in the field at universities and elsewhere, NSF program directors knowledgeable in the particular field of research, the Chief Scientist of the U.S. Antarctic Research Program, the logistics staff of the Antarctic Program, and lastly the scientific staff of the Antarctic Program for parallel study of scientific merit, budget, and final evaluation of the other reviews.

Participation by U.S. Scientific Personnel

Following selection of scientific proposals to receive Foundation support, arrangements are made to send scientists designated by grantee institutions and agencies to carry out investigations in Antarctica. Each new group of personnel selected annually must reach the Antarctic at the beginning of the austral summer, which in the Southern Hemisphere corresponds to the winter months in the Northern Hemisphere. The length of time each member of the group remains in Antarctica depends on the nature of the investigations for which he is responsible. For example, field work in geology and biology and traverse studies must be conducted away from established stations, and, therefore, requires extra logistic support to enable the scientists to live and work in the field, possible only during the Antarctic summer. Members of each group engaged in such investigations usually remain in Antarctica only for the austral summer, after which they are returned to the United States. They are referred to as the "summer contingent" of a given team. Other members of a group, known as the "winter contingent," are engaged in studies which can be continued at established stations on a year-round basis. Examples of the latter are meteorology, auroral studies, cosmic ray investigations, geomagnetism, and station seismology.

The first group of U.S. scientists to carry out research in the Antarctic following the IGY left the United States in the fall of 1958 and returned November–December 1959. This group is referred to as the U.S. Antarctic Research Program Team I.

The second group of scientists (Team II) left the United States in the fall of 1959. The summer contingent of this group returned February–March 1960, and the winter contingent will return November–December 1960.

Team III departed October–November 1960, with the summer contingent returning in February–March 1961 and the wintering complement expected to return in November–December 1961.

Even though additional disciplines beyond those included in the IGY have augmented the program, the change in the number of wintering-over personnel has not been significant because investigation has been primarily concerned with meteorology, glaciology, and upper atmosphere physics—work suitable for year-round operations. The most noteworthy

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change in the program has been the additional personnel working in the fields of biology, geology, cartography, and related programs, most suitable to summer efforts. Thus, the major enlargement has been in the area of summer personnel. The breakdown of U.S. scientific personnel in Antarctica is shown in the following table.

	1959 wintering-over team	1959–60 summer team	1960 wintering-over team
Administration	0	7	0
Biology	3	11	2
Cartography	1	2	0
Geology	0	13	0
Glaciology	3	9	2
Meteorology	13	1	17
Oceanography	0	4	2
Psychology	0	1	0
Traverse Seismology and Gravity	2	2	1
Traverse Engineering	2	0	2
Upper Atmospheric Physics	8	1	9
Total	32	51	35

A steady increase in the number and dollar amount of proposals received by the Foundation indicates a mounting interest in Antarctic research, particularly on the part of universities and other private institutions. Private institutions received 42 percent of funds available to Team I and 48 percent to Team II; it is anticipated they will receive approximately 55 percent of the funds available to Team III.

Exchange Scientists

Throughout the IGY, scientists from several countries cooperating in Antarctic research were exchanged between national expeditions, thus developing closer cooperation and mutual understanding.

The practice of exchanging scientists has been continued following the IGY. During fiscal year 1960 exchanges were arranged between the United States and the USSR and between the United States and France. A Soviet glaciologist is at the U.S. McMurdo Station; the U.S. counterpart—a seismologist-geophysicist—is at the Soviet Mirny Station. A French glaciologist accompanied the U.S. traverse party to northern Victoria Land, and in return the French Antarctic Expedition has suggested that arrangements can be made for an American scientist to winter over at either the Kerguelen Island Station or the Dumont d'Urville Station on the Continent.

The United States is also participating with Australia and France in the International Australian Analysis Center. It replaces the IGY Weather Central originally located at the Little America Station. A U.S. meteorologist is currently spending his second year in Australia assisting in the daily collection, analysis, and forecasting of Antarctic weather data.

In preparation for the forthcoming season, proposals are being considered for continuation of the Soviet-U.S., French-U.S. exchanges of scientific personnel. Discussions have been initiated with the United Kingdom, Belgium, Norway, and Chile for other possible scientist exchange programs.

Current Research Support

The Antarctic Research program covers many disciplines. Investigations underway encompass the following:

Observations and measurements of the aurora and airglow in the Antarctic include a study of geographical distribution, auroral spectral features, a determination of auroral height and form, and a survey of radio absorption. Geomagnetic observations are made at each of the stations, with additional field programs for the determination of absolute magnetic values. Experiments in ionospheric physics are carried out in many stations to probe the ionosphere for the determination of change in height, density, and diurnal effect; to measure radio noise; and to study low-frequency atmospheric phenomena, including field observations to establish latitude control of these effects. Surface and upper-air meteorological data are collected at all stations and on traverses, including special observations into the carbon dioxide and ozone content of the upper atmosphere.

Seismological investigations make use of permanent seismographs to record and measure earthquake waves and their travel paths, and of artificial vibrations to study ice thickness and sub-ice geology. Oceanographic research is carried out at stations along the Antarctic coasts and from the U.S. Navy ships sailing in Antarctic waters. Studies in biological and medical sciences include bacteriology, marine fishes, bird migration, psychology, and the study of insect distribution on the Antarctic Continent and in the surrounding area. Glaciological research is conducted to study the regimen and deformation of ice shelves, snow accumulations and wastage, thickness of the ice cap, and the chronological banding of the ice at depth.

Fiscal year 1960 marked the beginning of a new era in Antarctic mapping for the United States. Coordination of aerial photography, ground control, and office compilation resulted in the initiation of production of maps of important areas of West Antarctica.

An expanding program of research in the same disciplines as the above, with increased studies in geodesy and cartography, cosmic radiation, gravity, and geology, will be conducted by the team of scientists arriving in the Antarctic in the fall of 1960. An increased number of seasonal field programs are being planned to occupy sites in Western Antarctica to study the mountain ranges and nunataks, to explore the geological relationship between Western Antarctica, the Antarctica Peninsula, and South America. Geodesy and cartography programs will support these activities by providing detailed maps of areas in which scientists must carry out their programs, as well as providing cartographic material for developing maps of large areas of Antarctica for use by such groups as the U.S. Navy in carrying out its responsibilities to support the scientific program.

Significant Research Developments

TOTAL SYNTHESIS OF CHLOROPHYLL.—The total synthesis of chlorophyll, a highly complex natural product, has been accomplished, a feat which defied the efforts of the world's greatest chemists for years. Starting from simple molecules of known structure not derived from the natural product, a Foundation-supported investigator completely synthesized the chlorophyll molecule and proved it to be identical to the natural product.

Chlyorophyll, the green plant pigment, is ultimately responsible for production of the food needed by all living creatures and for the fossil fuels—coal and oil. It converts the energy of the sun into the chemical energy necessary to change carbon dioxide and water into sugar and starch through the process known as photosynthesis. It consists of two components—blue-green chlorophyll *a*, and yellow-green chlorophyll *b*, in a ratio of three to one. They differ very slightly in structure. Chlorophyll *a* is the one which has been synthesized.

The structure of chlorophyll as developed over the past 40 years has been proven accurate by this synthesis. It consists of 4 pyrrole rings joined to a magnesium atom in the center of the molecule. The pyrroles are also found in hemoglobin, the red blood pigment. Improved understanding by biologists of the role of chlorophyll in photosynthesis is sure to result. The new and ingenious methods of synthesis developed will most certainly be useful in the synthesis of other complex materials.

* * *

FACTORS REGULATING FEEDING BEHAVIOR IN MAN.—A new concept of how appetite is controlled stems from Foundation-sponsored studies on

integrations within the nervous system as they affect feeding behavior and satiety in man and various vertebrates. A multi-factor concept of regulation of feeding is based on the conclusions that appetite is satisfied by: (1) gastric distention resulting from the processes of eating, (2) by relief of low blood sugar or inadequate supply of glucose, (3) by shifting of body water, due to secretions into the gastro-intestinal tract with subsequent tissue dehydration, and (4) the thermal stress of elevation of the metabolic rate resulting from the intake of food itself. This concept acknowledges the ability of the central nervous system to take many different kinds of changes within the body and integrate them into a pattern of response. Whether all of these factors act upon the hypothalamus or lower brain centers is not known, but all of them must act eventually upon feeding reflexes, which means that they must either directly or through other neural pathways affect the motor nerve nuclei of the brain stem.

One can understand how the three generalized changes—sugar lack, water movement, and temperature gradients—might act upon the same neuron or upon all neurons. Whatever their critical actions, the end result of a deficiency of food must be sensitization of reflexes necessary for feeding, as a lack of water in a similar fashion must facilitate drinking reflexes. The key reactions within the brain must be selective enough to provide a basis for specific hungers or appetites. This implies a type of discrimination within the brain stem and lower centers, and it calls to mind Sherrington's conclusion that there is a spinal-hunger state. He noted "as a broad rule, spinal reflexes are more easily elicited when a well-nourished animal is hungry and expecting food, and less easily when it has just heavily fed. There is, so to say, a spinal hunger."

* * *

THE FIRST SYNTHETIC ANTIGEN.—The culmination of several years work on the preparation of high molecular weight polypeptides has been the discovery of the first synthetic antigen. (Antigens are substances which stimulate the production of antibodies.) This substance, a copolymer of 3 amino acids—lysine, tyrosine, and glutamic acid in the proportion of 1 : 2 : 3—stimulates antibody production in test organisms. The antigenic polypeptide has been shown to be devoid of helical structure and hence it appears that only a short sequence of amino acids including L-tyrosine is necessary for antibody formation. This work represents another step toward an understanding of immune reactions in living organisms and of the nature of biological specificity. In the search for a means of producing effective, safe, and widespread immunization, agents of this type will play an extremely important role.

* * *

ALTERING THE STRUCTURE OF BIOLOGICAL MACROMOLECULES.—A new and simple method has been developed by a Foundation grantee for introducing sulfur in the form of thiol (–SH) groups into biological macromolecules—polysaccharides and nucleic acids, as well as proteins. This is accomplished through the use of a sulfur-containing succinic anhydride compound which displaces amino ($-NH_2$) groups in proteins and hydroxyl (–OH) groups in polysaccharides and nucleotides.

Thiol groups when introduced into the macromolecules may be located at active sites and, therefore, provide an excellent tool for probing molecular structure and for altering physical, chemical, and physiological characteristics of a broad spectrum of biological substances.

* * *

TRANSMISSION OF NERVE IMPULSE.—More complete understanding of the nature of nerve activity has been made possible by the isolation and identification of the acetylcholine receptor protein from the electric tissue of the electric eel. Acetylcholine is a chemical which plays a crucial role in transmitting nerve impluses.

When the nerve membrane is excited, acetylcholine is freed from its storage form and combines with the receptor protein. This combination triggers a change in the ionic permeability of the membrane, allowing sodium ions to enter and potassium ions to leak out, thus generating an electric current. This current propagates the neuron's message to another neuron or to an effector cell (e.g. muscle). Within milliseconds, the receptor-acetylcholine complex separates as a result of enzyme action and once again the nerve cell returns to its resting stage, ready for the next stimulus.

Identification of the receptor protein was made possible by comparing, in vitro, the binding strength of the receptor protein with acetylcholine-type compounds with the effect of these compounds on electrical activity in isolated electrical eel tissue. A striking correlation was observed between binding strength in the receptor protein solution and effect on electrical activity. (See photographs on page 21.)

* * *

GRAVITY RESPONSE DEPENDENT ON HEREDITARY FACTORS.—Although behavior is greatly influenced by the environment, there is a growing body of evidence that genetic factors play an important part in determining certain kinds of behavioral variation.

Fruit flies (Drosophila) have been shown to vary in their tendency to fly upward or downward when faced with a choice between the two alternatives. In an experiment, conducted with the aid of a National Science Foundation grant, fruit flies are introduced into a maze in which they encounter successive choice points where they may fly either upward

or downward. (See page 30.) The height of the terminal point reached by a fly depends on its response to gravity at the various choice points. If it always selects the upward choice, it finishes at top, the downward choice at bottom; if it sometimes goes upward and sometimes downward, it finishes at an intermediate position.

When a fly population is introduced into the maze, the individuals sort themselves out so as to give rise to a frequency distribution depending on their aggregate responses to gravity at the choice points. Introducing genetically different populations into the maze results in changes in the frequency distribution. This indicates that the variability in gravity response is dependent, at least in part, on the genetic variability in the population.

* * *

FINE STRUCTURE OF GENES DETERMINED.—Major questions of modern biology are the molecular structure of genes and how this structure allows the coding of genetic information. The discovery by an NSF grantee that subunits of a gene are arranged linearly within a gene is a major contribution to the solution of these questions.

The genetic material, at least in lower organisms, is deoxyribonucleic acid (DNA) which consists of a coiled double chain of simpler components called nucleotides. However, individual hereditary units (genes) have not been isolated, so it is not possible to determine by chemical techniques that a particular gene consists of a linear array of nucleotide pairs. But, it is possible to determine the most probable arrangement of separable genetic units utilizing the technique of genetic recombination. This technique is well known to geneticists who have used it to show that genes are arranged linearly within chromosomes. Determination of the fine structure of a gene, however, requires special materials and a selective device to detect rare recombinations between units that may be separated only by the spacing between nucleotides in the DNA molecule. Utilizing microorganisms, it is possible to obtain very large populations of offspring and by using selective techniques to detect events that occur once in 10,000 times or less.

A small section, the size of about 1,000 nucleotides of a DNA molecule, of the genetic material of a bacterial virus has been analyzed by recombination techniques. A large number of mutations of a gene which controls the ability of the virus to grow on certain bacteria has been obtained. If each mutation affects only a portion of a gene, then it is possible, by allowing two viruses with different mutant genes to reproduce within a single bacterium, to obtain progeny viruses that have the unmutated portion of the gene from each of the parent viruses. The "recombined" virus is able to grow on bacterial cells on which

neither of its parents could grow. If a large series of mutations are tested for recombination, then the array of results expected will depend on how the elements are connected with each other, that is, whether the arrangement is linear, branching, circular, or other. A total of 145 mutant genes were tested for recombination of the altered sections within the gene and it was shown that the mutated elements within the gene fit a linear pattern. Though all other possibilities were not eliminated, it is highly probable that the fine structure of a gene is a linear array of nucleotide pairs and perhaps the unit of recombination is a nucleotide pair.

* * *

PROGRESS IN DETERMINING MECHANISM OF ACTION OF VITAMIN B_{12}.—The first specific lead as to the chemical role of Vitamin B_{12} and to the discovery of the coenzyme to which the vitamin is changed in the body has recently been reported. Vitamins are essential substances which the body cannot itself manufacture.

Vitamin B_{12}, essential to animal life, was first isolated from liver in 1958. Its administration is the effective therapy for pernicious anemia.

The coenzyme, a complex organic cofactor, together with its protein entity make up an enzyme which is involved in the rearrangement of the carbon skeleton of essential amino acids (the building blocks of which proteins are composed). It acts as a carbon carrier transferring the carbon from one amino acid (glutamic) to a second (β-methyl aspartate). The coenzyme has the basic structure of Vitamin B_{12} to which two adenine-containing compounds are attached. Exposure to light destroys the activity of the coenzyme by splitting of the adenine complex.

* * *

LABORATORY STUDY OF BARGAINING BEHAVIOR IN BILATERAL MONOPOLY SITUATION.—The feasibility of the study of classical problems of economics under controlled laboratory conditions has been demonstrated by a Foundation-supported study of bargaining behavior in a situation known to economists as "bilateral monopoly." It represented the first active collaboration between an economist and an experimental psychologist.

In the bilateral monopoly situation the bargainers consist of a single "buyer" and a single "seller." Some actual situations that approach bilateral monopoly are: a franchised dealer negotiating with a manufacturer regarding quotas and wholesale price; two public utilities bargaining about the division of some price they have set on a joint service; and labor leaders in a unionized industry dealing with management representatives. This bargaining situation has been of long standing interest

to economists and there are a dozen "classical" theoretical solutions which attempt to describe the way in which the price, profit, or other payoff will be divided. These solutions are not in mutual agreement. The chief contribution of the new research is the development of an experimental situation of bilateral monopolistic bargaining in which several of the proposed theoretical solutions could be tested.

The results of the experimentation demonstrated that the actual outcome of bargaining in this situation cannot be predicted from economic considerations alone, but is subject to a variety of psychological and cultural forces as well. The experiments show that there is a clear tendency for bargainers to negotiate contracts at that quantity which maximizes joint payoff. Furthermore, they show that the greater the amount of information the bargainers have about their own and the other person's situation, the more likely they are to settle for maximizing joint payoff. Parallel tendencies are found with regard to the negotiated price at which the transaction is made, with a tendency to approach a fifty-fifty split of the maximum joint payoff under conditions of complete information.

A most important psychological factor in determining differential payoff, especially under incomplete information, is the level of aspiration (the amount of payoff the bargainer wanted or hoped to receive). In almost all cases studied, the bargainer who began with the higher level of aspiration did in fact receive the larger share of the joint payoff.

* * *

PREHISTORIC INHABITANTS OF ARIZONA.—An archaeological study of eastern Arizona has been supported by the Foundation in an attempt to gather information about the pre-history of this little-known area. Evidence has been discovered, near St. Johns, of a primitive people without pottery and probably without agriculture, living in the midst of other tribes with far more advanced cultures. Excavations have indicated that the tribe lived by hunting and gathering wild plants. Tools appear to have been limited to simple implements such as grinding stones and stone-tipped spears. Except for the addition of permanent homes they lived as did their more nomadic ancestors two thousand years before.

Just 70 miles away, other cultures grew corn, fired pottery, and built sturdier, larger, and more complex pit houses. The remote tribe, which existed for more than 2,000 years and inhabited the site as late as 300 A.D., defended itself against its more advanced neighbors and apparently refused to accept the cultural advances of its enemies.

For another discovery of this expedition, see page 27.

* * *

POSITRONIUM.—Positronium is the name given to a short-lived atom comprising a positron and an electron. The atom is similar to the normal hydrogen atom except that the proton, which forms the nucleus of the hydrogen atom, is replaced by a positron, a particle similar to the electron but with a positive electrical charge. Positronium is held together by the attractive force between the positively charged positron and the negatively charged electron in a manner entirely analogous to the attraction between proton and electron which holds together the hydrogen atom. The principal differences between hydrogen and positronium arise from the much lighter weight of the positron as compared to the proton. The positron has the same weight as an electron, so an atom of positronium has a weight equal to twice the electron weight while hydrogen weighs about 1,840 times as much as an electron. As a consequence of this weight discrepancy the radius of the positronium atom is twice the radius of hydrogen.

Positronium is an uncommon chemical element because of its very short lifetime, generally of the order of one ten-millionth of a second. The short lifetime is due to the annihilation of positrons and electrons when they come into proximity to one another—one of the classic illustrations of conversion of matter into radiation. The two particles are annihilated and generally two photons (electromagnetic radiation) are created which carry off the energy associated with the masses of the material particles.

A study of the chemical behavior of positrons and positronium in aqueous solutions has been carried out under a Foundation grant. It reveals that the concept of an oxidation potential is applicable to this problem and that the position of positronium in the electrochemical scale is between that of zinc and cadmium. This is of interest not only because positronium can be considered as a new chemical element, but also because it was never before obvious that ordinary chemical concepts can be applied to the extreme dilution of single atoms present in solutions. This work should also contribute a better understanding to problems related to the structure of water and liquids. The idea that the atom of positronium may be present in some form of cavity in water may possibly be related to some tentative explanations of the viscosity and compressibility of liquids in terms of such hypothetical cavities.

* * *

CHILEAN EARTHQUAKE TSUNAMI RECORDED.—Wave recorders at a depth of 330 feet have been operated off La Jolla, Calif., and at San Clemente Island under a Foundation grant made in May 1959 to continue installations originally made during the IGY.

The San Clemente gage consisted of three recorders located in a

triangle, which made it possible to analyze the records to determine the direction from which the waves travelled. The waves are generated by storms, and since the longest waves travel the fastest, it was possible to locate a given storm from its bearing and the regular decrease in length of the waves produced by it. Storms thus tracked in the Southern Hemisphere agreed with the weather maps as they now exist.

The gage at La Jolla recorded the large tsunami waves received from the Chilean earthquake on May 23, 1960. This is the most detailed tsunami wave recording yet made, as activity was recorded continuously for 7 days. Analysis will yield much new information about the selective attenuation of the energy of a tsunami.

* * *

INCREASING CARBON DIOXIDE IN ATMOSPHERE.—A sensitive infrared analyzer has been applied to the problem of measuring atmospheric carbon dioxide. This work began during the IGY and has been continued under NSF sponsorship. Since the method is much more precise than previous chemical methods, the results for the first time have clearly demonstrated annual cycles of carbon dioxide in the atmosphere. The air at the South Pole shows no seasonal variation, whereas on Mauna Loa there is a change from about 310 parts per million in October to 316 in May. Superimposed on these annual cycles is a steady increase, of the order of one part per million per year. Such an increase has been expected on theoretical grounds, from the burning of coal and petroleum, but this is the first convincing analytical proof of it.

* * *

GLACIAL EPOCHS MORE CLOSELY ESTABLISHED.—Various isotope techniques are yielding important results in the study of undisturbed cores of sediment from the ocean bottom. The ratio of oxygen-16 to oxygen-18 in the calcareous shells of various marine animals gives the temperature of the water at past epochs and hence is a good indicator of climate. The carbon-12/carbon-14 ratio and the protactinium-231/thorium-230 ratio give an absolute dating of these climate epochs. In this way, the investigator has found the date of the peak of the last interglacial period to be 96,000 years ago, with the previous glaciation having ended 10,000 years earlier.

* * *

IMAGE TUBE DEVELOPMENT PROVIDING SIGNIFICANT HELP TO ASTRONOMERS.—A new research tool that is giving astronomers previously unobtainable data may prove to be as great an advance over conventional astronomical photography as photography was over visual observations.

The device is called a photoelectric image intensifier, or image tube.

The development of image tubes, as well as investigations using these tubes, have been sponsored by the National Science Foundation.

In essence an image tube is an electronic device for amplifying the signal produced by a photon, or light unit—that is, faint light is in effect made brighter. This enables astronomers to observe heavenly objects heretofore too faint to be identified, or to use much shorter exposure times to lessen atmospheric distortion of brighter objects.

These tubes have already increased telescope speeds by as much as 30 times, and have the potential of increasing them by a factor of 100.

Identification of a very dense star cluster at the center of the Andromeda galaxy is an important result of use of one of the tubes. Little was previously known about this very small and bright light source except that it usually had the appearance of a star. Using the image tube mounted on the coudé spectograph of Lick's 120-inch telescope, astronomers made two spectroscopic exposures in about 15 and 45 minutes which ordinarily require 5–15 hours.

To state it differently, the 120-inch telescope with the image tube obtained results that would have required a 660-inch telescope without the tube.

An analysis of the spectroscopic results plus photometric data obtained independently shows that the bright object is apparently a large, dense cluster of stars similar to the well-known globular clusters but very much more massive. It is about 24 light years in radius, whirling at high speed, and contains a mass of stars equal to 10 million times the sun's mass.

If our sun were in the center of the cluster we would see about 10 thousand times as many stars in the night sky as we do now, and the total light from them would be greater than the light of the full moon.

A second investigation using an image tube recorded the infrared lines of the sun's corona in about one minute. The first photography of these lines, by Lyot at the Pic du Midi Observatory about two decades ago, required 4 hours. The fastest film now available requires an exposure in excess of half an hour. The need for the sky to be extremely transparent for an extended period had made earlier attempts most difficult.

Thirdly, an image tube recorded an observation of binary stars, a use for which the tubes are extremely valuable. Binary or twin stars revolve around each other. To the naked eye and frequently to telescope observations, they appear as one star. An investigation recorded binaries with separations as small as .3 second of arc using the image intensifier, while separations of 1.5 seconds of arc are almost impossible to photograph without it.

With the image tube it was possible to make exposures at 1/100

second, and record the binary images before atmospheric turbulence distorted them.

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Research-Related Activities

Scientific Conferences and Symposia

The Foundation during 1960 sponsored and provided partial support for 44 conferences and symposia. In most cases, sponsorship was shared with one or more private or public agencies, including universities and scientific societies.

CONFERENCE ON OPTICAL PUMPING—Ann Arbor, Mich., July 8–15, 1959; Chairman: Peter Franken, Department of Physics, University of Michigan, Ann Arbor, Mich.; Cosponsor: University of Michigan.

INTERNATIONAL SYMPOSIUM ON FLUID MECHANICS OF THE IONOSPHERE—Ithaca, N.Y., July 8–15, 1959; Chairman: Henry G. Booker, School of Electrical Engineering, Cornell University; Cosponsors: International Scientific Radio Union, International Union of Theoretical and Applied Mechanics, International Union of Geodesy and Geophysics, International Astronautical Union.

CONFERENCE ON HIGH TEMPERATURE PROBLEMS IN AERONAUTICS—Stanford, Calif., Aug. 5–8, 1959; Chairman: Nicholas J. Hoff, Head, Department of Aeronautical Engineering, Stanford University, Stanford, Calif.; Cosponsors: Air Force Office of Scientific Research, Office of Naval Research, Office of Ordnance Research, Institute of the Aeronautical Sciences, American Society of Mechanical Engineers.

SEMINAR IN MATHEMATICS—University of New Brunswick, Fredericton, New Brunswick, Canada, Aug. 17–Sept. 11, 1959; Chairman: W. L. G. Williams, McGill University, Montreal, Canada; Cosponsor: Canadian Mathematical Congress.

GORDON CONFERENCE ON PHOTONUCLEAR REACTIONS—Kimball Union Academy, Meriden, N.H., Aug. 24–29, 1959; Chairmen: Peter Axel, Physics Research Laboratory, University of Illinois and A. O. Hanson, Department of Physics, University of Illinois, Urbana, Ill.; Cosponsor: Gordon Research Conferences.

FIRST INTERNATIONAL OCEANOGRAPHIC CONGRESS—United Nations Headquarters, New York, N.Y.; Aug. 30–Sept. 12, 1959; Chairman: Roger Revelle, Scripps Institute of Oceanography; Cosponsors: UNESCO, Special Committee on Oceanic Research of the International Council of Scientific Unions, American Association for the Advancement of Science, Department of Defense, and private foundations.

SYMPOSIUM ON THE DIFFERENCES AMONG GLOBULAR CLUSTERS—Toronto, Ontario, Canada, Aug. 31, 1959; Chairman: John F. Heard, David Dunlap Observatory, University of Toronto, Richmond Hill, Ontario, Canada; Cosponsors: American Astronomical Society, University of Toronto.

1959 INTERNATIONAL PLASMA PHYSICS INSTITUTE—Seattle, Wash., Aug. 31–Sept. 5, 1959; Chairman: Ronald Geballe, Department of Physics, University of Washington, Seattle, Wash.; Cosponsors: Boeing Scientific Research Laboratory, University of Washington.

CONFERENCE ON DIFFERENTIAL EQUATIONS—Mexico City, Mexico, Sept. 1959; Chairman: Solomon Lefschetz, Director, Center for Differential Equations, Research Institute for Advanced Study (RIAS), Inc.; Cosponsors: Research Institute for Advanced Study (RIAS), Inc., National University of Mexico, Office of Naval Research.

IMMUNOCHEMICAL APPROACHES TO PROBLEMS IN MICROBIOLOGY—New Brunswick, N.J., Sept. 1–3, 1959; Chairmen: Michael Heidelberger and Otto J. Plescia, Institute of Microbiology, Rutgers, the State University, New Brunswick, N.J.; Cosponsor: Rutgers, the State University.

SYMPOSIUM ON COLOR CENTERS IN ALKALI HALIDES—Corvallis, Oreg., Sept. 8–11, 1959; Chairman: Allen B. Scott, Department of Chemistry, Oregon State College, Corvallis, Oreg.; Cosponsors: Oregon State College, Office of Naval Research, U.S. Air Force Office of Scientific Research.

CONFERENCE ON THE GEOCHEMISTRY OF CARBONATE MINERALS AND ROCKS—Coonamesset, Mass., Sept. 14–18, 1959; Chairman: Robert M. Garrels, Laboratory of Mining Geology, Harvard University, Cambridge, Mass.; Cosponsor: The Geochemical Society.

INTERNATIONAL SYMPOSIUM ON HIGH TEMPERATURE TECHNOLOGY—Asilomar, Calif., Oct. 6–9, 1959; Chairman: Nevin K. Hiester, Manager, Chemical Engineering Section, Stanford Research Institute, Stanford, Calif.; Cosponsors: Air Force Office of Scientific Research, Air Research and Development Command, Army Research Office, Office of the Chief of Research and Development, Department of the Army, Atomic Energy Commission, National Aeronautics and Space Administration, Office of Naval Research, Aerojet-General Corporation, Corning Glass Works, Esso Research and Engineering Company, General Electric Company, Gladding, McBean and Company, Fansteel Metallurgical Corporation, Food Machinery and Chemical Corporation, Hughes Aircraft Company, Radio Corporation of America, Stanford Research Institute, Union Carbide Corporation, Westinghouse Electric Corporation.

SYMPOSIUM ON SYSTEMATICS—St. Louis, Mo., Oct. 14, 15, 1959; Chairman: Robert L. Dressler, Missouri Botanical Garden, St. Louis, Mo.; Cosponsor; Missouri Botanical Garden.

THIRD ASTROMETRIC CONFERENCE—La Plata Observatory and the Cordoba Observatory, Argentina, Oct. 30–Nov. 3, 1959; Chairman: Dr. R. P. Cesco (La Plata), and Dr. L. Gratton (Cordoba); Cosponsors: National Academy of Sciences, Special Committee of the International Astronomical Union on Astrometry in the Southern Hemisphere, and the Organization of American States.

HISTORY OF THE USE OF QUANTITATIVE METHODS IN THE SCIENCES—New York, N.Y., Nov. 20–21, 1959; Chairman: Pendleton Herring, President, Social Science Research Council, New York, N.Y.; Cosponsor: Social Science Research Council.

CONFERENCE ON PLASMA PHYSICS—U.S. Naval Postgraduate School, Monterey, Calif., Dec. 3–5, 1959; Chairman: Frederic H. Coensgen, Lawrence Radiation Laboratory, Livermore, California; Cosponsor: American Physical Society.

CONFERENCE ON ASTRONOMICAL OBSERVATIONS FROM ABOVE THE EARTH'S ATMOSPHERE—Cleveland, Ohio, Dec. 30, 1959; Chairman: Fred Hoyle, Cambridge University, England; Cosponsor: Case Institute of Technology, American Astronomical Society.

INTERNATIONAL SYMPOSIUM ON MAGNETO-FLUID DYNAMICS—Washington, D.C., and Williamsburg, Va., Jan. 17–23, 1960; Chairman: Hugh L. Dryden, National Aeronautics and Space Administration, Washington 25, D.C.; Cosponsors: International Union of Theoretical and Applied Mechanics, National Academy of Sciences, National Aeronautics and Space Administration, Air Force Office of Scientific Research, Office of Naval Research.

PHYSIOLOGY OF PARASITISM—New Brunswick, N.J., Jan. 29–30, 1960; Chairman: Leslie A. Stauber, Department of Zoology, Rutgers, the State University, New Brunswick, N.J.; Cosponsor: Rutgers, the State University.

SYMPOSIUM ON COMPARATIVE STUDIES OF IONIZING, ULTRAVIOLET, AND VISIBLE RADIATION—Asilomar, Calif., Feb. 1960; Chairman: Frank L. Campbell, Division of Biology and Agriculture, National Academy of Sciences—National Research Council, Washington 25, D.C.; Cosponsors: National Academy of Sciences-National Research Council, Atomic Energy Commission.

SYMPOSIUM ON DIFFERENTIAL GEOMETRY—Tucson, Ariz., Feb. 1960; Chairman: C. B. Allendoerfer, University of Washington, Seattle, Wash.; Cosponsor: American Mathematical Society.

CONFERENCE ON THE POLARIZATION OF STARLIGHT—Kitt Peak and Steward Observatories, Tucson, Ariz., Feb. 6, 1960; Chairmen: W. A. Hiltner, Yerkes Observatory, University of Chicago and Jesse R. Greenstein, California Institute of Technology; Cosponsor: Lowell Observatory.

FOURTEENTH ANNUAL SYMPOSIUM ON FUNDAMENTAL CANCER RESEARCH—Houston, Tex., Feb. 25–27, 1960; Chairman: T. C. Hsu, M. D. Anderson Hospital and Tumor Institute, Houston, Tex.; Cosponsors: The University of Texas, M. D. Anderson Hospital and Tumor Institute, University of Texas Postgraduate School of Medicine, Texas Division of the American Cancer Society, Texas State Department of Health.

REGIONAL DEVELOPMENTAL BIOLOGY CONFERENCES—Alligator Point Marine Laboratory of Florida State University, Tallahassee, Fla., March 18–19, 1960; Kenyon College, Gambier, Ohio, March 18–19, 1960; Mount Holyoke College, South Hadley, Mass., March 28–29, 1960; University of Arizona, Tucson, Ariz., April 21–22, 1960; Asilomar, Pacific Grove, Calif., May 19–21, 1960; Chairman: Emil Witschi, President, American Society of Zoologists, Department of Zoology, State University of Iowa, Iowa City, Iowa; Cosponsor: American Society of Zoologists.

SYMPOSIUM ON OPTICAL SPECTROMETRIC MEASUREMENTS OF HIGH TEMPERATURES—Chicago, Ill., March 23–25, 1960; Chairman: Thorfin R. Hogness, Deputy Director, Laboratories for Applied Sciences, University of Chicago, Chicago, Ill.; Cosponsors: University of Chicago, Jarrell-Ash Company.

SYMPOSIUM ON LIFE AND LIGHT—McCallum-Pratt Institute, Baltimore, Md., March 28–31, 1960; Chairman: William D. McElroy, Mergenthaler Laboratory for Biology, Johns Hopkins University, Baltimore, Md.; Cosponsor: Johns Hopkins University.

MIDWEST CONFERENCE ON THEORETICAL PHYSICS—Lafayette, Ind., April 1–2, 1960; Chairman: Solomon Gartenhaus, Department of Physics, Purdue University, Lafayette, Ind.; Cosponsor: Purdue University.

HISTOCHEMISTRY OF THE NERVOUS SYSTEM—New York, N.Y., April 10, 1960; Chairman: Oliver H. Lowry, President, Histochemical Society, School of Medicine, Washington University, St. Louis, Mo.; Cosponsor: Histochemical Society.

SYMPOSIUM ON THE STRUCTURE OF THE EYE—New York, N.Y., April 11–16, 1960; Chairman: George K. Smelser, Department of Anatomy, Columbia University, New York, N.Y.; Cosponsor: Columbia University.

INTERNATIONAL CROSS-FIELD SEMINAR ON SOLAR-WEATHER RELATIONSHIPS—Lake Arrowhead, Calif., April 15–22, 1960; Chairman: Walter Orr Roberts, Director, High Altitude Observatory, University of Colorado, Boulder, Colo.; Cosponsors: Committee on Cosmic-Terrestrial Relationships of the American Geophysical Union, High Altitude Observatory of the University of Colorado, University of California at Los Angeles.

SYMPOSIUM ON SUBDWARF STARS—Allegheny Observatory, University of Pittsburgh, Pittsburgh, Pa., April 19, 1960; Chairman: Martin Schwarzschild, Princeton University, Princeton, N.J.; Cosponsors: Allegheny Observatory and American Astronomical Society.

THIRD BIOLOGICAL WASTE TREATMENT CONFERENCE—New York, N.Y., April 20–22, 1960; Chairman: W. Wesley Eckenfelder, Department of Civil Engineering, Manhattan College, New York, N.Y.; Cosponsors: National Institutes of Health, Public Health Service, Manhattan College.

CONFERENCE ON SCIENCE MANUSCRIPTS—Washington, D.C., May 5–6, 1960; Chairman: Nathan Reingold, History of Science Society, Library of Congress, Washington 25, D.C.; Cosponsor: History of Science Society.

CONFERENCE ON TROPICAL BOTANICAL PROBLEMS OF CONCERN TO THE UNITED STATES—Fairchild Tropical Garden, Coconut Grove, Fla., May 5–7, 1960; Chairman: Frank L. Campbell, Division of Biology and Agriculture, National Academy of Sciences-National Research Council, Washington 25, D.C.; Cosponsor: National Academy of Sciences-National Research Council.

THE ROLE OF COMPUTER TECHNIQUES IN RESEARCH ON BRAIN FUNCTIONS AND BEHAVIOR—Cambridge, Mass., May 10–12, 1960; Chairman: Walter A. Rosenblith, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Mass.; Cosponsor: Massachusetts Institute of Technology.

CONFERENCE ON MECHANISMS OF ACTION OF STEROID HORMONES—Endicott House, Dedham, Mass., May 20–22, 1960; Chairmen: L. L. Engel and C. A. Ville, Massachusetts General Hospital, Harvard University, Cambridge, Mass.; Cosponsor: Harvard University.

INTERNATIONAL SYMPOSIUM ON NERVOUS INHIBITION—Seattle, Wash., May 31–June 4, 1960; Chairman: Ernst Florey, Department of Zoology, University of Washington, Seattle, Wash.; Cosponsor: University of Washington.

PHYSIOLOGICAL AND BEHAVIORAL ASPECTS OF TASTE—Ithaca, N. Y., June 1960; Chairman: Morley R. Kare, Department of Veterinary Physiology, New York State Veterinary College, Cornell University, Ithaca, N.Y.; Cosponsor: Cornell University.

CONFERENCE FOR DIRECTORS OF UNIVERSITY COMPUTING LABORATORIES—Chicago, Ill., June 2–4, 1960; Chairman: Philip M. Morse, Director, Computation Center, Massachusetts Institute of Technology, Cambridge, Mass.; Cosponsor: American Mathematical Society.

SYMPOSIUM ON BIOLOGICAL CLOCKS AND ANIMAL NAVIGATION—Cold Spring Harbor, N.Y., June 5–15, 1960; Chairman: Arthur Chovnick, Long Island Biological Association, Cold Spring Harbor, N.Y.; Cosponsors: Long Island Biological Association, National Institutes of Health, Office of Naval Research.

FIRST INTERNATIONAL POWDER METALLURGY CONFERENCE—Biltmore Hotel, New York, N.Y., June 13–17, 1960; Chairmen: Kempton H. Roll, Executive Secretary, Metal Powder Industries Federation, and Fritz V. Lenel, Department of Metallurgical Engineering, Rensselaer Polytechnic Institute, Troy, N.Y.; Cosponsors: Metal Powder Industries Federation, Powder Metallurgy Committee, Institute of Metals Division of the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

NINETEENTH GROWTH SYMPOSIUM—Waltham, Mass., June 20–22, 1960; Chairman: Edgar Zwilling, President, Society for the Study of Development and Growth, Biology Department, Brandeis University, Waltham, Mass.; Cosponsor: Society for the Study of Development and Growth.

FOURTH BERKELEY SYMPOSIUM ON STATISTICS AND PROBABILITY—University of California, Berkeley, Calif., June 20–July 30, 1960; Chairman: Jerzy Neyman, Director of the Statistical Laboratory, University of California, Berkeley, Calif.; Cosponsors: Office of Naval Research, Office of Ordnance Research, Air Force Office of Scientific Research, National Institutes of Health.

Three patents have been issued on inventions arising out of Foundation-supported research during the 1960 fiscal year, the first to result from Foundation-supported scientific activities. Patent No. 2,932,797 and Patent No. 2,932,798 both relate to "imparting energy to charged particles" and were developed during the course of research supported through a grant to Midwestern Universities Research Association. These patents have been obtained and are being administered, pursuant to agreement with MURA, by the Research Corporation, a nonprofit organization which distributes its total net income in support of scientific research through grants to academic and scientific institutions. The Foundation has secured for the Federal Government irrevocable, royalty-free, nonexclusive, nontransferable licenses to practice these inventions and cause them to be practiced for governmental purposes.

Patent No. 2,918,699, entitled "Press" was developed under a grant to Brigham Young University. Applications for patents on this invention have also been filed in the United Kingdom (No. 14,370/59) and in Canada (No. 771,918). The Foundation has also secured for the Government irrevocable, royalty-free, nonexclusive and nontransferable licenses to practice this invention and cause it to be practiced for governmental purposes. The Research Corporation is administering this invention pursuant to an agreement with Brigham Young University.

Fiscal Analysis of Research Programs

In fiscal year 1960, a total of 1995 grants were made in support of basic research to 362 institutions throughout the United States and its possessions; also to Japan, Lebanon, Netherlands, Southern Rhodesia, France, West Germany, Israel, Italy, England, Chile, Canada, Bermuda, Australia, and Argentina. Research expenditures totaled $78 million—$62 million for research grants and $16 million for facilities.

The average 1960 research grant was for the sum of $30,008 for a period of 2.2 years. This compares with the average grant in 1954 (earliest for which records are readily available) of $10,465 for 1.9 years.

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Table 1.—*Distribution of research grant funds by type of expenditure*[1] *fiscal year 1960*

Object	Average grant fiscal year 1960[2]	
	Amount	Percent
Salaries	$16,615	63.7
Permanent Equipment	3,813	14.6
Expendable Equipment	2,236	8.6
Travel	1,029	3.9
Other	2,411	9.2
Total direct	26,104	100.0
Indirect	3,904	15.0
Total	30,008	

[1] Based on budget estimates at time of activation.

[2] Based on 1,943 grants awarded totaling $58,303,861 for an average duration of 2.20 years.

The accompanying table summarizes the research grant program by subject categories. A detailed list of grants showing institution, principal grantee, title of project, duration, and amount is given in appendix C.

Table 2.—*National Science Foundation grants, by fields of science, fiscal year 1960*

Field	Number	Amount
Biological and medical sciences:		
Developmental biology	65	$1,706,495
Environmental biology	129	2,650,000
Genetic biology	74	2,100,300
Metabolic biology	116	3,103,100
Molecular biology	116	5,542,700
Psychobiology	83	2,192,730
Regulatory biology	121	3,527,275
Systematic biology	149	2,767,150
General biology	38	1,144,660
Total	891	24,734,410
Mathematical, physical, and engineering sciences:		
Astronomy	62	2,169,500
Atmospheric	44	3,912,525
Chemistry	222	5,462,500
Earth sciences	127	4,128,735
Engineering sciences	184	5,702,405
Mathematical sciences	132	3,648,600
Physics	145	6,444,100
Total	916	31,468,365
Social sciences:		
Anthropology	49	717,850
Economics	16	526,986
History and philosophy of science	12	85,750
Sociology	32	758,600
Total	109	2,089,186
Antarctic research (life and physical sciences)	79	3,625,851
Grand total	1,995	61,917,812

EDUCATION IN THE SCIENCES

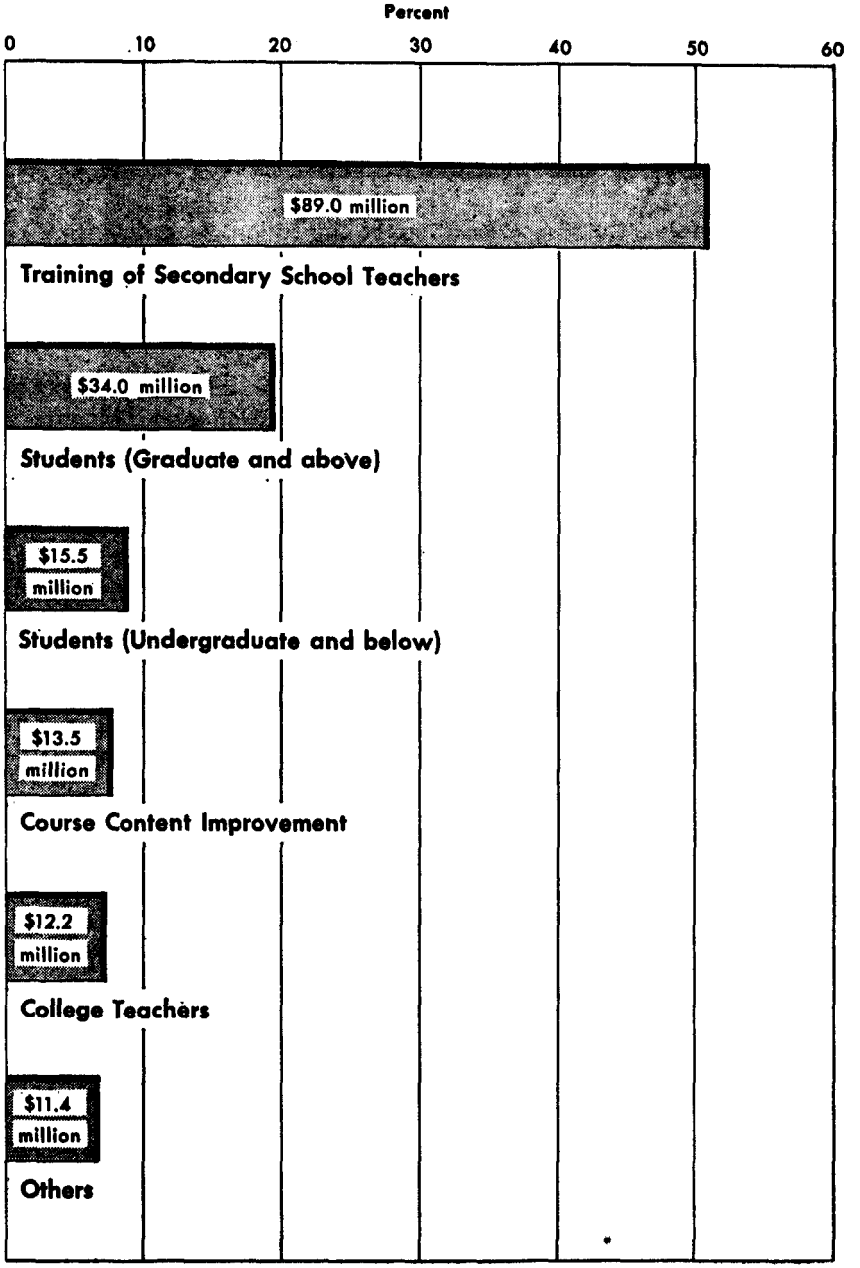
Nine years have elapsed and much money and effort have been expended for the promotion of education in the sciences by the Foundation since the initial grant for fellowships was made in 1952.

An appraisal of this activity conducted by the Foundation, through the Division of Scientific Personnel and Education, shows that a marked degree of success has attended these developing programs. The evidence indicates that the overall beneficial effect of the Foundation's educational activities is without precedent. The degree of acceptance of these activities by the scientific-educational community has been gratifying and, in some respects, startling; yet it is understandable because the Foundation's programs have been predicated on the requirements of that community. The success and acceptance of these education programs have stemmed from the fact that these efforts have made significant contributions toward meeting needs as they have been identified by those best equipped to know.

In the early years, primary emphasis was placed on the science-educational needs of the more advanced scholars—the graduate students and established scientists—through the fellowships programs. Initiated in 1952, with 624 awards at a cost of $1.5 million, these programs have increased their coverage to provide 4,010 fellowships representing a total obligation of $13.5 million in 1960.

The second period saw the continuance and diversification of these efforts and the advent of programs developed around the needs of the science, engineering, and mathematics teachers—programs, first, for college teachers; later, and with greater emphasis, for secondary school teachers. The program of institutes which began with 2 summer institutes in 1953 had grown by 1960 to 649 institutes—412 summer, 33 academic year, and 204 in-service, at a cost of over $33 million. One-half of all funds for education in the sciences has been used in support of secondary school teacher programs.

Figure 1. ***Distribution of Funds for Education in the Sciences Programs; By Problem Area, 1952–60, Inclusive.***



High school and college student programs were launched in 1953 with a very modest budget which has grown in 1960 to $11 million.

Support for activities designed to effect an improvement in science courses and curricula has increased since its beginning in 1954 to approximately $6 million in 1960.

The data presented in figure 1 represent the distribution of NSF funds according to broad program areas for education in the sciences. Funds for specific program activities are presented, as appropriate, in the general text.

Principles Guiding Operation of Education Programs

It seems appropriate at this time to restate the basic principles that have guided the Foundation in carrying out its responsibilities in scence education.

1. A successful attack on the problems of education in the sciences is a matter of critical importance to the Nation's welfare. This attack must be launched and prosecuted with sustained vigor and perception and should be based on the Nation's needs both now and in the future, whether in times of peace or war.

2. The educational system of the Nation is varied, complex and decentralized, but its fundamental strength rests on such attributes. Such assistance as the Foundation can bring to bear on the problem of improving education in the sciences must be rendered so as to respect and preserve what have proved to be fundamental strengths. The Foundation's programs must not result in NSF assuming any measure of control over the processes of education.

3. There is no substitute for excellence. The Foundation strives to encourage initiative and imagination on the part of scientists, scientist-teachers, educational institutions, and scientific organizations in devising promising new ways of improving education in the sciences. The Foundation will recommend support of those activities which, on the basis of the fullest internal and external review, seem most likely to be worthwhile. Each proposal will be judged individually on its intrinsic merit.

4. To be successful, attacks on problems of education require mutual and sympathetic cooperation between eminent teachers and eminent scientists. The Foundation will actively solicit and encourage such cooperation. Further, NSF's programs must be developed with the fullest cooperation and advice of the scientific-educational community. Only in this way can they attain the degree of relevance that is a prerequisite to success.

5. There is no one solution to the problems of education in the sciences. Concerted action by many individuals and groups working on

many facets simultaneously is necessary. The Foundation's activities must supplement, not compete with, those of others.

6. It is of paramount importance that education in the sciences be based upon the substantive content and nature of contemporary science itself. The scientific personnel and education activities of the Foundation will be based on this principle.

It will be noted that a basic theme underlies all these principles—cooperation with scientist-educators in the pursuit of excellence. To this end, in fiscal year 1960 the Foundation obtained in formal ways the counsel of more than 1,000 scientists who served on various panels and committees in reviewing proposals in science education and applications for fellowships. The opinions of many others were sought in informal ways. Special advisory panels were appointed to counsel with the staff on institutes, special projects, and course content.

Fellowship Programs

Fellowships have proved to be effective instruments in encouraging and facilitating the scholarly pursuit of knowledge. They provide an impetus toward the conquest of new frontiers of knowledge. They are investments in the future of individuals of high potential, individuals upon whom society is dependent to a marked degree for its future progress.

Awarding fellowships was among the first of the Foundation's activities. From the two original programs in 1952, this activity has grown to include, in 1960, seven different fellowship programs which have provided 13,350 awards through fiscal year 1960. These NSF fellowship programs are as follows:

1. *Graduate Fellowships* for students studying for a master's or a more advanced degree in science, mathematics, or engineering. (Initiated in 1952.)

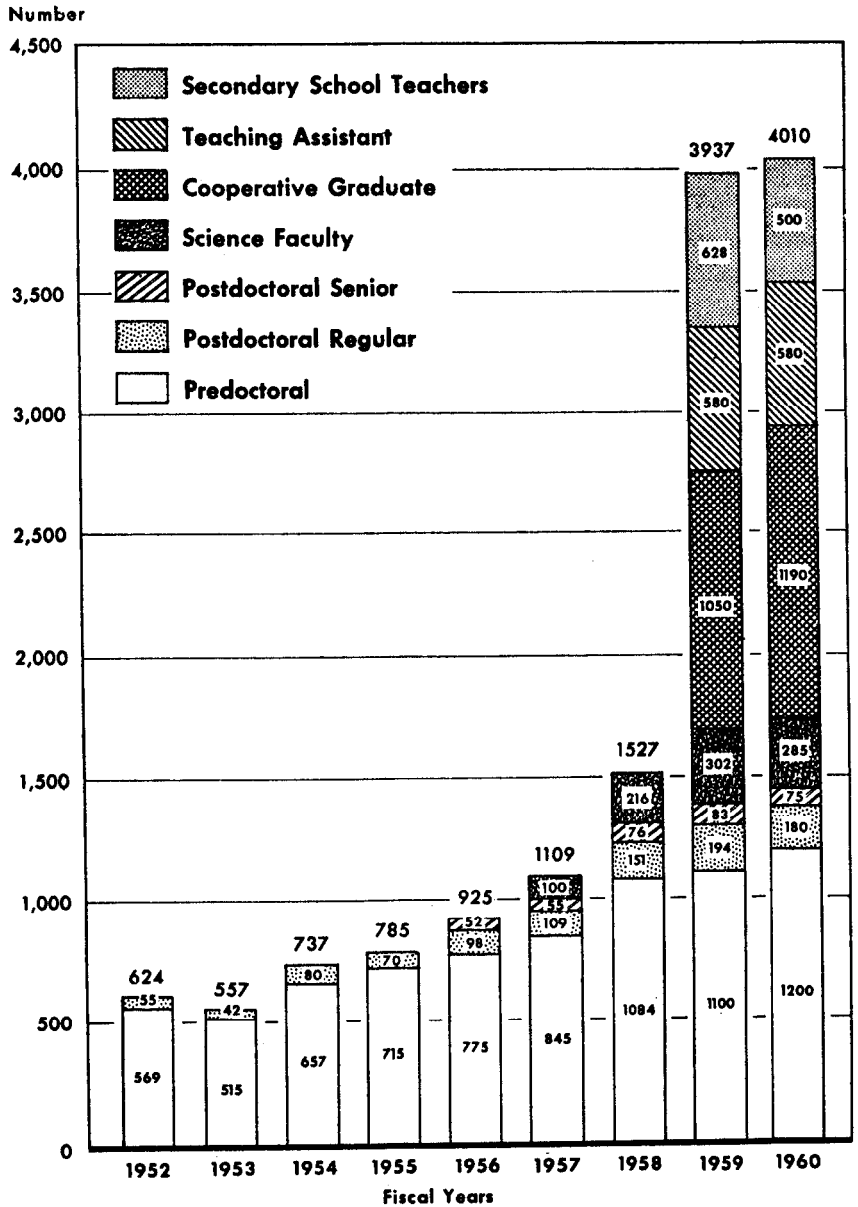
2. *Cooperative Graduate Fellowships* similar to graduate fellowships except that certain aspects of the program are administered jointly by the cooperating institutions and the National Science Foundation. (Initiated in 1959.)

3. *Summer Fellowships for Graduate Teaching Assistants* for support of summer study by graduate teaching assistants. (Initiated in 1959.)

4. *Postdoctoral Fellowships* primarily for individuals who have recently received a doctoral degree in science, mathematics, or engineering. (Initiated in 1952.)

5. *Senior Postdoctoral Fellowships* primarily intended for recognized senior scientists, mathematicians, and engineers. (Initiated in 1956.)

Figure 2. ***Growth of National Science Foundation Fellowship Programs. Number of Awards Offered, Fiscal Year 1952–60.***



6. *Science Faculty Fellowships* for junior college, college, and university teachers of science, mathematics, and engineering. (Initiated in 1957.)

7. *Summer Fellowships for Secondary School Teachers* for the support of individual graduate study by secondary school teachers of science and mathematics. (Initiated in 1959.)

A total of 4,010 fellowship awards were offered in 1960, representing a cost of approximately $13.5 million.

In addition to the previously listed programs, the Foundation, at the request of the Department of State, administered for the second year the U.S. component of a program of North Atlantic Treaty Organization (NATO) Postdoctoral Fellowships in Science. Under this program a total of 41 awards were offered to U.S. citizens in fiscal year 1960. For the first time, similar responsibilities were undertaken in 1960 for providing administrative guidance in the United States for a new fellowship program initiated by the Organization for European Economic Cooperation (OEEC)—the OEEC Senior Visiting Fellowships. The objective of this program is to strengthen insitutions in significant areas of research and training. A total of 27 awards were offered to U.S. citizens.

Recipients of NSF fellowships are selected in national competition solely on the basis of ability. Initial evaluation is performed by panels of scientists appointed by, and operated under the aegis of, the National Academy of Sciences-National Research Council, the Association of American Colleges, or the American Association for the Advancement of Science. Awards are made by the Foundation on the basis of the panels' recommendations and in compliance with statutory requirements. (See Appendix E for listing of fellowship awards.)

Graduate Fellowships (Predoctoral)

This program fosters nationwide competition, and awards are offered to those candidates for advanced degrees having the highest ability and those judged to have the greatest potential for developing into well-qualified scientists, mathematicians, and engineers. Because the standards for selection are high, these awards enjoy a high prestige value and are very much sought by many of the Nation's ablest students.

In fiscal year 1960 a total of 4,696 applications were received; the Foundation selected 1,200 persons for awards. In addition, 2,272 applicants were accorded Honorable Mention.

Cooperative Graduate Fellowships

The Cooperative Graduate Fellowship Program, like the Graduate Fellowship Program, is intended to support graduate students of the

highest ability in the pursuit of their scientific studies. This program, however, is designed to achieve broader distribution of awards among participating institutions; the institutions themselves play an important part in the preliminary evaluation of applicants and in the administration of the program.

Fiscal year 1960 marked the second year of the program's existence. All institutions which confer doctoral degrees in the science areas covered by these awards were invited to participate, thus increasing the number of participating institutions to 152, as compared with 115 in the first year.

A total of 3,091 individuals applied through 144 colleges and universities. The Foundation selected 1,190 individuals, representing 134 institutions, for awards.

Summer Fellowships for Graduate Teaching Assistants

First offered in 1959, this program was designed to enable graduate teaching assistants at designated participating institutions to devote full time, during the summer, to their own study and research in the sciences, mathematics, and engineering. Individuals apply through their own institutions and are initially evaluated by them. They are then evaluated centrally, with final selections being made by the Foundation solely on the basis of the applicants' ability.

As in the Cooperative Graduate Fellowship Program, all institutions which confer doctoral degrees in the science areas covered by these awards were invited to participate. There were 150 participating institutions in this year's program, compared with 115 institutions in fiscal year 1959.

Of the 1,362 individuals who applied in 1960, through 127 colleges and universities, the Foundation selected 580 awardees representing 118 institutions.

Postdoctoral Fellowships (Regular)

The Postdoctoral Fellowship Program, now in its ninth year of operation, offers support to individuals who have, in most cases, recently received doctoral degrees in science, mathematics, or engineering, and who need and are qualified for additional advanced training as investigators in their chosen fields. Since 1956 there have been two award periods each year—one in October and the other in March. Tenures may range from 6 to 24 months depending on the program planned by the individual.

There were two competitions in fiscal year 1960, with awards announced in October 1959 and in March 1960. Of the 782 applicants, the Foundation selected 180 persons for awards.

Senior Postdoctoral Fellowships

The Senior Postdoctoral Fellowship Program offers well established scientists, mathematicians, and engineers the opportunity to pursue additional study and/or research with a view toward increasing their competence in their specialized fields or toward broadening their knowledge in related fields of science. Tenures of 3 to 24 months are available, although the usual tenure is for 9 or 12 months.

Of the 259 applicants in this year's program, the Foundation selected 75 individuals for awards.

This program has received the enthusiastic support of the scientific community and appears to be meeting an important need. A renewal policy in the Senior Postdoctoral Fellowship Program has been established and becomes effective in the fiscal year 1961 competition, as follows:

> Any person who has held a Senior Postdoctoral Fellowship for 2 years is ineligible for a period of 5 years to hold another such fellowship.

Science Faculty Fellowships

The Science Faculty Fellowship Program provides an opportunity for college and university teachers of science, mathematics, and engineering with 3 or more years of science teaching experience at the collegiate level to improve their competence as teachers. Tenures of 3 to 15 months are available. A unique feature of this program is the provision which allows awardees to undertake their fellowship studies in either one, two, or three consecutive summer periods.

A review of this program, carried out in 1959, indicated that it should be divided administratively into two parts—one to be a competition among applicants with a Ph. D. degree, and the other for applicants in a non-Ph. D. category. The 709 applicants this year were thus categorized and the resulting groups of applicants were evaluated by two independent panels. The Foundation selected 285 individuals for awards, dividing the awards proportionately between the two groups as determined by the ability level and the number of applicants in each group.

Summer Fellowships for Secondary School Teachers of Science and Mathematics

This fellowship program enables secondary school teachers of high ability to undertake study programs in the subject matter of science and mathematics during one, two, or three summers. These fellowships, emphasizing study on an individual basis, are intended to supplement the

Foundation's institute programs, the latter being especially designed for training groups of teachers.

A total of 2,221 teachers—representing a 40 percent increase over 1959—applied for these fellowships. Many applicants failed to qualify because they lacked the undergraduate training prerequisite to graduate study in science or mathematics. The Foundation selected 500 individuals to be offered awards.

Extramural Fellowships

1. North Atlantic Treaty Organization (NATO) *Postdoctoral Fellowships in Science.*

Again, as in fiscal year 1959, the Foundation administered the program of NATO Postdoctoral Fellowships in Science. This program is designed to stimulate the exchange of scientists among the NATO countries by the fellowship mechanism, each member nation being charged with selecting fellows from among its own citizens.

Applications for fiscal year 1960 fellowships were received from 162 U.S. scientists; 41 applicants were offered awards by the Foundation.

The fellows will study in Canada, Denmark, France, the Federal Republic of Germany, Italy, The Netherlands, Norway, the United Kingdom—all NATO countries—as well as Israel and Sweden.

2. Organization for European Economic Cooperation (OEEC) *Senior Visiting Fellowships.*

In order to assist scientific and technical institutions to incorporate more quickly into their own advanced teaching and research programs the most recent developments in their own and other countries, the Organization for European Economic Cooperation has established a program of OEEC fellowships. Each member or associated OEEC country administers the OEEC fellowship program for its own nationals. In fiscal year 1960 the Foundation assumed the responsibility for administering this new program for citizens of the United States, including the selection of fellows.

This program emphasizes the strengthening of the scientific work of the institutions of the fellowship recipients, rather than research training of individual scientists, as such, or individual academic study. Fields supported include the mathematical, physical, biological, and engineering sciences, but not the social sciences or medicine. Awards normally are tenable for periods of 8 weeks to 6 months, and in unusual circumstances for as long as 1 year. Recipients of awards are usually expected to study abroad in one or more countries that belong to or cooperate with the Organization for European Economic Cooperation.

Thirty-five scientists applied for awards; 27 grants were made. The awardees will study in 10 European countries.

Institute Programs

The Foundation's institute programs are directed toward raising the level of the teaching of science, mathematics, and engineering in our Nation's schools. Consisting of three major types—Summer Institutes, Academic Year Institutes, and In-Service Institutes—these programs provide supplemental training in subject matter for high school and college teachers, as well as for staff personnel of technical institutes and elementary schools. As contrasted with the individualized study made available through fellowship programs, the institute programs offer "group" activities and employ course materials especially prepared to meet the subject matter needs of participating teachers.

A secondary objective of institute programs is to provide colleges and universities opportunity to carefully review science and mathematics courses now available to both pre-service and in-service teachers who seek to improve their teaching competence in these areas.

Since the program's inception in 1953, the Foundation has made grants for the support of 1,661 institutes—1,057 Summer Institutes, 102 Academic Year Institutes, and 502 In-Service Institutes. The largest portion of these, 1,418 or 85 percent, was for secondary school teachers. In 8 years of operation, a total of 81,000 opportunities for study have been made available through the NSF institute programs—opportunities for 73,550 high school teachers, 5,550 college teachers, 1,750 elementary school teachers, and 150 technical institute teachers. The institute programs have grown from an operation which involved the expenditure of $21,000 in 1953 to one with an estimated obligation in fiscal year 1960 of more than $33 million.

For fiscal year 1960 the Foundation supported 649 institute programs. Of this number, 412 were Summer Institutes; 33 Academic Year Institutes; and 204 In-Service Institutes. As shown in the table below, over 31,000 teachers received financial assistance which enabled them to pursue further study in the fields of science and mathematics.

Summer Institutes

A total of 412 NSF-sponsored summer institutes were held in the 1960 fiscal year with 22,000 teacher-participants (20,310 received NSF assistance). Each of these institutes offers courses directed toward a particular educational level and a specific level of attainment in a particular subject-matter area or, alternatively, in several scientific disciplines. In addition to course work, the institutes commonly provide seminars and

Table 3.—*Study Opportunities*[1] *in NSF Institute Programs*

	Fiscal year 1960	Fiscal years 1953–60
Summer institutes:		
High school	17,415	47,000
College	2,273	5,500
Elementary school	542	1,100
Technical institutes	80	150
	20,310	53,750
Academic year institutes:		
High school	1,494	4,850
College	43	50
	1,537	4,900
In-Service institutes:		
High school	8,888	21,700
Elementary school	405	650
	9,293	22,350
Total	31,140	81,000

[1] The above figures, representing study opportunities, do not reflect the number of individual teachers who were granted support. In some cases, a teacher may have attended more than one institute in a program and/or more than one program over a period of years.

colloquia, as well as lectures by eminent visiting scientists. Ample opportunity is provided for informal discussions between participants, and between participants and staff. Such discussions and other group-learning activities are encouraged in the typical institute through special arrangements which enable participants to live in the same dormitory, eat together, go on field trips, attend special lectures, etc.

Summer Institutes for High School and College Teachers of Science and Mathematics

This summer institute program is now in its seventh year of operation. Through these institutes, supplemental training has been made available to teachers of biology, radiation biology, chemistry, earth sciences, engineering, general science, geology, history and philosophy of science, isotope technology, mathematics, and physics. Institutes in radiation biology and isotope technology are sponsored jointly by the Foundation and the Atomic Energy Commission.

Of the 379 summer institutes supported by Foundation grants during the past fiscal year, 38 were for college teachers only; 24 for secondary school and college teachers, and the remaining 317, for secondary school teachers only.

The number of participants for each institute ranged from 15 to 150, the average number being 50 per institute. The average duration of a summer institute was approximately 7 weeks, although some institutes were of only 4 weeks' duration and others were in session for as many as 12 weeks.

Summer Institutes for Elementary School Supervisors and Teachers

Developed on an experimental basis in 1959, this program provides institutes designed to give elementary school supervisors and teachers opportunity to increase their knowledge of science and mathematics, so that appropriate components of these subjects can be taught more effectively to elementary school students. In fiscal year 1960 the Foundation continued to support this program by sponsoring 15 institutes, which were attended by approximately 550 participants.

Summer Institutes for Technical Institute Personnel

Organized and administered in a manner similar to the institutes for high school or college teachers, the Summer Institutes for Technical Institute Personnel are specifically designed to meet subject-matter needs of teachers of science, mathematics, and engineering in technical institutions not conferring the baccalaureate degree. In 1960, as in 1959, two institutes of this type were supported with approximately 80 participants.

Summer Conferences for College Teachers

Each summer conference is designed as a short course or as a lecture series in a specialized subject-matter area of science, mathematics, or engineering. Sixteen were supported in fiscal year 1960.

Academic Year Institutes

The Academic Year Institute Program supports efforts of universities and colleges in providing opportunities for experienced secondary school teachers of science and mathematics to spend an entire academic year in full-time study of the subject matter of their disciplines. Planned and conducted by the individual universities and colleges, the institute courses are especially designed to meet the needs of teachers whose formal scientific education is inadequate. These courses are aimed primarily at increasing the competence of teachers by improving their knowledge of subjects they teach.

Grants for two institutes held in 1956–57 marked the beginning of the Academic Year Institute Program. Because these institutes have been so successful in meeting the need for subject-matter training for experienced teachers, the number of institutes had been increased to 33 by the 1960–61 academic year, with places for 1,537 teachers.

In-Service Institutes

In-service institutes make it possible for science and mathematics teachers to continue studies on a part-time basis during the academic year at colleges and universities within commuting distance to their homes. Participating teachers receive no stipends, but are given modest travel and book allowances through sponsoring institutions which receive Foundation support to cover costs of operation. During 1959–60 a total of 182 in-service institutes for secondary school teachers received support and offered instruction for 8,650 participants. For the 1960–61 school year about 8,900 secondary school teachers will participate in 191 in-service institutes.

Approximately half of the course work offered in these institutes will be in the field of mathematics, with the remainder covering the range of the biological, physical, and earth sciences. As an innovation, two in-service institutes will be conducted in radiation biology, with joint support from the National Science Foundation and the Atomic Energy Commission. Noteworthy also are 19 institutes which will present background material for teachers who wish to familiarize themselves with the new physics course developed by the Physical Science Study Committee. (See page 100.)

In-service institutes for elementary school supervisors and teachers are similar to those for secondary school teachers. Courses offered have been especially designed to meet the elementary schools' need for informed instruction and supervision in science and mathematics in line with a primary objective of the program to give colleges and universities opportunity to experiment with course materials adapted to the training of elementary teachers.

The In-service Institutes Program will in the 1960–61 academic year support 13 institutes for elementary school personnel which will provide instruction for 405 teachers, supervisors, and principals.

Special Projects in Science Education

The Special Projects in Science Education activities deal primarily with the development and experimental testing of new ideas for the improvement of science education and of public understanding of science. The first projects of this kind were supported in 1953, consisting of mod-

est programs for secondary school science education and supplemental training of science teachers. From these early efforts, two major NSF operational programs emerged—Institutes and Course Content Improvement.

The major program categories included under the Special Projects in Science Education are: Secondary School Programs; College Programs and Teacher Improvement Programs; and Public Understanding of Science.

Secondary School Programs

Programs directed toward the secondary school level are intended to motivate high school students' interest in, and understanding of, science, mathematics, and engineering. Special projects focused on this objective are planned by universities, colleges, scientific societies, research organizations, and other groups, and supported by grants from the Foundation.

Visiting Scientists (Secondary Schools)

Grants are made under this program to professional groups to sponsor the visits of outstanding scientists to secondary schools for the purpose of acquainting students and faculties with the sciences as vital activities and providing counsel relative to careers and education in the sciences. In addition, an increasing opportunity for closer liaison between science faculties of colleges and universities and science teachers and students in secondary schools is made possible.

For fiscal year 1960, grants were made to the: American Chemical Society, American Institute of Biological Sciences, American Institute of Physics, Mathematical Association of America, and the University of Puerto Rico.

Traveling Science Libraries

This program is designed to interest the high school student in science and mathematics through the reading of stimulating books in these subject areas. The American Association for the Advancement of Science, assisted by a committee of experts, selects 200 books each year as representative of the books most appropriate for high school students in the various fields of science. Books are chosen for content, intrinsic interest, and a writing style suitable to the reading audience.

During the 1959–60 school year, 375 sets of 200 books each were sent to 1,678 high schools and preparatory schools, as well as to 4 county libraries serving a large number of small schools. During the summer months, many sets were loaned to National Science Foundation-sponsored institutes for science teachers.

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In addition, a traveling science library program for elementary schools was initiated during the past school year. A total of 802 elementary schools received sets of 160 books, and there were indications that this library service is particularly helpful to students of unusual ability.

Traveling Science Demonstration Lectures

This program provides opportunities for secondary school students and teachers to observe special science lecture-demonstrations in physics, chemistry, biology, and mathematics. Especially trained secondary school science teachers present the demonstration lectures. Currently four centers are established for the training of teachers. A total of 120 teachers began training in the summer of 1960.

The Oak Ridge Institute of Nuclear Studies (ORINS) is presently experimenting with academic-year training sessions of 12 week's duration for locally supported teachers; these sessions parallel the summer training sessions held at all four centers—ORINS, Michigan State University, Oklahoma State University, and the University of Oregon.

During academic year 1959–60, visits were made to about 1,700 high schools by the NSF-supported traveling teachers; about 12,000 teachers and 700,000 students were reached. In addition, 35 locally supported teachers have been trained and have returned to their own school districts for more intensive work over a longer period of time.

Science Clubs

Through the Science Clubs program, the Foundation provides support for extracurricular science projects carried on under the guidance of national youth organizations. The objective of this program is to stimulate the interest of pre-college age students in science and in scientific and engineering careers.

In fiscal year 1960, the Foundation continued to provide partial support to Science Service, a nonprofit organization which provides direction and central administrative services to the organization known as Science Clubs of America. Currently there are over 25,000 local affiliated Science Clubs, chiefly at junior and senior high schools, with a total membership of about 600,000. The Foundation also provided support to the Junior Engineering Technical Society for administering the development and distribution of 16 academic units (booklets) to over 650 local affiliated clubs. These booklets present topics pertinent to engineering, technology, or applied science. The Junior Engineering Technical Society provides brochures for career guidance; also ideas and materials for building chapter programs, and for improving the scientific potential of its members.

Summer Training for Secondary School Students

Through this activity, support is provided to colleges, universities, and other non-profit research institutions for programs offering opportunities to high-ability secondary school students to study and work with experienced scientists and mathematicians at the sponsoring institutions.

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

About 7,100 students participated in this program at 136 different institutions during the summer of 1960.

State Academies of Science

This program provides aid to State Academies of Science and similar organizations for programs designed primarily to increase our young people's interest in science. Academies of Science are uniquely qualified for implementing programs of this type because of their active involvement with Junior Academies of Science and because of the broad diversification of professional talent represented in the academies' memberships. As the focal point for scientific interest in a region or community, each academy of science has an unusual opportunity to marshal all local and regional science resources in behalf of improved science education.

Programs of the separate academies cover a broad spectrum of activities: visiting scientists programs; special field trips; expanded junior academy activities; preparation of instructional material for teachers in connection with science fair programs; joint conferences of high school science teachers, college scientists, industrial scientists, and school administrators; etc.

During fiscal year 1960, a total of 43 grants were made to 28 State academies, 5 metropolitan academies, and 2 museums.

Science Career Information

Through this program the Foundation makes grants to scientific organizations for administering the preparation and distribution of career-guidance materials which give authoritative information to students considering professional careers in the various fields of science.

Ten grants were made to the: American Meteorological Society, American Society of Zoologists, American Institute of Biological Sciences, Botanical Society of America, Society of American Bacteriologists, Metallurgical Society of AIME, American Institute of Physics, American

Chemical Society, Council of Chief State School Officers, and National Academy of Sciences.

College Programs and Teacher Improvement Programs

The basic objectives of these programs are the improvement of science education and the development of more well qualified scientists and engineers. These programs provide opportunities for the undergraduate to improve his understanding of science, mathematics, and engineering, as well as assist teachers in developing their subject-matter backgrounds in these areas.

Visiting Scientists (Colleges)

This program facilitates visits by distinguished scientists to colleges and small universities for periods of two or three days to give lectures, to conduct classes and seminars if desired, and to meet students, faculty members, and administrative officers on an informal as well as formal basis in order to stimulate interest in science. These visits also make it possible for smaller institutions to become aware of developments in specialized fields of science and technology not commonly represented on the small college or university campuses. The program is administered through grants to appropriate professional scientific societies.

It is estimated that approximately 1,500 visits will be made to colleges during 1960–61, and that about half the colleges in the Nation will receive visiting scientists who represent one or more disciplines.

Visiting Scientists (Foreign)

Under this program grants are made to national professional societies to arrange for the visits of eminent foreign scientists to the science departments of our major colleges and universities. Such visits are usually for a period of a few weeks to several months. The visiting foreign scientists give lectures, conduct seminars, and meet with students and faculty with the objective of augmenting the quality of the research and educational activities of these institutions. Through these visits, leaders of American science are able to become better acquainted with the current state of knowledge in various scientific and engineering disciplines throughout the world.

Undergraduate Science Education

The Undergraduate Research Participation Program makes it possible for educational institutions to provide research training to high-ability undergraduates who have potential for scientific research and college teaching. This research experience is also intended to encourage participants to pursue graduate work in science. The Undergraduate Research

Training Program enables institutions or departments without active research in progress to initiate an investigative activity in which undergraduates could participate.

The 490 grants made in 1960 will help provide 3,338 undergraduates with a research experience in a variety of disciplines in the mathematical, biological, physical and engineering sciences, certain of the social sciences, and experimental psychology.

Research Participation for Teacher Training

Through this program, an opportunity is offered to teachers from secondary schools and small colleges to participate in scientific research during the summer. Initially the primary objective of this program, which began in 1959, was to improve the teaching of science through enlivening research experience provided teachers. However, with the development of this and other programs for teachers, emphasis has shifted somewhat to the objective of strengthening the Nation's research potential by providing teachers with the incentive and opportunity to become actual contributors to scientific knowledge. Recognizing that research and teaching are not mutually exclusive activities, the primary objective of developing teachers as teachers remains.

In fiscal year 1960, a total of 87 grants were made to educational institutions, making it possible for approximately 750 (500 secondary school and 250 college) teachers to obtain research experience during the summer of 1960.

Supplementary Training for Science Teachers

This program is aimed at improving the quality of science teaching at all educational levels through specialized conferences, workshops, etc., often of an experimental character. Programs may take the form of conferences directed toward improving instructional techniques, instruction in recent scientific advances, or inquiries into means of fostering new lines of educational scientific activity. NSF supported 41 of these projects in fiscal year 1960 with 4,000 teachers participating.

Special Field Institutes

Special Field Institutes supplement the advanced educational opportunities presently provided by university graduate schools or other advanced training centers for alleviating shortages of personnel in specialized scientific areas of critical importance in academic as well as scientific circles. These institutes are commonly cooperative graduate programs that assemble limited staff resources from several campuses and include industrial and Government scientists with unique specialization. Convening for a limited period of time to organize knowledge in un-

charted areas and to instruct research workers, faculty members, and postdoctoral and advanced predoctoral students, these institutes provide a well-conceived, short-term program of advanced study not readily available in usual graduate school situations.

Sixteen grants were made in 1960 for dealing with current advances in such fields as theoretical physics; mathematics and statistics; geophysical, oceanographic, and engineering applications of fluid dynamics; ethnography and anthropology; forest biology; marine sciences; and dynamical astronomy.

Public Understanding of Science

Under the Public Understanding of Science program, support is provided to educational institutions and scientific organizations to assist in developing ways of improving the lines of communication between the scientific community and the lay public in order to develop a broader concept of the impact of science upon the economy, welfare, and security of the Nation.

Since information on science is presented to the public primarily through the mass circulation media, initial experimental efforts are being directed toward steps to improve the quality and quantity of science news appearing in such publications.

These efforts in 1960 consisted of 13 grants for activities, such as conferences of scientists and newspaper editors, workshops for science reporters, and seminars for experienced science writers. Approximately 85 editors, 150 reporters, and 200 professional science writers participated.

Course Content Improvement Programs

Modernizing the content of science and mathematics curricula and courses, as well as all types of aids to learning and teaching, is essential to upgrading education for today's age of science. Content, adapted to the learner's level, must continuously reflect science as on-going inquiry and science at the level of understanding achieved by current knowledge. The purpose of the Foundation's Course Content Improvement Programs is to provide support for projects which engage the Nation's finest talent in the difficult and urgent task of achieving these goals.

These programs have evolved steadily since 1954. The complexity of problems in this domain, together with their far-reaching implications, led to an initially cautious approach through relatively small grants for a variety of exploratory studies. Support was increased considerably in fiscal years 1957 and 1958, when the first major effort was launched—the development of a new high school physics course. The results and

success of pilot projects, along with growing realization among first-rank scientists that such efforts merit high priority among their responsibilities, justified a further substantial increase to about $6 million annually in fiscal years 1959 and 1960.

First priority has thus far been given to new courses and materials for secondary schools, nearly 85% of program funds being allocated to this educational level during the period 1954–1960. In addition to continuing substantial support for high school projects, major effort must be focused upon the improvement of college and university programs, both through undertakings involving nationwide teams of scientists, mathematicians, and engineers and through modernization of curricula and courses within the great diversity of higher educational institutions and scientific and engineering fields. Also, recognition of the vital importance of elementary and junior high school experience in developing proper attitudes and laying the groundwork for subsequent schooling makes imperative a thorough study of science and mathematics curriculum improvement at this level.

Evaluation of projects supported by these programs points up two important aspects of course content improvement: first, assurance of excellence in content, for which perhaps the best guarantee is development and constant improvement of materials by top-level scientists, working with outstanding teachers and other experts; second, determining pedagogical feasibility through school trial, careful study of results, and revision of materials based thereon—an integral element in most projects. The widespread interest in course content developments is reflected in the great number of requests for information received by the projects, the Foundation, and other organizations. Substantial interest is also emerging in Europe, Asia, South America, and other parts of the world.

Course Content Studies and Development

Elementary-Junior High School

Foundation support for course content studies and development for elementary and junior high schools continued to be quite limited in fiscal year 1960 because further study of the problems involved and clarification of the Foundation's responsibilities are still required. These studies are now underway.

Another important need is an effort by scientists to identify significant content and to experiment with materials for pupils and teachers. The University of California received a grant to continue its interdisciplinary project on science for the first six grades; the University of Illinois, a grant for experimental work on instruction in principles of physical

science focused on astronomy. The basic importance of mathematics content throughout the elementary and secondary curriculum is conceded by all; the School Mathematics Study Group is continuing its highly promising work on sample courses for grades 7 and 8, and beginning the preparation of material for grades 4 through 6.

High School

Educational Services Incorporated received a grant to complete the first phase of work on a new high school course prepared by the Physical Science Study Committee. As the result of a 4-year effort by some of the Nation's most notable physicists, most materials for this course are now available to all interested schools. Some 30,000 students in 650 schools have already taken the course.

The School Mathematics Study Group received further support through Yale University for revision of sample textbooks and teacher's commentaries for grades 7 through 12, materials for teacher education, special materials for gifted students, and further evaluative studies. The American Institute of Biological Sciences was granted additional funds for efforts by the Biological Sciences Curriculum Study to devise and test textbooks, laboratory and field studies, teacher education materials, and other aids for high school biology. In chemistry support was given to two projects. Grants were made to Earlham College for the Chemical Bond Approach Project to prepare a second version of a text and laboratory guide for trial in some 50 schools during 1960–61, followed by a definitive edition to be published for general use. The University of California received funds for the Chemical Education Materials Study, which is beginning to devise and test text, laboratory, film, monograph and other materials for another type of high school chemistry course.

A related and difficult problem is that of helping teachers and school administrators learn more about new curriculum developments sponsored by various foundations and organizations. One approach will be tried by the National Council of Teachers of Mathematics through a grant for a series of eight regional conferences of mathematics supervisors.

College and University

Projects at colleges and universities follow three general patterns. One pattern involves a conference, series of conferences, or committee study to examine a field and define broad guidelines for curriculum reform. Support was provided for such studies on: introductory physics courses; chemistry for non-majors; and the undergraduate curriculum for chemistry, civil engineering, chemical engineering, sanitary engineering, experimental mechanical engineering, and anthropology.

A second type of activity, which may evolve from a project of the first sort, is the formation of a continuing body to conduct basic studies, provide liaison among specific course-content projects, supply information about developments, and stimulate efforts on the part of individual institutions or groups of colleges. The Mathematical Association of America received a grant to enable its Committee on the Undergraduate Program in Mathematics to assume this responsibility for that field, and comparable commissions concerned with college physics and experimental mechanical engineering have been recommended by the conferences in those fields.

The third kind of undertaking in the college and university studies category is the development of a specific new course which promises to be of wide interest and which includes elements of a truly novel nature. In this area grants were made to Harvard University for a new introductory biology course, to Ohio State University for work on a new laboratory program in organic chemistry, to Lehigh University and North Carolina State College for coordinated projects in experimental mechanical engineering, and to the Massachusetts Institute of Technology for a laboratory course on the principles of instrumentation.

Supplementary Teaching Aids

The objective of the Supplementary Teaching Aids program is to support the development of such aids to learning as new laboratory apparatus, motion pictures, and television presentations which have been designed to extend the range and scope of science, mathematics and engineering courses in significant ways.

For the design and development of prototypes of new laboratory equipment, 32 grants were made in 1960. Projects include an educational wind tunnel using smoke to visualize air flow, a small hypersonic wind tunnel, stereophotomicrography for submacroscopic anatomy, demonstrations for use with overhead projectors, equipment for instrumental chemical analysis, design of inexpensive computers, and a low-cost mass spectrophotometer.

Two educational television projects were granted support. A series of eight half-hour programs produced under a grant to the University of California at Berkeley will enable Nobel Laureate Wendell M. Stanley and his colleagues in the Virus Laboratory to bring the story of modern virus research and its implications for basic biology to large audiences. The use of television in providing teachers of mathematics with background knowledge and a detailed understanding of new curricula is the subject of a project sponsored by the Minnesota Academy of Science.

Educational film projects in a variety of fields were supported. Anthropology films, sensitively edited, can give the student an understanding of unfamiliar cultures; with this purpose in mind, a grant was made to Harvard University for the completion of a series of documentary films on !Kung Bushmen of South Africa. Under grants to the State University of Iowa and the University of Minnesota, films on principles of fluid mechanics will be produced. Iowa also received a grant for films on the biology of slime molds and the use of these organisms in teaching. Yeshiva University was awarded support to begin a series of films for high school and college biology courses which endeavor to put the viewer in the position of an original observer of plants and animals as an attempt is made to uncover fundamental principles through close observation of organisms in their natural environments. Yale University has received support for a series of short films for advanced high school and college courses in chemistry. A grant to the University of Illinois provides for experimentation with the use of films in presenting demonstration classes on new approaches to the teaching of elementary school mathematics.

Scientific Manpower Program

The Scientific Manpower Program is responsible for carrying out those functions of the National Science Foundation Act which require the maintenance of a register and clearinghouse of information on scientific and technical personnel. Through this program the Foundation makes available information on the Nation's resources of scientific and technical personnel, both for the purpose of administering its own programs and for the provision of information as required by other agencies concerned with science-oriented programs. In addition to providing information on the Nation's collective resources of scientific manpower, the Register program makes possible the location and identification of individuals with specialized skills when needed for important Governmental purposes, including mobilization.

The National Register of Scientific and Technical Personnel

On January 1, 1953, the National Science Foundation formally established the National Register of Scientific and Technical Personnel, which is the only comprehensive program for registration of the Nation's scientists. Information on more than 127,000 scientists was collected by the National Register during 1954–55.

Scientists were recircularized during 1956–58 and the National Register for that period includes information concerning some 170,000 scientists. In addition, a "finder's list" is maintained which includes about

20,000 engineers representing different geographical areas and engineering specialities.

During fiscal year 1960 the principal activities of the National Register were directed toward: (1) preparing a report covering the collection, tabulation, and analysis of data which was submitted to the House Committee on Science and Astronautics in "A Study of Scientific and Technical Manpower"; (2) analyzing the data collected and issuing a summary report, "Salary Profile of Scientists in the National Register of Scientific and Technical Personnel, 1956–58"; (3) servicing requests for Register information from industry, the scientific community, Government agencies, etc.; (4) developing questionnaires, revising specialty lists, and coordinating cooperating society operations for the recircularization of registrants according to the two-year cycle plan; and (5) coordinating the actual mailings to the scientific community.

A Study of Scientific and Technical Manpower

In response to a request from the House of Representatives Committee on Science and Astronautics, the National Science Foundation submitted, in January 1960, a comprehensive report covering (a) the status of the scientific and technical manpower register and the Foundation's manpower studies, and (b) the projected plans for the future, short-range and long-range, in these areas.

The report in summary made the following points concerning the National Register:

1. Approximately 90 percent of scientists in fields now considered of mobilization importance should be registered.
2. Certain applied and other science fields should be covered as they, in turn, are deemed important for this purpose.
3. Substantive information on employment and professional characteristics will be brought up to date at no longer than two-year intervals. Methods will be sought to maintain current addresses within one year.
4. Registration should be on a voluntary basis during peacetime. In a mobilizing situation, however, registration of scientists should be geared into other more comprehensive registration programs, some or all of which may be mandatory.
5. In view of the complexities of registering engineers, based on diverse training, types of jobs held, and the large number of engineers in the country, the Foundation has turned to the engineering profession to study this problem. The need for better information on numbers and professional characteristics of engineers is not questioned.

Salary Profile of Scientists in the National Register of Scientific and Technical Personnel, 1956–58

Salary information was published on some 137,000 full-time employed scientists, comparing fields of specialization, type of employer, work activity, level of education, and age group. The median annual salary for scientists employed full-time during the years 1956–58 was about $7,900. About 50 percent were in fields of chemistry and in life sciences, which include agricultural, biological, and medical sciences. Almost half the registrants worked for private industry or were self-employed; 28 percent were employed by educational institutions, and 19 percent worked for various Government agencies. Thirty-eight percent of the scientists reported that they were engaged in research, development, and design, and 16 percent reported that they were engaged in teaching.

Table 4.—*Median annual salaries of full-time employed scientists, by field, 1956–58*

Scientific and technical fields	Number	Salary
Total, all fields	136, 808	$7, 938
Agricultural sciences	9, 479	6, 625
Biological sciences	17, 616	6, 934
Medical sciences	1, 838	10, 873
Psychology	10, 938	6, 856
Earth sciences	12, 767	7, 975
Meteorology	2, 104	6, 924
Geography	965	6, 762
Mathematics	9, 866	7, 638
Astronomy	354	7, 400
Physics	12, 450	8, 462
Chemistry	34, 860	8, 660
Chemical engineering	4, 759	10, 219
Sanitary engineering	3, 330	8, 465
Other engineering	12, 836	9, 069
Other specialties	2, 646	7, 359

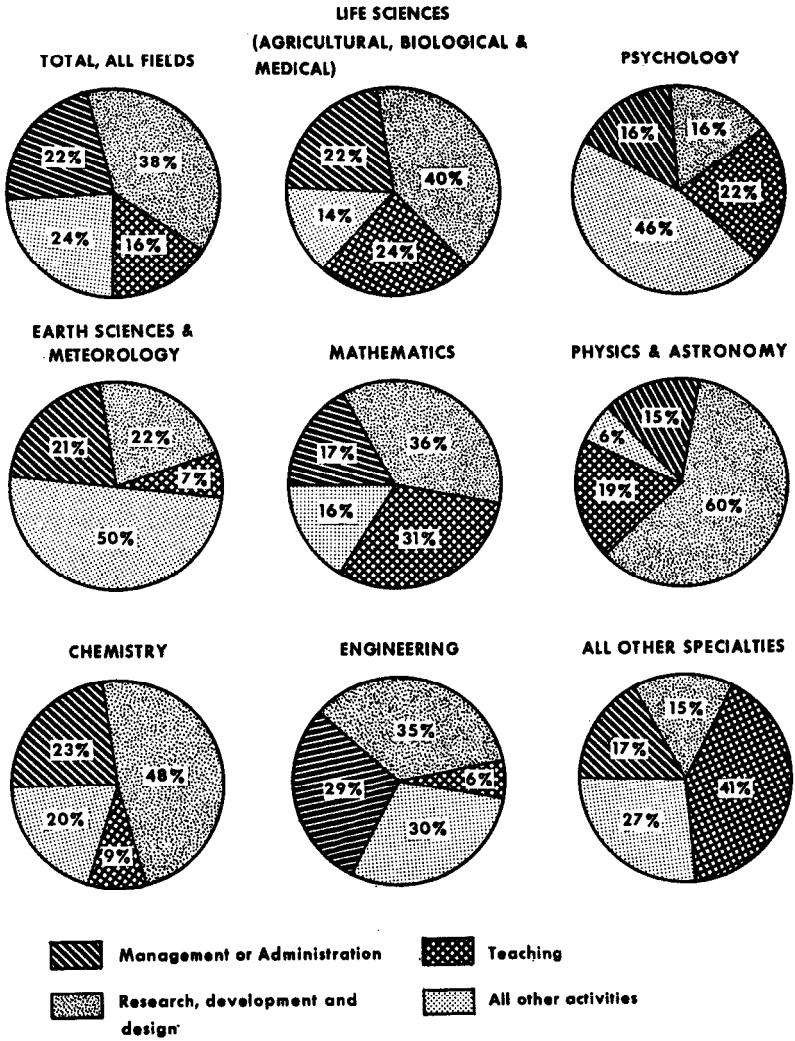
NOTE: Excludes 3,057 who gave no report of salary.

Source: National Register of Scientific and Technical Personnel, 1956–58.

Examples of Register Information Supplied During 1960

Register information on the professional and economic characteristics of U.S. scientists is made available to meet the needs of Government agencies and private organizations. In addition to the publication of Register materials, a number of special-purpose tabulations have been prepared. Generally, the Foundation makes available information in the form of statistical summaries. Individuals are identified only where

Figure 3. ***Field of Science and Work Activity of Full-Time Employed Scientists.****



Source: National Register of Scientific and Technical Personnel, 1956–1958.

* Total of 139,865 Scientists

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an urgent need exists, where other sources cannot be used, and when it is in the national interest.

Information from the Register supplied in 1960 included: identification of top-level physicists with knowledge of the Japanese language; salary information on psychologists, pharmacologists, pharmaceutical chemists, hydrobiologists, and oceanographers; identification of physi-

cists with optical specialities and foreign language ability; educational background of geneticists and professional characteristics of other selected biological scientists; identification of poultry science specialists; professional characteristics of astronomers; information on age distribution and doctoral degrees held by scientists in a number of sub-fields of experimental biology; and extent of foreign language proficiency of geologists.

1960–61 National Register Program

The Foundation obtains its data through contracts with eight professional scientific societies, each of which is responsible for a specific area of coverage of information required for the National Register. The eight contractors work with, and through, about 200 specialized societies which obtain registrations under common standards established by the Foundation. The scientific societies circularize individual scientists, members and non-members alike, to insure the most complete coverage possible. Cooperating societies include the American Chemical Society, American Geological Institute, American Institute of Biological Sciences, American Institute of Physics, American Mathematical Society, American Meteorological Society, American Psychological Association, and Federation of American Societies for Experimental Biology. The U.S. Public Health Service cooperates in the registration of sanitary engineers; the U.S. Civil Service Commission in the maintenance of a roster of selected Government scientists and engineers.

During the spring of 1960 the scientific societies and the Public Health Service mailed out the revised questionnaire and specialties list. Some 350,000 questionnaires were mailed and it is anticipated that a total of 250,000 scientists will be registered by the end of calendar year 1960.

The task of coding, editing, and IBM processing about 100,000 questionnaires is scheduled for completion by the fall of 1960. This information will permit the National Register to develop current data relating to the Nation's supply, training, utilization, and general characteristics of scientific and technical personnel, and issue a preliminary report by the end of calendar year 1960. Processing of all questionnaires received will continue into 1961, and current plans are to prepare a final report of the data in the 1960 National Register by the end of calendar year 1961. Additional reports, as appropriate, will be prepared from data in the National Register.

Scientific Manpower Studies

The Scientific Manpower Studies activity is a part of the Foundation's function of providing ". . . a clearinghouse of information covering all scientific and technical personnel . . ." This program is directed toward meeting the scientific manpower information needs of Government

agencies, private organizations, and the public generally. Data on the supply, demand, education, and characteristics of the Nation's scientific and technical personnel resources are provided through published materials and through special studies, memoranda, etc. The Scientific Manpower Studies activity is the central program in the Federal Government for the provision of these types of material.

The program in fiscal year 1960 was concentrated on three general areas of study: improvement of basic data, demand studies, and scientific manpower in foreign countries. Funds provided to other Government agencies, universities, and research organizations have made it possible to initiate studies to improve information in these areas.

Manpower Studies Underway

Among the more important specific studies either initiated this year, continued as part of a series, or still underway from previous years are the following: surveys of scientific, engineering, and technician employment in private industry (see table 5 for some of the results of the 1959 industry survey), State governments, colleges and universities, and the Federal Government; a pilot survey of the employment of scientists and engineers in local governments; studies of students enrolled for advanced degrees; a survey of nonacademic mathematical employment; a methodological study of the identification of scientific and technical occupations in industry; pilot studies of the demand for scientists and engineers in the chemical and electrical equipment industries; a follow-up study of college graduates of June 1958 to determine employment and advanced training patterns; an analysis of the characteristics and employment plans of science doctorates of 1959; a study of high school backgrounds of doctorates of 1958; a registry of high school teachers of science and mathematics; a survey of Federal support of science education; a study of distinguishing characteristics of scientists and nonscientists; a study of professional manpower in Communist China; a revision of a study on Soviet professional manpower; and a followup study of engineers and related occupations from census population sample surveys.

These projects conform to the general series of studies recommended in *A Study of Scientific and Technical Manpower,* previously mentioned, and in the Foundation's report, *A Program of National Information on Scientific and Technical Personnel.* This latter report led to the designation of the Foundation to act as a "focal agency" for the coordination of studies of scientific manpower within the Federal Government. During the past year the Foundation has acted in this capacity in conjunction with studies of several Federal agencies and is appointing an Interagency Advisory Council in connection with this coordinating responsibility.

Table 5.—*Scientists and engineers in industry, by function and occupational group, January 1959*

Occupational group	All scientists and engineers	Scientists and engineers primarily engaged in					
		Research and development	Management and administration of		Exploration	Production and operations	All other activities
			Research and development	Other activities			
All groups	764, 100	236, 800	40, 300	65, 200	14, 300	294, 000	113, 500
Engineers	615, 400	174, 800	30, 800	57, 000	2, 700	255, 100	95, 100
Chemists	71, 500	33, 900	5, 000	3, 600	200	22, 500	6, 300
Physicists	14, 900	11, 200	1, 500	200	100	1, 400	500
Metallurgists	11, 400	4, 100	1, 100	1, 200	(1)	4, 400	500
Geologists and geophysicists	14, 800	600	200	1, 000	11, 000	1, 700	300
Mathematicians	11, 300	6, 200	700	500	100	2, 500	1, 300
Medical scientists	7, 000	900	200	200	(1)	2, 200	3, 500
Agricultural scientists	5, 600	1, 200	300	300	(1)	2, 100	1, 600
Biological scientists	5, 500	3, 200	400	200	100	900	900
Other scientists	6, 600	400	200	1, 100	(1)	1, 400	3, 500

[1] Less than 50 cases.

NOTE: Totals have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

Source: Scientific and Technical Personnel in American Industry—A report on a 1959 survey (NSF–60–62).

Manpower Studies Published

Comparison of U.S. and U.S.S.R. Science Education—During the hearings on fiscal year 1961 appropriations before the Subcommittee on Independent Offices of the Committee on Appropriations of the House of Representatives, Foundation representatives were asked to provide a series of reports comparing science education in the United States and Soviet Union. This material was published as a part of the congressional hearings on the Foundation's fiscal year 1961 budget.

The following are among the major findings of this report on U.S. and U.S.S.R. education:

(1) A total of 46 million students are enrolled at all levels of formal education in the United States, and 36 million in the U.S.S.R. At the higher educational level there are nearly 3½ million enrolled in the United States and only 2.2 million in the U.S.S.R. As of 1959, about 8.3 million persons in the United States had graduated from college compared with about 3.7 million persons in the U.S.S.R.

(2) Higher education in the U.S.S.R. emphasizes engineering, science, and medicine; most diplomas are granted in these fields. Less than a quarter of the baccalaureates awarded in the United States are earned in these fields. Nearly one-third of the Soviet baccalaureates are in engineering, compared to about one-tenth in the United States.

(3) The U.S.S.R. currently has nearly 1 million professionally trained engineers, typically with at least a 5-year engineering-institute diploma. Engineers in the United States numbered about 850,000 in 1959, and perhaps a third or more of them did not possess a formal academic degree. Currently the U.S.S.R. is outproducing the United States in engineering graduates at a rate of approximately 3 to 1.

(4) Scientists and research scholars are developed in both countries through an exacting course of training at institutions of higher education. At the present time the United States has more than 135,000 persons who have earned a doctorate. In the U.S.S.R. there are nearly 105,000 persons with similar advanced degrees. About half of the U.S. doctorates are degrees in the natural sciences and engineering, while in the U.S.S.R. more than three-quarters are in science and engineering. Currently, the United States is awarding about 9,000 doctorates annually with about half in science and engineering. Annual production of similar degrees in the U.S.S.R. is now about 5,000 with about three-quarters in the sciences or engineering. (See figure 4.)

(5) Women represent a substantial proportion of the work force in both countries, particularly in the professional occupations.. About two-thirds of the women professionals in the United States are teachers or nurses. In the U.S.S.R. education and medicine also account for about

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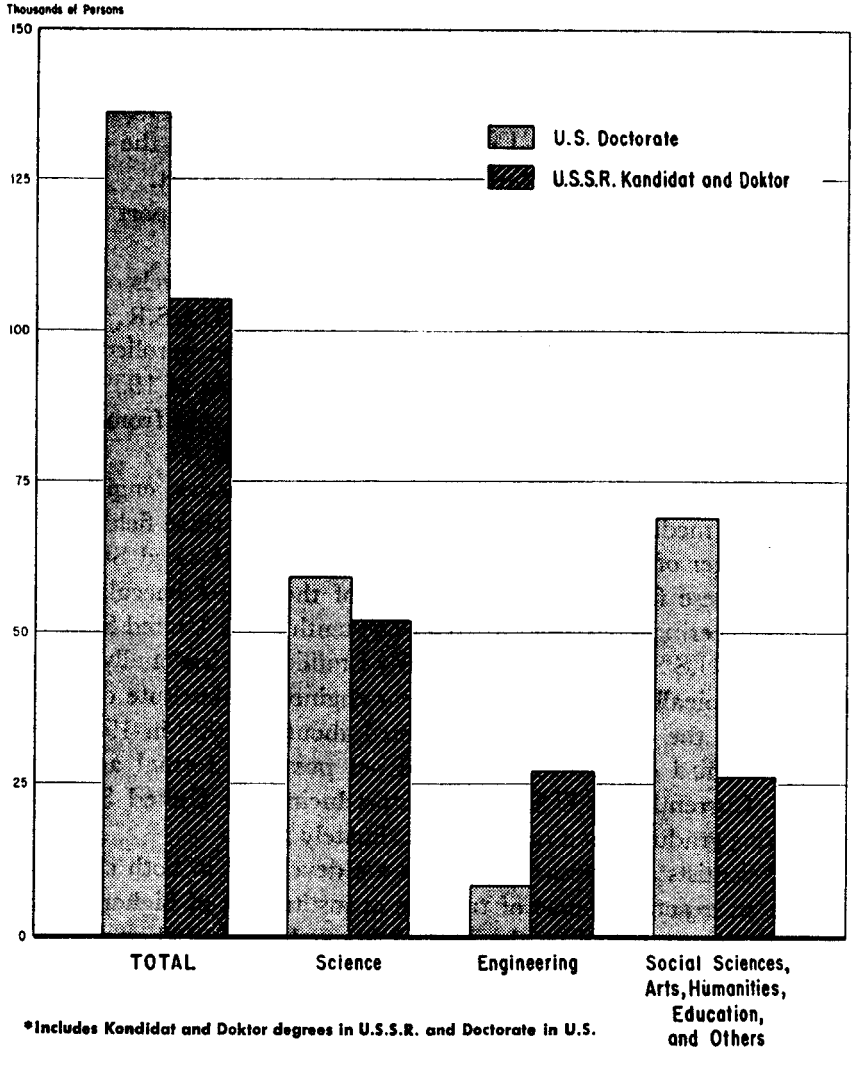
Figure 4. ***Estimated Number of Advanced Degree Holders,* 1959, United States and U.S.S.R.***



*Includes Kandidat and Doktor degrees in U.S.S.R. and Doctorate in U.S.

two-thirds of the professionally employed women. However, in the U.S.S.R. about 16 percent of these women are in engineering and they represent nearly one-third of the total in the occupation. Less than 1 percent of U.S. engineers are women.

Scientific Manpower–1959—Papers presented at the Eighth Conference on Scientific Manpower, held in conjunction with the annual meeting of the AAAS meeting in Chicago, December 1959. The conference theme was "Higher Education and Training in Emerging Fields of Science and Technology."

Statistical Handbook on Science Education.—A compilation of data on education, in general, and science and engineering education, in particular. This report is divided into three parts: the first is concerned with human resources data such as enrollments at all levels of education, degrees granted, number of teachers and faculty; the second with institutional, facility, and financial data such as number of schools, value of property, expenditures and income of institutions, and student support; and the third consists of appendix tables which contain more detailed information on the first two sections.

In addition, organizations which have received Foundation support for their manpower activities have released several reports, including "Identification of Scientists and Technical Personnel," by Surveys and Research Corporation, Washington, D.C., and "The Science Doctorates of 1958 and 1959, Their Numbers, Background, and Employment," by the National Research Council, Washington, D.C.

DISSEMINATION OF SCIENTIFIC INFORMATION

The fundamental purpose of the Foundation's program for the dissemination of scientific information is to make the results of research more readily available to scientists and engineers throughout the country. The Foundation, through its Office of Science Information Service (OSIS), is directing its efforts toward: (1) improving present scientific information services through the use of known and tested procedures, and (2) promoting a national research program for developing new techniques for handling information. As a part of this effort, NSF vigorously fosters increased cooperation and coordination among organizations active in this area, both within and outside of the Federal Government.

Program responsibilities cover four general subject areas: documentation research, foreign science information, scientific publications, and research data and information services. During fiscal year 1960, 184 grants and contracts totaling $4.8 million were awarded for these activities.

Coordination of Scientific Information Activities on a National Basis

Fiscal year 1960 marks the first full year of operations since assignment, by Congressional Act and Executive Order, to the Foundation of responsibility for national leadership in the scientific information field. The Foundation has taken steps to implement fully its role as coordinator of information activities throughout the country. This has involved the constructive evaluation of existing systems and practices for the dissemination of scientific information—providing support where necessary—and the development of solutions to problems through cooperation and coordination of the agencies and organizations concerned. The Foundation has supported and participated in an increasing number of meetings of representatives of Government and professional and private

groups throughout the country aimed at improving the effectiveness of information services in the various fields of science.

The Science Information Council, established by the Foundation in December 1958, has advised and made recommendations to NSF on a broad range of scientific information problems. It is composed of representatives of private industry, education, professional societies, Government, and others concerned with information problems.

Coordination Within the Federal Government

Considerable emphasis has been placed on closer coordination of scientific information activities of Federal agencies. In the first year since its establishment, the Federal Advisory Committee on Scientific Information (FACSI) has served as an effective forum for the discussion of common problems and as a mechanism for coordinating plans and suggestions for the improvement and expansion of agency programs for the dissemination of scientific information. (Membership consists of senior members of 17 Federal agencies, with significant scientific information programs.) In the translations area, for example, an ad hoc committee has worked effectively to develop the P.L. 480 program for the translation, overseas, of important foreign scientific literature requested by Government scientists.* Also related to the translation problem have been efforts during 1960 to coordinate the administration of mechanical translation research activities sponsored by several Federal agencies. This resulted in the formation of an Interagency Committee on Mechanical Translation Research. These two committees are part of the overall FACSI structure.

The full Federal Advisory Committee has participated in such matters as the development of a Federal policy for the support of non-Government publications, and the planning and operation of a program for obtaining cost data concerning scientific information activities of Federal agencies to help identify the size and scope of information activities within the Government.

Other interagency efforts illustrative of the coordinating role of the Foundation have included the convening of meetings of representatives of those agencies conducting scientific information programs in Latin American countries as a preliminary step to the possible development of a Governmentwide program in Latin America. Similarly, the Foundation has held interagency meetings to discuss the coordinate Government

* The Agricultural Trade Development and Assistance Act of 1954 (P.L. 480) as amended in 1958 permits financing of the overseas translation program with foreign currencies credited to the United States from the sale of surplus agricultural commodities abroad.

support of those abstract journals of special interest to the programs of one or more agencies.

Cooperation Among Private and Professional Organizations in the United States

In the field of scientific abstracting and indexing, support has been made available to the National Federation of Science Abstracting and Indexing Services (NFSAIS) in its efforts to coordinate and improve the work of organizations engaged in this field. In fiscal year 1960, such activities have included the preparation of a Bibliography of U.S. Abstracting and Indexing Services which has been compiled by the Library of Congress with the advice and assistance of the National Federation. The final list, which includes about 500 services, was published by the Federation in June 1960. Knowledge of the individual services will make it possible to effect cooperation on a wider, more comprehensive scale. Now under preparation is a union list of periodicals covered by member services of the Federation which will make it possible to identify gaps in coverage of important literature and also assist scientists to locate information more readily. In a third area of activity, the Foundation has enabled Federation representatives to visit the Soviet All-Union Institute of Scientific and Technical Information. All phases of the operations of the Soviet and United States abstracting systems were considered, as well as the possibility of exchanging materials and other cooperative measures.

In the area of foreign science information, for example, NSF has sponsored a working conference of officers and editors of 28 professional societies and academic institutions which administer the translation and publication of important Soviet journals. The Foundation has sought particularly to stimulate interest on the part of societies to develop new or improved approaches to making available significant foreign science literature.

The Foundation has been devoting particular attention to the stimulation and support of discipline-wide studies of communication patterns and problems which could lead to fundamental solutions of information problems in all areas of science. This has involved meetings and close working relationships with representatives of the American Institute of Biological Sciences, the American Institute of Physics, and the American Chemical Society. Recently, discussions have also been held with organizations in the earth sciences and psychology fields concerning the undertaking of discipline-wide investigations of their information and publication problems.

Finally, in order to further cooperative activity between Government agencies and private organizations, the Foundation has undertaken separate actions designed to strengthen professional activities and representation in the field of documentation. In the first instance, the Foundation has supported the establishment of the Office of Documentation within the National Academy of Sciences-National Research Council. This Office provides advice on documentation to Government and private groups, serves as a focus in the United States for international documentation activities, and acts as a mechanism for U.S. participation in international meetings. In the second instance, the Foundation has assisted the American Documentation Institute, the leading organization and spokesman for documentation in the United States, to establish a full-time professional secretariat. This action will enable the Institute better to provide leadership, professional representation, and exchange of information in the field of documentation.

International Cooperation

The purpose of Foundation activities on the international level has been to bring about more effective cooperation among national and international organizations concerned with scientific documentation, and to stimulate international cooperation where this is likely to be more effective or economical than national action. To this end, NSF has been cooperating with various international bodies including the International Federation for Documentation (FID) and the Abstracting Board of the International Council of Scientific Unions (ICSU). NSF has also worked with the European Productivity Agency in studying means for establishing a European Translations Center.

A study of scientific information activities of international organizations is in preparation by the Library of Congress under a grant from the Foundation.

Scientific Information Notes

National and international developments in the dissemination of scientific and technical information are reported in *Scientific Information Notes,* published bi-monthly by the Office of Science Information Service. This journal (originally entitled *Science Information News*) is serving effectively as a vehicle for the exchange of information among groups working in the field.

Documentation Research

The Foundation objective in this area is to stimulate and support both the improvement of existing methods and the development of new methods for handling scientific information. In this context, informa-

tion handling includes analysis of the content of scientific publications, selection of significant information for abstracts and index data, coding for storage and retrieval, searching for stored information, identification of information for selective dissemination, and automatic translation from one natural language to another.

The major current trend in documentation research is the growing concentration on development of ways of using machines to store and search information and to process automatically the language of documents for information retrieval and translation.

Use of Mechanical Aids

Serious research on ways to use machines to supplement human skills in organizing and searching large volumes of information began about a decade ago and has proven to be an extremely complex and difficult problem. Research tasks in this area require the combined talents and insights of linguists, mathematicians, logicians, computer engineers and programmers, librarians, and other information specialists. Rising interest in the possibilities of mechanized information handling has resulted in expansion of the research effort. Projects which received NSF support during 1960 include the following:

1. A large-scale test program at Western Reserve University for evaluating mechanized procedures developed for the automatic processing and searching of metallurgical literature.
2. At Chemical Abstracts Service, a program on mechanization of processing and searching of chemical information, including research on the semantics of chemical literature.
3. A program to investigate the organization of large files of information with a multi-level structure and self-organizing capability at the Electrada Corporation.

Other active NSF-supported projects in this area include mechanized linguistic analysis of scientific texts and identification of significant words and phrases for indexing and abstracting (University of Pennsylvania), systematization and mechanization of the operations of information searching systems and development of a normalized language (ITEK Corporation), and comparative studies of various indexing and classification systems (Association of Special Libraries and Information Bureaux and the National Book League of England, and Herner and Company of Washington, D.C.).

Mechanical Translation

With respect to research on mechanical translation, the Foundation is supporting two types of projects: (1) those concerned with developing

workable automatic procedures for translating foreign languages, and (2) those designed to provide better understanding of languages and of the basic problems of translation. One of the principal problems in mechanical translation is the lack of sufficiently precise knowledge about language to permit the preparation of machine instructions for dealing with syntactic structures and semantic choices.

The goal of research in mechanical translation is the eventual automatic production of translations from one language into another. This research may also contribute significantly to the development of procedures for automatic linguistic analysis for other purposes, such as automatic indexing and abstracting and mechanized search systems.

During 1960, Foundation-supported research on mechanical translation was expanded by a grant to the University of Washington for research into the lexicographical and structural problems of the Chinese language.

Continuing activities supported by grant include research on new logico-mathematical methods for the analysis of languages for machine translation (Cambridge Language Research Unit, England); also research on automatic translation of Russian into English (Harvard University and University of Cailfornia) and German into English (Massachusetts Institute of Technology).

Patterns of Scientific Communication

Precise, objective knowledge of the information needs of scientists is being sought as the basis for improving the dissemination, organization, and use of scientific information. Such findings should be helpful in designing information storage and retrieval systems of the utmost utility and service to scientists.

During the past year a *Review of Studies in the Flow of Information Among Scientists,* prepared for the Foundation by the Bureau of Applied Social Research, Columbia University, was made available. This report discusses completed studies and various methods used for gathering data, synthesizes the findings wherever they are at all comparable, and suggests other approaches that seem feasible and promising.

The Case Institute of Technology was given a grant to determine the feasibility of developing measures of the value of recorded scientific information and of the productivity of scientists in terms of the new information their work produces.

Research Information Center and Reviews of Documentation Research

Continued support was provided for the maintenance of the Research Information Center and Advisory Service for Information Processing,

which had been established the year before at the National Bureau of Standards. The Center collects all publications and reports pertaining to research on the processing of information expressed in language and other nonquantitative forms, such as photographs and circuit diagrams; and from time to time it prepares and issues background or state-of-the-art papers on particular research areas. In addition, the Foundation let a contract to Documentation, Inc. for a thorough state-of-the-art survey of coordinate indexing which makes use of individual indexing terms or short compound terms that are combined during a search. The study will cover operating experience, research and experimentation, and unsolved problems; it will include discussion of the various refinements devised to enable this type of indexing to handle relationships of various kinds among terms.

Publications on Documentation Research

The fifth and sixth in a series of descriptive reports entitled *Current Research and Development in Scientific Documentation* were published in October 1959 and May 1960. This semiannual report describes research and development projects under way in the United States, as well as foreign projects on which information can be obtained. An important feature of the latest edition is a new section describing research on problems not immediately connected with scientific documentation, but whose solution is likely to have an impact on the future of information handling. It covers selected work in automatic programming, pattern and speech recognition, linguistic analysis, and artificial intelligence.

Descriptions of some 50 technical information systems were published in *Nonconventional Technical Information Systems in Current Use,* No. 2, September 1959, and its March 1960 supplement. This publication describes systems which embody new principles for organizing subject matter or which employ automatic equipment for information storage and search, or for preparation of indexes.

Foreign Science Information

In the foreign science area the Foundation reinforces efforts of American scientists to learn about research activities going on in all countries and to obtain the results of research published in all languages. Although formidable problems still remain, in recent years there has been a significant increase in the amount of source and translated material available to U.S. scientists.

Translations

Stimulated largely by NSF's program, total U.S. and Western efforts in translation now cover some 5 percent of all Russian scientific and

technical journals. The Foundation, through scientific societies for the most part, supports the translation, in whole or in part, of 45 Russian journals. Other Federal agencies, foreign government organizations such as the Department of Scientific and Industrial Research in England, and certain private firms in this country have combined to make it possible for U.S. scientists to choose from 85 translated Soviet journals in various scientific fields.

There has also been a correspondingly larger output of selected article translations by private organizations. The availability of these items has been improving with the expansion of operations of the Special Libraries Translation Center, supported in part by the Foundation and by the Office of Technical Services of the Department of Commerce.

In addition to the increased availability of translations, there has been a marked growth in recent years in the volume of research journals published abroad, a large part of which normally flow to the United States. For example, in the Soviet Union alone some 300 new scientific journals have been published in the last 5 years. Similarly, this period marks the publication of 100 primary scientific journals in Communist China.

Importance of Foreign Scientific Literature

Stimulation of the broadening interest in foreign scientific literature has been a long term process. In part, this has resulted from Foundation initiative in granting funds for projects, such as cover-to-cover translations, travel to international meetings, or support for international conferences. Of equal importance has been the feedback to professional societies which has led to their growing interest in the problem.

Examples of this activity in 1960 include:

1. The American Mathematical Society which has received Foundation support for several years for translating Soviet mathematical material. The Society, with NSF support, is now studying the quality of mathematical research in China, Japan, and East Central Europe, in addition to the Russian translation work.

2. The American Institute of Biological Sciences (AIBS) which translates seven Soviet biological journals under grants from the Foundation. As a result of this experience and with Foundation aid, the AIBS sent representatives to the Far East to determine the kind of biological research now underway. The committee members are seeking ways to effect better communication and interchange of information with the Asiatic countries.

3. American Rocket Society representatives who contacted Japanese scientists at an international conference in Europe and completed arrangements to obtain English versions of Japanese

astronautical reports for publication in the Society's journal. U.S. material is being sent to Japan in exchange.

Professional Society Survey of Foreign Scientific Literature

Foreign scientific literature now available, much in translation, provides evidence of the quality of the research underway throughout the world. As a result of stimulation and support by the Foundation, a number of professional societies are now undertaking surveys of those countries whose research effort is little known in the United States and whose languages are understood by few Americans. These surveys should provide guidance as to the advisability of expanding the translations program to include scientific journals of these countries.

Other Approaches

In November 1959, NSF sponsored a working conference of officers and editors of 28 professional societies and academic institutions translating Soviet journals to discuss means for improving the dissemination of translated journals among U.S. scientists. The Foundation also sought to stimulate interest on the part of the societies in developing other approaches in addition to cover-to-cover journal translations. Emphasis was placed upon selective translation, critical reviews, and state-of-the-art papers.

Discussions have been held with members of the Science Council of Japan concerning the possible publication in English of outstanding Japanese scientific periodicals in such fields as theoretical physics, astronautics, genetics, and virology. A grant was made to the National Diet Library to prepare an English version of the *Index to Periodical Articles, Natural Sciences Section* which will list virtually all scientific publications issued in Japan. The journal, published quarterly, will hereafter appear monthly.

The Foundation made available reviews of mainland Chinese science for publication in appropriate U.S. scientific society journals, including the reprint of a comprehensive review of Communist Chinese science published as a supplement to *Science News Letter*. In cooperation with the Association of Asian Studies, the American Mathematical Society, the Social Science Research Council, the Library of Congress, the Department of Agriculture Library, and the Department of Commerce, the Foundation is supporting studies to learn more about Chinese publishing practices, to evaluate their scientific output, to identify the literature already available in the United States, to enhance the availability of such literature, and to assure the translation of significant research results.

In Latin America, the Foundation is developing its information program in close cooperation with the Pan American Union, the Organization of American States (OAS), the National Academy of Sciences-National Research Council, and other Federal agencies. A grant has been made, for example, to the Pan American Union for a cooperative study of the resources, services, and potential for expanding documentation centers in Latin America. Agreement has been reached whereby the Centro de Documentacion Cientifica y Tecnica de Mexico will undertake a comprehensive listing and evaluation of all Latin American scientific periodicals together with an analysis of present publication practices. The Foundation is working with the NAS–NRC Inter-American Scientific Cooperation Committee in developing approaches to the various existing information problems, including the identification of priorities, short-term, and long-term needs. OSIS has explored with several Federal agencies the extent of scientific information programs now being conducted in Latin American countries, together with problems and difficulties experienced and ways and means to bring about needed improvement.

Public Law 480 Translation Activities

An important adjunct to the Government effort to utilize more effectively the results of foreign research is the program of scientific information activities undertaken abroad by Federal agencies using foreign currencies accruing under Public Law 480. Under Foundation leadership, a translation project is underway in Israel and new programs were initiated in 1960 in Poland and Yugoslavia. A total of 31,420 pages of Russian, 9,032 pages of Polish, and 11,500 pages of Yugoslavian scientific material was in the process of being translated and distributed under this program at the end of the 1960 fiscal year.

The significance of this program lies in fostering increased availability of scientific research results to the United States and the rest of the world through close cooperation of scientific and governmental organizations within the countries concerned. Noteworthy has been the assistance of the scientists of Poland and Yugoslavia in calling to the attention of the Foundation the availability of newer and better scientific papers and books other than those which were known to the United States. It is expected that this program will stimulate these countries to publish more of their research results in English. Other countries may be expected to join in this effort.

Studies on Foreign Scientific Information Activities

The Foundation is supporting several studies on the organization and functions of scientific information activities abroad.

The study of scientific information activities of international organizations prepared by the Library of Congress has been extended to cover additional organizations.

A grant for a comprehensive study of the complex science information activities in the USSR was made to the Massachusetts Institute of Technology. This study is to include information on the recent major changes in the industrial information system, the newly formed Council for Cybernetics and its activities related to machine processing of information, as well as other heretofore unknown areas of such activities in the Soviet Union.

To enable U.S. scientists to develop foreign science information programs most suited to their needs and to facilitate exchange of information with their colleagues abroad, the Foundation has taken steps to make available relevant background information on foreign research to the U.S. scientific community. For example, in addition to the survey of mathematics research in Communist China, the Foundation has issued a grant to the American Association for the Advancement of Science for support of a symposium "Science in Communist China," at which state-of-the-art reviews in various fields of science will be presented. Publication of these reviews is expected.

In this connection the directory prepared by the Scandinavian Council of Applied Research listing all research institutions and their publications in Norway, Sweden, Finland and Denmark, will be made available to U.S. scientists by the NAS–NRC under Foundation support.

It is also planned to have an international directory, prepared in Western Germany, updated and translated. This directory contains brief summaries on major research and educational institutions, manpower, and budgets in various countries of the world. The necessary additional work will be done in Germany.

Research Data and Information Services

Through this program, the Foundation has increased its efforts to develop means by which the many specialized data and information service centers in the United States can be coordinated as a national system for serving the needs of the entire science community. Because of the differing requirements for data and reference services and the economic factors involved, emphasis is placed on the improvement of information services in the broad disciplines and technologies which for the most part provide basic sources of information for the highly specialized services.

Science Information Exchange

During the past fiscal year, the Foundation led efforts among Government agencies to establish a Science Information Exchange to collect, correlate, and disseminate information and data about all current research tasks, publicly or privately supported, in the mathematical, physical, engineering, life, and social sciences. It is planned that this new clearinghouse service (SIE) will incorporate present activities of the Bio-Science Information Exchange cooperatively supported for several years by a number of Federal agencies. It will also be administered by the Smithsonian Institution.

Survey of U.S. Data and Reference Services

A contract has been negotiated with the Batelle Memorial Institute to prepare an inventory of specialized information services in the United States with a view to publishing a national directory of the scope and nature of their activities. The results of this survey will be of special interest to planners of new data and reference services and will also assist in promoting the more efficient use of existing facilities.

In the area of critically evaluated data, the Foundation has continued to support the coordinating activities of the Office of Critical Tables of the National Academy of Sciences-National Research Council.

As part of the effort to improve existing services, support has been provided to Chemical Abstracts Service for the study and development of new or modified existing techniques to improve user access and reference to this immense collection of information of interest to chemists and other scientists.

"Unpublished" Information

The program of the Foundation in this area seeks to provide for systematic public announcement and dissemination of all significant unclassified scientific and technological information which is not published promptly in scientific journals and books.

In 1960, support was continued to the Office of Technical Services, Department of Commerce, for expansion of its program for announcing and disseminating Government research reports, particularly those containing basic research information. Foundation support of the Science and Technology Division of the Library of Congress was for the continued expansion of its catalogs and bibliographic records of Government reports. This has permitted the Division's Reports Reference Center to perform more comprehensive literature searches and to provide a higher quality reference service for an increasing number of users.

The Foundation is supporting basic studies to determine the factors

which promote or impede the announcement and publication of information presented orally at meetings and those which influence the availability, announcement, and publication of scientific information contained in unclassified Government reports.

Inventory of Federal Scientific Information Activities

Since 1958, the Foundation has been conducting a survey of Government agencies with scientific information activities to determine the quantity and subject matter of the scientific reports which they issue, the availability of these reports to scientists outside the Government, and the policies and procedures of these agencies with respect to their scientific information programs. The data obtained from this survey are being published in a series of bulletins entitled "Scientific Information Activities of Federal Agencies." The bulletins identify subject areas of agency research and development activities, names and types of information services provided, documents generated, how they are announced, and means for obtaining them. In 1960, three new bulletins were issued, covering the Office of Naval Research (NSF 59–19), The Department of Commerce—Part I (NSF 59–58), and the Government Printing Office (NSF 60–9). Others are in preparation and a contract has been let for continuing this effort during the next year.

Scientific Publications

The Foundation conducts and supports projects aimed at improving the effectiveness of the dissemination of scientific information through publication. Two classes of projects are supported: (1) those aimed at assisting present scientific publishing, and abstracting and indexing services; and (2) those directed toward developing new and improved systems for providing faster, more comprehensive scientific information at the lowest possible cost.

During fiscal year 1960, the Foundation's continuing activities in support of scientific publication resulted in grants to 57 publications of various types. Uses to which these funds were put included: initiating needed new primary journals; assisting existing primary journals to publish cumulative indexes, eliminate manuscript backlogs, and meet other financial emergencies; enabling abstracting and indexing services to expand their coverage; supporting experimental journals; and publishing a number of significant single items which could not be published without subsidy, including monographs, long papers, symposium proceedings, reviews, bibliographies, and data compilations.

The principal trends in scientific publishing evidenced by 1960 fiscal year activities of this program are as follows:

1. Increased interest in finding out more about the existing situation in publishing.

2. Willingness to experiment with new publication techniques and methods.

3. Improvement of U.S. abstracting and indexing of scientific literature.

4. Discipline-wide studies of communications patterns and problems.

5. Coordination of support of scientific publications by Federal agencies.

Situation in Scientific Publishing

Attempts have been made in recent years by individual societies, journals, and disciplinary groups to obtain adequate background and "yardstick" data on scientific communication media in their fields of interest. These attempts, while often useful for individual segments of publishing, have not been comprehensive and inclusive enough to give a sufficiently clear picture of the scientific publishing situation on a national basis.

To remedy this deficiency and provide valuable knowledge for planning purposes, the Foundation in 1959–60 launched a series of national surveys on scientific communication media. Professional scientific societies were studied first, because they publish the majority of research journals. Data were gathered on dues structure, membership, annual meetings, and journal support; a report was published in the fall of 1960. A comprehensive survey of research journals is currently under way and will be followed by studies of scientific symposia and conference proceedings, and scientific monographs. In addition, the publication "climate" in industry is being studied and a report on this source of research publications will be completed in 1961.

Experiments with New Publication Techniques and Methods

Many scientific journals have been published for years in the same format and by the same printing procedures in spite of improvements in printing design, economics, and methods. However, recent publications problems and financial crises have encouraged publishers to consider new publication techniques and methods. Moreover, a few individuals and organizations have been investigating the possibility of different methods for publication, and the publishing of "experimental journals". As an example, *Chemical Abstracts* is receiving support from the Foundation to enable it to experiment with, and publish, a permuted title index to current chemical literature; and in the field of plant taxonomy a pilot project is being supported to permit machine handling of pertinent data

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for plant species so that valuable indexes can be produced that are not feasible with present methods.

Improvement of U.S. Abstracting and Indexing of Scientific Literature

The Foundation, in consultation with scientific societies, existing abstracting and indexing services, and the National Federation of Science Abstracting and Indexing Services, has sought ways to identify gaps in U.S. coverage of scientific literature and to take steps to fill these gaps. Where new services are required, the Foundation has aided their establishment (for example, *GeoScience Abstracts*). In other cases, the Foundation has sought to expand existing services to cover areas of the literature not now included in any U.S. service. During 1960, for example, the Foundation granted additional support to *Biological Abstracts* to continue its expansion of coverage of the biological literature. Discussions with interested scientists, with societies, and with existing services have set plans in motion to expand present services to cover adequately the literature of geophysics.

Other services which have been aided to expand their subject coverage, eliminate backlogs, prepare cumulative indexes, survive financial difficulties, and reorganize certain phases of their operation on a sounder basis include: *Mathematical Reviews, Meteorological Abstracts & Bibliography, Bibliography of Extraterrestrial Radio Noise, Index to the Literature of American Economic Entomology,* and *Annotated Bibliography on Operations Research.*

Discipline-Wide Studies of Communications Patterns and Problems

One of the more promising developments which could lead to fundamental solutions to the publications problems in important areas of science is the increase in discipline-wide studies of communications patterns and problems.

The American Institute of Biological Sciences, recognizing that the field of biology has become one of the most diversified and splintered of all fields of science, is currently planning a long-range study of biology publications problems. Foundation support has been given for an initial feasibility study and it is expected that further support will be needed for the projected major study. In addition, the AIBS, with support and encouragement from the Foundation, has initiated studies into the feasibility of a centralized editorial-business management office at the Institute for a group of biological journals. It is hoped that this study will demonstrate whether professional services can be made available to small journals on a cooperative basis, in cases where journals cannot afford such

services individually, but where the growth of literature has made it difficult for them to continue with only part-time volunteer management by interested scientists.

Although, in the field of physics, the American Institute of Physics has maintained high journal standards for many years, and competently investigated problems as they arose in that field, it launched with Foundation support a needed full-scale study project into physics documentation in general.

The American Chemical Society is continuing to study publications problems arising in chemistry in order that chemists may have the type of literature and source material most required.

Recently, organizations in the earth sciences and psychology fields have expressed interest to the Foundation in undertaking discipline-wide investigations of their publications problems.

Coordination of Support of Scientific Publications by Federal Agencies

The Foundation has held a number of meetings with representatives of other Federal agencies, to discuss and to coordinate Federal support of particular journals (especially abstracting journals) which are of special interest to the programs of one or more agencies. These meetings have concerned such publications as the *Arctic Bibliography, Meteorological Abstracts & Bibliography,* and *Applied Mechanics Reviews.*

In addition, the Foundation has initiated discussions by the Federal Advisory Council on Scientific Information, with a view to developing a Federal policy for the support of non-Government publications.

SPECIAL INTERNATIONAL PROGRAMS

Greater concern with international scientific programs began in 1954 when the Foundation accepted a portion of the responsibility for U.S. participation in the International Geophysical Year 1957–58. The Office for the International Geophysical Year was established in 1955 to carry out Foundation responsibilities in this activity; near the close of the IGY, the name was changed to the Office of Special International Programs.

Many other programs of the Foundation have with growth developed international aspects which are handled through the appropriate division or office.

The Office of Special International Programs has been assigned responsibility for directing the U.S. Antarctic Research Program (see pp. 61 to 66), an outgrowth of the International Geophysical Year, and for initiating and developing cooperative and experimental programs in international science. The Office also provides liaison for the Foundation with international science activities of other Government agencies, which in some cases calls merely for the exchange of information and in others for the recruitment of scientific experts for particular assignments.

International Geophysical Year

The International Geophysical Year (IGY) was an 18-month period extending from July 1, 1957, through December 31, 1958, during which the scientists of 66 nations conducted geophysical observations over the entire globe. Planning and coordination of the world-wide IGY program was carried out by a Special Committee of the International Council of Scientific Unions. The formulation and conduct of the U.S. scientific programs was directed by the United States National Committee for the IGY, established by the National Academy of Sciences as the U.S. adhering body to the International Council of Scientific Unions. The Foundation's responsibility was to obtain and

administer Congressional appropriations for the program, which totaled $43.5 million, and to coordinate the interests of the U.S. Government in the undertaking.

The observational period of the IGY ended with the year 1958. However, by this date the collection of IGY data had only begun, and in fact is still going on; it is estimated that roughly 80 percent of the data is now available in the IGY World Data Centers. The IGY was followed by a program known as International Geophysical Cooperation–1959 (IGC–59) during which geophysical research in certain fields was continued on an international scale. The data from the IGC–59 effort are also being collected in the IGY World Data Centers.

During the past year the Foundation concluded its use of IGY appropriations by making grants for post-observational analysis of the IGY data, principally of an interdisciplinary research nature, and for the work of the IGY World Data Centers to fulfill their responsibilities for the collection, interchange, and publication of the data.

IGY World Data Centers

The three IGY World Data Centers are World Data Center A in the United States, World Data Center B in the USSR, and World Data Center C maintained by eight nations of Western Europe, Japan, and Australia. These Centers will house three complete sets of data, available to the scientists of the world. Copies of the data may be obtained from the Centers at a nominal cost to cover reproduction costs.

World Data Center A is organized into 11 subcenter archives, on the basis of different IGY disciplines, located at various institutions and agencies throughout the United States. A central coordination office for the U.S. World Data Center is maintained by the National Academy of Sciences in Washington, D.C.

All World Data Center A discipline subcenters will issue cumulative six-monthly catalogs in the calendar year 1960, both as an indication of data flow and as a users' index. The coordination office of World Data Center A will publish these cumulative six-monthly catalogs in combined form. Publications based on IGY observational data are being issued under disciplinary-report series by the appropriate archive subcenters and under a general-report series by the coordination office.

Communications regarding IGY data interchange in general should be addressed to: Director, World Data Center A, National Academy of Sciences, 2101 Constitution Avenue, NW., Washington 25, D.C. Inquiries concerning data in specific disciplines should be addressed to the appropriate subcenter listed below:

1. IGY World Data Center A: Airglow and Ionosphere; Cen-

tral 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.

Annals of the IGY

A comprehensive history of the IGY, including its organizational structure, planning phases, operational aspects, and results, is being published in a series of volumes entitled, *Annals of the International Geophysical Year,* by the Pergamon Press, Ltd., London. The following volumes have been published to date:

Volume I (1959)—Part I, The First International Polar Year; Part II, The Second International Polar Year; Part III, The Inception and Development of the IGY.

Volume IIA (1959)—Parts I–IV, The International Geophysical Year Meetings (first four CSAGI assemblies).

Volume IIB (1959)—Part V, The CSAGI Antarctic Conferences; Part VI, The CSAGI Arctic Conference; Part VII, The CSAGI Regional Conferences; Part VIII, The CSAGI Discipline Conferences.

Volume VII (1959)—Parts I–III, IGY Instruction Manuals

(Part I, World Days and Communications; Part II, CSAGI Guide to World Data Centers; Part III, Arctic Communication).

Volume VIII (1959)—Geographical Distribution of the IGY Stations.

Volume IX (1959)—The Membership and Programs of the Participating Committees.

Future volumes of the *Annals* will include key scientific data in summary working form and results of the program. Present international agreements provide for at least 25 additional volumes of the *Annals*.

Digests of most recent IGY results continue to be issued monthly in the *IGY Bulletin,* published by the U.S. National Committee for the IGY, National Academy of Sciences, Washington, D.C.

Foreign Science Program

During 1960, the activities of the Foreign Science Program have been mainly of a planning and liaison nature. A modest number of grants, however, have been made.

A grant to the National Academy of Sciences is supporting an exchange of scientists between the United States and the USSR, implementing the Bronk-Nesmeyanov Agreement signed in July 1959 between the Academies of Science, of the two countries. The Agreement, which covers a 2-year period, provides for about 40 exchange visits from each side by scientists who will lecture and observe research, plus an indefinite number of invitations to scientific meetings. Arrangements are now under way for visits by 13 Americans and 8 Soviets. Invitations have been sent by the National Academy of Sciences to the Soviet Academy for Soviet attendance at 24 scientific meetings; to date, nine Soviet scientists have attended two of these meetings. The Soviet Academy has arranged invitations for U.S. attendance at two meetings in the USSR. Discussions have begun in connection with the organization of a joint symposium in the field of radioastronomy.

To develop more comprehensive firsthand information on specific areas of science in foreign countries, grants were made to several distinguished American scientists for studies of microbiology in Japan, a review of research in geography in Western Europe, and a study of mathematical activity in Poland. These grants will result in reports that will be useful to the Foundation in its future programming and also may be distributed to U.S. research workers in these fields.

Assistance was provided to a number of outstanding American scientists to attend an international conference in Israel on "Science in the Advancement of New States." Subjects such as what science might do

to bring about the transformation of underdeveloped countries, future possibilities of energy sources, climate control, education and training, and international exchange of information were discussed. Attendance at this conference will serve to increase interest and provoke thought in this area among key American scientists.

International Science Education Program

The primary objective of this program is to strengthen our Nation's total scientific effort through improved programs of science education by providing American scientists and educators with the opportunities to join their foreign colleagues in endeavors that may prove of great value in raising the quality of science education in the United States. At the same time these program activities may result in raising the standards of education in the sciences throughout the Free World.

During fiscal year 1960 the Congress broadened the Foundation Act to authorize international scientific activities, previously centered around a one-way flow directed towards improving education in the sciences in the United States. Beginning in the past year, a number of cooperative programs were entered into or considered in which a two-way flow led to the exchange of ideas and information of great potential benefit to scientists and science educators in other countries, as well as to those in the United States. For example, inclusion of over 70 leading science teachers from abroad in the 1960 NSF Summer Institutes proved of considerable worth to the institutes program. It is expected that these foreign teachers will play key roles in improving science education in their own countries based on the experience gained at the Foundation-supported institutes. Another example of such programs is the extended support of science-curricula survey projects sponsored by international scientific organizations.

In general, the activities of the International Science Education Program are considered to be experimental in design and/or concerned with cooperative programming with international regional organizations or foreign institutions. Considerable attention has been given to assuring appropriate American participation in the ever-increasing number of cooperative projects being undertaken through the Office for Scientific and Technical Personnel of the Organization for European Economic Cooperation (OEEC). Similarly, attention is being devoted to developing and supporting cooperative projects with the science education components of the North Atlantic Treaty Organization (NATO), the Organization of American States, and the Asia Foundation.

Program Activities

During the 1960 fiscal year modest support was offered to projects developed under the three general program categories: curricula development programs, teacher-training programs, and science student programs. A new category—experimental cooperative programs—was initiated during the year.

Curricula Development Program

In conjunction with the serious attention being given to improving secondary school and undergraduate science curricula in the United States, support was given for studies of science subject matter taught in educational systems abroad. Grants were made for studies conducted by recognized American professional groups, in cooperation with foreign scientists and educators, for survey projects undertaken by approved exchange missions under the Lacy-Zaroubin Agreement, for international conferences on science education, and for the translation of foreign educational materials.

Teacher-Training Program

Under this program international cooperative projects were supported that were directed toward the quality improvement of U.S. teacher-training programs. Distinguished lecturers and leading science teachers from abroad participated in 1960 summer institutes. Furthermore, United States representation was assured at OEEC-sponsored teacher-training seminars and conferences. In addition, considerable staff assistance was given to the Asia Foundation in organizing two pilot teacher-training 1960 summer institutes in Pakistan and to the Organization of American States in presenting an experimental science institute in Argentina.

Science Student Program

Through these projects support was provided for science education activities that enabled science students and scholars to participate in international science education programs aimed at keeping them informed of latest scientific knowledge achieved abroad. Foundation support was offered to professional societies to administer a Visiting Foreign Scientist Program under which eminent foreign scientists visited the science departments of U.S. colleges and universities for the purpose of augmenting the quality of the research and educational activities at these institutions. Support was extended to International Special Field Institutes providing scholars and students from various nations with the opportunity to meet and exchange ideas and developments in a special field of scientific interest. The NATO program of advanced-study insti-

tutes has aroused wide interest, and participation of American graduate students and senior scientists was made possible through Foundation travel support.

Experimental Cooperative Program

As its role in international science becomes increasingly important, the Foundation is exploring methods of fostering closer contact between scientists and science teachers in the United States and Latin America. Successful Latin American participation in projects under the three previous general categories has been arranged. A further significant step in this direction was taken during the year. A pilot experimental exchange program, cooperatively supported by the Foundation and the Organization of American States, was planned making it possible for a limited number of U.S. scholars to take part in science activities in Latin America and for Latin American scientists to take part in research and training activities in the United States during the two-year period of July 1960–62. Responsibility for fostering these exchanges of senior staff members has been essentially placed on the institutions of higher learning concerned.

Relationships With International Science Programs of Other Government Agencies

Liaison with Science Officers of the Department of State

The Office of Special International Programs has continued to provide liaison for the Foundation with the science attaché program of the Department of State. At the request of the Science Adviser to the Secretary of State, briefing sessions for newly appointed Science Officers have been arranged prior to their departure for overseas posts in order to acquaint them thoroughly with Foundation programs. The suggestion has been made that Foundation staff members traveling abroad visit the Science Officers in the respective areas, and up-to-date information on the Foundation is furnished the Science Officers through a continuous flow of its publications.

Cooperation with the International Cooperation Administration

In 1957 the Foundation entered into a participating-agency service agreement with the International Cooperation Administration. Under its terms the Foundation agrees to secure, on a reimbursable basis, the services of certain scientific and technical experts for particular assignments in various countries, as requested by the International Cooperation Administration. During 1960 these requested services were for assignments in Indonesia, the Philippines, and Europe.

A science faculty member on leave from Louisiana State University made a comprehensive survey of Indonesian science as consultant to the Council for Sciences at Djakarta, Indonesia, from October to January. A formal report based on the survey was furnished to the Council, which included a critical evaluation of science facilities and activities and recommendations for their improvement under the supervision of the Council.

A similar survey of Philippine science was carried out between February and May by a scientist on leave from the faculty of Yale University as consultant to the Government of the Philippines to assist its National Science Development Board. The initial portion of the survey, completed in 1959, proved so valuable to the Board that the services of the consultant were requested for a second assignment in 1960. These surveys carefully evaluated Philippine science and recommended methods of improvement.

For U.S. representation in the European area, requests were made for experts to participate in meetings called by the Organization for European Economic Cooperation. These meetings related to the work of the two science components of the OEEC—the Applied Research Division and the Office for Scientific and Technical Personnel. Qualified scientists and technical experts drawn from universities, industry, and Government were recruited to represent the United States at various meetings.

THE NATIONAL RESEARCH AND DEVELOPMENT EFFORT, 1953–1960

Background of Survey Program

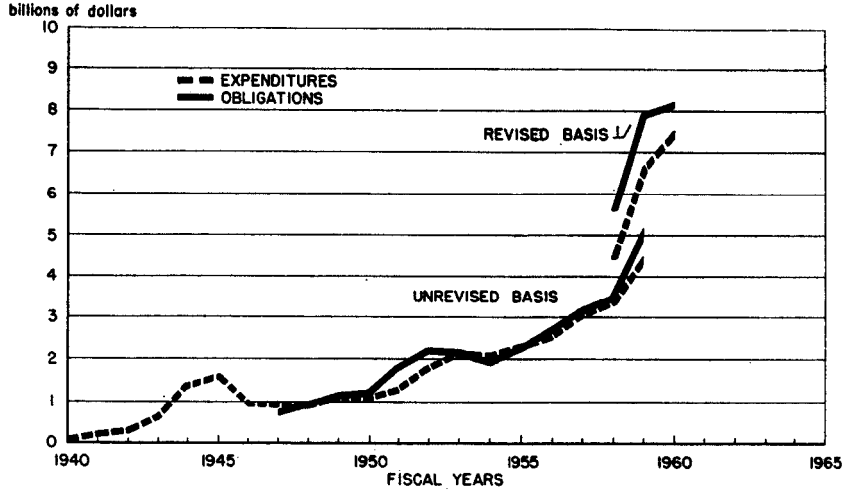
From its inception, the National Science Foundation has been concerned with the measurement and appraisal of the national research and development effort. Prior to the work undertaken by NSF in this field, little had been done. NSF's pioneering studies, conducted by its Office of Special Studies, have provided the first systematic and comprehensive information on the finances of research and development in the United States.

The Foundation began with a study of the Federal Government, and published the results first in 1953 under the title *Federal Funds for Science.* Prior to 1952, the U.S. Bureau of the Budget compiled statistical information on funds obligated by Federal agencies for research and development at colleges and universities. As these statistics became more important as bases for science policy formulation, the Foundation assumed responsibility for their annual compilation. Over the years, the study has expanded so that now *Federal Funds for Science*—an annual publication—includes the entire Federal program for research and development. The most recent issue contains a chart (fig. 5), indicating the trends in Federal expenditures and obligations for the past 20 years.

This initial effort to survey the Federal research and development program brought to light the need for information on the national scientific research and development effort. Further, the President's Executive Order 10521 of March 1954 specifically directed the National Science Foundation "to make comprehensive studies and recommendations regarding the Nation's scientific research and its resources for scientific activities."

A series of surveys begun in 1954 represents the first comprehensive examination of the Nation's research and development effort in terms of both dollars and manpower. Findings of the initial surveys were

Figure 5. *Trends in Federal Research and Development Budget.*



[1] Data based on expanded definition of development. For further details, see technical notes in *Federal Funds for Science VIII. The Federal Research and Development Budget, Fiscal Years 1959, 1960, and 1961.* Washington 25, D.C.: Supt. of Documents, U.S. Government Printing Office, 1959.

NOTE: Data include funds for both conduct of research and development and increase of R&D plant. Pay and allowances of military personnel in research and development included in totals in 1955 and subsequently.

Sources: Bureau of the Budget; National Science Foundation.

published in seven complete reports.[1] They form the basis for a statistical time series and provide benchmark information on the national R&D effort. The total effort is analyzed in terms of four sectors of the economy—the Federal Government, private industry, the colleges and universities, and "other nonprofit institutions."

Dr. George B. Kistiakowsky, Special Assistant to the President for Science and Technology, at the Tenth Anniversary Dinner of the National Science Foundation, May 12, 1960, referred to this phase of the Foundation's interest as follows: "Until the midperiod of the decade, economists had to guess the amount of research and development per-

[1] National Science Foundation. *Funds for Scientific Activities in the Federal Government, Fiscal Years 1953 and 1954* (1958); *Science and Engineering in American Industry. Final Report on a 1953–54 Survey* (1956); *Research and Development by Nonprofit Research Institutes and Commercial Laboratories, 1953* (1956); *Research by Cooperative Organizations. A Survey of Scientific Research by Trade Associations, Professional and Technical Societies, and Other Cooperative Groups, 1953* (1956); *Scientific Research and Development in Colleges and Universities—Expenditures and Manpower, 1954* (1959); *Scientific Research Expenditures by the Larger Private Foundations* (1956). Washington 25, D.C.: Supt. of Documents, U.S. Government Printing Office. *Research Expenditures of Foundations and Other Nonprofit Institutions, 1953–54.* National Science Foundation, Washington 25, D.C.; 1958.

formed within the United States. At that point, the National Science Foundation, on the basis of a thorough survey of the 1953 period pegged the dollar figure for R&D, not at the estimated $2.5 billion, but at more than double that amount—$5.4 billions.[2] Today it has more than doubled again, the Foundation's estimate being on the order of $12 billion."

The 1954 series broke new ground. For the first time, these surveys gave a systematic picture of how much research and development was being done in each of the various fields of science and in each sector of the economy, how much the Nation was spending on research and development, who was footing the bill, who was performing the work, and how many persons were engaged in research and development in each of the sectors and in each scientific field.

Trends in Total R&D Effort

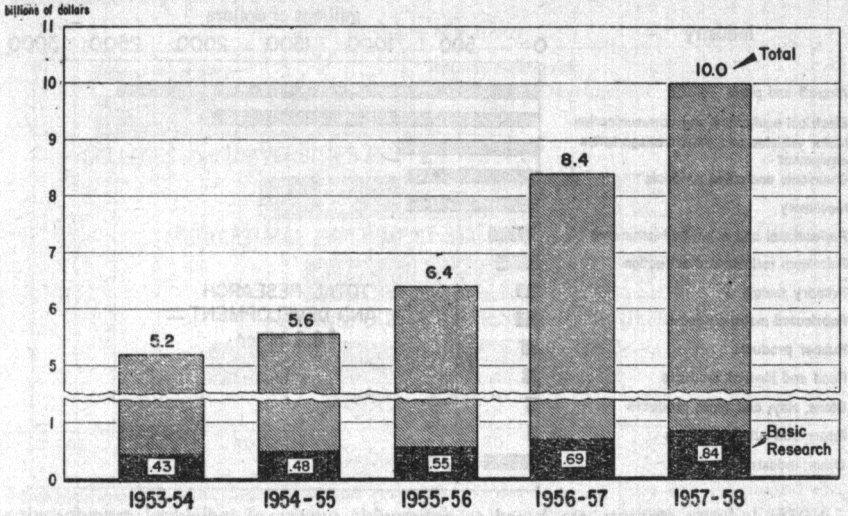
Information provided in the 1954 and subsequent statistical series shows that there has been a rise in current dollars expended for scientific research and development for each year since the first study. The 1958 total, $10 billion, was almost double the $5.2 billion estimated for 1954. Figure 6 shows the totals for research and development and the portions going for basic research for five years beginning with the year 1953–54.

Projected estimates of national totals have been published for the years 1959 and 1960—$11.2 and $12.4 billion, respectively. Figure 7 shows the increase in R&D funds for each year, by sector. The increase in research and development since the base year is primarily owing to a rise of almost 160 percent in the volume of funds used in the performance of research and development by private firms and certain types of related organizations which compose the "industry sector." Funds for performance of research and development by industry rose from $3.6 billion in 1953–54 to a projected $9.4 billion in 1959–60. During the same period, the other three sectors—the Federal Government agencies, colleges and universities, and other nonprofit institutions—also increased their expenditures for the performance of research and development.

These aggregates provide overall trend information. Equally important, however, is the knowledge afforded by each annual survey regarding the activities in each sector. Figures 8, 9, and 10 present the composition of each sector. Figure 8 shows that two industries, aircraft and parts and electrical equipment and communication, performed together 54 percent of the total for the industry sector during 1958.

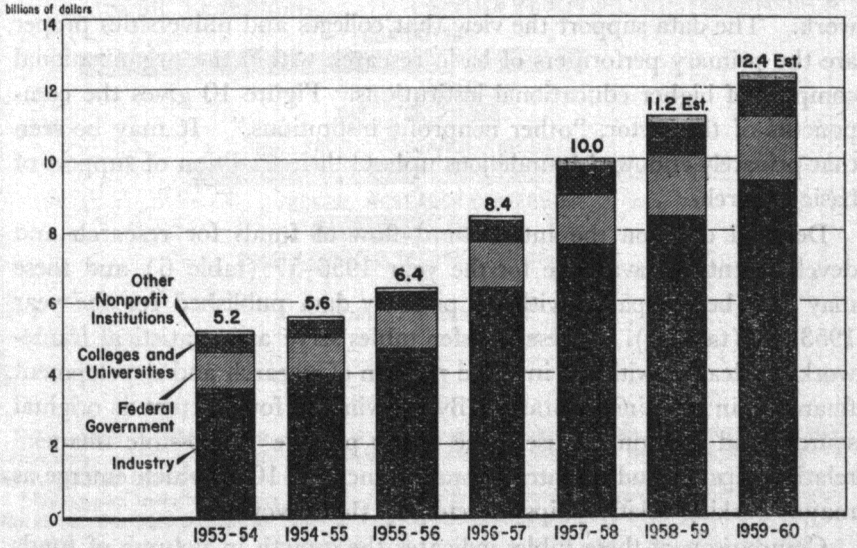
[2] This figure was originally estimated at $5.4 billion but later revision places the 1953–54 estimate at $5.2 billion.

Figure 6. *Funds Used for Basic Research Performance and for Total Research and Development in the United States, 1953–58.*



Source: National Science Foundation, 1960.

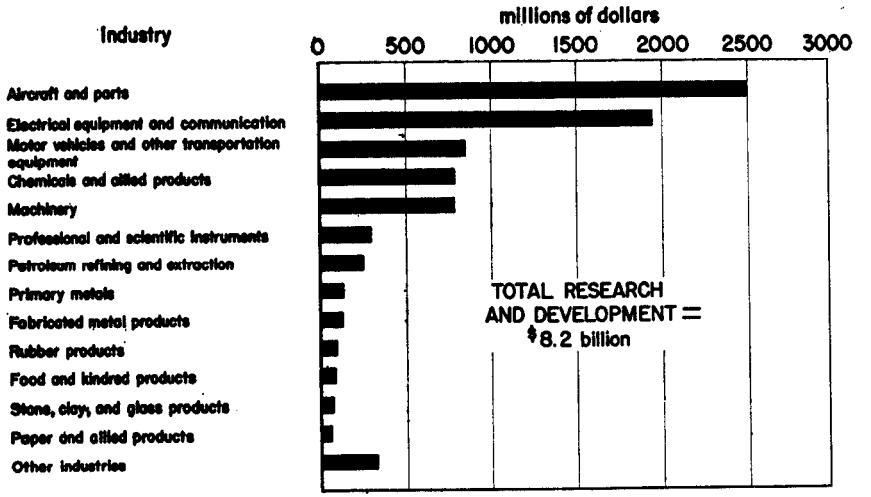
Figure 7. *Funds Used for Performance of Research and Development in the United States, by Sector, 1953–60.*



NOTE: Data on R&D funds for 1956–57 and 1957–58 are revised.

Source: National Science Foundation, 1960.

Figure 8. *Funds Used for Performance of Research and Development, by Industry, 1958.*



NOTE: Industry statistics are based on nationwide surveys of individual manufacturing and nonmanufacturing companies. They include the R&D activities of Federal contract research centers administered by industrial firms, but do not cover certain industry-oriented organizations, such as trade associations, that account annually for an estimated 1 percent of total industrial R&D performance.

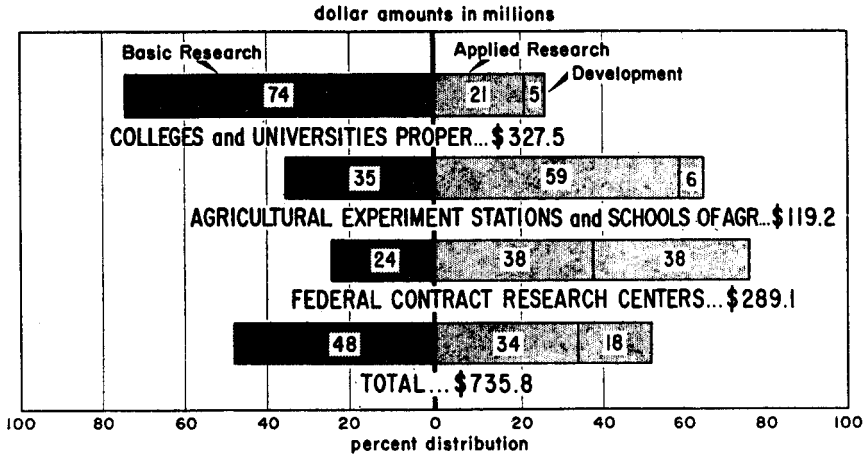
Source: National Science Foundation, 1960.

Figure 9 indicates the analysis of certain research expenditures in colleges and universities, by organizational unit, and by character of the work. The data support the view that colleges and universities proper are the primary performers of basic research within the organizational complex of higher educational institutions. Figure 10 gives the components of the sector, "other nonprofit institutions." It may be seen that privately endowed foundations uphold their tradition of support of basic research.

Detailed data on the intersectoral flow of funds for research and development are available for the year 1956–57 (table 6) and these may now be compared with the primary data published for the year 1953–54 (table 7). These transfer tables serve as a statistical framework for dealing with the involved pattern of research and development financing in the United States. By showing all four sectors as original sources and as ultimate users, the tables provide 16 possible financial relationships (including intrasectoral financing), 10 of which emerge as major working relationships reflected by the surveys.

Comparison of these tables indicates the growth in volume of funds in each sector. The major role of industry as a spender for performance of research and development is highlighted by the magnitude of its

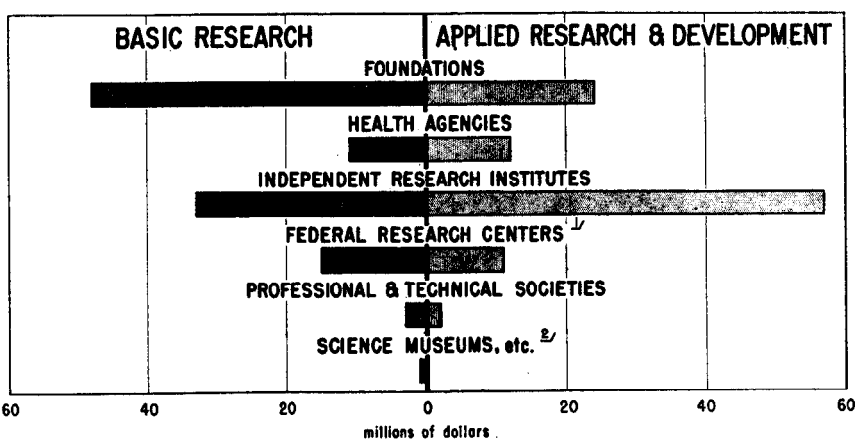
Figure 9. ***Expenditures for Separately Budgeted Research and Development in Colleges and Universities, by Character of Work and Organizational Unit, Fiscal Year 1958.***[1]



[1] Expenditures for separately budgeted research and development form one component of the total for colleges and universities. The remainder is comprised of departmental research and indirect costs of research.

Source: National Science Foundation, 1960.

Figure 10. ***Funds Used for Research and Development, by Type of Nonprofit Institution and Character of Work, 1957.***



[1] For example, RAND Corp., which is an independent organization, Brookhaven National Laboratory, and National Radio Astronomy Observatory, the latter two being administered by Associated Universities, Inc.

[2] This group includes science museums, zoological and botanical gardens, and arboretums. Not shown are $0.3 million for applied research and development.

NOTE: Data are based on reports from organizations in their role as sources or sponsors of research and development.

Source: National Science Foundation, 1960.

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Table 6.—*Transfers of R&D funds, by sector as source and as performer, 1953–54 (revised)* [a]

(Millions of dollars)

Sources of R&D funds, by sector	R&D performers, by sector					Percent distribution, R&D sources
	Federal Government agencies	Industry	Colleges and universities	Other nonprofit institutions	Total	
Federal Government agencies	$970	[b] $1,430	[b] $280	[b] $60	$2,740	53
Industry	.....	2,200	20	20	2,240	44
Colleges and universities [c]	.....	.....	130	.....	130	2
Other nonprofit institutions [c]	.....	.....	20	20	40	1
Total	970	[b] 3,630	[b] 450	[b] 100	5,150	100
Percent distribution, R&D performance	19	70	9	2	100	

[a] Data on sources of funds are based on reports by the performers. This table was published in *Reviews of Data on Research and Development*, No. 16, "Funds for Research and Development in the United States, 1953–59," Washington 25, D.C.: Supt. of Documents, U.S. Government Printing Office, December 1959. For full information, including a discription of each sector, the reader should refer to this bulletin.

[b] Includes funds from the Federal Government for research centers administered by organizations in this sector under contract with Federal agencies.

[c] Data include State and local funds received by these institutions and used for research and development.

NOTE: Percentages based on unrounded figures.

Source: National Science Foundation, December 1959.

Table 7.—*Transfers of R&D funds, by sector as source and as performer, 1956–57 (revised)* [a]

(Millions of dollars)

Sources of R&D funds, by sector	R&D performers, by sector					Percent distribution, R&D sources
	Federal Government agencies	Industry	Colleges and universities	Other nonprofit institutions	Total	
Federal Government agencies	$1,280	[b] $3,200	[b] $380	[b] $70	$4,930	59
Industry	.....	3,180	20	30	3,230	38
Colleges and universities [c]	.....	.....	170	.....	170	2
Other nonprofit institutions [c]	.....	.....	30	40	70	1
Total	1,280	[b] 6,380	[b] 600	[b] 140	8,400	100
Percent distribution, R&D performance	15	76	7	2	100	

[a] Data on sources of funds are based on reports by the performers. This table in preliminary form was published in *Reviews of Data on Research & Development*, No. 16, "Funds for Research and Development in the United States, 1953–59," Washington 25, D.C.: Supt. of Documents, U.S. Government Printing Office, December 1959. For full information including a description of each sector the reader should refer to this bulletin.

[b] Includes funds from the Federal Government for research centers administered by organizations in this sector under contract with Federal agencies.

[c] Data include State and local funds received by these institutions and used for research and development.

NOTE: Percentages based on unrounded figures.

Source: National Science Foundation, December 1959.

funds in both years. As the transfer-table data indicate, a substantial and growing proportion of funds used by the industry sector in the performance of research and development came from the Federal Government. In fact, the most significant change in the distribution of total funds among the sectors as sources, from 1953–54 to 1956–57, was the growing volume of Federal funds, which amounted to 59 percent of the total for 1956–57, as compared with 53 percent for 1953–54.

On a relative basis, funds used for performance of research and development within Federal Government laboratories were less in 1956–57, than in 1953–54, as the performance by the industry sector grew. The relative position of colleges and universities and other nonprofit institutions as sources of funds was virtually unchanged. As performers, both these sectors showed slight percentage decreases.

Basic Research Trends

Similar information has been obtained on basic research funds. The surveys disclose that funds used in performing basic research increased from $432 million in 1953–54 to a projected $1 billion in 1959–60, an increase of 150 percent. Throughout the period, these funds were about 8 percent of estimated total R&D funds (fig. 6).

The twofold increase in funds for basic research during the five-year period, 1954–58, indicates that colleges and universities ($208 to $392 million) and industry ($151 to $272 million) showed the largest absolute increases. The other two sectors, Federal Government and other nonprofit institutions, showed the greatest increase in relative terms, a rise of more than 130 percent. (See tables 8 and 9.)

Colleges and universities stand out as the most important users of funds for the performance of basic research in both years—accounting for about half the total—and they are relatively less important as sources of funds. The totals for colleges and universities combined with other nonprofit institutions comprise more than half the national total for performance of basic research in both years.

For the Federal Government, the picture is reversed in that this sector is still the source of the largest amount of funds for basic research—half the total—but continues to be less important from the point of view of funds reported for performance.

The largest intrasectoral entry for both years, the amount retained within the industry sector for the performance of basic research, rose by almost $100 million during the period. The largest intersectoral transfer in both years is that from the Federal Government to colleges and universities, and this rose by about $120 million from 1953–54 to 1957–58. Colleges and universities comprise the only sector, from a source point of

Table 8.—*Intersectoral transfers of funds used for performance of basic research, 1953–54 (revised)* [a]

(Millions of dollars)

Sources of basic research funds used	Basic research performers					Percent distribution, basic research sources
	Federal Government	Industry	Colleges and universities	Other nonprofit institutions	Total	
Federal Government	$47	[b] $19	[b] $119	[b] $10	$195	45
Industry	.....	132	11	4	147	34
Colleges and universities [c]	.....	.....	62	.....	62	14
Other nonprofit institutions [c]	.....	.....	16	12	28	7
Total	47	[b] 151	[b] 208	[b] 26	432	100
Percent distribution, basic research performance	11	35	48	6	100	

[a] Data on sources of funds are based on reports by the performers. This table was published in *Reviews of Data on Research & Development*, No. 22, "Funds for the Performance of Basic Research in the United States, 1953–58," Washington 25, D.C.: Supt. of Documents, U.S. Government Printing Office, August 1960. For full information, including a description of each sector, the reader should refer to this bulletin.

[b] Includes funds from the Federal Government for research centers administered by organizations in this sector under contract with Federal agencies.

[c] Data include State and local funds received by these institutions and used for basic research.

Source: National Science Foundation, August 1960.

Table 9.—*Intersectoral transfers of funds used for performance of basic research, 1957–58 (preliminary)* [a]

(Millions of dollars)

Sources of basic research funds used	Basic research performers					Percent distribution, basic research sources
	Federal Government	Industry	Colleges and universities	Other nonprofit institutions	Total	
Federal Government	$111	[b] $42	[b] $240	[b] $30	$423	51
Industry	.....	230	14	5	249	30
Colleges and universities [c]	.....	.....	111	.....	111	13
Other nonprofit organizations [c]	.....	.....	27	25	52	6
Total	111	[b] 272	[b] 392	[b] 60	835	100
Percent distribution, basic research performance	13	33	47	7	100	

[a] Data on sources of funds are based on reports by the performers. This table was published in *Reviews of Data on Research & Development*, No. 22, "Funds for the Performance of Basic Research in the United States, 1953–58," Washington 25, D.C.: Supt. of Documents, U.S. Government Printing Office, August 1960. For full information, including a description of each sector, the reader should refer to this bulletin.

[b] Includes funds from the Federal Government for research centers administered by organizations in this sector under contract with Federal agencies.

[c] Data include State and local funds received by these institutions and used for basic research.

Source: National Science Foundation, August 1960.

view, whose own funds for basic research are all used for performance within the sector.

Instrument of Policy

A background of comprehensive statistical data is essential to the development of science policy. Much of the factual information contained in the Foundation's policy reports has been drawn from Foundation studies. Such statistical information has been useful in the development of national science policy as well as policy relating to the operation of programs of the Foundation and of other Federal agencies. A good example concerning both types of policy development relates to the payment of indirect costs of federally sponsored research. Information developed in the 1958 survey of universities and colleges has had a strong impact on Federal policy relating to indirect costs as well as on individual agency policy.

The recently established Federal Council for Science and Technology within the Executive Office deliberates on matters of policy and program coordination and future planning among Federal agencies and makes recommendations to the President. The Foundation has served the Council in a number of its policymaking areas by conducting pertinent statistical and analytical studies.

Impact of Research and Development

In addition to its broad charter outlined above, the Foundation is charged with the responsibility for "appraising the impact of research upon industrial development and upon the general welfare."

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 forcefully established with the Foundation's estimates for 1957 of $10 billion for research and development in the country as a whole and the employment of more than 300,000 scientists and engineers in this activity.

Extending the knowledge furnished by the fact-finding operations, the Office of Special Studies has undertaken a number of special analytical studies. These will provide better understanding of the nature and significance of the survey data. Specific examples of such projects are:

(1) *Case Institute of Technology.* The project conducted by Case Institute of Technology has been directed toward producing objective and quantitative procedures for allocating funds to and within the research and development activity of a company and tracing the relation of research and development to the growth of a company. Personnel at Case Institute have worked with chemical firms on a case history approach

to develop a methodology adaptable, at least experimentally, to other industrial firms.

(2) *Carnegie Institute of Technology.* A study at the Carnegie Institute of Technology has sought to understand the determinants entering into the level of research and development within the economy, particularly with reference to an individual industrial firm. Linked with this objective is the further goal of gaining insight into the diffusion of innovation within the economy.

(3) *Survey of Research Projects on Economic and Other Impacts of Scientific Research and Development.* The survey of projects pertaining to analysis of the impact of research and development has covered colleges and universities, research institutes, professional associations, and foundations. A publication on the survey pertaining to colleges and universities was released during 1960.

(4) *A Selected Annotated Bibliography on Impact of Research and Development on the Economy.* A selected annotated bibliography has been published to provide references representative of typical approaches to the study of research and development and to serve as a guide for further investigation.

(5) *Cost Index of Research and Development.* This project, in cooperation with the Department of the Army, Office of the Director of Research and Development, involves the development of an index to deflate R&D expenditures. It may offer insight on relations of various cost elements which will assist in planning and projecting research costs in constant and current dollars. The U.S. Bureau of Labor Statistics, under contract to this Office, is now undertaking to implement the index design and it is hoped that preliminary estimates of a cost index will become available during the next fiscal year.

(6) *Relation of Data on Research and Development to Overall Economic Activity.* The relation of research and development expenditures to the national income and gross national product accounts is being explored in order to obtain appropriate dollar measures of the level of scientific effort compared with total economic activity. This involves separation of the elements entering into existing measures of expenditures for both research and development and gross national product from the point of view of determining which of several types of relations are meaningful and useful for studies of scientific effort and economic growth.

Conclusion

With a strong base of fundamental information about the central forces of the R&D effort, the Foundation has begun to formulate a more

specialized and analytical examination of science and technology. Activities under this broadened approach to science and technology include analyses of the magnitude and character of research and development, the education of scientists and engineers, the utilization of scientific and supporting personnel, development of scientific facilities, dissemination of scientific information, effects of technological advances, and the organization and administration of the scientific community. In addition, having dealt in the past with some of these components in laying the groundwork for overall analyses, the Foundation feels the increasing importance of viewing the totality of all scientific activities in relation to the economy. Accordingly, the Foundation plans to synthesize these elements in a broad concept of science and technology and an understanding of each of their roles.