantitative techniques as these develop from the fields of mathematics and mathematical statistics. Support was provided for research dealing with sensory processes, learning, problem-solving behavior, and the relationship between brain mechanisms and behavior. During the past year an increasing number of grants were made for the field study of animal behavior, reflecting the growing attention to ethology. For example, research is being carried out dealing with the behavior of the African mountain gorilla, the exact territorial pattern of behavior of the kob (an African antelope), and the behavior of the howler monkey in Panama—the only isolated and protected primate population which has been studied systematically.

The *Regulatory Biology* program deals with interactions between organisms such as host-parasite interrelations, integrative responses to external stimuli, and with processes originating within plants and animals which involve regulatory functions of organs and cells. Grants during 1959 were awarded for studies on synthetic media, various biological rhythmic processes, hormone interrelationships, physiological adaptations and specializations leading to evolutionary change, orientation to polarized light and other external stimuli, interactions between the hypothalamus and pituitary, control of red blood cell formation, immune reactions, etc. About one-third of the grants support investigations on plants. The remainder is about evenly divided between three categories consisting of invertebrates, vertebrates other than mammals, and, finally, various aspects of mammalian physiology.

The majority of research grants in the *Systematic Biology* program were for the support of monographic or revisional studies on particular groups of organisms or for systematic studies on specified faunas or floras. Some were made in support of large-scale biological explorations in little-known areas, such as the Sixth Archbold Expedition for Biological Exploration in New Guinea and the Plant Survey of the Guiana Region of South America. Other biologists were given support for collecting in all continents, but with more limited objectives. Grants made by this program are playing a vital role in the resurgence of systematic biology. Although funds have been limited, grant support has contributed, among other things, to the stability of going research programs and to the innovation of many new ones throughout the broad spectrum of organisms, both living and fossil; to the collection, preparation, and study of new collections, often from the outermost corners of the globe; to the preparation and publication of the results of research, which in this field often means monographic reports; and to the improvement of the large research collections that must be classed as part of our national scientific heritage.

Proposals of a *general* nature which cut across several program areas continued to be handled by the Division through a special category. This scheme has proven to be a useful one in that it insures that the division has the necessary flexibility to handle proposals which otherwise do not fit into individual relatively circumscribed program areas. The range of such proposals in fiscal year 1959 varied greatly and included, for example, the support of several projects in biometrics; grants for the support of stocks of important biological material; support of the Mobile Desert Laboratory at the California Institute of Technology; and a variety of research equipment grants for the use of groups of scientists working in "coherent areas" of biological research.

Facilities for Research in the Biological and Medical Sciences

During the past year, the scope of facilities support remained limited to specialized biological facilities. These are generally facilities which are unique either in program or in location, not found in the usual university or college departments covering the life sciences. Included are such facilities as marine and field stations, systematic biology museums which house collections of various life forms, and controlled-environment laboratories.

In fiscal year 1959, 17 grants totaling $3,269,800 were made. A grant went to the University of Wisconsin for the construction of the first "biotron"—a laboratory for the study of both animal and plant growth and development under controlled-environment conditions. Climatic variables which will be controlled include temperature, humidity, light intensity, and air movement. The biotron should approach the status of a national or regional laboratory, with access being provided to competent investigators from other institutions. Support was also provided for renovation of the phytotron (similar to the biotron, but limited to plant studies) at the California Institute of Technology.

Among the grants was one to the Woods Hole Oceanographic Institute which will permit greater use of oceanographic vessels for the conduct of basic biological investigations; to the Jackson Memorial Laboratory for the construction and equipping of an addition to the main laboratory building; to Duke University and to the University of Florida for construction of laboratory buildings at their marine laboratories.

Support was provided for rehabilitation of systematic biology facilities at the Bishop Museum of Hawaii, which houses some of the leading collections of Pacific area life forms; also for major repairs and modernization of buildings at the Long Island Biological Laboratory, a major center of genetics research.

To round out the picture of the kind of facilities supported during 1959, it might be well to mention a grant to the University of California for support of basic research facilities at the White Mountain Research Station where high-altitude physiological research is conducted, another to the University of Chicago for the construction of a laboratory to permit study of the comparative behavior of animals, and finally the one to the University of Missouri for the construction of an animal calorimeter for determining heat losses.

DIVISION OF MATHEMATICAL, PHYSICAL, AND ENGINEERING SCIENCES

Current Research Support

An expansion in basic research potential in astronomy has occurred since World War II that promises to make possible a vast number of important discoveries within the next 10 years. This may be credited almost entirely to the development of radically new types of instrumentation, as well as to the greatly increased financial support currently available to the astronomical community for the purpose of developing and purchasing these instruments. Considerable support provided by the *Astronomy* program is being devoted to research leading to instrumentation developments in order to increase the range of spectral sensitivity of astronomical observing equipment, the overall sensitivity of the equipment to weak sources, and the resolving power (i.e., the ability of the equipment to record as separate sources two or more individual objects, such as markings on the surface of the moon and planets). Astronomy is also being revolutionized by the availability of new high-altitude platforms for telescopes. Balloons are already being successfully used, and space vehicles will soon permit observations from beyond the earth's atmosphere.

A new program for *Atmospheric Sciences* was established in July 1958 to meet growing interests in scientific studies of the atmospheric environment. The global observational programs of the IGY added much emphasis, as did the scientists' recent successes in sending aloft space satellites and increasing precipitation through modern weather modification. This new program deals with research in meteorology, upper atmosphere studies, cloud physics, and the energy transfer processes between earth, sea, and air. To meet the most critical need for orderly progress in atmospheric sciences, a threshold of long-term, stable support for basic research and the provision of adequate research tools and facility needs have been the major objectives during the first year.

The weather modification program is handled as part of the Atmospheric Sciences research support program. It was established under Public Law 85–510, which directs the Foundation to ". . . . initiate and support a program of study, research, and evaluation in the field of weather modification." A full range of laboratory and field experimental work is already being supported, together with the study and improvement of the physical and statistical evaluation methods employed in determining the results of any seeding operation. The program has the objective of studying more intensively than has been attempted before the scientific basis of weather modification.

In the *Chemistry* program grants were made principally in the areas of organic and physical chemistry. Support for organic chemistry during 1959 provided for studies of solvolysis reactions, small ring compounds and polycyclic systems of theoretical interest, structure and total synthesis of natural products, transannular reactions, molecular rearrangements, and the chemistry of divalent carbon. In physical chemistry support was provided primarily for investigations of spectroscopic methods such as nuclear magnetic resonance, electron paramagnetic resonance, and infrared spectroscopy; kinetics and mechanisms of reactions; thermodynamic properties of molecules; and quantum mechanical calculations of molecular structure. Research was also supported in inorganic chemistry on boron compounds, the transition elements, and the properties of optically active complex inorganic compounds; in analytical chemistry, on polarography, gas chromatography, and on chelating agents.

A shift in emphasis in the *Earth Sciences* program has resulted in greater support for oceanography, so that a more significant fraction of the scientific programs of oceanographic institutions might be free of pressure for immediate practical results. As in the past, the program has also been concerned with geophysics, geochemistry, and geology. These areas commonly overlap both with the life and other physical sciences—geochemistry with chemistry, geophysics with classical physics, paleoecology with environmental biology, geology with engineering sciences, paleontology with systematic biology. During the year interest has noticeably increased in seismology and crustal studies, based on the need for more information about the crust and mantle of the earth.

The *Engineering Sciences* program, recognizing the broad responsibilities of the engineering profession, recommends for support research which should provide either new knowledge concerning basic physical properties, or generalizations that reflect better understanding or more realistic predictions of the behavior of systems. If engineering sciences grants are identified by scientific fields, most of the research effort is in transfer and rate mechanisms, fluid mechanics, the properties of materials, and the mechanics of solids. During this year two grants were made in the increasingly significant field of plasma dynamics. They are somewhat unique in that they involve the interdisciplinary efforts of highly trained investigators in the sciences of aerodynamics, thermodynamics, electrodynamics, chemistry, atomic and molecular physics, and applied mathematics. Another grant which will coordinate activities of engineers, physicists, and chemists is in the field of magnetic resonance research.

The *Mathematical Sciences* program has continued its support of all areas of theoretical mathematics. Emphasis tends to mirror the patterns of interest of the mathematical community, which in turn usually correspond with the fields in which most significant progress is being made. Thus, algebraic topology is an area which is flourishing, and is attracting increasing efforts on the part of research mathematicians. Among other areas in which substantial results are being achieved, one might note a renewed activity in differential geometry and the theory of finite groups.

The *Physics* program has continued to place major emphasis on high-energy physics, particularly cosmic rays. More emphasis than in previous years has also centered on low-temperature research, such as that exploring the dynamics of liquid helium. A noticeable trend upward is also apparent in theoretical physics and in solid state research. There has been an increase in cooperative research in high-energy physics in which unique facilities, such as the cosmotron at Brookhaven and the bevatron at Berkeley, are used by research workers from other institutions. In this program the visiting scientist spends a few days or weeks taking extensive photographs of phenomena of interest to him, and then making the measurements and calculations in a more leisurely manner back at his own institution. This spreading of the usefulness of the high-energy machines among institutions otherwise cut off from active fields of research tends to unify the field of experimental nuclear physics. Fundamental to the success of this type of research are means for reducing the records to a form suitable for input to the high-speed calculating machines now available.

The National Observatories

1. *The National Radio Astronomy Observatory.*—After years of planning and construction, many of the facilities of the Observatory are approaching completion or are actually in operation. The smaller of the two principal instruments, an 85-foot radio telescope, went into part-time operation during March 1959 and into full operation a few months later. This instrument is named after a man who was a principal contributor to its design, the late Dr. Howard E. Tatel. Constructed by the Blaw-Knox Co., the precision of the parabolic surfaces is such as to permit its use at radio wavelengths as short as 3 cm. The feed of the instrument is of an unusually advanced design that provides three distinct elements capable of receiving information simultaneously on 3.75 cm., 21 cm., and 68 cm. This arrangement permits the telescope to operate with a productivity equivalent to that of three 85-foot telescopes equipped with more conventional feeds. Receivers of the greatest possible sensitivity are being provided or planned for. Several important research projects have already been carried out by the staff and visiting astronomers, and many more are planned. (See p. 46.)

The larger of the two steerable telescopes planned for the Observatory is a 140-foot dish. Construction of this instrument is well advanced, the concrete pier having been completed, as well as some of the moving parts. It seems reasonable to hope that this instrument will be in full operation during the calendar year 1961, despite the fact that the plans require that the 2,000-ton, 140-foot dish retain its shape in all operating positions to within a few millimeters.

Other facilities at the site of the Observatory at Green Bank, W. Va., include an office-laboratory building, a residence hall, and a maintenance building. All of these will be in operation by the end of October 1959. The facilities and staff, which now numbers 40 people, have been carefully selected to provide the finest in research opportunities for all qualified U.S. scientists desiring to do research in the area of radio astronomy.

2. *The Kitt Peak National Observatory.*—Construction of the Kitt Peak National Observatory was started in 1959. It will have two major telescopes for observing the stars: a 36-inch reflector scheduled for operation during the fiscal year 1960, and an 84-inch reflector to be completed in 1961 or 1962. Although not the world's largest, nor of

radically new design, these instruments will incorporate all of the advanced techniques of recent years in order that observations of extremely faint stars can be made.

The Observatory's solar telescope, however, is intended to be the largest in the world. It will have a parabolic mirror 60 inches in diameter with a focal length of 300 feet, which will form a solar image several times larger and more brightly illuminated (per square second of arc) than is attainable with any other ground-based instrument.

The conversion of an undeveloped mountain top on an Indian reservation into a modern astronomical observatory that will rank among the world's foremost is a formidable task. In addition to telescopes, buildings, onsite roads, and utilities on the mountain, a city laboratory building is being constructed in Tucson. This building, adjacent to the University of Arizona campus, with instrument shops and offices, will provide a base station for the resident staff and visiting astronomers. It is anticipated that most of these supporting facilities will be completed and occupied during the fiscal year 1960. A permanent paved access road is being constructed from the base of Kitt Peak to the Observatory, but will probably not be completed until a later date.

Long-range plans for the Kitt Peak National Observatory have envisioned the eventual installation on the mountain of a very large reflecting telescope with an aperture of perhaps several hundred inches. However, with the sudden dawning of the space age, these plans have been placed in abeyance in favor of a new and exciting project, namely, the design, construction, and operation of a large, orbital (satellite) optical telescope. It seems appropriate that this project should be undertaken at Kitt Peak under the management of the Association of Universities for Research in Astronomy, Inc., because the magnitude of the effort would tax the resources of a single university very heavily. This program looks beyond the specialized, smaller orbital telescopes now being planned at several other observatories. The Kitt Peak space telescope would be an accurately pointable instrument of high resolving power which can make observations on command from the ground and communicate them back to the earth. This is definitely a long-range project; it may be many years before such a sophisticated, fully operable telescope can be placed in orbit. At present an aperture of about 50 inches is being considered. It would be most desirable to place the instrument into a 24-hour orbit, i.e. at an altitude of about 22,000 miles above the surface of the earth, in order to keep it in view of the ground station at all times. It is hoped that this telescope may eventually form a part of the total instrumentation of the Observatory and be available, as are the other telescopes, to all qualified U.S. astronomers. The ultimate cost will probably be very large, and close liaison with other U.S. Government agencies, particularly the National Aeronautics and Space Administration, will be maintained during all phases of the project.

Facilities for Research in the Mathematical, Physical, and Engineering Sciences

Support provided for facilities in the mathematical, physical, and engineering sciences totaled $12.3 million in fiscal year 1959, including the national observatories described above.

As in the last few years, the largest portion of facilities money went for support of the two national astronomical observatories. The National Radio Astronomy Observatory at Green Bank, W. Va., received $4,350,000 in 1959 which makes a total since 1957 of $9.5 million. The Kitt Peak National Observatory received $4,405,000 during the year, bringing the amount spent for this observatory up to approximately $7.5 million.

Grants for research reactors were four in number totaling $2 million, and were made to Texas A. & M. College, Georgia Institute of Technology, University of Buffalo, and Cornell University. In 1959, assistance to the amount of $1.5 million for the establishment of computing centers was given to the following institutions: North Carolina, Oklahoma, Yale, Iowa State, and Cornell.

OFFICE OF SOCIAL SCIENCES

During fiscal year 1959, the Foundation established an Office of Social Sciences to support research and related activities in basic social science disciplines. This Office replaces the previous Social Science Research Program and represents a further step in the development of Foundation activities in the area. It is clear that the intellectual, economic, and social strength of our Nation requires a vigorous approach to social problems, with scientific techniques of study making their maximum contribution. The Foundation, in supporting basic scientific research in the social sciences, endeavors to assist social scientists to improve their research techniques, to accumulate fundamental knowledge about human behavior and society, and to develop sound theoretical bases for further inquiry. Support of basic social science research within the framework of the National Science Foundation stimulates interchange between natural and social scientists and will undergird any effort on the part of others to deal with social problems and public policy.

The *Anthropological Sciences* program includes basic research in archeology, physical and cultural anthropology, linguistics, and related fields. Grants made in fiscal year 1959 include support for the study of the ethnography of little understood cultures, such as the Seminole of Florida, the Nyaturu of Kenya, and the Ibo of Nigeria. Such field research adds to our knowledge of the varieties of human culture and the processes of sociocultural change. Some of the archeological projects are concerned with investigation of new and improved dating processes, such as beach-ridge dating and obsidian-hydration dating. An expedition to the Middle East will investigate the paleoecological aspects of the beginnings of food production. Projects in linguistics include the application of statistical methods to problems of historic linguistic reconstruction and a study of paralanguage among the Taos. A grant has been made to two cryptologists to enable them to apply modern techniques of cryptoanalysis and structural linguistics to the still unsolved puzzle of Mayan hieroglyphics.

The *Sociological Sciences* program has been active in support of laboratory studies of individual choice behavior which are directed to increasing our knowledge of how individuals make decisions in the face of incomplete information and uncertain outcomes. Techniques for the measurement of attitudes and investigation of the dynamics of attitude formation and change are other areas in which experimental research is being supported, including studies of how resistance to attitude change is built up, and of the nature and extent of changes in attitude which follow the receipt of items of information that disagree with previously held beliefs. The increased use of mathematical concepts and techniques in the sociological sciences is evidenced by grants for the construction and testing of probability models for conformity behavior and for experimental simulation of social processes on electronic computers.

The core of the *Economic Sciences* program has been mathematical economics, and grants have been made for econometric studies of parameter estimates, resource allocation, and time-series analysis. In addition, grants of interest and importance to basic economic theory, which are not econometric in technique, have been made in 1959. Among these are studies of international economic transactions, investigations of economic behavior at the level of the individual consuming household, and research into the economic aspects of technological inventions.

The *History and Philosophy of Science* program provided support for research in the history of metallurgy, studies of early American naturalists, and investigations of the development of mathematical proportionality. Research in the philosophy of science covered grants for studies on inductive probability, the philosophy of fundamental physical theory, and the foundations of measurement.

OFFICE OF SPECIAL INTERNATIONAL PROGRAMS
ANTARCTIC RESEARCH PROGRAM

Current Research Support

Unlike the programs previously discussed which are organized by scientific discipline, the *Antarctic Research* program is supported on a geographical basis and covers many disciplines.

Investigations underway include the following: observations and measurements of aurora and airglow at each of the Antarctic stations; studies in the biological and medical sciences, including bacteriology, marine fishes, bird migration, psychology, and transmission of disease in isolated communities; geomagnetic observations made at each of the stations; glaciological studies, including snow accumulation, movement of glaciers, thickness of the icecap, and chronological banding in the ice; studies in ionospheric physics at many of the stations by probing the ionosphere with radio transmitters and recording of special radio signals; the collection of meteorological data at all stations and on the traverses, with additional data from balloon-carried radiosondes; oceanographic research carried out at each of the shoreline stations and from the Navy supply ships in the Antarctic; seismology investigations, including station studies with permanent seismographs to record and measure earthquake waves, and traverse seismology in which artificial vibrations are used to study ice thickness and subsurface geology.

An expanded program of research in the same disciplines as the above, with the additions of studies in geodesy and cartography, cosmic rays, gravity, and geology, will be conducted by the next team of scientists going to the Antarctic in the fall of 1959.

(A description of the organization of the Antarctic Research Program can be found under "Special International Programs.")

Significant Research Developments

STRATOSCOPE INSTRUMENTATION MAKES POSSIBLE HISTORIC SUNSPOT PHOTOS.—The Stratoscope I 12-inch balloon-borne solar telescope project supported by NSF made three successful flights from Lake Elmo, Minn., during the summer of 1959, obtaining a great many of the clearest photographs ever obtained of the sun's surface, in time sequence. The photos show details of the umbra and penumbra (center and surrounding magnetic areas) of sunspots, including a large group that seriously interrupted radio communications in August, as well as of the polygonal convection cells elsewhere on the sun's surface. (See p. 27.)

These flights marked the first successful control from the ground of an astronomical instrument in space, for the aiming and focusing of the telescope was accomplished by remote control from a trailer van stationed beneath a point in the estimated trajectory of the balloon. The field of view of the telescope was continuously monitored on the ground by a closed-circuit television system. It is expected that many of the techniques developed in connection with this project will find application in other models of space instruments, both balloon borne and satellite borne.

During the flights the telescope remained at an altitude of over 15 miles for the period its camera operated, then was parachuted to earth. Purpose of sending the telescope up in a balloon was to get it above the earth's atmosphere, which prevents clear visibility of celestial objects. At its height of 80,000 feet, Stratoscope I was above about 98 percent of the earth's atmosphere.

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RESOLUTION OF FINE STRUCTURE OF GALACTIC NUCLEUS.—The source of radio emission known as Sagittarius A is one of the most intense in the whole sky. Lying very nearly in the center of our galaxy (200 million billion miles from the earth), many radio astronomers have believed it to be the nucleus of the Milky Way. It is used as the zero from which galactic longitude is measured in the newly adopted system of galactic coordinates.

An investigator working at NSF's National Radio Astronomy Observatory at Green Bank, W. Va., successfully used the new 85-foot Tatel radio telescope to resolve Sagittarius A into at least four component parts. One of the first results obtained with this telescope, this finding indicates that parts of the source may not be located at the center of the galaxy; as a result, a considerable revision in ideas of the physical structure of the galactic center might be necessary. Whether one of the observed components is the nucleus and the components are subordinate to it, or whether all the components taken together make up the galactic nucleus, must now be answered.

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THE NEWLY DISCOVERED ENERGY GAP AND SUPERCONDUCTIVITY.—The explanation of superconductivity, the vanishing of electrical resistance in certain materials near absolute zero, has been a major unsolved problem in theoretical physics for the past half century. Recently, however, a new theory of superconductivity has been proposed which in explaining this phenomenon suggests the existence of an "energy gap" of a definite magnitude in the electronic excitation spectrum of the superconductor. Measurements of the transmission of submillimeter radiation through thin superconducting films and measurements of the reflection of this radiation from bulk superconductors have helped verify the predictions of this theory. Indeed, by very ingenious experiments using this latter technique in the far infrared, NSF grantees have provided the most direct demonstration to date of the existence of this energy gap.

During the same period another NSF grantee has measured very accurately the specific heat of certain metals in the superconducting state to test experimentally still another aspect of this new theory which predicts the behavior of the electronic specific heat contribution. This work has provided additional verification of the existence of this energy gap.

These two experiments taken together comprise a major advance in our understanding of the phenomenon of nonresistant flow of electrical current.

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GENE STRUCTURE CORRELATED WITH PROTEIN SYNTHESIS.—Much research in genetics today is oriented toward solving the important problem of how genes act to control the metabolic (chemical) activities of cells. Specific chemical reactions in the cell are controlled by specific protein molecules known as enzymes, the synthesis of which is controlled in turn by genes that are thought to determine the exact sequence of the many subunits (amino acids) in the protein molecules.

A genetic system is being investigated which may lead us closer to an ultimate understanding of the relationship between the fine structure of genes and the chemistry of the cell. A map has been constructed for a series of changes (mutations) within the particular gene that controls the production of the specific enzyme responsible for the synthesis of the amino acid, tryptophan, in the bacterium *Escherichia coli.* Mutations at any point within this gene may cause loss of some or all of the enzyme activity. In some cases, even though much of the specific enzyme activity is lost, an altered protein can be detected by immunological techniques; in other cases, no related protein of any kind is formed. In either case, it is possible to produce reverse mutations in the gene, so that the enzyme activity and other characteristics of the normal protein are fully or partially restored. Thus, the investigators now have a series of proteins, including the original active protein, more-or-less enzymatically inactive altered proteins produced by mutated genes, and altered proteins whose activity has been partially or fully restored by reverse mutation. They are now determining the amino acid sequence in each of these kinds of proteins, and they hope to correlate differences in amino-acid sequence both with changes in the enzymatic activity of the protein and with the position of the mutation sites in the gene.

With such a knowledge of the fine structure of the gene, the enzyme whose production it controls, and the chemistry of the cell, it should eventually be possible to repair hereditary defects in cellular metabolism by deliberately changing the gene itself or by externally controlling the synthesis of its products.

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BIOLOGICAL CLOCKS.—An apparently universal characteristic of living organisms is the ability to orient themselves in space and time by mechnisms best described as "biological clocks," in much the same manner as manmade systems.

Amphipods (sand fleas), for example, possess biological clocks which respond to the elevation of the sun, from which they get the cues initiating their vertical migrations. There is other evidence indicating that certain animal forms have multiple rhythms interacting with each other simultaneously in different frequencies so that rhythm mixing results in new cycles. Some of these clocks are triggered by temperature stimuli, while others may be linked to different environmental cues, such as light stimulation or moisture stimulation. It is obvious then that highly timed stimuli apparently can be stored in organisms at primitive levels, although we are relatively ignorant of the evolution of such systems within organisms from lower to higher level and from general modalities to highly discriminating sensory organs within any one organism.

A hypothesis developed by a Foundation-supported investigator assumes that all organisms are capable of time measurement in that their "clocks" have a common and ancient basic mechanism. This basic element is an oscillatory system with a natural period evolved to match, approximately, the earth's rotation, its annual circling of the sun, and interacting with the revolution of our moon around the earth. As an example, one of the best known biological rhythms is that of the daily period periodicity of the onset of running activity in small rodents. An analysis of this periodic system has shown that the hamster "clock" has an error that does not exceed 2 minutes in 24 hours in its activity pattern. Within limits such patterns of activity may be modified within various organisms by appropriate techniques, but it has also been demonstrated that there are limits within which these systems may be violated without causing great stress and eventual death to the organisms involved.

Potentially important contributions to the development of man-machine systems may be derived from investigations of orientation components and systems in organisms. Various flying, terrestrial, and aquatic animals exhibit unique abilities of sensing, direction finding, time discrimination, and integration of information over time, directly relevant to the attainment of analogous objectives in the field of bioastronautics. These organisms possess the abilities to filter information, detect and identify targets, discriminate faint signals from noise, navigate considerable distances on coordinates not yet identified, and intercept moving targets by methods which demand continued investigations.

One example of a compact and efficient navigational system is the vocal and auditory apparatus of a bat. Although it weighs less than 1 gram, this system orients flight maneuvers in darkness, discriminates faint echoes from minute moving targets from louder noise in the same frequency band, and guides the interception of individual flying insects at rates up to one every second. Still more compact sensory and integrating mechanisms for detecting and filtering chemical, optical, and mechanical signals are to be found in insects. Complex patterns of sensory input are analyzed within a fraction of a second, and the output of a few milligrams of nervous tissue results in a definitive decision and appropriate action. Even the smallest and simplest of these mechanisms is capable of recognizing patterns of sensory input rather than merely responding when some threshold intensity is reached.

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MECHANISM OF ACTION OF THYROID GLAND CONTROL OF METAMORPHOSIS OF TADPOLE TO ADULT AMPHIBIAN.—The iodine-containing hormone (thyroxine) produced by the thyroid gland has long been known to exercise a vital role in the regulation of developmental processes. For example, a deficiency of thyroxine results in cretinism—a form of idiocy in humans.

In amphibians, the complex metamorphic changes which transform the fishlike tadpole into the adult land form are subject to thyroid regulation. Among the changes involved are resorption of gills and tail, development of limbs, and numerous other transformations involving jaws, teeth, skin, brain, and behavior. Tadpoles, in which the thyroid is rendered inactive by the removal of the pituitary gland, do not undergo metamorphosis. By rearing such tadpoles in solutions of thyroxine of graded concentrations, an investigator has discovered that specific metamorphic changes are triggered by particular concentrations of the hormone. Another experimental series, involving substances identical to the basic portion of the molecular structure but differing in the chemical composition of the reacting groups (analogs), indicated that various compounds had different levels of activity and sites of action in addition to the effects of quantities of thyroxine. It seems that the qualitative nature of the chemical molecule of the thyroid hormone can selectively regulate specific developmental events.

The transforming tadpole may be viewed as a complex mosaic of parts, many of which are responsive to thyroid hormones. The nature of the response depends not only upon the part in question, but also upon the hormone concentration, and perhaps upon the relative proportion of the different molecular forms of the hormone. Alteration of one or more of the normal factors can produce an abnormal sequence of developmental events.

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DEPTH PERCEPTION OF HUMAN INFANTS WELL DEVELOPED BY TIME LOCOMOTION IS POSSIBLE.—A new technique of testing for visual depth perception is being used to shed some light upon an age-old controversy about native and learned factors in the perception of distance. Does a baby learn through experience to avoid falling over a vertical edge, or is this ability to discriminate distance an inborn one? A "visual cliff" apparatus has been developed to study this problem. (See photo on p. 24.) The child is placed on a board which spans a large fenced-in sheet of glass. On one side of the center board a textured linoleum surface is laid directly under the glass (the "near" side); on the other side, a matching linoleum surface is laid 3½ feet below the glass (the "far" side). The cues to safe descent are exclusively visual; tactual, olfactory, or auditory cues are the same on both sides of the center board. The investigators find that by the time locomotion is possible, the crawling child shows a very strong preference for the "near" side, avoiding what appears to be a sharp dropoff. The same avoidance of an apparent dropoff has also been observed in very young rats, goats, and chickens. It appears even in rats that have been dark reared until 20 minutes prior to testing. Depth appears to be discriminated on the basis of visual stimulation, even when chances for previous learning are minimal.

* * *

TEST TUBE PRODUCTION OF HEMOGLOBIN IDENTIFIES CELL PARTICULATE WHICH SYNTHESIZES PROTEINS.—Cell particulates called microsomes are known to play a major role in protein synthesis. Only now with the successful synthesis of a specific protein—hemoglobin, the oxygen-carrying protein in the red blood cells—outside the living cell is their role being more fully understood.

Microsomes were extracted from the red blood cells of the rabbit and mixed with two enzymes from the same type cell, energy-yielding phosphate compounds, and a complete mixture of amino acids. Three of the amino acids were labeled with radioactive carbon atoms. After incubation, it was found that hemoglobin was produced containing the labeled amino acids in the same ratio as that occurring in the natural rabbit hemoglobin.

The red blood cell microsomal protein contains two of the three amino acids which were labeled before being added to the mixture, but in a different ratio than that in rabbit hemoglobin. The ratio in the synthesis product was that of hemoglobin, thus showing that the microsomes were making hemoglobin and not microsomal protein.

The microsomes are essential to the experiment. Without them no labeled amino acids were taken up. The microsome must therefore perform the role of a jig or template for the manufacture of specific protein molecules.

* * *

HORMONE SYNTHESIS RESULTS IN LARGEST MANMADE PROTEIN MOLECULE.—A pituitary hormone that is the largest polypeptide (protein) molecule yet produced in the laboratory has been successfully synthesized. The molecule consists of 13 amino acids linked in a specific sequence fairly similar to ACTH in structure. This hormone stimulates the melanocyte cells, which produce a skin coloring pigment. The hormone may prove useful in treating albinism.

The particular significance of this synthesis is that it can be used to study the relationship of chemical structure to biological activity. It has been determined that relatively small fragments of the hormone, containing key amino acid sequences, may possess the ability to perform the functions of the complete hormone when large enough levels are used. Whether or not these fragments are capable of sustaining all of the biological functions of the intact hormone remains to be established.

* * *

CATALYST BLOOD FACTOR IDENTIFIED THAT TRANSFORMS SOLUBLE FIBRIN INTO THE INSOLUBLE FORM (BLOOD CLOT).—A catalytic factor has been obtained from blood which apparently occurs as a complex with fibrinogen and has the ability to transform 1,000 to 10,000 times its own weight of soluble fibrin into the insoluble form. For the first time it is now possible to study blood clotting at the molecular level and perhaps minimize the trauma of surgery and accelerate wound healing.

The blood-clotting process is believed to occur in the following manner. Fibrinogen, a complex polypeptide, is split by thrombin; a peptide bond-breaking catalyst, to small units called fibrin monomers. These monomers polymerize into chains. After a high degree of polymerization has been achieved, the chains are cross-linked forming a blood clot. If the cross-linkages occur in the presence of calcium ions and the previously mentioned catalytic factor, the linkage is very strong and the clot is quite resistant to dissolution.

* * *

METHOD DEVELOPED FOR GROWING WINTER GRAINS IN TROPICS IN A THIRD OF USUAL TIME.—Winter rye has been grown which produces grain without cold temperatures and in one-third of usual time. Grain is normally produced by winter rye in eight months, including a cold spell of 6 to 8 weeks. With the use of a newly developed technique, it now becomes feasible to raise winter rye and probably most other winter grains in the tropics in 2½ months.

The rye plants were grown in a phytotron (a building in which it is possible to control the various environmental factors). In this case the temperature was kept at a constant 62° F. When the plants were a month old and had about 10 leaves each, they were sprayed with a plant-growth hormone, gibberelin.

Gibberelin spray eliminated the need for the prolonged cold period required by nature for the production of winter grains. It is believed that during the cold period the plants normally secrete and accumulate the hormones necessary for growth and flowering.

* * *

ENZYMATIC SYNTHESIS OF DNA (BASIC HEREDITARY MATERIAL) LEADS TO UNDERSTANDING OF CHEMISTRY OF DNA FORMATION.—As previously reported, the addition of a bacterial enzyme to a mixture of nucleic acid building blocks (nucleoside triphosphates) has resulted in the production of DNA (deoxyribonucleic acid) provided a small quantity of DNA is used as a primer.

The synthetic material is composed of macromolecules possessing a high degree of intramolecular organization involving purine and pyrimidine rings. The molecular structure is two stranded (double spiral), apparently linked by hydrogen bonds similar to natural DNA.

The process of synthesis is autocatalytic (the more DNA produced, the faster the reaction). As long as only the secondary structure of the DNA primer is disrupted, the double-stranded DNA macromolecules are still produced.

However, the use of an unusual DNA primer (AT-Polymer), not obtained naturally and containing only two of the four naturally occurring nucleic acid components resulted in the production of large amounts of AT-Polymer. This occurred even though all four were present.

* * *

Excavation of the Oldest Continuously Inhabited City in the New World—Dzibilchaltun.—Northern Yucatan, in Mexico, is the site of the ruins of a Mayan city inhabited for more than 3,000 years, from 2,000 B.C. in pre-Mayan times till after the Spanish conquest by Cortez.

Partial excavation of the ruined pyramids and temples of Dzibilchaltun has revealed a city of 20 square miles with a central 10-square-mile area. This "downtown" section had pyramidal temples, palaces, and buildings of vaulted stone with thatched houses on stone foundations crowded between the larger buildings. Surrounding this area were the "suburbs" with fewer pyramids, but equally crowded with stone-vaulted temples and residential platforms. A 1½-mile-long, 60-foot-wide limestone causeway spanned the center of Dzibilchaltun—8 feet high in some places.

The significance of the excavation of the oldest continuously inhabited city in the New World is that it will provide an unexcelled yardstick for studying the historic development of Mayan culture over a continuum of more than three millennia.

* * *

Effect of Temptation on Changes in Attitude.—The theory of cognitive dissonance holds that when a person is forced to do or say something in disagreement with his privately held opinion, there will be a tendency for opinion to change in such a way as to bring it into correspondence with the act performed. Secondly the greater the pressure used to induce the discordant act, the less will be the tendency to change opinion. In an experimental test of this theory, changes in moral attitudes following either cheating on a test or refraining from cheating were investigated. A sample of students were offered a prize for good performance on a test and were given an opportunity to cheat. Those who did not take advantage of the opportunity and did not cheat became more severe in their attitudes toward cheating, while those who did cheat became more lenient. The greater the motivation to cheat (tested by varying the value of the prize), the greater each of these effects was. This study is one of the first to explore the consequences when an individual is faced with the decision to comply with, or violate, a standard and, if verified by further research, will increase our ability to predict human behavior.

Evidence Found of Large Volcanic Eruption.—During a Foundation-supported cruise of the oceanographic research vessel R/V *Vema,* the precision depth recorder picked up a subbottom echo from an apparently continuous layer that extends from about 12° N. to 12° S. latitude, and is about 5° longitude wide. It ranges from within a few inches of the surface to as much as 120 feet below the sea floor. In the 11 cores that were obtained, the layer consisted of a clean, pure, nearly white volcanic ash with an average thickness of 4 inches. The purity of the ash suggests that it was deposited over a very short period of time. Also the sediments above and below the ash are quite similar, indicating that no permanent major environmental change resulted from the ash fall.

It is possible that this represents the volcanic debris from one major eruption. If so, it is larger than any single explosive eruption known in historic times. It is also possible that the ash is the product of multiple eruptions over a short period of time and from several volcanic centers. Although the limits of the ash are by no means known, in the area thus far covered its volume exceeds 30 cubic miles, more than a thousand times the volume of the famous Krakatao volcanic eruption in 1883, which resulted in concussion heard 2,500 miles away.

Thus far an isotopic date for the ash layer has not been obtained. Further work on dating is planned.

* * *

Oceanographic Cruise Results in Discovery of Mollusk Thought to be Extinct for 300 Million Years.—The same cruise through the Caribbean and down the west coast of South America into the South Atlantic made possible many samplings of sediments and living animals and plants from the deep ocean. Several specimens of neopilinids in good condition were dredged up from the bottom of the Peru-Chile trench, one of which proved to be a brandnew species which has been named "Neopilina (Vema) ewingi." These small organisms were thought to have lived only during the Paleozoic era of geologic time and were believed to have died out at least 300 million years ago. Their existence today is therefore as important biologically as was the discovery of the coelecanth fish off the African coast several years ago. All fossil forms of neopilinids so far discovered have come from sediments deposited in relatively shallow water. The newly discovered form came from a depth of about 18,000 feet. Thus, either the neopilinids were adapted to living in both deep and shallow water from the beginning of their existence, or they gradually moved into deeper water as the competition for life increased in the shallow waters off the continental shelves, and as they moved became progressively adapted to life without light and under extreme pressure.

* * *

SEQUOIA MIGRATIONS ESTABLISHED.—An NSF grantee has been able to trace the history of the giant redwood or "Big Tree" from tropical swamps 60 million years ago through adaptation to drier and cooler climates. This involved migration from California to western Nevada and back to California again. The modern trees are found in discontinuous patches from the northern to southern Sierra Nevada range. Fossil sequoia have been found in sediments up to 70 million years old in California and Nevada.

The ancient species occurred in humid subtropical to warm temperate climates and was associated with other warmth- and moisture-loving forms. During the 10 or 20 million years of the early Tertiary period, the climate became drier and cooler. In response the sequoia adapted itself to the less tropical conditions, so that by about 25 million years ago a tree much like the modern Big Tree had evolved, able to stand cooler winters but still requiring a great deal of summer moisture. The Sierra Nevada had not yet developed to their present great heights, enabling the trees to spread to what is now western Nevada, benefiting from what was then a mild, humid climate providing an ideal natural nursery.

As the Sierra Nevada was uplifted, rainfall on the eastern side of the range was drastically reduced and many of the leafy trees, such as birch, sycamore, elm, and certain maples, found today only in the eastern United States, were effectively eliminated from the area. The sequoia and a few others managed to survive by migration across the top of the rising mountains.

Later, faced with the much lower winter temperatures of the Pleistocene glacial epoch, Big Tree again migrated down into warmer climates, remaining only in areas where there was enough summer moisture for its shallow root system. The glacial ice, cutting through many valleys, isolated patches of the sequoia one from another, in the areas where they are generally found today.

* * *

A FRESH LOOK AT THE PHYSICAL WORLD AS A MANY-BODY PROBLEM.—Investigations carried out under one NSF grant may be expected to lead to a unification of approach to problems in many branches of physics, and to a significant advance in our knowledge of the physical world. Less sophisticated theories have in the past failed to explain many common physical phenomena, especially those encountered in the study of nuclear structure. This is so because of the extreme complexity of so many nuclei. An exact solution may be found for problems involving the simplest of all nuclei, that of hydrogen. But as the number of particles in a nucleus increases, the number of interactions among the particles shortly becomes so numerous that, while equations can be written, they are too complex to be solved.

The brilliant new theoretical approach which is enabling physicists to overcome these obstacles is known as the "many-body" solution, and provides a method of dealing with highly complicated physical phenomena by approximations. With solutions sufficiently exact to be extremely valuable, the new technique has proven very successful and has opened up an entire new field for dealing with particles too numerous to be treated individually, but too few to be treated statistically.

* * *

EQUIPMENT DEVELOPED WHICH PRODUCES ULTRA-HIGH PRESSURES AND HIGH TEMPERATURES.—An apparatus has been developed which can produce ultra-high pressures and high temperatures similar to those produced by the device which successfully synthesized diamonds, but using different principles.

The equipment called a tetrahedral anvil can generate pressures up to 100,000 atmospheres (1.5 million pounds per square inch) at 3,000° C.; and for very short periods, at temperatures as high as 50,000° C. It consists of four anvils with triangular faces. Hydraulic rams drive the anvils together, compressing the sample and developing pressure in three dimensions. Heat is supplied to the sample from electrical resistance heaters beneath the anvil faces.

Investigations are now being conducted on the chemical and physical properties of matter at high pressures and high temperatures with the apparatus. It should be particularly valuable in geochemical research by increasing the understanding of the nature of the earth's interior and the manner in which minerals develop. In metallurgy, its use may lead to the development of metals with all sorts of properties hitherto impossible to produce.

Research-Related Activities

Scientific Conferences and Symposia

During the past fiscal year, the Foundation sponsored and provided partial support for 41 scientific conferences and symposia. In most instances, sponsorship was shared with one or more private or public agencies, including universities and scientific societies.

1958 International Conference on Semiconductors—Rochester, N.Y., August 18–22, 1958; Chairman: John Bardeen, Urbana, Ill.; Cosponsor: The University of Rochester.

Properties of Metals at Low Temperatures—Geneva, N.Y., August 25–29, 1958; Chairman: Milan D. Fiske, General Electric Co., Research Laboratory, Schenectady, N.Y.; Cosponsor: General Electric Co., Research Laboratory.

Fracture Colloquium—Dedham, Mass., September 8–11, 1958; Chairman: B. L. Auerbach, Department of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.; Cosponsor: Committee on Ship Steel and Materials Advisory Board of the National Academy of Sciences-National Research Council.

Conference on Fundamental Research in Plain Concrete—Allerton Park, Ill., September 8–12, 1958; Chairman: Clyde E. Kesler, University of Illinois, Urbana, Ill.; Cosponsors: American Concrete Institute, American Society of Civil Engineers, Portland Cement Association, Reinforced Concrete Research Council.

Conference on Basic Research in Civil Engineering—Washington, D.C., September 10–11, 1958; Chairman: Martin Mason, dean of engineering, George Washington University, Washington, D.C.; Cosponsors: American Society of Civil Engineers, George Washington University.

Stopping Power Conference—Gatlinburg, Tenn., September 15–18, 1958; Chairman: Edwin A. Uehling, Department of Physics, University of Washington, Seattle, Wash.; Cosponsor: National Academy of Sciences-National Research Council Subcommittee on Penetration of Charge Particles in Matter.

1958 International Conference on Small Angle X-Ray Scattering from Metals—Kansas City, Mo., September 23–25, 1958; Chairman: J. C. Grosskreutz, Department of Physics, Midwest Research Institute, Kansas City, Mo.; Cosponsor: Midwest Research Institute.

International Symposium on the Physical Chemistry of Process Metallurgy—Pittsburgh, Pa., April 27–30, 1959; Chairman: Augustus B. Kinzel, American Institute of Mining, Metallurgical & Petroleum Engineers, Inc., New York, N.Y.; Cosponsor: Metallurgical Society of the American Institute of Mining, Metallurgical & Petroleum Engineers, Inc.

Symposium on Partially Ordered Sets in Lattice Theory—Monterey, Calif., April 1959; Chairman: J. H. Curtiss, American Mathematical Society, Providence, R.I.; Cosponsor: American Mathematical Society.

Conference on the Design and Conduct of Research Programs in Weather Modification—Shenandoah National Park, Va., May 1–3, 1959; Chairman: John W. Tukey, Department of Mathematics, Princeton University, Princeton, N.J.; Cosponsor: Division of Mathematics, National Academy of Sciences-National Research Council.

Symposium On Liquid Dielectrics—Philadelphia, Pa., May 3–7, 1959; Chairman: Louis J. Frisco, Dielectric Laboratory, Johns Hopkins University, Baltimore, Md.; Cosponsor: The Electromechanical Society, Inc.

International Symposium On Distance Measuring Equipment and Techniques—Washington, D.C., May 5–12, 1959; Chairman: Waldo E. Smith, American Geophysical Union, Washington, D.C.; Cosponsors: American Geophysical Union, International Association of Geodesy.

Symposium On Quantitative Biology—Cold Spring Harbor, N.Y., June 3–10, 1959; Chairman: M. Demerec, Biological Laboratory, Long Island Biological Association, Cold Spring Harbor, N.Y.; Cosponsor: Long Island Biological Association.

General Petroleum Geochemistry Symposium—New York, N.Y., June 4, 1959; Chairman: Bartholomew S. Nagy, Department of Chemistry, Fordham University, New York, N.Y.; Cosponsor: Fordham University.

18TH GROWTH SYMPOSIUM—University of Wisconsin, Madison, Wis., June 11–13, 1959; Chairman: Ralph O. Erickson, Department of Botany, University of Pennsylvania, Philadelphia, Pa.; Cosponsor: Society for the Study of Development and Growth.

CONFERENCE ON OPTICAL PUMPING—Ann Arbor, Mich., June 15–19, 1959; Chairman: Peter Franken, Department of Physics, University of Michigan, Ann Arbor, Mich.; Cosponsor: University of Michigan.

MEETING OF THE AMERICAN SOCIETY OF HEATING & AIR-CONDITIONING ENGINEERS—Philadelphia, Pa., January, 1959; Chairman: John Everetts, Jr., American Society of Heating & Air-Conditioning Engineers, Philadelphia, Pa.; Cosponsor: The Technical Advisory Committee on Physiological Research and Human Comfort.

PILOT CROSS-DISCIPLINARY CLINIC ON THE INSTRUMENTATION REQUIREMENTS FOR CLOUD AND WEATHER MODIFICATION—Cambridge, Mass., February 11–13, 1959; Chairman: Lloyd E. Slater, Foundation for Instrumentation Education and Research, New York, N.Y.; Cosponsors: American Meteorological Society, Foundation for Instrumentation Education and Research, Meteorology Department, Massachusetts Institute of Technology.

TWO REGIONAL DEVELOPMENTAL BIOLOGY CONFERENCES—Alligator Point, Fla., March 13–14, 1959, and Colby College, Waterville, Maine, March 23–24, 1959; Chairman: Victor Twitty, Department of Zoology, Stanford University, Stanford, Calif.; Cosponsor: American Society of Zoologists.

MIDWEST CONFERENCE ON THEORETICAL PHYSICS—Evanston, Ill., March 13–14, 1959; Chairman: Max Dresden, Department of Physics, Northwestern University, Evanston, Ill.; Cosponsor: Northwestern University.

SECOND CONFERENCE ON THE NUCLEAR OPTICAL MODEL—Tallahassee, Fla., March 16–17, 1959; Chairman: Alex E. S. Green, Department of Physics, Florida State University, Tallahassee, Fla.; Sponsor: Florida State University.

SYMPOSIUM ON ASTRONOMICAL ASPECTS OF COSMIC RAYS—University of Rochester, Rochester, N.Y., March 30–April 2, 1959; Chairman: Malcolm P. Savedoff, Department of Physics, University of Rochester, Rochester, N.Y.; Cosponsors: University of Rochester, American Astronomical Society.

TECHNICAL CONFERENCE ON PHYSICAL METALLURGY OF STRESS-CORROSION FRACTURE—Pittsburgh, Pa., April 2–3, 1959; Chairman: R. W. Shearman, The Metallurgical Society of the American Institute of Metallurgical Engineers, New York, N.Y.; Cosponsor: The Metallurgical Society of the American Institute of Metallurgical Engineers.

THIRD SYMPOSIUM ON ROCK MECHANICS—Golden, Colo., April 20–22, 1959; Chairman: Lute J. Parkinson, Department of Mining Engineering, Colorado School of Mines, Golden, Colo.; Cosponsor: Colorado School of Mines.

SECOND ASTROMETRIC CONFERENCE—Cincinnati, Ohio, April 20–23, 1959; Chairman: Paul Herget, Director, Cincinnati Observatory, Cincinnati, Ohio; Cosponsor: Cincinnati Observatory, University of Cincinnati.

CONFERENCE ON THE ECOLOGY AND BEHAVIOR OF THE MOUNTAIN GORILLA—Washington, D.C., September 30, 1958; Chairman: Fairfield Osborn, New York Zoological Society, New York, N.Y.; Cosponsor: New York Zoological Society.

SPECIAL CONFERENCE ON CLOUD PHYSICS—Woods Hole, Mass., September 1958; Chairman: Helmut Weickmann, Section of Meteorology, American Geophysical Union, National Academy of Sciences, Washington, D.C.; Cosponsor: American Geophysical Union Committee on Cloud Physics.

SYMPOSIUM ON IMAGE INTENSIFICATION—Fort Belvoir, Va., October 6–7, 1958; Chairman: Robert S. Wiseman, Warfare Vision Branch, U.S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va.; Cosponsor: U.S. Army Engineer Research and Development Laboratories.

CONFERENCE ON SYSTEMATIC MUSEUMS AS RESOURCES FOR BASIC RESEARCH—University of the State of New York, Albany, N.Y., October 13–14, 1958; Chairman: William N. Fenton, New York State Museum and Science Service, Albany, N.Y.; Cosponsor: The University of the State of New York.

CONFERENCE ON VERTEBRATE SPECIATION—University of Texas, Austin, Tex., October 26–November 1, 1958; Chairman: W. Frank Blair, Department of Zoology, University of Texas, Austin, Tex.; Cosponsor: University of Texas.

JOINT MEETING OF INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING AND THE STRUCTURAL DIVISION OF AMERICAN SOCIETY OF CIVIL ENGINEERS—New York, N.Y., October 1958; Chairman: Frank Baron, Department of Civil Engineering, University of California, Berkeley, Calif.; Cosponsor: American Society of Civil Engineers.

SYMPOSIUM ON PLANETARY RADIO ASTRONOMY—Gainesville, Fla., December 28, 1958; Chairman: Alex G. Smith, Department of Physics, University of Florida, Gainesville, Fla.; Cosponsors: University of Florida, American Astronomical Society.

SPECIAL CONFERENCE ON CONTEMPORARY GEODESY—Harvard University, December 1958; Chairman: Milton O. Schmidt, University of Illinois, Urbana, Ill.; Cosponsors: Section of Geodesy of the American Geophysical Union, Astrophysical Observatory of the Smithsonian Institution.

SECOND CARIBBEAN GEOLOGICAL CONFERENCE—Mayaguez, P.R., January 5–9, 1959; Chairman: John D. Weaver, professor of geology, University of Puerto Rico, Mayaguez, P.R.; Cosponsors: University of Puerto Rico, Economic Development Administration of the Commonwealth of Puerto Rico.

SYMPOSIUM ON ELECTROMAGNETIC THEORY—Toronto, Canada, June 15–20, 1959; Chairman: George Sinclair, University of Toronto, Toronto, Canada; Cosponsor: Commission VI of the International Scientific Radio Union.

INTERNATIONAL SYMPOSIUM ON CIRCUIT AND INFORMATION THEORY—Los Angeles, Calif., June 16–18, 1959; Chairman: R. A. Epstein, Jet Propulsion Laboratory, Institute of Radio Engineers, Pasadena, Calif.; Cosponsors: Institute of Radio Engineers, International Scientific Radio Union.

INTERNATIONAL CONFERENCE ON MOLECULAR QUANTUM MECHANICS—Boulder, Colo., June 17–21, 1959; Chairman: Robert G. Parr, Department of Chemistry, Carnegie Institute of Technology, Schenley Park, Pittsburgh, Pa.; Cosponsor: University of Colorado.

FOURTH BIENNIAL SYMPOSIUM ON ANIMAL REPRODUCTION—Urbana, Ill., June 18–20, 1959; Chairman: N. L. VanDemark, University of Illinois, Urbana, Ill.; Cosponsor: University of Illinois.

CONFERENCE ON THE PREPARATION AND DISTRIBUTION OF CHEMICAL COMPOUNDS OF CERTIFIED HIGH PURITY—Washington, D.C., June 22–23, 1959; Chairman: Clem O. Miller, Division of Chemistry and Chemical Technology, National Academy of Sciences-National Research Council, Washington, D.C.; Cosponsor: National Academy of Sciences-National Research Council.

THE INTERDISCIPLINARY CONFERENCE ON ATMOSPHERIC POLLUTION—Santa Barbara, Calif., June 29–30, 1959; Chairman: Kenneth C. Spengler, American Meteorological Society, Boston, Mass.; Cosponsor: The Committee on Air Pollution, American Meteorological Society.

WORKSHOP ON BIOLOGICAL PHENOMENA IN SUBMOLECULAR LEVELS—Marine Biological Laboratory, Woods Hole, Mass., June, July, and August, 1959; Chairman: Albert Szent-Gorgyi, Institute for Muscle Research, Marine Biological Laboratory, Woods Hole, Mass.; Cosponsor: Marine Biological Laboratory.

Support of Travel to International Meetings

Personal contact between highly competent scientists from all over the world, conducting similar types of research, is one of the most important means by which ideas are exchanged. This sort of cross-fertilization is vital to the advancement of scientific knowledge. The Foundation, therefore, partially defrays travel costs for a limited number of American scientists to attend selected international meetings and congresses abroad. The grant to the scientist generally provides for a round-trip, air-tourist fare between his home institution and the location of the meeting. In the 1959 fiscal year, 419 scientists received such awards at a cost of approximately $330,000.

Training Aspects of Research Grants

The research grants program continued to contribute significantly to the training of both predoctoral and postdoctoral research assistants and associates. During 1959, approximately 2,000 of these people received the highest caliber of training through their participation in research projects under the supervision of many of this country's most competent scientists.

Combining this number with the approximately 4,000 awards offered through the Foundation's formal fellowship programs gives a total of 6,000 who have been provided with the opportunity to further their scientific education and laboratory training under the most favorable and productive conditions.

Fiscal Analysis of Research Programs

During the 1959 fiscal year, 1,809 grants were made in support of basic research to 333 institutions in all 50 States, the District of Columbia, Puerto Rico, Argentina, Bermuda, Canada, France, Israel, and Turkey. Expenditures for research in the sciences totaled $64.5 million—$49 million for research grants and $15.5 million for facilities.

The average 1959 research grant amounts to $27,153 for a period of 2.26 years, or $12,015 a year. (See fig. 1.) While the duration of the average grant has increased only slightly in the past year, the amount has increased by 40 percent. This is a reflection of the ability to provide more nearly adequate support for requests for research funds.

Facilities grants were discussed in detail previously in the sections dealing with the programs of research divisions and offices.

Table 1 summarizes the research grant program by subject categories. A detailed list of grants showing institutions, principal grantee, title of project, and amount is given in appendix C.

Table 1.—National Science Foundation grants, by fields of science, 1958–59

Field	Fiscal year, 1958		Fiscal year, 1959	
	Number	Amount	Number	Amount
Biological and medical sciences:				
Developmental	48	604, 300	87	1, 591, 700
Environmental	78	953, 600	119	2, 333, 700
Genetic	57	711, 150	78	1, 780, 650
Metabolic	74	1, 482, 350	116	3, 141, 600
Molecular	78	1, 609, 100	148	4, 059, 400
Psychobiology	62	968, 800	77	1, 518, 800
Regulatory	70	1, 075, 280	103	2, 575, 245
Systematic	103	1, 036, 350	182	2, 568, 600
General	35	440, 100	57	891, 910
	605	8, 881, 130	967	20, 461, 605
Mathematical, physical, and engineering sciences:				
Astronomy	33	1, 017, 830	51	1, 955, 175
Atmospheric sciences	....	....	46	2, 920, 769
Chemistry	134	2, 323, 900	199	4, 406, 445
Earth sciences	70	1, 246, 395	85	2, 063, 860
Engineering sciences	88	1, 538, 400	129	4, 311, 900
Mathematical sciences	72	1, 242, 100	94	2, 556, 175
Physics	69	2, 139, 200	142	5, 509, 100
	466	9, 507, 825	746	23, 723, 424
Social sciences:				
Anthropological	22	384, 100	23	353, 700
Sociological	14	182, 100	14	279, 000
Economic	5	93, 300	5	137, 900
History and philosophy of science	8	66, 450	11	118, 700
	49	725, 950	53	889, 300
Antarctic research (life and physical sciences)	13	922, 800	43	4, 057, 200
Total	1, 133	20, 037, 705	1, 809	49, 121, 529

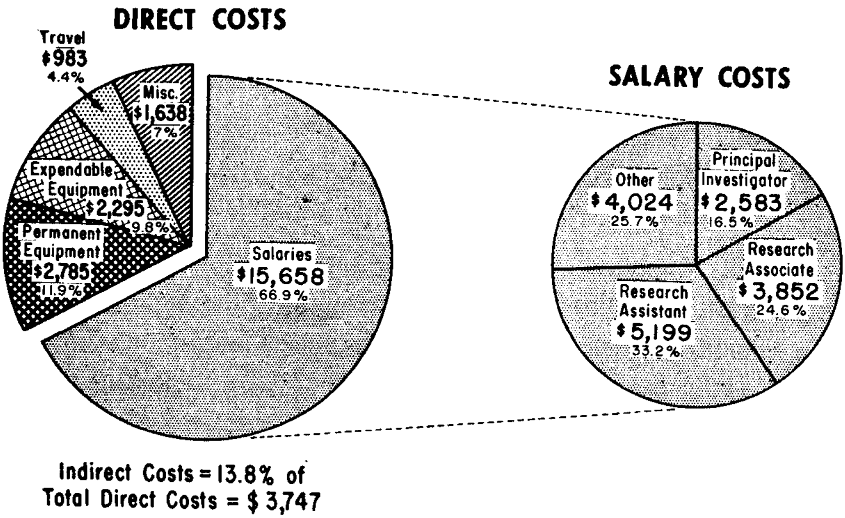

Figure 1.—*Distribution of research grant funds, by type of expenditure, based on average grant for fiscal year 1959 of $27,153.*

TRAINING AND EDUCATION IN THE SCIENCES

The availability of increased funds in fiscal year 1959, $62.5 compared to $20.5 millions in 1958, made possible a more vigorous and varied attack on the problems of science education by the Division of Scientific Personnel and Education. Old programs were expanded and new programs were established.

As in the past, the program activities of the Division were directed toward the attainment of excellence in science education and were focused on specific problems within the following general areas:

(1) Motivation and support of high-caliber students and advanced scholars in science, mathematics, and engineering.

(2) Supplemental training in subject matter for teachers of science, mathematics, and engineering at all levels in the educational system.

(3) Development of new and more realistic course-content materials and teaching and learning aids.

(4) Improvement of information about the training, utilization, and need for scientific and technological manpower.

The Foundation's general approach to problems of science education is based fundamentally on the principle that the improvement of education in the sciences must come from within the scientific and educational communities themselves. Such improvement requires close cooperation between those whose work is primarily research and those who teach.

For the most part, support has gone directly to educational institutions, professional societies, and other organizations of scientists and science teachers for the implementation of activities which they themselves have developed and which our advisers have agreed show promise of success. These advisers—scientists and science teachers—come from the high schools, the colleges and universities, industry, and governmental agencies.

Motivation and Support of High-Caliber Students and Advanced Scholars

Since the most important element in science education is the learner, primary attention must be given to him. His interests must be developed and his motivations strengthened. If he is to become an advanced scholar, it must be possible for him to remain in school. A major share of NSF funds has gone to the support of programs in this area. Programs reach students at every level in the educational structure, from the junior high school (science clubs and student science projects) through the highest levels of graduate training (senior postdoctoral fellowships).

One of the most interesting—potentially one of the most promising—of the new programs this year was the Summer Science Training Program for Secondary School Students. Through the support provided, about 6,000 highly selected high school students were able to spend time on the campuses of colleges and universities and at research activities of other kinds and to participate in scientific activities in a variety of ways.

A number of other programs are directed toward the motivation and training of precollege students who are interested in science and mathematics. Many of the projects to be conducted under the new State Academies of Science Program will reach these youth. A considerable amount of support will be provided by the State academies for activities in the junior academies of science and for enrichment of the science club and science fair programs.

Additional support was given to each of the "old" programs which have been directed primarily toward secondary school students: Visiting Scientists, Traveling Science Libraries, Traveling Science Demonstration Lectures, Science Clubs and Student Science Projects, and Career Information.

The first substantial effort to improve the training of undergraduate students of science, mathematics, and engineering was launched during the past year under the program title "Undergraduate Research Participation." Essentially, the program makes possible participation by undergraduate students in actual research being conducted in colleges, universities, and other nonprofit research institutions. Under the 213 grants which were made, approximately 2,200 students were able to participate in scientific activity of a relatively high order. Not only should this program help to motivate many of the more able undergraduate students to continue into graduate work, but it should contribute much to their actual training in the methods and techniques of science.

Two new programs were initiated for the support of graduate students and advanced scholars—the Cooperative Graduate Fellowship Program and Summer Fellowships for Graduate Teaching Assistants. The Cooperative Graduate Fellowship Program is similar in many respects to the established program of Graduate Fellowships. The essential differences are that the cooperating institutions participate in the evaluation of applicants and that they receive specific amounts to apply toward the cost of education of the fellows. The program of Summer Fellowships for Graduate Teaching Assistants is an innovation aimed at making it possible for the graduate teaching assistant to pursue his own studies and research during the summers, and thus hasten the completion of his graduate work. The need for the program is reflected in the fact that more than 1,200 teaching assistants in 105 institutions applied for these fellowships in the first year of operation.

Supplemental Training for Teachers

While many factors combine in the "effective" science teacher, the fundamental one is knowledge of his field. For a number of years, an increasing amount of support has been provided for programs which supplement the subject-matter knowledge of teachers—particularly at the secondary school level. This support, in the past, has been concentrated largely in the now well-known summer institutes. Growing programs of Academic Year and In-Service Institutes have extended the opportunities of secondary school teachers to obtain supplemental subject-matter training. That the same problem exists at the college and university levels has been recognized and is being dealt with through Summer Institutes and Summer Conferences for College Teachers and Science Faculty Fellowships.

A number of new programs in the area of supplemental teacher training inaugurated in 1959 have been designed to bolster weak spots in the area of teacher qualifications; these programs now span the entire spectrum from the elementary and junior high schools through the graduate levels.

Secondary school teachers of science and mathematics differ widely in the extent and quality of their subject-matter training. Many are trying to provide adequate instruction to their students when they themselves have had little or no formal training in the subjects which they are teaching. Others are bona fide graduate students who need the opportunity to progress in their fields of specialization. In the past, efforts have been made to reach both groups—and those between the extremes—through the institutes programs. Many summer institutes have been designed to reach teachers at particular levels within this range.

These institutes have not been adequate, however, to serve the needs of the best qualified of the secondary school teachers of science and mathematics—those whose primary need is to pursue graduate study toward advanced degrees in their fields of specialization. For this reason, the new program of Summer Fellowships for Secondary School Teachers was designed and introduced during fiscal year 1959. The mechanism of this program is very similar to that used in the Graduate Fellowship programs, and in the summer of 1959 the first awardees—selected by the Foundation through a national competition and studying in their individually designed programs of study at the institutions of their choice—began receiving stipends for durations of one to three summers.

The Research Participation for Teacher Training Program provided another method of improving the professional competence of the best qualified science and mathematics teachers in secondary schools and colleges. This program made it possible for teachers with an adequate subject-matter background to participate in ongoing research programs at institutions with established research traditions. This experience provided the participating teacher an insight into science not gained by course work.

Three important new activities designed for groups of science teachers not previously included or to meet other special needs were launched within the institutes framework. These programs were directed toward groups of teachers of science, mathematics, and engineering whose needs had not been met through other programs.

Growing recognition of the importance of science education as a part of the general education program at the elementary school level led to the first tentative and experimental approach by the Foundation in this area—to help determine the responsibilities of the Foundation and ways in which it might best meet these responsibilities. A small program of 12 Summer Institutes for Elementary School Teachers and Supervisors was supported.

There was a special need for programs designed for science and mathematics instructors in technical institutes, who teach generally at the college level and whose academic backgrounds are widely varied. For this reason, two exploratory special Summer Institutes for Technical Institute Personnel were supported.

For a number of reasons, it appeared that the Summer Institutes for College Teachers were not completely filling the need for summer supplemental training. Two of the most important factors to be considered were that the institutes were too long in duration for many teachers and that many teachers had need for more specialized training than the institutes could offer. Accordingly, the new program of Summer Conferences for College Teachers was introduced on an experimental basis in 1959. Approximately 20 summer conferences—all of less than 4 weeks in duration, and covering a variety of specialized subject matter areas—were supported. About 530 college and university teachers attended.

The programs for the supplemental training described above are more or less formalized and "programmatic" in nature. A concentrated effort is being made to discover ways to meet still other needs in the training of teachers at all levels. A number of projects of this nature were supported in 1959, ranging from highly specialized field institutes to short conferences on college teaching and workshops for teachers at the lower academic levels.

Course-Content Materials and Teaching Aids

It is necessary, of course, that we have well-motivated students and scholars working under the direction of well-qualified teachers if we are to meet our national need both for scientific literacy in the whole population and for adequate numbers of highly competent scientists and science teachers at all levels. But this is not sufficient; another factor which cannot be overlooked is the provision of improved instructional materials—the tools which enable the teacher to best do his job.

The ever-increasing acceleration in the acquisition of scientific and technological knowledge, together with its manifold impact on every area of human thought and activity, has produced a serious lag between advances in science and technology and their presentation in the classroom.

The complexity and implications of this problem led to an initially experimental approach by the Foundation through grants both for relatively small, exploratory projects in several fields and for a pioneering major effort to bring scholarship of the highest order to the development of a new physics course for the high schools. The success of these ventures, particularly of the Physical Sciences Study Committee in devising the new physics course, led to support for comparable projects in other disciplines and for a variety of efforts to improve course content and develop new supplementary teaching aids.

Improvement of Scientific Manpower Information

Basic to the understanding of the problems of science education and to the development of programs to meet these problems is manpower information. We must know, in a substantive way, not only our present and future needs for scientists, technologists, and teachers at all levels and in all fields, but we must be able to assess the status of training and education with respect to meeting these needs. For this reason, the activities of the Scientific Manpower Program have been expanded in ways designed to provide better and more current information of many kinds.

Other Activities

Because our international relationships are vital and science education cannot be contained within national boundaries, an effort was made during fiscal year 1959 to explore ways in which we could profit by the experience of our international neighbors in coping with our own problems. These exploratory activities touched upon each of the major problem areas in which we have program interests—students and advanced scholars, the training of teachers at the secondary-school and college levels, course content and teaching aids, and the collection and dissemination of scientific manpower information.

Fellowship Programs

Traditionally, fellowships are considered by the academic community as a form of grant to selected individuals to enable those individuals to further their own education. Fellowships are clearly distinct in concept from grants designed to underwrite a specific project—research or development—and do not normally require that the recipient render any services to the donor.

The National Science Foundation fellowship programs provide support for scientific study or work in mathematics, the sciences, and engineering. Fellows are selected in national competition solely on the basis of ability. They have freedom of choice in selecting the educational institutions which they desire to attend.

Seven fellowship programs were in operation during fiscal year 1959—Graduate (Predoctoral), Postdoctoral (Regular), Senior Postdoctoral, Science Faculty, Cooperative Graduate, Summer Fellowships for Graduate Teaching Assistants, and Summer Fellowships for Secondary School Teachers.

A total of 3,937 fellowships were awarded in 1959; their value was approximately $13.1 million. (Appendix F shows the distribution of fellowship awards by type, field, and State.)

Graduate Fellowships (Predoctoral)

The *Graduate Fellowships* program offers support to unusually able students working for master's or more advanced degrees to enable them to complete their studies as quickly as possible. In 1959, a total of 1,100 awardees were selected from 4,506 applicants; program support amounted to approximately $3.2 million. Honorable mention was accorded 1,979 applicants.

Stipends for these 1959 awards were set at $1,800, $2,000, and $2,200 per year depending on the level of the fellowship—first year, intermediate, or terminal. In addition to stipends, financial support is provided for tuition, dependents, and other allowances.

Postdoctoral Fellowships

Postdoctoral Fellowships are intended especially for those individuals who have received a doctor's degree within the past 5 years. The program's objective is to improve the capabilities and stature of such persons as investigators in their chosen fields of research.

In fiscal year 1959, there were 778 applications and a total of 194 awards for tenure ranging from 6 to 24 months, depending on the program planned by the individual. The cost of the program for those accepting awards was approximately $1.1 million.

Postdoctoral fellows are provided with stipends at the rate of $4,500 per year ($5,000 per year for portions of tenure beyond 12 months), plus allowances for dependents, travel, and special expenses.

Senior Postdoctoral Fellowships

The *Senior Postdoctoral Fellowships* program is designed to enable recognized senior scientists, engineers, and mathematicians to be relieved of their normal professional responsibilities so that they may pursue a full-time program of study designed to broaden their knowledge and to improve their capabilities as investigators.

During 1959, 241 scientists applied for these fellowships; 83 individuals were offered awards. The estimated cost was $767,000.

Tenures are from 3 to 24 months, with stipends of the salary-matching type not exceeding $12,000 per year. Allowances for travel and special expenses are available.

Science Faculty Fellowships

The aim of the *Science Faculty Fellowships* program is the direct improvement of science education by providing college and university faculty members with the opportunity to improve and update their knowledge of the fields in which they have specialized (or of closely related fields), and hence their competency as college teachers. This program permits faculty members to be relieved of teaching responsibilities in order to pursue a full-time study program.

Of the 1,069 individuals who applied, awards were offered to 302. The cost of this program during 1959 was about $2.3 million.

Science Faculty Fellows may elect tenures ranging from 3 to 15 months and receive stipends on a salary-matching basis (not to exceed $12,000 per year) as of the time of application. In addition, they are provided with allowances for travel, special expenses, and tuition, if required.

Summer Fellowships for Secondary School Teachers of Science and Mathematics

New in fiscal year 1959, the program of *Summer Fellowships for Secondary School Teachers of Science and Mathematics* permits secondary school teachers of high ability to undertake individually planned programs of summer study to improve their subject matter competence, and thus enhance their effectiveness as teachers.

Tenures from one summer of 6 weeks to three full summers are available. Stipends total $75 for each week of tenure. In addition, the Foundation awards cover the cost of tuition, plus limited travel and dependency allowances. The selection of 628 awardees was made from 1,578 applicants during 1959, the first year of the program, at a cost of approximately $1.5 million.

Summer Fellowships for Graduate Teaching Assistants

A second new program introduced in 1959, the *Summer Fellowships for Graduate Teaching Assistants,* enables graduate teaching assistants of participating institutions to devote full time, during the summer, to their own study and research.

A total of 1,260 teaching assistants submitted applications for fellowships for the summer of 1959 and 580 were offered awards. Program support amounted to about $500,000 for those accepting awards.

A summer fellow may select a tenure ranging from 8 to 12 weeks, at a weekly stipend of between $50 and $75 (determined by the institution). Tuition and required fees are paid by the Foundation.

Cooperative Graduate Fellowships

The *Cooperative Graduate Fellowships* program established during the past year has, like the older program of Graduate Fellowships, the function of offering support for predoctoral studies. It differs, however, in that the institutions themselves play a larger part in the evaluation of applicants and in the administration of the program. A greater distribution of fellows among the Nation's schools of graduate study has been achieved through this program.

A Cooperative Graduate Fellow receives a stipend of $2,200 for a 12-month tenure. The amount may be augmented by the institution at a rate not exceeding $800 per year. In lieu of tuition and fees, a cost-of-education allowance of $1,800 is provided to the institution for each fellow. Fellows may undertake limited teaching duties as a justifiable part of their academic training.

A total of 2,872 individuals applied through 111 colleges and universities in 1959. The Foundation offered awards to 1,050 individuals, representing 105 institutions. The cost of the program was about $3.7 million.

NATO Science Fellowships

The North Atlantic Council of the North Atlantic Treaty Organization established the *NATO Science Fellowships* program in the fall of 1958. The program is designed to stimulate the exchange of scientists among the NATO countries by the fellowships mechanism; each member nation is charged with selecting fellows from among its own population. The Foundation, at the request of the Department of State, administered the program under the title "NATO Postdoctoral Fellowships in Science" for the United States.

Of the 91 Americans who applied, 20 were selected and will study in various NATO countries and Sweden.

Institutes Programs

The primary objective of the institutes programs is to improve science instruction through making it possible for teachers in secondary schools and colleges to obtain additional knowledge of subject matter and to become acquainted with new developments in science and mathematics. The institutes are characterized as "group" activities—as contrasted with the individual activities of fellows—and employ course materials specially prepared to meet the subject matter needs of the teachers.

Four major institute programs are supported by the Foundation: (1) Summer Institutes for High School Teachers of Science and Mathematics, (2) Summer Conferences for College Teachers, (3) Academic Year Institutes for High School and College Teachers, and (4) In-Service Institutes for High School Teachers. Limited experimental programs also being supported include Summer Institutes for Elementary School Teachers and Supervisors, Summer Institutes for Faculty of Technical Institutes and Technical Curricula in Junior Colleges, and In-Service Institutes for Elementary Science Teachers.

Fiscal year 1959 costs totaled $33.6 million for 348 summer institutes for high school and college teachers, 12 summer institutes for elementary school teachers and supervisors, 32 academic year institutes, 182 in-service institutes, 20 summer conferences, 12 elementary summer institutes, 11 elementary inservice institutes, and 2 summer programs for technical institute personnel. The 1959 program was about two and a half times as large as that of 1958.

Proposals for institutes originate with the colleges and universities and the institutes are conducted by them. The Foundation does not participate in the selection of participants or the operation of the institutes.

Summer Institutes

From a program that started out in 1953 with approximately 100 participants, 42 of whom received NSF stipends, the summer institutes program had grown by 1959 to one with 21,000 participants, 20,000 of whom received NSF stipends.

The content offered by these institutes has grown also. From a modest beginning of two different programs, the offerings have become more varied until institutes in the summer of 1959 represented 12 different fields in science and mathematics. There are NSF summer programs in each of the 50 States and Puerto Rico.

Two additional summer training activities were established in fiscal year 1959—Summer Conferences for College Teachers and Summer Programs for Technical Institute Personnel. An experimental program to provide summer institute experience for elementary-school supervisors and teachers in the area of science and mathematics also was initiated in the summer of 1959.

1. *Summer Institutes for Secondary School and College Teachers.*—The summer institutes for high school and college teachers have increased from 2 in 1953 to 348 during the summer of 1959. They are designed to improve the competence of the participating teachers by providing courses that are specially aimed at overcoming deficiencies in their knowledge of the subject matter of science and mathematics. Most of the participants have completed their formal coursework a number of years ago, and others must teach courses in science and mathematics for which they have not had adequate academic preparation.

The institutes vary in length from 4 to 12 weeks. The average in 1959 was 7 weeks. The number of participants in each institute in 1959 varied from 10 to 150.

Of the 348 summer institutes in 1959, 30 were for college teachers only; 19 were for both secondary school and college teachers; and the remaining 299 were for secondary school teachers only.

Adequate balance in geographic distribution was maintained; for example, 57 percent of the institutes were held east of the Mississippi and 43 percent were held west of the Mississippi. There were 51 summer institutes in New England and New York, 86 in the other Eastern States and the District of Columbia, 53 in the Southeastern States, 52 in the Midwest, 61 in the Southwest and Hawaii, 41 in the Rocky Mountain and Northwest region (including Alaska), and 4 in the Commonwealth of Puerto Rico.

The National Science Foundation grants provided funds for participant support. The maximum amount awarded a participant was set by the Foundation at $75 per week for stipend, plus allowance for dependents and travel. While most institutes followed this schedule and granted the maximum allowable amounts to each awardee, a few distributed their available funds in smaller amounts to more participants. Many of the institutes accepted a few registrants beyond those who received stipends.

The National Science Foundation in addition awarded each host institution sufficient funds to pay necessary tuition and fees for the stipend holders. The Foundation grant also covered direct costs occasioned by the institute to the extent that they exceeded the amount already allowed for tuition and fees.

One of the essential features of this program is that the institutes are managed so that the participants are treated as a special group and their identity maintained. They are usually housed together, and often spend scheduled out-of-class time together in company with their instructors.

2. *Summer Institutes for Elementary School Teachers and Supervisors.*—This program was developed on an experimental basis in 1959. These experimental institutes are specifically designed to give key teachers and supervisory personnel in elementary schools an opportunity to increase their knowledge of the sciences and mathematics, in order that science and mathematics can be taught more effectively to students in the elementary schools.

This experimental program of 12 institutes provided training for 515 teachers and elementary school science supervisors.

3. *Summer Programs for Technical Institute Personnel.*—Also experimental in nature, these programs are specifically designed to meet the subject matter needs, primarily in science and mathematics, of the teacher in technical institutions not conferring the baccalaureate degree. The first two programs in this category were supported in fiscal year 1959.

4. *Summer Conferences for College Teachers.*—Summer conferences were supported for the first time as a formal program activity in 1959. The conferences are specifically designed to consider specialized subject matter areas of science and mathematics. Through the use of short courses or series of lectures of less than 4 weeks' duration, these conferences facilitate an exchange of ideas among the participants and

provide them an opportunity to learn of recent subject material advances.

There were 546 college teachers of science and mathematics supported in this program of 20 conferences during 1959.

Academic Year Institutes

Academic year institutes are full-time, year-long programs of study in science and mathematics designed especially for secondary school teachers in these fields. Financial support for the teacher and for the host institution is provided by a grant from the Foundation. The courses of study are planned by the colleges and universities which sponsor them; each institution supplies the facilities and administers its own program.

For the 1959–60 Academic Year Institute program, 32 colleges and universities received awards. The 32 institutes represent 32 different institutions in 29 States. Seven of these institutes are in the field of mathematics only, while the other 25 give training in the principal sciences, as well as in mathematics. Twenty-two of the institutes will continue through the summer of 1960; 10 are for the academic year only. Supplementary experimental grants were made to three institutes for support of eight college teachers—"teachers of science"—in each institute. It is estimated that the 1959–60 program will give support to over 1,500 teachers from all 50 States.

During this year, supplementary grants were also made to 19 of the 1958–59 institutes to enable them to extend their programs through the summer of 1959 for about 450 teachers.

Foundation grants to sponsoring institutions provide a maximum stipend of $3,000 per academic year, plus additional allowances for dependents, travel, and books. Institutions receive support for the operational costs, so that teachers do not have to pay tuition or fees.

In-Service Institutes

In-service institutes provide support in the form of grants to institutions of higher learning for programs offering opportunities to teachers from secondary schools for further study in the subject matter of the sciences and mathematics during out-of-school hours in the academic year.

Participating teachers receive no stipends but are given a travel allowance at the maximum rate of 7 cents per mile for each trip from home to institute and return. The sponsoring institutions receive support for direct costs of operation. In 1959, 182 grants for in-service institutes were made to 162 different institutions in 40 States, the District of Columbia, and Puerto Rico.

It is estimated that about 9,000 secondary school teachers will have an opportunity for further study under this program during the 1959–60 school year.

A very limited program of in-service institutes for elementary school teachers and supervisors of mathematics and science will be supported on an experimental basis during the 1959–60 school year. Eleven grants were made to 11 different institutions in 10 States and Puerto Rico. About 350 elementary school teachers and supervisors will have an opportunity for further study under this program.

Special Projects in Science Education

The Special Projects in Science Education Programs are concerned principally with the experimental testing and development of promising new ideas for the improvement of science instruction and with new and more effective methods for increasing interest in and understanding of science. From experiments carried out in this manner have evolved such operational programs as the institutes program and the course content improvement program.

A total of $8.9 million was obligated in fiscal year 1959 to carry out these special projects, which fall into three general categories: secondary school programs, college programs and teacher improvement programs, and international science education programs.

Secondary School Programs

These projects are planned by universities, colleges, scientific societies, research organizations, and other groups to enlist interest in and promote understanding of science, mathematics, and engineering by students in the secondary schools.

1. *Visiting Scientists (Secondary Schools)*.—Under this project, grants are made to professional societies for the administration of programs of visiting scientists to secondary schools to acquaint students and faculty with the sciences as vital activities and to provide counsel concerning careers and education.

Participating scientists receive travel expenses, and may receive a modest honorarium not exceeding $50 per day of school visitation.

Grants for 1959 were made to the American Chemical Society, American Institute of Biological Sciences, American Institute of Physics, and the Mathematical Association of America.

2. *Traveling High School Science Library Program.*—The primary objective of this program is to stimulate the interests of high school students in science and mathematics through making available to schools, on a loan basis, a carefully selected library of general-interest books covering a broad spectrum of science fields. Since 1955 this program has

been conducted, with support from the Foundation, by the American Association for the Advancement of Science. During 1958–59, 375 sets of 200 books each were circulated to 1,309 high schools and preparatory schools, including 26 Armed Forces dependents' schools in foreign countries.

Eight sets were loaned to State and county library systems for demonstration and bookmobile circulation; 153 sets were loaned to NSF-sponsored institutes and to summer programs for academically talented high school students for use during the summer of 1959.

An auxiliary service of this program has been the publication from time to time by AAAS of various kinds of booklists: (1) *The Traveling High School Science Library,* an annotated bibliography of the 200 titles currently in use in this library; (2) *An Inexpensive Science Library,* a list of paperbound science and mathematics books; and (3) *The AAAS Science Book List,* containing over 1,000 annotated titles.

3. *Traveling Science Demonstration Lecture Program.*—Support is provided by NSF for the training and subsequent expenses of selected teachers in demonstrating scientific principles in the classroom. These teachers travel over designated areas of the country, visiting secondary schools upon request.

Participating teachers receive salaries equal to their normal monthly salary for a 12-month period. In addition, all travel expenses are paid. The institutions which provide summer training are completely reimbursed for this expense and also perform the administrative arrangements for the academic-year visits.

Support for this program for fiscal years 1956 through 1958 has been granted to the Oak Ridge Institute of Nuclear Studies; this activity was expanded in 1959 to several other centers. Five grants were made to four institutions: ORINS (two grants), Michigan State University, Oklahoma State University, and the University of Oregon.

In general, the program provides for 3 months of summer training for 20 teachers at each of the centers, and full support for these teachers during the academic year. However, ORINS has trained an additional 20 teachers who were recommended by State education departments or local schools systems. These teachers are supported during the summer by the National Science Foundation grant, and during the rest of the year by their own school systems. ORINS, in addition, is running 2 institutes during the academic year, spring and fall, for 20 teachers each, with the same curriculum as the summer course.

During the 1958–59 academic year, teachers trained at Oak Ridge made visits to 194 areas and made contacts with 409 high schools, 3,000 teachers, and more than 100,000 students.

Visits by traveling lecturers have resulted in many significant changes in the teaching of science, according to a large number of letters received from schools visited. These letters recount in detail the improvements which the schools have been able to make in science demonstrations, laboratory equipment, assignments for students, and project work after contact with one of the demonstration-lecturers.

4. *Science Clubs and Student Projects.*—The primary objective of this program is to stimulate an interest in science and in scientific and engineering careers, particularly among precollege-age students by providing grants for the support of extracurricular science projects under the guidance of national youth organizations.

Since 1952, the National Science Foundation has provided partial support to Science Service, a nonprofit organization which administers the program of Science Clubs of America. Science projects carried out by the members of these clubs are displayed at science fairs, culminating in the annual National Science Fair.

A grant was also awarded to 4–H Clubs of America to defray the costs of a joint conference of 4–H Club leaders, college scientists, and U.S. Department of Agriculture scientists to explore methods of expanding interest and understanding of science through 4–H Club activities.

5. *Summer Training for Secondary School Students.*—This series of projects provides grants to colleges, universities, and other nonprofit research institutions to enable them to offer opportunities to unusually able secondary school students to study and work during the summer with experienced scientists and mathematicians at the sponsoring institutions.

Two general types of training programs were presented. Most common were institute-type training courses, varying in duration from 2 to 11 weeks, and featuring classroom work, laboratory exercises, and field trips centered around a specified area of science. In some cases, however, the training was based upon student participation in actual research projects of appropriate scope under the guidance of scientists.

A total of 116 grants were made to 109 different institutions in 36 States, the District of Columbia, and Puerto Rico. About 6,000 students participated in this program during the summer of 1959.

6. *State Academies of Science.*—State Academies of Science and similar organizations receive support through this program for projects to strengthen interest in science, especially among young people. Academies of Science are uniquely qualified for implementing many such types of projects because of their active involvement with Junior Acad-

emies of Science and science fairs, and because of the broad diversification of professional talent represented in their memberships.

In 1959, 30 grants were made to 23 different academies in 22 States and the District of Columbia.

7. *Science Career Information.*—Preparation and distribution of career guidance materials by scientific organizations—material designed to give authoritative information to students considering professional careers in various fields of science—are supported by this program.

During fiscal year 1959, grants of this nature were made to the American Institute of Physics, the American Geological Institute, the American Physiological Society, and the Florida State University.

College Programs and Teacher Improvement Programs

These programs are planned by universities, colleges, scientific societies, research organizations, and other groups to stimulate student interest in and understanding of science, mathematics, and engineering and to increase the knowledge and broaden the professional outlook of science teachers.

1. *Visiting Scientists (Colleges).*—The Foundation provides support to national professional societies for visits by distinguished scientific lecturers to colleges and universities throughout the country. Visiting scientists lecture, conduct seminars, and meet with students, faculty, and administrative officers for the purpose of stimulating interest in science and providing counsel concerning scientific education and careers in science.

2. *Undergraduate Research Participation Program.*—This is a newly developed program which provides support in the form of grants to colleges, universities, and other nonprofit research institutions to foster undergraduate participation in research. The purposes of the program are to interest undergraduates in research by actually sharing in an ongoing program, and to provide training in the techniques of research. Participating undergraduates in some cases receive stipends to enable them to spend time on research training, and the sponsoring institutions receive support for a share of operating expenses.

A total of 213 grants were made under this program in 1959, with 2,205 undergraduates participating during the summer of 1959.

3. *Research Participation for Teacher Training.*—This program provides support to colleges, universities, and other nonprofit research institutions for programs offering opportunities to teachers from secondary schools and small colleges to participate in scientific research during the summer months.

Participating teachers receive stipends comparable to those in summer institutes, and the sponsoring institutions receive support for a share of operating expenses.

Fifty-six grants were made to 54 institutions in 29 States and the District of Columbia; these projects provided research training for approximately 400 high school teachers and 145 college teachers during the summer of 1959.

4. *Supplementary Training for Science Teachers.*—Support in the form of grants is given colleges, universities, scientific societies, and nonprofit scientific institutions for various activities aimed at improving the quality of science and mathematics teaching at all educational levels. Examples are short conferences on the improvement of science teaching; longer conferences involving specialized instruction in science; and other special summer training programs for science teachers.

Altogether, 37 grants were made to 25 institutions and 9 societies for conferences and other teacher training activities located in 24 States; approximately 3,000 teachers participated in these activities.

5. *Special Field Institutes.*—During 1959, eight special field institute grants were made in support of outstanding special programs providing advanced training in highly specialized subjects for college faculty members, research workers, and advanced graduate students.

The principal objective of this program is to provide support for instructional and operating expenses so that educational institutions can offer important special programs for the advancement of scientific knowledge.

Six of these institutes provided intensive summer instruction and seminars lasting from 2 to 12 weeks; the other program involved part-time participation during the academic year. It is estimated that 127 college professors and 80 graduate students will participate in these programs, together with over 50 research scientists.

Specialized subjects in which instructional and research programs were offered include: dynamical astronomy, geophysical fluid dynamics, marine science, archeology, phytonematology, physiological optics, theoretical physics, and computer programming for research scientists and engineers.

International Science Education Programs

The activities in International Science Education, begun in fiscal year 1959, have developed under three general program groupings: Curricula development programs, teacher-training programs, and science student programs. Limited support was provided in 1959 for a variety of special pilot projects which may lead to fruitful operational programs.

1. *Curricula Development Program.*—In an effort to improve the science curricula available in this country, studies of science subject matter taught in foreign educational systems are being supported. Such studies are conducted by appropriate professional groups in cooperation with foreign scientists and educators. Major attention is being given to preuniversity and undergraduate curricula. Assistance is also available to interested and qualified American groups to undertake survey projects under the sponsorship of international regional organizations and also under the exchange program currently underway with the U.S.S.R. under the Lacy-Zaroubin agreement.

2. *Teacher-Training Program.*—Projects supported under this heading are aimed at improving the quality of our Nation's teacher-training programs through cooperative projects with other countries and by making use of the experience and wisdom accumulated by other educational systems. Grants can be made to international teacher-training institutes where the close personal contact that would be brought about between American secondary and college teachers with their counterparts in other nations can lead to greatly enhanced backgrounds and an invaluable appreciation of mutual problems. The Foundation assures appropriate American participation at such institutes by providing travel and living expenses for scientists and science teachers selected from our Nation's schools and colleges. Visiting foreign staff projects are also supported whereby distinguished foreign scholars contribute to Foundation-sponsored summer and academic year institutes programs.

3. *Science Student Program.*—Foundation support is offered through these projects for a number of special science education activities aimed at enabling science students and scientists to engage in international educational programs with the primary objective of making it possible for these individuals to keep abreast of the current state of knowledge and scientific advancement throughout the world. For example, assistance is given to the professional societies and institutions of higher learning to administer a program of visiting foreign scientists whereby eminent foreign scientists are invited to spend periods of a few days to a few weeks in science departments of our colleges and universities with the objective of augmenting the quality of the research and educational activities of these institutions. Increasing attention is being given to the development and support of international field institutes whereby scholars and students from many nations can gather together for a few days or weeks to exchange ideas and developments in a special field of scientific interest.

Course Content Improvement Program

The purpose of the NSF Course Content Improvement Program is to encourage and assist first-rank research scientists and teachers in attempts to incorporate modern scientific knowledge and theory into school curricula. As a result of experience and promising results obtained in previous years, 1959 funds for these programs were substantially increased to $6.1 million. This permitted expansion into a wide range of disciplines and inauguration of additional major efforts.

Course Content Studies and Development

Activities under this heading provide support for first-rate mathematicians, scientists, engineers, teachers at appropriate levels, and associated experts in education and the communications arts to develop subject matter content and model instructional materials for courses in mathematics and science in elementary and secondary schools and for courses in mathematics, the sciences, and engineering in colleges and universities. Projects ranging from small-scale experiments to comprehensive programs are national in scope and significance.

1. *Science and Mathematics in Elementary Schools.*—Throughout the country, elementary schools may soon teach science in every grade, along with mathematics. The problem is to identify significant content; to determine at what levels particular concepts can be grasped (taking variations in student backgrounds and abilities into account); and to develop written materials, apparatus, and other aids for pupils and teachers. Teachers' manuals and similar materials are particularly important, for many elementary school teachers have had little preparation in science. In this field, projects are still exploratory and experimental. Among them are work by mathematicians and teachers at Stanford University on adding geometry and other topics in grades 1–6, investigation by a group at the University of California at Berkeley on science for these grades, and development of teaching materials in geology under the sponsorship of the American Geological Institute and the University of Minnesota.

2. *Mathematics.*—The school Mathematics Study Group was organized in mid-1958 to carry out an extensive program to improve mathematics teaching in elementary and secondary schools. Many eminent mathematicians and accomplished teachers are engaged in this project, which is sponsored by Yale University and directed by Prof. E. G. Begle. One goal is to provide a sound basis for a solid college course in calculus and analytical geometry by the end of the 12th grade. Sample texts and teacher guides for grades 7 and 9–12 will be tried experimentally during 1959–60. Special manuals are being written for in-service teachers and

soft-cover books on special topics will be prepared for students. A related University of Minnesota project will test the use of the new courses in correspondence study by talented students in small schools lacking advanced work in mathematics.

3. *Physics.*—High school physics is the subject of the pioneering comprehensive study. By September 1960, revised instructional materials will be available through commercial channels for all schools wishing to adopt the course. The result of 4 years of effort by several score of the Nation's top physicists, as well as several hundred teachers who participated in developing the material and testing preliminary versions, the course focuses upon the great ideas of physics and provides insights into the way these ideas have developed. A textbook, laboratory guide, a special kit of apparatus, films presenting major experiments not readily conducted in the classroom, examinations, a teachers' guide, and supplementary books on special topics have been fashioned into a carefully articulated learning experience. This course represents a new approach to high school physics and, for the first time in many years, brings the indispensable range and depth of knowledge of a number of eminent scientists into the development of a secondary school curriculum. The Physical Science Study Committee, of which Prof. J. R. Zacharias is chairman, under the sponsorship of the Massachusetts Institute of Technology and Educational Services, Inc., has made educational history with the aid of grants from NSF and from other groups.

4. *Chemistry.*—Several approaches may prove desirable in high school chemistry. Conferences in 1957 and 1958 led to a summer writing conference at Reed College in 1959, where research leaders and college and secondary school teachers prepared a preliminary textbook and demonstration and laboratory experiments for a course using chemical bonds as the central theme. Meanwhile an interim committee of distinguished chemists, sponsored by Ohio State University, is preparing plans for a chemistry project comparable to that in physics.

5. *Life Sciences.*—In the life sciences a large group of eminent biologists and teachers have initiated the Biological Sciences Curriculum Study (BSCS) under the chairmanship of Dr. H. Bentley Glass of Johns Hopkins University and the sponsorship of the American Institute of Biological Sciences. It is the intention of the BSCS, first, to develop a new high school course in biology, and later to contribute to the improvement of biological instruction at other levels.

Support has also been granted to the National Academy of Sciences for completing the revision of a sourcebook of laboratory and field studies for high school biology, the preliminary edition of which has received widespread commendation.

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6. *College Studies.*—The Foundation is supporting a variety of course content and curriculum studies for colleges and universities, including development of teaching resources in anthropology, review of curricula in psychology, sourcebooks of experiments for general physiology and general plant pathology, development of a new freshman chemistry course at Johns Hopkins University, a research-oriented course at Purdue University for senior aeronautical engineering students, and a conference on the subject of materials in electrical engineering curricula.

Supplementary Teaching Aids

Under this program grants are awarded to colleges, universities, and professional organizations to enable highly competent mathematicians, scientists, and engineers, aided by teachers, media experts, and technicians, to develop audiovisual aids and new laboratory equipment for extending the range and to enhance the quality of their instruction. Support is not provided under this program for projects of merely local significance, nor for the purchase of equipment to improve facilities in a single educational institution.

1. *Films.*—To fulfill a long-time need of science teachers, the Foundation has awarded a grant for the collection of reliable information on content and presentation in existing science films and for study of means for encouraging the production of needed films and their more effective use.

One use of films is to stimulate interest in science through brief reports by active scientists on their work. This is the object of "Horizons of Science," a project started with the aid of grants to the Educational Testing Service. Each month through the school year subscribers will receive a 20-minute film, usually confined to a single report but sometimes giving short treatments of several topics. Film can also give everyone in a large lecture theater a close view of experiments and demonstrations. This is a feature of Foundation-supported lectures to be presented by scientists of the Rockefeller Institute to New York high school students during short vacations. Films can assist teachers by presenting key experiments difficult or impossible to conduct in school, plus the stimulation of a "visit" from a distinguished scientist. For its high school physics course the Physical Science Study Committee is preparing about 60 such films, each about 20 minutes in length. A project in microbiology at the University of California at Davis illustrates another approach, the preparation of a series of very short films to be used like lantern slides, but capable of showing movement, growth, and other events which are difficult or impossible to depict in single photographs.

2. *Television.*—More than 700 school systems and institutions of

higher education now can use television as an aid in classroom teaching, but its potentialities require much further exploration. Partial support was provided for one venture sponsored by the Greater Washington Educational Television Association, in which 16 school systems, a number of university and Government laboratories, and many scientists pooled their talents to produce a science course for 30,000 5th- and 6th-graders in nearly 300 schools. In a weekly presentation, scientists from different laboratories discussed major current investigations in fields studied in the regular lessons; televised in color, these programs were kinescoped so that they can be used in other areas.

3. *Laboratory equipment.*—Under an experimental program for stimulating the development of new, inexpensive laboratory equipment, NSF grants were awarded for 16 projects, including an integrated set of instrument "building blocks" for instruments used in analytical chemistry, a supersonic wind tunnel, and transparent plastic models of vertebrate embryos. Descriptions of apparatus developed under these grants will be published and commercial supply houses are likely to consider production of many items. A grant was also awarded to the American Institute of Physics to publish drawings of new apparatus for college physics.

Scientific Manpower Program

The *Scientific Manpower* program has as its principal function obtaining and disseminating information concerning the Nation's scientific manpower resources. Its functions are carried out through two major activities: (1) The National Register of Scientific and Technical Personnel, and (2) Scientific Manpower Studies. The cost of the program in 1959 was $780,000.

The National Register of Scientific and Technical Personnel

The National Register of Scientific and Technical Personnel is maintained to insure that information on the resources of scientific manpower is available, and that individual scientists and engineers with specialized skills can be identified and located as required in the national interest.

During 1959, the principal activities of the Register have been directed toward (1) bringing up to date as promptly as possible the processing of Register data in order to maximize its usefulness, (2) continuing the coverage of scientists through the cooperative efforts of the scientific societies, and (3) servicing miscellaneous requests for Register information.

To expedite the processing of present and future Register data, a machine processing laboratory was established during 1959 at the Register Records Center operated by North Carolina State College. A preliminary listing contained data collected on some 170,000 scientists during the period from January 1957 to December 1958.

Preliminary analyses of these data for 1957–58 were started. The data deal with a wide variety of factors, such as salary, age, level of education, field of study, professional specialties, function, type of employer, and foreign-language facility.

Agreement has been reached with the cooperating scientific societies, and planning is underway to determine the procedures and schedules to be used in a 1960 circularization of the scientific community to secure current information. It is planned that the questionnaire will provide for updating information on present registrants and complete information on new registrants.

Scientific Manpower Studies

The responsibilities of this activity are to develop data regarding the supply, demand, training, and characteristics of scientific and technical personnel, and to provide a central clearinghouse for scientific and technical manpower information. The Scientific Manpower Studies activity is the central program in the Federal Government for the provision of such information.

During fiscal year 1959, the program, by means of funds provided to other Government agencies and to research organizations, has initiated a series of projects designed to fill some of the more important gaps in information. The program has concentrated on four principal areas: (1) improvement of basic data on scientific and technical personnel; (2) studies of demand for scientists and engineers; (3) studies in the selection of scientific and technical vocations; and (4) scientific and technical manpower in foreign countries.

Among the more important specific projects begun this year were: a survey of scientific and technical employment in private industry and State governments; a survey of scientific and technical personnel in colleges and universities; a survey of scientists and engineers in Federal Government employment engaged in research (in cooperation with the Civil Service Commission); programs of study of graduate students, by level and by field; a survey of nonacademic mathematical employment; a procedural study of the identification of scientific and technical occupations; pilot studies of the demand for scientists and engineers in several industries; a study of Communist China's scientific and technical manpower; and a followup study of college graduates to determine beginning career patterns.

These projects are in accord with the series of studies recommended in the Foundation's report "A Program for National Information on

Scientific and Technical Personnel." This report was prepared in answer to a Bureau of the Budget request for such a coordinated program. One of the recommendations of this report was the following:

> To insure prompt, efficient, and thorough implementation of this program, an appropriate Federal agency should be given specific responsibility for coordinating the several projects for analyzing the data produced, and for assuring that the findings will be made public.

The National Science Foundation, upon request of the Bureau of the Budget, has agreed to act as the "focal agency" for this responsibility.

During this fiscal year the following reports were completed:

Foreign Language Knowledge of American Scientists, 1954–55.—Three out of every four scientists included in the National Register of Scientific and Technical Personnel reported knowledge of at least one foreign language. The total who reported some competence in a foreign language was about 97,000 scientists. About 2 percent of these have some knowledge of Russian, 1 percent of Chinese or Japanese. Such knowledge for the most part stems largely from nativity and family background.

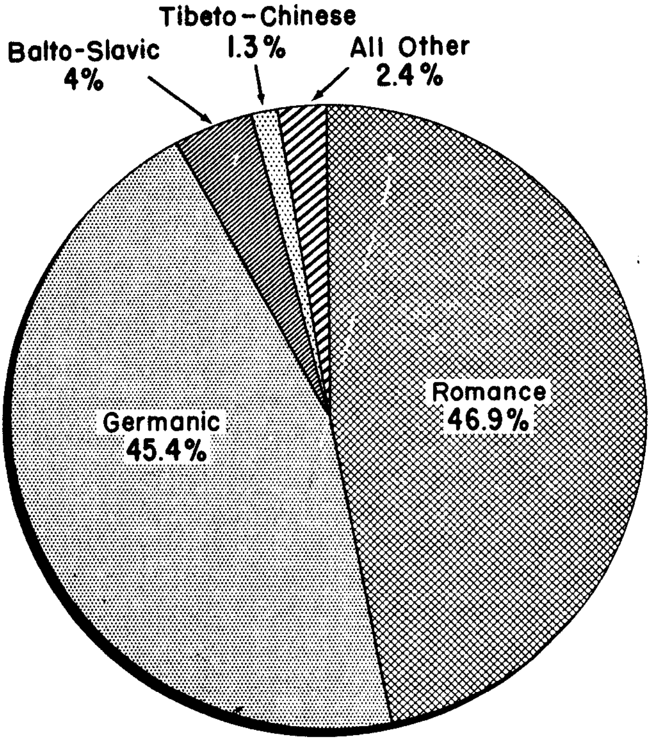
German was the language reported most often and French next, obviously a reflection of educational requirements for scientific training, particularly at the graduate level. Figure 2 shows the distribution of the major groups of languages reported by the scientists.

Chemists, chemical engineers, physicists, and astronomers showed a greater concentration in the Germanic languages; psychologists and earth scientists, in French and other Romance languages.

Scientists and Engineers in American Industry, January 1957—A Preliminary Report.—American industry employed 738,000 scientists and engineers as of January 1957 (approximately two-thirds of the national total)—528,000 engineers, 152,000 scientists, and 58,000 administrators of scientific and engineering activities. About one-third of these scientists and engineers were engaged in research and development activities.

The largest occupational group by far were the engineers, numbering 528,000. Among the scientists, chemists were the most numerous group—72,000. Employment in other scientific fields was as follows: Life scientists (medical, agricultural, and biological), 16,600; earth scientists (geologists and geophysicists primarily), 14,200; physicists and mathematicians, 12,100 and 12,400, respectively; and metallurgists, 10,800. (See fig. 3)

Engineers and chemists contributed the largest occupational groups among the 228,000 industrial scientists and engineers engaged in research



Language	No. of scientists with some degree of proficiency	With major proficiency
Germanic	44,168	31,202
Romance	45,628	30,080
Balto-Slavic	3,843	2,929
Tibeto-Chinese	1,240	816
All Other	2,395	1,928

Figure 2.—Foreign language knowledge of American scientists, by major language group, 1954–55.

and development. However, employment in research and development is of greater relative importance in certain fields, as will be noted from figure 4. Three-fifths of the physicists were in research and development, the largest proportion among all the occupational groups.

By major industry group, the aircraft industry employed the greatest number of research and development scientists, and electrical equipment the next greatest. The chart below shows the number of scientists in all activities and those in research and development for the major industry groups.

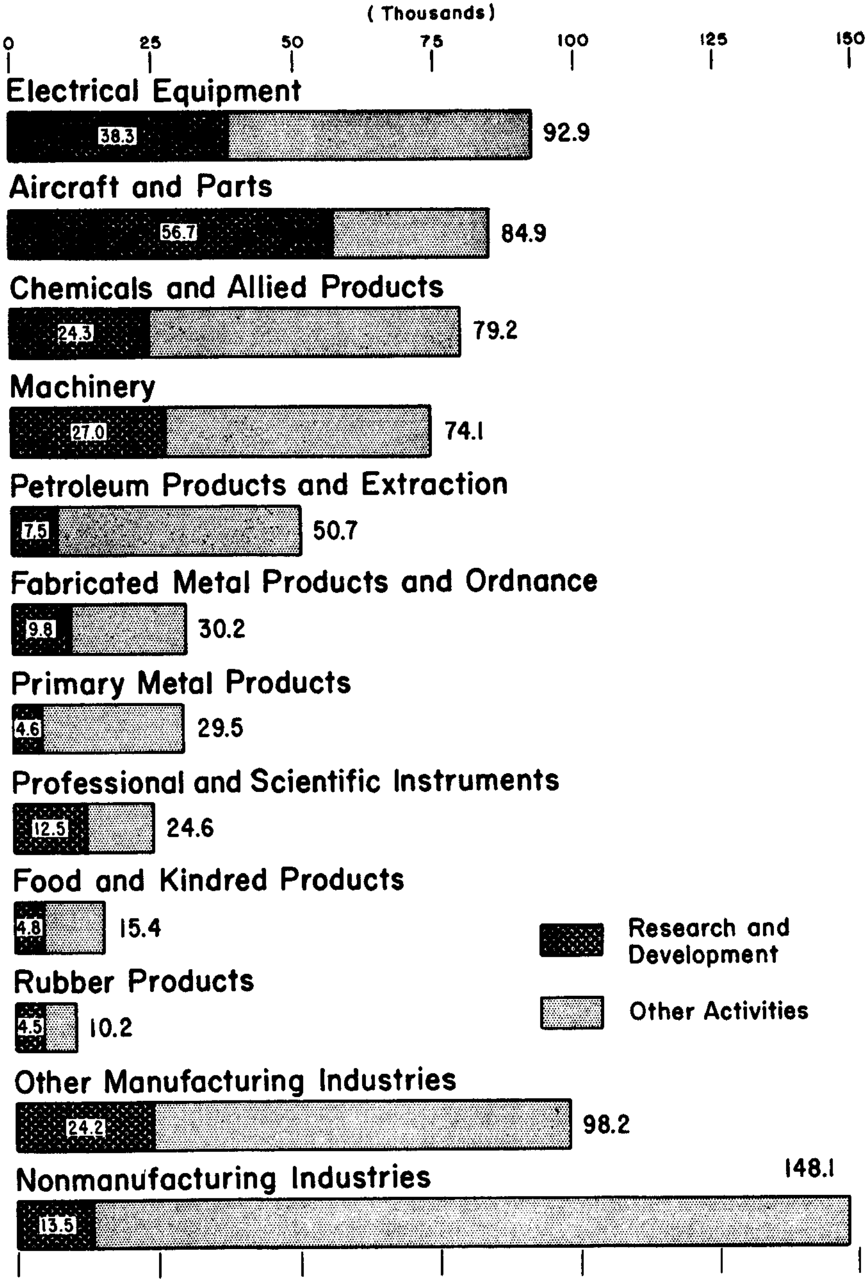
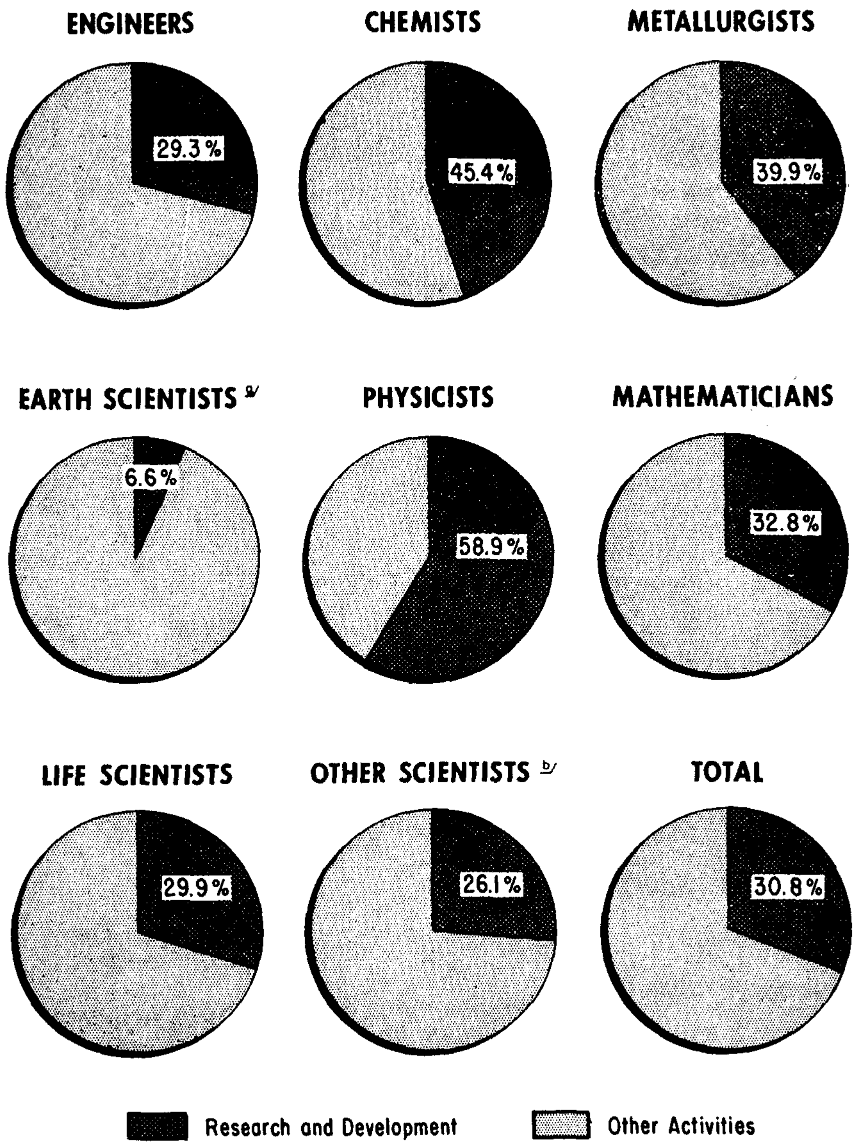


Figure 3.—Scientists and engineers in research and development activities and in all activities, by industry, January 1957.



a/ The small proportion of earth scientists employed in research and development work reflects the exclusion of field exploration from research and development under the survey definition.
b/ Includes scientists and engineers employed as administrators.

Figure 4.—Percentages of scientists and engineers in industry performing research and development, by occupational group, January 1957.

American Science Manpower—Employment and Other Characteristics, 1954–55.—Of the 116,000 employed scientists listed in the National Register in 1954–55, the largest group (some 41,000 persons) were employed in the fields of chemistry and chemical engineering. (See table 2.)

Almost half of the 116,000 scientists were employed in private industry, and nearly one-third by educational institutions. About 44 percent were engaged in research, development, or field exploration; slightly less than one-fifth were in management or administration and about the same proportion in teaching. Almost 8,000 (7 percent) were women.

Table 2.—*Distribution of all employed scientists, by field, 1954–55*

Employment field	All scientists	
	Number	Percent
Total—all fields	115, 775	100. 0
Life sciences	24, 629	21. 3
Agricultural sciences	8, 126	7. 0
Biological sciences	15, 612	13. 5
Medical sciences	891	. 8
Earth sciences	13, 829	12. 0
Geology and geophysics	11, 991	10. 4
Meteorology	1, 838	1. 6
Physics and astronomy	11, 452	9. 9
Chemistry and chemical engineering	40, 655	35. 0
Chemistry	32, 452	28. 0
Chemical engineering	8, 203	7. 0
Mathematics	8, 670	7. 5
Engineering, except chemical	4, 611	4. 0
Psychology	10, 163	8. 8
Geography	522	. 4
All other fields [a]	1, 244	1. 1

[a] Includes all other scientific and nonscientific specialties.
Source: National Register of Scientific and Technical Personnel, 1954–55.

Scientific Manpower—1958.—Papers presented at the Seventh Conference on Scientific Manpower, held in conjunction with the AAAS meeting in Washington, D.C., in December 1958, are included in papers presented at the symposium on "Demographic and Sociological Aspects of Scientific Manpower."

In addition, this program provided much information on scientists and engineers to the Foundation for planning and operating its programs and to other Government agencies, many private organizations, and the general public.

EXCHANGE OF SCIENTIFIC INFORMATION

The scientist's problems regarding information are: How can the present volume of research results be published promptly? What is being published of interest to me, where is it, and how can I get it? The Office of Science Information Service seeks ways and means to answer these questions by fostering cooperation and coordination of scientific information activities of Federal agencies and non-Government organizations.

Scientific information has become a major problem, particularly since World War II, as a result of rapid scientific progress multiplying the volume of new scientific information beyond the point where it can be effectively published or handled through existing methods. Accompanying this problem there has been an increased consumption of fundamental science by technology. The scientist needs his information faster. Formerly the timelag between development of a fundamental idea and its utilization by technology was measured in tens of years; now it may be measured in months and weeks.

During the 1959 fiscal year increased interest in this problem by the President and Congress culminated in the assignment to the Foundation of greatly expanded responsibilities for leadership in a national effort to improve the availability of research information to scientists.

The National Defense Education Act of 1958 defined NSF objectives for providing or arranging for the provision of a wide range of information services leading to a more effective dissemination of scientific information and the development of new or improved methods, including mechanized systems, for making scientific information available.

Under the terms of title IX of the act, the Office of Science Information Service (OSIS) was established by the Foundation, replacing the former Office of Scientific Information. The act also provided for the establishment of a Science Information Council made up of representatives of private industry, education, professional societies, Government, and others concerned with information problems. The group advises and makes recommendations to OSIS.

OSIS has also established the Federal Advisory Committee on Scientific Information, composed of senior members of 17 Federal agencies with significant scientific information programs, to coordinate Federal activities in the field.

Coordination of Scientific Information Activities on a National Basis

The Office of Science Information Service has proceeded on the assumption that much is to be gained by close cooperation with, and support of, existing information services, both public and private, where they are functioning effectively. This policy is inherent in applicable language of the National Defense Education Act and was emphasized strongly in recommendations to the President by his Science Advisory Committee. Many of the information services rendered by scientific societies and professional institutions are world famous for their quality. It is essential that the Federal Government continue to cooperate with and assist such private groups in maintaining and improving their specialized services.

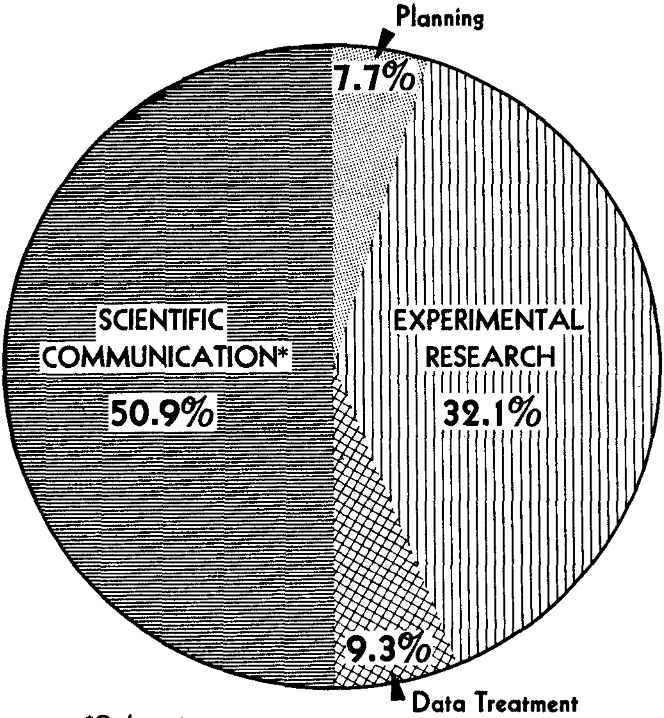
Other objectives of OSIS programs are to identify and analyze strengths and weaknesses of existing information practices; to foster cooperation and coordination among public and private agencies for the solution of problems in the field; and to encourage and support research for developing new and improved techniques of information handling.

The four major programs within the Office of Science Information Service are *Documentation Research, Foreign Science Information, Publications and Information Services,* and *Unpublished Research Information.*

In the 1959 fiscal year, 146 grants totaling about $3.8 million were made; comparable figures for the 1958 fiscal year were 89 grants and $1.9 million.

Documentation Research

Scientists need new techniques to help them find and digest the material they want without time-consuming searches through the literature. To develop these techniques it is necessary to have a clear understanding of the actual information requirements of scientists, as well as a precise knowledge of the ways in which scientists communicate. The Foundation supports research of a fundamental nature that will produce new knowledge, insights, or techniques for the development of systems to meet scientists' information needs.



*Oral or written
Data from Case Institute of Technology for N.S.F.—1957–1958

Figure 5.—*How industrial chemists spend their working time.*

Support of research by the Documentation Research program falls into three principal areas: studies of present patterns of scientific communication; the organization and searching of scientific information, including the development of mechanized systems; and mechanical translation from one natural language to another.

Studies of Scientists' Information Requirements

Two studies of the pattern of scientific communication were completed during fiscal year 1959: *The Flow of Information Among Scientists—Problems, Opportunities, and Research Questions,* prepared by the Bureau of Applied Social Research, Columbia University, and *An Operations Research Study of the Scientific Activity of Chemists,* from the Operations Research Group, Case Institute of Technology. (See fig. 5.)

A subsequent grant has been made to the Bureau of Applied Social Research at Columbia University for the preparation of a critical review of all studies to date of scientists' use of information. The review will serve to summarize what has been learned so far and to outline questions and problems needing further study.

Research on Information Storage and Retrieval

Several long-range projects in this area are being supported by NSF grants.

One such grant has been given to the University of Pennsylvania for an investigation of linguistic transformation for information retrieval, a continuation of work performed under previous NSF grants. The promising results of the earlier work have justified the expansion of support. Among the results thus far achieved is a computable method for recognizing the syntactic structure of English sentences. This has resulted in an actual program, now working on a Univac computer, for the constituent, or phrase-structure analysis of English sentences.

Short-range storage and retrieval research projects include studies of the relative efficiency of different systems of classification and indexing, and a test program to evaluate certain characteristics of the two most widely used chemical notation systems for structural formulas.

Mechanical Translation

OSIS is currently supporting research on five mechanical translation projects, three of which are directed toward procedures for Russian-to-English translations.

The Harvard Computation Laboratory has in operation a comprehensive Russian-to-English automatic dictionary of electronics and mathematics. The laboratory is now producing word-for-word translations; as word order, multiple meaning, and other problems are solved, the quality of translating will improve. The dictionary is used as a research tool in a continuing program to achieve fully automatic translation.

At Georgetown University research continues on the mechanical translation of Russian chemical and French physics texts. Several different techniques have been developed, including provision for selecting proper meanings of words and for their rearrangement into English word order. These techniques are now being tested on general-purpose computers.

A group at the University of California, through linguistic analyses of an extensive body of Russian text in the field of biochemistry, is developing a dictionary and translation rules.

Detailed studies of the way in which the German and English languages function are being made at the Massachusetts Institute of Technology. Such knowledge is believed to be necessary to the achievement of high-quality mechanical translation.

The Cambridge Language Research Unit in England is studying the semantic organization of languages to develop procedures for the mechanical handling of variations of meaning as well as form. These procedures are being tested first on punched cards.

Research Information Center and Advisory Service on Information Processing

Research and development in scientific documentation is growing at a rapid pace. Projects supported by Foundation grants represent only a portion of the active work in the field. In order to foster communication among research workers, the Documentation Research Program collects and publishes information about these activities. Brief descriptive accounts of work in progress appear in the semiannual NSF report, *Current Research and Development in Scientific Information.*

To extend this clearinghouse service for information in the field, a Research Information Center and Advisory Service on Information Processing is being supported at the National Bureau of Standards, with a portion of the financial support for the center contributed by the Council on Library Resources. The center staff has undertaken a continuing study of available reports and publications about information processing and will prepare reviews of progress in particular research areas. The center will provide Federal agencies and cooperating private organizations with technical advice on problems encountered in research projects on information processing.

Research Conferences

Support and staff assistance was given to the International Conference on Scientific Information, held in Washington, D.C., in November 1958. At the conference, progress in research on scientific information problems and the need for additional work were discussed. The conference proceedings will be published by the National Academy of Sciences.

Foreign Science Information

The Foreign Science Information program is concerned with the broadest aspects of the international exchange of scientific information. This involves attention to U.S. collections of original foreign research publications; support of translation and domestic dissemination of foreign scientific information; studies of the scientific information systems and the information resources of other countries; and interchange of scientific information between the United States and other countries.

Although during 1959 procurement and translation of scientific information of Soviet origin continued to be of primary importance, greater attention was given to increasing our knowledge of scientific achievement in other countries, including Japan, mainland China, Poland, and Yugoslavia.

Translation of Russian Scientific Documents

OSIS, in cooperation with the Office of Naval Research and the National Bureau of Standards, supported the efforts of 28 professional societies and academic institutions in cover-to-cover translations of 35 Russian scientific and technical journals and 18 books and monographs, as well as special articles and collections of scientific papers. This support permitted the translation of approximately 70,000 pages of foreign scientific information, a significant increase over the 1958 support program when the 29 journals, 10 books and monographs, and other materials translated totaled 37,000 pages.

Translation Centers

Within the Federal Government, interagency cooperation stimulated by the Foundation led to the establishment of a Foreign Technical Information Center in the Office of Technical Services of the Department of Commerce. This center collects scientific and technical translations prepared by Government agencies, announces their availability, and provides copies to the public on request.

In the interest of further reinforcing a cooperative national attack on the translation problem, the Foreign Science Information program continued its support of the Special Libraries Association Translation Center at the John Crerar Library in Chicago. SLA collects translations from non-Government sources and forwards them to the Department of Commerce for announcement simultaneously with Government-prepared translations.

In January 1959 the Office of Technical Services began issuance of a semimonthly publication entitled *Technical Translations,* which provides a central source of information in the United States on translated technical literature available to science and industry. It lists and abstracts translations available from the Office of Technical Services, The Special Libraries Association Translation Center, cooperating foreign governments, educational institutions, and private sources.

Special Information Resources

Support was also given to the Midwest Interlibrary Center (MILC) for continuation of its program of building a comprehensive collection of foreign chemical and biological serial publications to serve as a national as well as a regional resource.

Studies and Surveys

Information studies on the organization and characteristics of scientific information and information systems in all nations which conduct research are underway. These include studies of Poland by the New

York Public Library and of Japan and Indonesia by the Pacific Science Board of the National Academy of Sciences. Similar studies are being developed for the U.S.S.R., mainland China, Czechoslovakia, Yugoslavia, Hungary, Korea, and other countries.

Oversea Activities

OSIS has played an important role in improving coordination with international scientific information activities. Help is being given to the European Productivity Agency in a study of the feasibility of establishing a Pan-European Translation Center to collect and organize translations of Eastern European and Oriental scientific literature from Western Europe.

The Foundation, as directed by the Bureau of the Budget and the President, is responsible for the coordination and administration of budget estimates and programs for scientific information activities undertaken overseas by Federal agencies using foreign currencies accruing under Public Law 480, 83d Congress. A total of $1.2 million was appropriated by Congress for this purpose. Although certain administrative difficulties exist, the Public Law 480 program offers an opportunity for a notable increase in the quantity of foreign publications and translations available in the United States. A contract for such a program in Israel became effective April 24, 1959, and about 10,000 pages of foreign scientific and technical materials are currently in process of translation there.

In May 1959, OSIS representatives visited Poland to negotiate a contract which provides for the translation and publication of an average of 500 copies of 19,000 pages of Polish scientific and technical information. It is expected that a contract will be negotiated with Yugoslavia. Feasibility surveys will be conducted in India.

Publications and Information Services

The Publications and Information Services program supports a variety of scientific publications; data and reference centers; and experiments, studies, surveys, and conferences. This support is to aid the dissemination of scientific information by helping to maintain, improve, and expand present means of publication, and by helping to establish and maintain information centers that provide scientists with specialized reference service.

Support of Scientific Publications

During 1959, grants were made in support of primary research journals to launch new publications and to aid existing periodicals. The former included two experimental publications: *Wildlife Disease,* the first research journal to be issued solely in microform (Microcard in this case); and *Physical Review Letters,* an experiment in rapid low-cost publication of short, up-to-the-minute articles on physics research. Typical of other new periodicals supported is the *Journal of Geophysical Research;* here the NSF grant assures publication for 2 years during which time it is believed the journal can become self-supporting. Representative of the existing primary journals receiving support in 1959 is *Genetics;* in this case the grant is for the publication of an accumulated backlog of papers as a separate volume. Other journals have received temporary support to enable them to publish cumulative indexes or to insure publication while regular income is being adjusted to meet sudden increases in costs or the need for immediate expansion of coverage.

Grants also were made in support of abstracting and indexing services. Typical is the grant made to *Biological Abstracts* to enable it to improve the adequacy of its coverage. Other reasons for such grants include supporting a new service until it can build up its regular income, permitting reorganization of a service to improve its effectiveness, and covering a financial crisis caused by a sudden rise in costs or the need to offer a temporary specialized service. Consultation with the National Federation of Science Abstracting and Indexing Services (formed in January 1958 with NSF support) aids in achieving coordination and consistency of overall pattern. The policy of temporary support only is applied here also; however, the periods of subsidy are somewhat longer than in the case of primary journals because costs are higher and possible sources of income are fewer.

Recognizing that good critical reviews constitute one of the most important—and most neglected—forms of scientific publications, the Publications and Information Services program made its first extensive grant in this area in December 1958. Under this grant four series of review papers are being prepared in physics, varying from comprehensive technical reviews of major area of the field to short, semitechnical synopses of limited subject scope.

Support of Information Services

Two significant grants in this area were made during 1959. The first was for continued support to the Office of Critical Tables of the National Academy of Sciences. This office is an information and coordinating center for projects engaged in developing critical physical data of all kinds. The second grant of this kind was to the Bio-Sciences Information Exchange administered by the Smithsonian Institution and jointly supported by a number of Government agencies. The exchange functions as a repository of knowledge on "who is working on what" in the bi-

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ological sciences and offers reference service on its holdings to all participating groups.

Studies and Surveys

Studies are being made to provide yardstick information for use in evaluation of proposals and to direct the way to improved publication and other dissemination methods. One is developing a breakdown of scientific reading habits of chemists and physicists in terms of the kinds of material covered and specific journals read. Other investigations underway concern the membership, dues, and publication structure of professional scientific societies; the editorial subscription and production practices of scientific journals; publication climate in industries engaged in basic research; an analysis by the American Institute of Physics of the overall publication picture in physics; and a somewhat preliminary study in the biological field being conducted by the American Institute of Biological Sciences.

Unpublished Research Information

The principal concern of the other programs of OSIS is with the dissemination of domestic and foreign scientific information generated through conventional publications channels. The Unpublished Research Information (URI) program seeks to increase the accessibility of unclassified, unpublished research information. The major sources of such information are research reports and memoranda of Government and private institutions, theses, dissertations and papers resulting from scientific conferences. This material frequently contains significant scientific information not otherwise found in published sources.

The development of the program and its accomplishments to date have been governed by two general precepts: attain systematic dissemination of unclassified research information not generated through conventional publications channels; and encourage the flow of such information to these channels.

Clearinghouse activities involving direct literature search service by OSIS were transferred to the Office of Technical Services, Department of Commerce, and to the Science and Technology Division of the Library of Congress.

Preliminary investigation was made of the feasibility of establishing a center, similar to the federally supported Bio-Sciences Information Exchange, for handling mathematical, physical, and engineering information generated by Government or federally sponsored projects. A similar study was made of the problem of handling materials information and data. Increasing attention will be given to these kinds of studies as the program develops.

Inventory of Government Scientific Reporting

In 1959 the Foundation, through the URI Program, accelerated its efforts to survey information activities of Federal agencies operating major scientific information programs. Bulletin No. 1 of the series, *Scientific Information Activities of Federal Agencies,* covering the information activities of the Department of Agriculture, was published in November 1958. Bulletin No. 2, released in June 1959, reported such activities for the Office of Naval Research.

Unpublished Research Reports

In 1959 continued support was given by a grant to the Office of Technical Services (OTS) of the Department of Commerce to increase the availability of unclassified Government research reports to the Nation's scientists and engineers.

A grant was made to the Library of Congress for continued support to enable it to expand further its reference collection of Government research reports and to provide reference and bibliographic services to insure accessibility of this information to the scientific community.

Other Activities

The OSIS responsibility for conducting the U.S. scientific exhibits program at the Brussels World's Fair was concluded in 1959. During the year a number of these exhibits were installed at the Chicago Museum of Science and Industry.

Other exhibits were prepared for use at meetings of scientific organizations where the problems of scientific information dissemination and programs for improvement in the field were topics of discussion.

To provide an effective means for the exchange of information among groups working in the scientific information field, the Office of Science Information Service began publication of a bimonthly news bulletin, *Science Information News,* in February 1959. The bulletin reports national and international developments and, it is hoped, will promote cooperation and coordination among scientific information services. Initial reaction indicates this bulletin fills a widespread need.

Providing U.S. Scientists With Soviet Scientific Information, published during the fiscal year, describes the overall U.S. effort to make available Russian scientific publications, translations, abstracts, indexes, and bibliographies. It also contains a reference list of 76 Russian journals currently being translated into English.

Current Research and Development in Scientific Documentation, No. 4, describes projects here and abroad in information requirements and uses, research on information storage and retrieval, mechanical translation, and in equipment development.

SURVEYS OF THE NATIONAL RESEARCH AND DEVELOPMENT EFFORT

A major Foundation responsibility is the measurement and appraisal of the total research and development effort. Each sector of the economy, pursuing its own interests, contributes its part to the whole effort. As a Federal agency, the Foundation is in a position to view the condition of the Nation with regard to its entire research and development activity. This view aids in the formulation of national science policy and the establishment of internal policies for the Foundation's programs in research and education.

The NSF Act of 1950 provided for such a mission in directing it to develop recommendations regarding national science policies. The President's Executive Order of March 1954 specifically directed it "to make comprehensive studies and recommendations regarding the Nation's scientific research and its resources for scientific activities" and to appraise "the impact of research upon industrial development and upon the general welfare."

Importance of Research and Development in the Economy

Scientific research and development, recognized for its part in achieving military objectives, is now being appraised for its significance as a national activity in our economic system. This recognition was more forcefully realized with the Foundation's estimate for 1957 of $10 billion for research and development in the country as a whole with the employment of more than 300,000 scientists and engineers.

Referred to as the "industry of discovery," research and development activity in the United States has in recent years expanded more rapidly than many other industries. Expenditures for this purpose rose from more than $2 billion [1] in 1947 to $5.2 billion [2] in 1953 and to the previously mentioned $10 billion in 1957.

That this upward trend will persist is indicated by the fact that the 1957–58 recession failed to halt its growth. Perhaps contributing to the continued increase is a new public awareness, created by the Soviet

[1] Department of Defense. Office of the Secretary of Defense (R&D), *The Growth of Scientific Research and Development.* Washington 25, D.C., 1953, p. 10.

[2] National Science Foundation. *Reviews of Data on Research & Development,* No. 1, "Expenditures for Research and Development in the United States, 1953." Washington 25, D.C., 1956.

satellite launchings, of the need for continuing research and development.

Many have realized that research and development contributes significantly to our domestic policy of maintaining a healthy economy. But until the past few years the intrinsic effects of research and development on the growth of the economy and on maintaining its level had only been vaguely explored. The theory that research and development acts in this way on the economy has been expounded by the late Prof. Sumner Slichter of Harvard University. He has stated that technological research leads to increased demand for goods, which in turn raises production and thereby acts as a source of greater income. Thus, research has a dynamic as well as a stabilizing effect. Research and development acts in this manner primarily because we have a free enterprise system. The competition by industry to bring about the innovations and new products as a result of research is responsible for these overall effects on the economy.

Thus, research and development also influences the competition among nations, extending to all levels, the military and civilian, i.e., competition with regard to weapons systems as well as to standards of living. Dr. Waterman, at the hearings before the Joint Economic Committee of the Congress in February 1959, testified: "The real point is that we are competing with the Soviet Union for the future . . . the economic implications of research and development are of a long-range nature. What we do now in planning our research and development effort, in giving it adequate support, may determine not only our own future but the future of the world as well."

The importance of research and development requires that ways be found to measure this effort. To do this it is necessary to obtain detailed data, which in turn will permit closer analysis of the effects of research and development.

Survey Program and Related Analytical Studies of the Foundation

Two measurements of the research and development effort are (1) dollars expended and (2) manpower employed. In the late 1930's and during the 1940's, statistics were primarily broad estimates of total volume of expenditures and manpower. Some of these estimates were prepared by the National Research Project of the Work Projects Administration, the National Resources Planning Board, the Office of Scientific Research and Development, the President's Scientific Research Board, and the Research and Development Board of the Department of Defense.

The Foundation's Office of Special Studies, benefiting from this earlier work, approached the problem of measurement on a systematic and comprehensive basis. The economy was divided into four "sectors"—Federal Government, industry, colleges and universities, and other nonprofit institutions.

Data are compiled in terms of both sources of funds and performers of research and development for all four sectors. This permits analysis of intersectoral relations and the construction of a transfer table showing the flow of funds for support of work by the sectors to others for the conduct of research, as well as for the basic research performed and/or supported by each sector.[3]

Surveys are conducted in each sector, largely by means of questionnaires either directly by the Foundation's staff or by contractual agreement with another Federal agency or outside institution. For the Federal sector and for most groups in the nonprofit sector, the surveys aimed for complete coverage; sampling was used for industrial firms and smaller philanthropic foundations.

The first comprehensive round of surveys covering the year 1953–54 was completed, with full reports issued covering the individual surveys in each sector. The data have been combined into an overall estimate for the country. This necessarily experimental series indicated deficiencies to be met, or at least acknowledged, for some of these are inherent in the subject matter, and laid the foundation for a permanent survey program.

The purposes served by the current program of statistical surveys are twofold, one being to supply a sufficient amount of information for analysis, and the other to formulate a statistical time series summarizing annual fluctuations in research and development activity. The demands on the Foundation to supply data on research and development activities have been great, and as a result continual updating of information is planned. A detailed survey of each sector will be conducted once every 4 or 5 years. In the intervening years only summary data will be collected, largely for the purpose of developing the time series. However, owing to the current interest in research and development data, this plan for the present has been modified to make the summary surveys somewhat more detailed in nature, but eventually it is hoped to confine them to total figures. In this way, adequate data on research and development will be available for each sector as well as for the country as a whole.

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[3] National Science Foundation. *Reviews of Data on Research & Development,* No. 1. "Expenditures for Research and Development in the United States, 1953." Washington 25, D.C., 1956; *Reviews of Data on Research & Development,* No. 5. "Funds for Basic Research in the United States, 1953." Washington 25, D.C., 1957.

Emerging from the data collection have come the tools for shaping analytical studies. Like the factfinding studies, they are the means for achieving the objectives and they continue to build the basis for guidance in policy matters and "appraising the impact of research on the general welfare."

Total National Activity

Based on its sectoral surveys, the Foundation estimates that research and development activity in 1956 totaled about $8.5 billion. In terms of "sources of funds" and "performers" of research and development, industry performed 76 percent of the total dollar volume and supplied 38 percent of this national total from its own funds. The Federal Government was the major source of funds, supplying 59 percent in addition to the 38 percent from industry, and the remainder came from colleges and universities and other nonprofit organizations. In interpreting these data, it should be borne in mind that the bulk of this amount represents development customarily performed by industry and largely financed by the Federal Government to meet its military objectives.

Knowledge regarding basic research, a foremost concern of the Foundation, is also gained from these surveys. Such information is useful to the internal formulation of policy. Here again the overall figures for 1956 show the Federal Government to be the major source of funds; the colleges and universities maintain their traditional position as primary performers of basic research.

From these surveys ensued some of the studies and actions dealing with the impact on the economy of research and development activity as outlined below.

(*a*) As a start in the direction of exploring this activity, a conference was held dealing with "Research and Development and Its Impact on the Economy" in the spring of 1958 which resulted in publication of the *Proceedings.*[4]

(*b*) On the same subject was the Director's presentation, quoted previously, before the Joint Economic Committee. An abridged version of his remarks was published in the NSF series, *Reviews of Data on Research & Development,* No. 13, "Research and Development and Economic Growth," in which Dr. Waterman stated:

> More and more emphasis is being given to research and development in the analysis of long-term growth as compared to the somewhat more traditional factors, particularly capital expenditures and

[4] National Science Foundation, *Proceedings of a Conference on Research and Development and Its Impact on the Economy.* Washington 25, D.C.: Supt. of Documents, U.S. Government Printing Office, 1958.

population. The 1959 *Economic Report of the President* has called attention to the extremely important role that research and development contributes to the growth of the economy.

(*c*) *Current Projects on Economic and Other Impacts of Scientific Research and Development, 1959.*—The survey of projects pertaining to analysis of the impact of research and development to date has been limited to colleges and universities. Over 100 projects were reported by 54 of the 140 responding institutions. Under the title shown above, publication of an inventory of these projects is planned for the fall of 1959. This survey may be extended to research institutes and privately endowed foundations.

(*d*) *Bibliography on the Economic and Social Implications of Scientific Research and Development.*—A selected annotated bibliography has been prepared. It is intended to provide references representative of typical approaches to the study of research and development, and to serve as a guide for further investigation.

(*e*) *Conference on Economic Analysis of Research and Development.*—In the spring of 1959 a 2-day symposium was held, convoking analysts from industrial firms and universities to present informal papers on their inquiries into the research process. The symposium was mutually fruitful to participants in providing a channel for communications and constructive critical discussion of the work in their fields.

Federal Government

During the fiscal year 1959 the Foundation published *Federal Funds for Science, VII—The Federal Research and Development Budget, Fiscal Years 1957, 1958, and 1959* based on data reported to the Foundation in the spring of 1958 by the Federal agencies participating in the Government's research and development programs. The President subsequently submitted supplemental requests for additional appropriations which had not been included in the budget for both fiscal years 1958 and 1959. Congress, recognizing the needs of science, in several cases increased funds for scientific research and development by a substantial amount over the original budget estimates.

Reviews of Data on Research & Development, No. 12, "Recent Legislative and Executive Actions on the Federal Budget for Scientific Research and Development, Fiscal Years 1958 and 1959," presented preliminary information on the extent of the major changes in the estimated obligations which were published in the seventh issue of *Federal Funds for Science.*

During the year, a survey was conducted of obligations and expenditures for scientific research and development for fiscal years 1958, 1959, and 1960. Among the changes introduced in reporting the survey, the most important in terms of the overall totals, relates to the expanded definition of development which now corresponds to the definition used in current surveys of the other sectors. Table 3 summarizes estimated obligations for fiscal year 1959.

With respect to the manpower studies of the Federal sector, the data on research and development personnel were collected as a part of a larger survey by the U.S. Civil Service Commission.

Table 3.—*Estimated Federal Obligations for Conduct of Research and Development, Fiscal Year 1959*

[Millions of dollars]

Agency	Estimated obligations, fiscal year 1959 [a]
Total, all agencies	$7,233
Department of Agriculture	119
Department of Commerce	28
Department of Defense [b]	5,581
Department of the Army	(992)
Department of the Navy	(1,249)
Department of the Air Force	(2,738)
Advanced Research Projects Agency	(427)
Departmentwide funds	(175)
Department of Health, Education, and Welfare	244
National Institutes of Health	(212)
Department of the Interior	62
Atomic Energy Commission	773
National Aeronautics and Space Administration	303
National Science Foundation	57
All other agencies	65

[a] These estimates were published in *Federal Funds for Science, VIII—The Federal Research and Development Budget, Fiscal Years 1958, 1959, and 1960.*

[b] Data reflect revised appropriation structure for research and development. Totals include pay and allowances of military personnel in research and development, separately identified procurement funds in support of R, D, T, & E, as well as the Research, Development, Test, and Evaluation appropriations.

NOTE: Detail will not necessarily add to totals because of rounding.

Industry

Two previous surveys of research and development performance by private firms were sponsored by the National Science Foundation and were conducted by the Bureau of Labor Statistics, U.S. Department of

Labor. The first survey covered the years 1953–54 [5] and the second 1956.[6] Preliminary figures on costs and manpower were released on the 1956 survey. A detailed report containing final revised figures is in the process of publication.

The 1957 survey was conducted by the Bureau of the Census in order that research and development data could be related to other economic statistics collected by that agency. A detailed survey covering the year 1958 is currently underway, being conducted also by the Bureau of the Census.

Preliminary returns from the 1957 survey were released in the fall of 1959 in *Reviews of Data on Research & Development,* No. 14, "Funds for Research and Development Performance in American Industry, 1957." For overall comparisons the Foundation has estimated the funds for total industrial research and development performance for the 5 years 1953–57 as presented in figure 6.

Colleges and Universities

The final report of a Foundation survey of colleges and universities was issued in December 1958, *Scientific Research and Development in Colleges and Universities—Expenditures and Manpower, 1953–54.* A survey for the year 1957–58 is now underway, this one being conducted for the Foundation by the U.S. Office of Education. The rapid growth of Federal financial support of scientific research and development at institutions of higher education during the postwar period has raised a number of issues of national education and science policy. Among these issues are:

(*a*) Relative responsibilities of Federal and non-Federal sources for financing academic research.

(*b*) Relationship of federally sponsored research to the issue of Federal aid to higher education.

(*c*) The compatibility of institutional objectives to those of sponsoring Federal agencies.

(*d*) The effects of Federal sponsorship of research upon the balance of institutional activities as between research and instruction. (For example, is Federal support of research tending to drive

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[5] *Science and Engineering in American Industry. Final Report on a 1953–54 Survey.* Prepared for the National Science Foundation by the U.S. Department of Labor, Bureau of Labor Statistics. Washington 25, D.C.: Supt. of Documents, U.S. Government Printing Office, 1956.

[6] National Science Foundation. *Reviews of Data on Research & Development,* No. 10, "Research and Development Costs in American Industry, 1956." Washington 25, D.C., 1958.

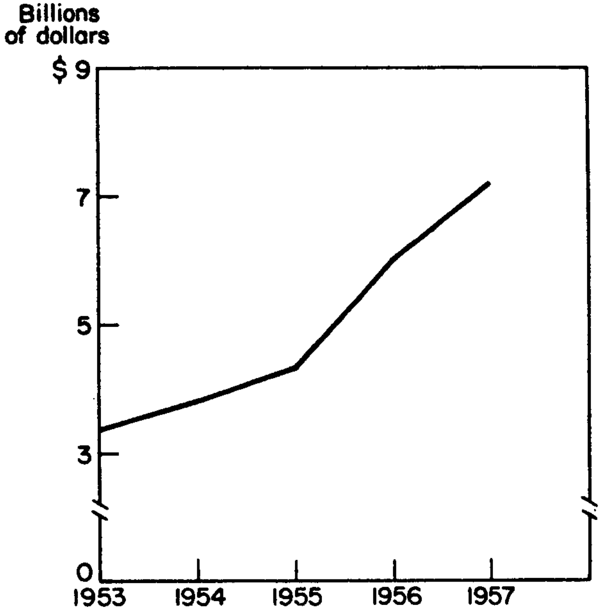

Figure 6.—Funds for research and development performed by private industrial firms, 1953–57

NOTE: Data for each year are expressed in terms of current dollars.

(a) Funds shown here are for private industrial firms, i.e., principally manufacturing and other industrial firms which account for more than 90 percent of the total amount for the "industry sector" as a whole. Also included in the sector as defined by NSF (but not represented in the chart) are independent commercial laboratories, trade associations, and research centers operated by private industrial organizations under contract with the Federal Government.

faculty out of teaching and into research because of better opportunities for promotion?)

(*e*) The effects of Federal sponsorship upon the balance among the institutional research activities, e.g., as between natural and social sciences and between the sciences and the humanities.

(*f*) The effects of Federal contracts for applied research and development upon basic research.

(*g*) Use of the research center as an institutional device for attaining research objectives of Federal agencies.

(*h*) Responsibilities of Federal agencies for paying indirect costs of sponsored research.

An assessment of these problems requires facts on the total research and development effort carried on at institutions of higher education, the proportion federally financed, the trends in Federal support by agencies, field of science, character of work, etc. (See figures 7 and 8.)

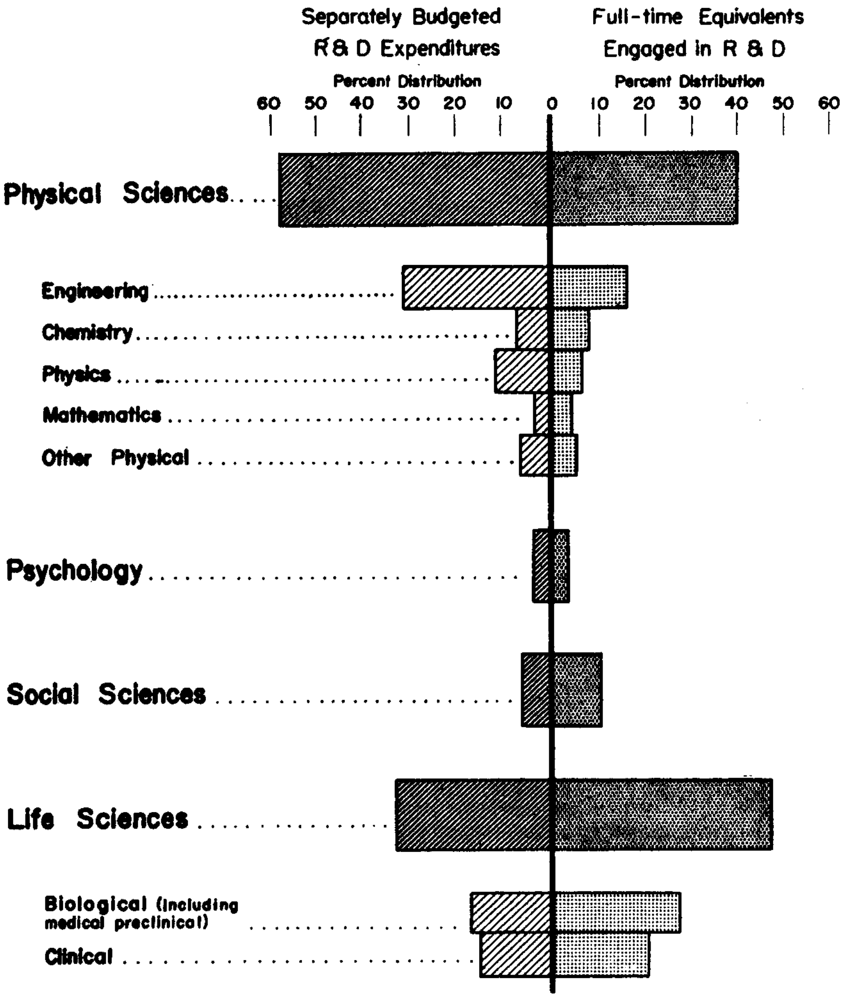

Figure 7.—*Separately budgeted research and development in colleges and universities proper, 1953–54. Comparison of expenditures and faculty, by field of science.*

NOTE: Excludes data on agricultural sciences.

(a) Separately budgeted research and development includes both research and development sponsored by outside agencies and that supported by "earmarked" university funds.

(b) Due to varying response factors, the institutional coverage of expenditure and manpower data is not completely comparable. Within the scope of the 190 large colleges and universities surveyed, 173 schools reported on expenditures and 180 reported on manpower. The chart is based on the schools reporting on both items.

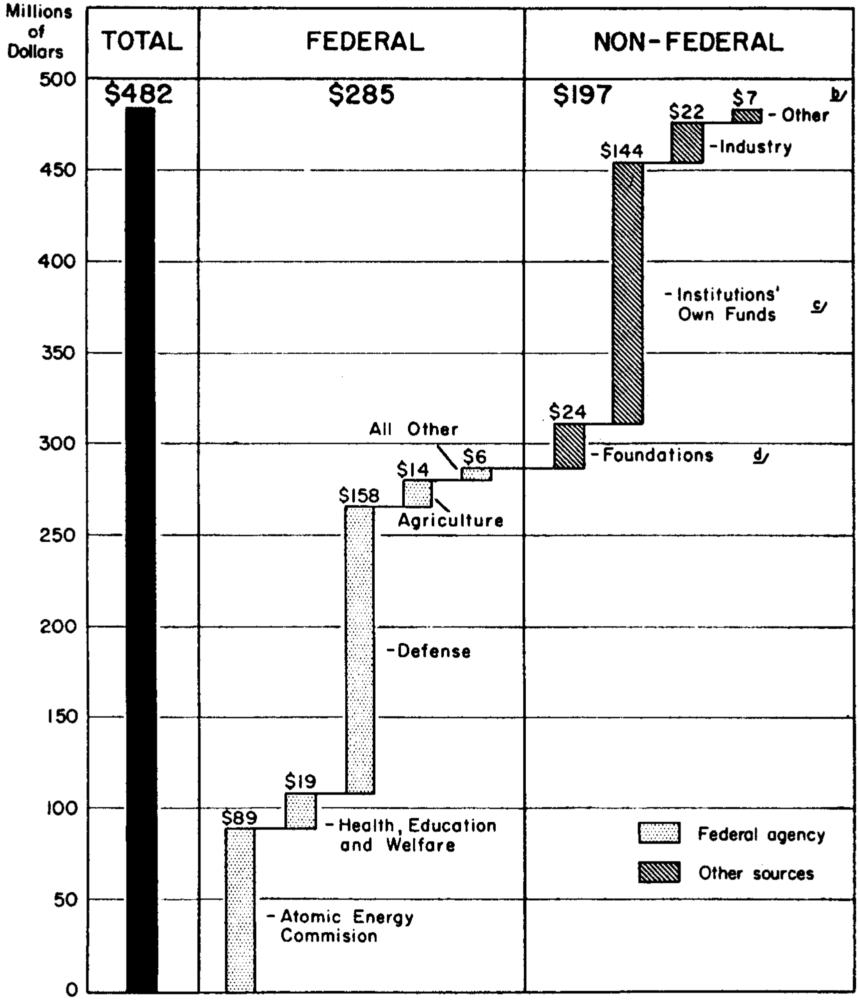

Figure 8.—*Total cost of research and development at colleges and universities, by source of support, fiscal year 1954.*[a]

[a] Includes colleges and universities proper, agricultural experiment stations, and Federal research centers.

[b] Includes gifts and grants, and other private sources.

[c] Includes State and local government funds.

[d] Includes health agencies.

Data obtained from the Foundation's 1953–54 survey of research and development at colleges and universities have contributed significantly to policy recommendations developed by the Foundation with respect to a number of the above problems.[7]

Other Nonprofit Institutions

Repeating the 1953–54 surveys of private foundations, research institutes, health agencies, and other nonprofit organizations, the Foundation has utilized the services of the U.S. Department of Labor, Bureau of Labor Statistics, to collect data on expenditures and personnel for the year 1957. Privately endowed foundations reported $71.5 million for support of research and development in that year, 67 percent of which was characterized as basic research. Health agencies reported $23 million, 47 percent of which was basic research, mostly in the life sciences.

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[7] See the following reports: National Science Foundation. *Government-University Relationships in Federally Sponsored Scientific Research and Development.* Washing 25, D.C.: Superintendent of Documents, U.S. Government Printing Office, 1958; and *Federal Financial Support of Physical Facilities and Major Equipment for the Conduct of Scientific Research.* Washington 25, D.C.: National Science Foundation, 1957.

SPECIAL INTERNATIONAL PROGRAMS

International Geophysical Year

General

The International Geophysical Year (IGY) 1957–58, the worldwide cooperative program in geophysical research conducted by 66 nations, came to a close on December 31, 1958. By this date there had successfully been completed 18 months of scientific observations begun on July 1, 1957.

The planning and execution of the U.S. portion of the IGY program were conducted by the U.S. National Committee for the IGY, National Academy of Sciences. Funding and coordination of Government interests were provided by the National Science Foundation.

Summary of Preliminary Results of the IGY

The data for the IGY are so extensive that it will take years to extract all the valuable material contained therein. Nevertheless, a large number of significant preliminary results have already been recorded.

A comprehensive report on these results for the entire 18-month period of the IGY was presented to the Subcommittee on Independent Offices of the Committee on Appropriations, House of Representatives, in February 1959, by members of the U.S. National Committee for the IGY and its technical panels, and is available in published form. The preliminary results covered in detail in the report can only briefly be mentioned here.

As a part of the IGY, the sun was subjected to the most comprehensive and detailed examination ever given by man to any extraterrestrial object. Solar manifestations were looked at both to discover more about the processes that occur in the sun, and to try to correlate these manisfestations with the complex phenomena that occur in the earth's atmosphere.

Every variety of geophysical instrument, including rockets and satellites, was used in the total IGY examinations. It is probably safe to say that every available vehicle was used by the farflung parties of scientists in the accomplishment of their missions.

Of the many measurements and accomplishments of the series of IGY satellites, two outstanding ones may be mentioned. With respect to instrumentation carried aloft by satellites, the identification of the Van Allen Radiation Belt is probably the most significant. Man has now established the fact that the earth is surrounded by two great doughnut-shaped zones of trapped charged particles at distances in the plane of the geomagnetic equator of about 600–4,000 and 8,000–12,000 miles altitude. Further, it has been established that for a given altitude this radiation is most intense in low geomagnetic latitudes and is much reduced at polar latitudes, and that it has a distribution relationship to the earth's magnetic field. A second significant preliminary finding resulted from careful ground-based observations of the Vanguard I satellite orbit and complicated calculations based upon the orbital data. An important contribution to geodesy was made by these calculations, as they permitted a refinement of our knowledge of the distribution of mass of the earth, indicating a slight excess in mass in the Southern Hemisphere over that in the Northern Hemisphere.

By means of rockets and balloons, important deviations between the latitude energy distribution of cosmic rays impinging upon the earth and the structure of the earth's magnetic field have been detected. Similarly, terrestrial magnetic field measurements tend to verify the existence of a strong electrical current in the high atmosphere above the earth's magnetic equator. Still further, the earth's magnetic field has been demonstrated to maintain a detectable influence far into space. This came as a consequence of studies of ionospheric phenomena called whistlers, which originate from atmospheric electrical disturbances that propagate along paths guided by the force of the earth's magnetic field.

The diurnal and seasonal variations of the ionosphere also demonstrate the close relations among solar variations and terrestrial responses. Careful and prolonged measurements of the aurora enable still closer identification of solar radiation and solar particle output and the resultant upper atmospheric consequences. An additional significant finding derived from the examination of these solar-terrestrial phenomena is that the sun's corona appears to be of great extent and that the earth itself may be immersed in this extremely tenuous material.

The sun's effects are not, however, confined to the earth's atmosphere. The liquid and solid portions of the earth respond to the energy in which they are bathed, and react between themselves and with the atmosphere as a gigantic heat engine with two fluids. And even the solid earth responds to the sun in the measurable form of the earth tides. The earth's intake and output of energy, primarily from the sun, are remarkably stable. The energy exchanges between the atmosphere and the oceans are on a vast scale. The circulation of winds and waters effects the exchanges necessary for this stability.

The understanding of meteorological phenomena will have been advanced immeasurably when the IGY data have been completely analyzed. In the oceans—our last terrestrial frontier—new currents and deep countercurrents have been identified and measured. The exchanges of gases, such as carbon dioxide, between the waters and the atmosphere have been measured all over the world, and as a result it has been established that the distribution of carbon dioxide gas is remarkably constant throughout the world. All the world's important glaciers and ice deposits have been measured and probed to complete the data that man must have in order to promote climatological research on its necessary long-time scale, and future similar measurements from time to time will yield epochal knowledge.

The first serious large-scale scientific examinations of the Antarctic form a noteworthy part of the IGY program. Tremendous depths of ice, up to 14,000 feet, were probed by seismic means and give for the first time an indication of the actual size of the Antarctic ice deposit. First mappings of the structure under the icecap were made. Many upper atmospheric measurements were completed and preliminarily substantiate the belief that cosmic rays are distributed in the Southern Hemisphere in the same fashion as they have been measured in the Northern Hemisphere. The simultaneity and general frequency of auroral occurrences in both hemispheres were established.

Meteorology particularly benefited from the investigations in the Antarctic where, until the IGY, meteorological knowledge was scant and upper air observations almost nonexistent. The Antarctic is the only place on earth where the ocean waters perform earth circuits without continental or other interruptions and where a high, frigid continent underlies a very large-scale circulation system.

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The earth's crust and interior were also subjected to careful scrutiny. Seismic stethoscopes measured natural and manmade disturbances of vibrations in the earth, both on land and at sea, and measured strains and deformations in the earth's crust. Mountain roots were in some cases found to penetrate through the earth's crust deeply into the mantle. Measurements of the value of gravity are tying in hitherto incomplete gravity networks and revealing mass distribution and mass anomalies.

The data now gathering in IGY World Data Centers will spur man's imagination concerning his entire world as never before. The continuing use of this data, and its vast research value, far outweighs the cost of the IGY effort and should greatly accelerate the pace of research in relevant areas.

World Data Centers

In accordance with agreements reached by the nations participating in the IGY, the data resulting from observations are being collected in three World Data Centers: World Data Center A, located in the United States; World Data Center B, established in the U.S.S.R.; and World Data Center C, maintained by eight nations of Western Europe, Japan, and Australia. If received by only one of the World Data Centers, data are immediately copied and sent to the other two centers so that three complete sets of IGY data will be in existence for the use of interested scientists in all parts of the world. Any individual or institution may obtain copies of the data from a center at a nominal sum to cover reproduction costs.

A third 6-monthly catalog of data was prepared by all IGY World Data Centers in January 1959. A fourth catalog will be prepared by September 1959. For each discipline, one of the Data Centers (A, B, or C) has the responsibility of preparing a final catalog of IGY data held by the IGY World Data Centers. The schedule for production of these catalogs varies considerably from discipline to discipline; it is expected that catalogs for most disciplines will be prepared by the end of 1960.

World Data Center A has been organized into 11 archives for different IGY disciplines located in various parts of the United States, with a Central Coordination Office in Washington, D.C., directed by the National Academy of Sciences. The locations of the 11 archives follow:

1. IGY World Data Center A: Airglow and Ionosphere; Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colo.
2. IGY World Data Center A: Aurora (Instrumental); Geophysical Institute, University of Alaska, College, Alaska.

3. IGY World Data Center A: Aurora (Visual); Rockefeller Hall, Cornell University, Ithaca, N.Y.

4. IGY World Data Center A: Cosmic Rays; School of Physics, University of Minnesota, Minneapolis 14, Minn.

5. IGY World Data Center A: Geomagnetism, Gravity, and Seismology; Geophysics Division, U.S. Coast and Geodetic Survey, Washington 25, D.C.

6. IGY World Data Center A: Glaciology; American Geographical Society, Broadway at 156th Street, New York 32, N.Y.

7. IGY World Data Center A: Longitude and Latitude; U.S. Naval Observatory, Washington 25, D.C.

8. IGY World Data Center A: Meteorology and Nuclear Radiation; National Weather Records Center, Asheville, N.C.

9. IGY World Data Center A: Oceanography; Department of Oceanography and Meteorology, Agricultural & Mechanical College of Texas, College Station, Tex.

10. IGY World Data Center A: Rockets and Satellites; National Academy of Sciences, 2101 Constitution Avenue NW., Washington 25, D.C.

11. IGY World Data Center A: Solar Activity; High Altitude Observatory, Boulder, Colo.

Communications regarding data interchange matters in general and World Data Center A as a whole should be addressed to: Director, World Data Center A, National Academy of Sciences, 2101 Constitution Avenue NW., Washington 25, D.C. Inquiries and communications concerning data in specific disciplines should be addressed to the appropriate archive listed above.

Publications based on IGY observational data are being issued under a disciplinary report series by the appropriate archives and a general report series by the Coordination Office.

Moscow Meeting of the CSAGI

The fifth reunion of the Comité Spécial de l'Année Géophysique Internationale (CSAGI), the international planning body for the IGY, was held in Moscow in July and August 1958. The four principal matters taken up by the CSAGI Moscow Assembly were (1) a review of the accomplishments of the first two-thirds of the IGY; (2) the question of the future of international cooperation in geophysics after the end of the IGY; (3) the problem of the collection, storage, and cataloging of data at the World Data Centers; and (4) the question of publication of IGY data and results.

A review of the accomplishments of the IGY was achieved largely through symposia in the various disciplines. Results reported by the

United States and the U.S.S.R. on their work in rockets and satellites were of particular interest.

International Geophysical Cooperation—1959

The question of the future of international cooperation in geophysics after the end of the IGY was given emphasis at the Moscow Assembly, where a proposal was introduced by the Soviet delegation to extend the entire IGY program for an additional year. The final decision on this proposal reached by the assembly was to recommend the continuation of geophysical research only in certain fields under a program to be known as "International Geophysical Cooperation, 1959" (IGC–1959). Included among the recommendations for continued cooperative work were a world magnetic survey, a limited solar activities program, Antarctic research, oceanographic studies, and rocket and satellite observations. The CSAGI recommendation for International Geophysical Cooperation—1959 was subsequently adopted by the International Council of Scientific Unions, the parent body of the CSAGI. Participation in the program is on a voluntary basis at national levels.

The National Science Foundation has accepted in principle the proposed program for continuation of international participation in geophysical sciences in 1959. Research proposals supported by the Foundation's Division of Mathematical, Physical, and Engineering Sciences represent U.S. contributions to the continuation of international participation in geophysical sciences in 1959.

Annals of the IGY

At the Moscow Assembly of the CSAGI it was agreed that the *Annals of the International Geophysical Year,* published for the CSAGI by the Pergamon Press, Ltd., London, should serve as a complete record of the IGY. All important IGY results and data will be published in the *Annals.* Such publication will not, however, preclude publication elsewhere.

The following volumes of the *Annals* are in published form:

- Volume I, The First and Second International Polar Years, the Inception and Development of the IGY.
- Volume IIA, The International Geophysical Year Meetings (first four CSAGI Assemblies), 1959.
- Volume III, The Ionosphere, 1957.
- Volume IV, IGY Instruction Manuals (nuclear radiation, aurora and airglow, longitudes and latitudes, geomagnetism, seismology, cosmic radiation), 1957.
- Volume V, IGY Instruction Manual (ozone, aurora and airglow, Antarctic radio communications), 1957.

Volume VI, Manual on Rockets and Satellites, 1958.

Volume VII, IGY Instructional Manual (world days and communications, CSAGI Guide to World Data Centers, Arctic communications, geographical distribution of IGY stations), 1959.

Additional volumes of the *Annals* are in process of publication.

U.S. Antarctic Research Program

General

The scientific research conducted in the Antarctic during the IGY developed results that indicated the need for a continuing program. To plan for continuing Antarctic research at the international level, the Special Committee for Antarctic Research (SCAR) was established by the International Council of Scientific Unions. This Committee, initially composed of representatives of the 12 nations who conducted programs in the Antarctic as part of the IGY, makes broad international program recommendations on the scientific work needed in the region. All of the 12 nations represented have agreed to continue scientific programs in Antarctica.

Following a U.S. Government policy decision to continue operations in Antarctica beyond the winter of 1958–59 on a basis consistent with the U.S. national interest, the National Science Foundation was designated the agency of Government to coordinate U.S. scientific programs in the region, and the Department of Defense was named the agency to provide logistic support to such programs.

A subsequent policy decision reduced the six-station network in the Antarctic maintained by the United States during the IGY to a four-station network: the Pole Station, the Byrd Station, the Naval Air Facility at McMurdo, and the Hallett Station. In addition to operating these four stations, the United States agreed to supply scientific personnel and equipment under cooperative arrangements with other countries at the following stations: the Scott Base (operated by New Zealand during the IGY and continued in the post-IGY period); the Wilkes Station (formerly maintained by the United States, now by Australia); and the Ellsworth Station (during the IGY operated by the United States, now maintained by Argentina). The U.S. IGY Little America Station was shut down at the close of the IGY.

Operation of the U.S. Antarctic Research Program

To undertake the detailed problems of coordinating a program of Antarctic research, the National Science Foundation established during 1958 the Antarctic Research Program under the Office of Special International Programs. Research proposals for Antarctic research are received from governmental agencies, universities, and other institutions; are evaluated through suitable review; selected to assure a balanced program; and supported to the extent of available funds and logistic support. Logistic planning and requirements are handled in cooperation with the U.S. Navy. (A description of research currently conducted as part of this program can be found under "Support of Basic Research in the Sciences," p. 46.)

The Antarctic Research Program must in one sense be a "package" program, because it crosses the lines of many scientific disciplines and because it involves a geographic area. However, at the same time the determination of program grants must be made on the basis of scientific competence as for any Foundation grant. The area is exceedingly remote and those who receive grants for research must have access to Antarctica through the facilities of the Naval Support Force. Thus, before processing a grant for research in the Antarctic, the National Science Foundation must make available more than funds; it must also assure the grantee that the travel accommodations to and from Antarctica, the living space for the research worker, and the scientific facilities necessary for this work have been developed and are on hand. All of these items contribute to the total cost of the research; the funds involved in an individual grant itself do not therefore indicate the full cost of the particular research project.

Considerable liaison work with the Naval Support Force and with the Department of State are necessary to arrange for the logistic support that each grantee must have. In addition to this, many grantees must work in cooperation with the scientists of other nations, and the necessary liaison work to arrange for such cooperative operations must also be supplied where necessary through arrangements by the Foundation's staff.

Two groups serve in an advisory capacity to the Foundation's Antarctic Research Program. Broad program objectives for this country, recognizing the recommendations of the SCAR, are considered by the Committee on Polar Research of the National Academy of Sciences and proposed to the Foundation as representing the opinion of the scientific community on the needs in certain areas of Antarctic research. The overall program suggestions made by the Academy's Committee serve as guidelines in the formulation of the Foundation's Antarctic Research Program.

To assure full cooperation and coordination of the intragovernment operations, the Interdepartmental Committee on Antarctic Research, composed of representatives of Government agencies with interests in the Antarctic, has been set up by the Foundation to examine proposals and programs of the represented agencies and the broad program suggested by the Committee on Polar Research. The first U.S. team of scientists to carry out research in the Antarctic following the IGY left the United States in the fall of 1958 and will return January–February 1960 (Team I).

A second group of scientists (Team II) will leave the United States in the fall of 1959; the summer contingent will return January–February 1960 and the winter contingent in January-February 1961.

The following table shows the number of U.S. scientists in Team I and the number planned for Team II at each station and aboard ships in Antarctic waters:

Station	Team I		Team II	
	Summer	Winter	Summer	Winter
McMurdo (U.S.)	6	3	16	6
Byrd (U.S.)	0	13	4	12
Pole (U.S.)	0	8	0	9
Hallett (U.S. joint with New Zealand)	0	1	0	5
Wilkes (Australia)	0	3	0	4
Ellsworth (Argentina)	0	1	0	5
Scott (New Zealand)	0	3	3	3
Shipboard	2	0	6	0
	8	32	29	44

Cooperation With International Science Activities of Other Government Agencies

International Cooperation Administration

Under the terms of an interagency service agreement between the Foundation and the International Cooperation Administration, certain scientific and technical services have been supplied to that agency for activities in different countries. These services have included during the past year representation by more than a dozen qualified scientists at committee meetings and symposia of the Organization for European Economic Cooperation and the furnishing of a science adviser to the Government of the Philippines in Manila.

Department of State

The Foundation has cooperated with the Department of State in establishing liaison for the exchange of information between the staff of the Foundation and the science officers of the Department of State who have assumed their overseas posts.