# Program Activities of the National Science Foundation

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Each year since its establishment in 1950, the Foundation has dedicated the largest portion of its appropriated funds to support efforts of scientists in the colleges and universities of the Nation to assure what, in *Science—The Endless Frontier,* Dr. Vannevar Bush called a "flow of new scientific knowledge." During fiscal year 1956, for example, out of a total appropriation of $16 million, Foundation support of basic scientific research was $9.6 million. These funds made possible 734 grants in the biological, medical, mathematical, physical, and engineering sciences to 258 institutions in 47 States, the District of Columbia, Hawaii, Puerto Rico, Canada, England, France, and Italy. Research grants for fiscal year 1956 averaged $13,800 to run for 2.1 years, or about $6,600 per year.

The table below summarizes the research support program by broad subject categories. A detailed list of the grants showing institution, principal scientist, title of project, and amount is given in appendix B, p. 112.

**National Science Foundation Research Grants by Fields of Science**

| Field | Fiscal years 1952–55 | | Fiscal year 1956 | | Total | |
|---|---|---|---|---|---|---|
| | Number | Amount | Number | Amount | Number | Amount |
| Biological and medical sciences: | | | | | | |
| Anthropological | 5 | $51, 700 | 13 | $133, 100 | 18 | $184, 800 |
| Developmental | 49 | 392, 695 | 23 | 211, 500 | 72 | 604, 195 |
| Environmental | 38 | 287, 960 | 47 | 473, 300 | 85 | 761, 260 |
| Genetic | 46 | 612, 700 | 30 | 395, 800 | 76 | 1, 008, 500 |
| Molecular | 103 | 1, 551, 150 | 80 | 1, 218, 580 | 183 | 2, 769, 730 |
| Psychobiology | 80 | 1, 001, 950 | 61 | 717, 700 | 141 | 1, 719, 650 |
| Regulatory | 144 | 1, 894, 295 | 72 | 1, 028, 850 | 216 | 2, 923, 145 |
| Systematic | 105 | 819, 280 | 79 | 603, 200 | 184 | 1, 422, 480 |
| General | 29 | 473, 910 | 21 | 342, 700 | 50 | 811, 610 |
| | 599 | 7, 085, 640 | 426 | 5, 124, 330 | 1, 025 | 12, 209, 970 |

**National Science Foundation Research Grants by Fields of Science—Continued**

| Field | Fiscal years 1952–55 | | Fiscal year 1956 | | Total | |
|---|---|---|---|---|---|---|
| | Number | Amount | Number | Amount | Number | Amount |
| Mathematical, physical, and engineering sciences: | | | | | | |
| Astronomy | 45 | $420,700 | 27 | $225,700 | 72 | $646,400 |
| Chemistry | 167 | 1,889,700 | 85 | 1,186,900 | 252 | 3,076,600 |
| Earth Sciences | 66 | 820,450 | 39 | 512,525 | 105 | 1,332,975 |
| Engineering | 127 | 1,302,300 | 55 | 726,200 | 182 | 2,028,500 |
| Mathematics | 88 | 835,550 | 39 | 712,350 | 127 | 1,547,900 |
| Physics | 139 | 1,941,600 | 58 | 1,105,800 | 197 | 3,047,400 |
| Sociophysical | 4 | 50,700 | 4 | 54,400 | 8 | 105,100 |
| General | 0 | 0 | 1 | 7,000 | 1 | 7,000 |
| | 636 | 7,261,000 | 308 | 4,530,875 | 944 | 11,791,875 |
| Total research grants | 1,235 | 14,346,640 | 734 | 9,655,205 | 1,969 | 24,001,845 |

The geographical distribution of Foundation grants and research funds for the 5-year period, 1952–56, is shown in figure 7 and the accompanying table.

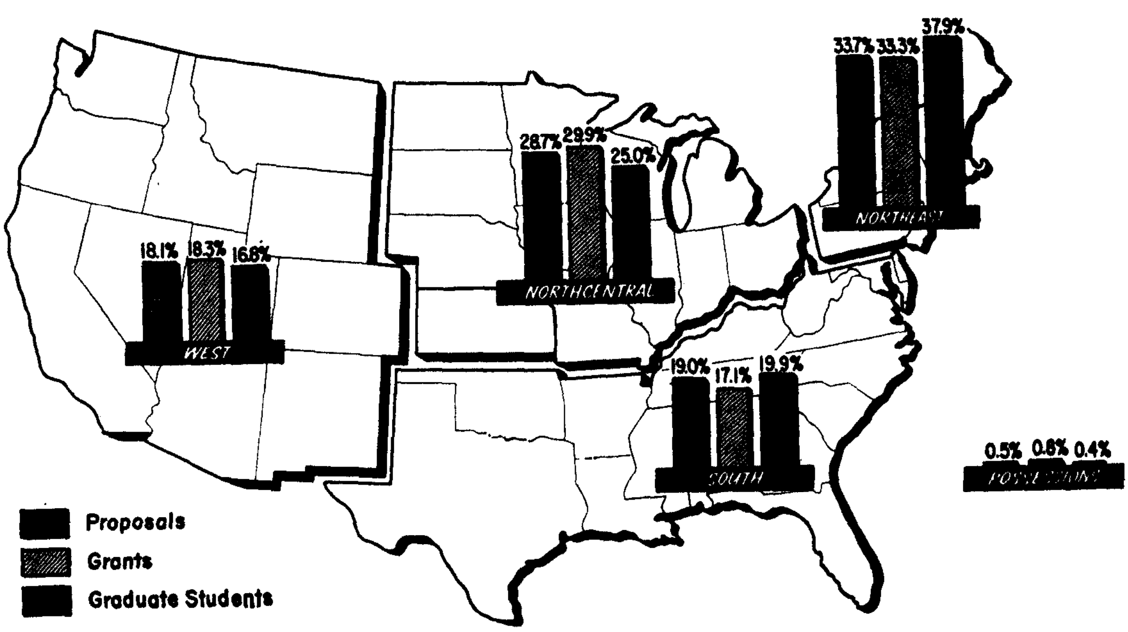


*Figure 7.—Regional comparison of proposals received (dollars), grants awarded (dollars), and graduate student population, fiscal years 1952–56.*

**Regional Distribution of Proposals Received, Grants Awarded, Graduate Students, and Total Population**

| Region | Fiscal years 1952–56 | | | | Academic year 1953–54 graduate students | | 1950 census total population (100,000's) | |
|---|---|---|---|---|---|---|---|---|
| | Proposals received | | Grants awarded | | | | | |
| | | *Percent* | | *Percent* | *Number* | *Percent* | *Number* | *Percent* |
| Northeast | $34, 840, 296 | 33. 7 | $8, 108, 075 | 33. 9 | 92, 000 | 37. 9 | 395 | 26. 2 |
| South | 19, 701, 775 | 19. 0 | 4, 102, 560 | 17. 1 | 48, 312 | 19. 9 | 443 | 29. 3 |
| North Central | 29, 681, 310 | 28. 7 | 7, 158, 860 | 29. 9 | 60, 511 | 25. 0 | 471 | 31. 2 |
| West | 18, 686, 215 | 18. 1 | 4, 368, 150 | 18. 3 | 40, 767 | 16. 8 | 197 | 13. 0 |
| Possessions | 514, 064 | . 5 | 183, 900 | . 8 | 936 | . 4 | 5 | . 3 |
| Totals | 103, 423, 660 | 100. 0 | 23, 921, 545 | 100. 0 | 242, 526 | 100. 0 | 1, 511 | 100. 0 |

From figure 8 and the following table, it can be seen that 73 percent of the total funds distributed have gone for salaries and 18 percent for equipment. Indirect costs amounted to 13 percent of direct costs.

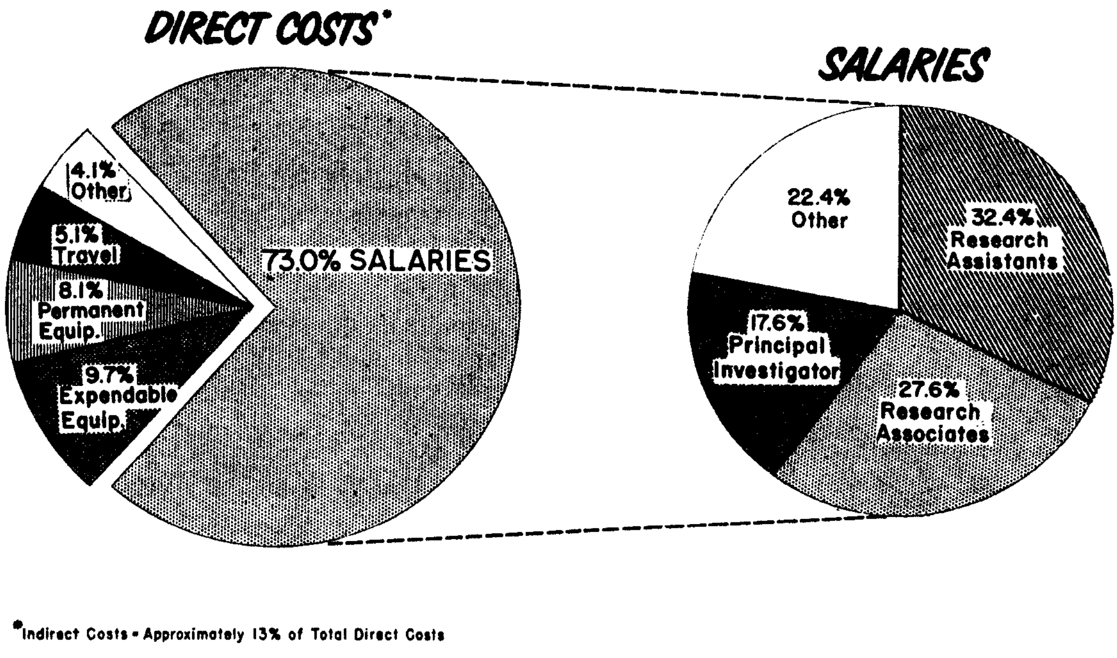


**Figure 8.**—*Analysis of the average National Science Foundation research grant by type of expenditure (estimated).*

**Analysis of Salaries Paid From Average Research Grant**[1]

| | *Average grant fiscal year 1956* | *Percent of salaries* |
|---|---|---|
| Principal investigator (total) | $1,566 | 17.6 |
| Summer | (1,057) | (11.9) |
| Sabbatical | (23) | (.3) |
| Academic | (486) | (5.4) |
| Research associate [2] | 2,450 | 27.6 |
| Research assistant [3] | 2,877 | 32.4 |
| Other [4] | 1,984 | 22.4 |
| Total | 8,877 | 100.0 |

[1] Based on budget estimates at the time of Board approval.

[2] Includes post-Ph. D. scientific personnel normally spending full time on research and usually not occupying tenure positions at the institution where they are doing the research.

[3] Includes graduate assistants enrolled at the grantee institution and working toward a master's degree or a doctorate.

[4] Includes laboratory technicians and assistants, undergraduate assistance, miscellaneous direct labor charges and retirement charges where the grantee's accounting system treats these as a direct charge.

## Toward Clearer Understanding

Understanding is incompletely served, however, by listing amounts of money expended to support basic reasearch in molecular biology, regulatory biology, psychobiology, earth sciences, engineering sciences, or mathematical sciences, unless these terms convey meaning to the reader. What, for example, is regulatory biology? Regulatory biology may be considered to be the scientific area concerned with biochemical and physiological mechanisms which regulate and control such vital processes as development, growth, functional activity, reproduction, and degeneration of living matter. The work of Dr. F. M. Strong and his colleagues at the University of Wisconsin, on factors which stimulate and inhibit cell division, represents the kind of basic research supported by the Foundation in regulatory biology.

### *Isolation of "Kinetin"*

Investigation of the processes of nutrition and metabolism in living organisms have led to the discovery and isolation of a new compound called kinetin which has the property of stimulating cell division. When a trace of kinetin (as little as one part in a million parts of other matter) is added to culture media for plant tissue cells which are long past the growth period, the cells divide and new cells continue to be formed indefinitely so long as kinetin is in the medium. When such rapidly growing tissue is placed in the same medium without kinetin, it stops growing (see photo section). Continuous growth can be achieved by appropriate additions of kinetin and another substance, called auxin. Substances having effects similar to that of kinetin now have been obtained from a number of plant and animal sources. This latter finding suggests that kinetin may actually be a component of the nucleic acids.

Recently, as a direct outgrowth of this work by Dr. Strong and his associates, another investigator has prepared an analog of kinetin which prevents, rather than stimulates, the division of animal cells.

A second interesting development which has resulted from this work was reported several months ago by Dr. Werner Braun of Rutgers University. Dr. Braun, with Foundation support, is investigating the effect of certain metabolic substances on the growth and multiplication of specific cell types in bacteria. He has found that a very small amount of kinetin added to cultures of the organisms which cause lobar pneumonia and undulant fever have the effect of changing nonvirulent strains to virulent ones. Furthermore, this effect could be reversed by the addition of a derivative of nucleic acid, which is a vital constituent of all living cells.

Similarly, we may analyze the meaning of the term, earth sciences. Scientists who study the core of the earth, its crusts, its oceans, its winds, its weather, and on beyond to its upper atmosphere including the ionosphere—these are earth scientists. Among them are meteorologists, oceanographers, seismologists, astronomers, engineers, physicists, and others. For a better understanding of the significance of the work of earth scientists, the gravity and seismic studies of the Colorado Plateau being made by Dr. George P. Woollard, of the University of Wisconsin, are described below. They are typical of Foundation-sponsored research in the earth sciences.

### *Gravity and Seismic Studies in Colorado*

As remote as are the stars and interstellar space, they are still more accessible to instruments than the interior of the earth. Below a depth of about 4 miles, rocks are beyond the range of sampling or visual observation, and ideas about the composition of the earth are based largely on inferences drawn from earthquake waves, gravity studies, magnetic studies, a few laboratory experiments, and general theories.

One of the principal theories of crystal structure is isostasy, which says that above a certain zone of compensation all columns of rock with equal area are equal in mass: mountains stand higher because they are lighter. The interpretation of seismic waves suggests also that the principal mountain ranges have roots of lighter material that extend downward several kilometers into the denser parts of the crust, just as an iceberg extends below the surface of the ocean. Recent seismic studies of the Colorado Plateau area, however, indicate that this large elevated region may not have roots; if so, it is unique. Dr. Woollard's studies of the plateau are designed to determine whether earlier work has been interpreted correctly.

In addition to the fact that the basic research pursued by Dr. Strong and Dr. Woollard extends man's knowledge of the laws of nature, it may turn out to be valuable, with reference, in the first instance, to the chemotherapy of cancer, and in the second instance, to firmer concepts of earth structure. When published, results of such research become part of the Nation's fund of scientific knowledge, freely accessible to scientists everywhere. They are particularly valuable to scientists who work in areas of applied and developmental research.

## Research-Support Programs

Immediately responsible for Foundation programs in support of basic research are the Division of Biological and Medical Sciences and the Division of Mathematical, Physical, and Engineering Sciences. A detailed list of the grants, recommended for support by these divisions and approved by the National Science Board for fiscal year 1956 is given in appendix B, and shows institutions, principal scientists, title of project, duration, and amount.

### *Research Supported by the Division of Biological and Medical Sciences*

In the *regulatory biology program* almost all phases of physiology and of the more physiological aspects of biochemistry were represented. The larger segments were in mammalian intermediary metabolism, endocrinology, microbial metabolism, and immunology, as well as invertebrate, plant, and cellular physiology. In the *molecular biology program* the greatest number of grants were in the field of protein and enzyme structure. Next in order were those dealing with the chemical reactivities and kinetics of proteins and enzymes. The program also supported a significant number of studies dealing with the metabolism and biosynthesis of amino acids, carbohydrates, phosphates, and sulfur-containing biological compounds.

In the *genetic and developmental biology program,* the Foundation supported research on transduction, i. e., the transfer of genetic information from one bacterium to another as by viral or other means. Various quantitative studies of the properties of animal viruses were supported as were pioneering studies on the genetics of microscopic algae. Support was provided for work in highly active fields, such as population genetics, as well as for relatively unexplored areas such as the endocrinology of the armadillo—seeking an understanding for the invariable production of quadruplets. In the *psychobiology program,* inquiries into the neurophysiology of learning have been given continued support as has been research on problems of brain biochemistry and behavior. A program of support has been continued for psychology departments in the small colleges aimed at strengthening both their research and training efforts.

Among the grants in the *systematic biology program,* somewhat less than half were in the field of regional studies of a group of plants or animals with other support being given to general taxonomy, and the preparation of indices. The *environmental biology program* included grants in various areas of environmental biology—paleoecology, phytosociology, structure and productivity of marine and fresh-water ecosystems, physiological ecology, microclimatology, ecological life histories of plants and animals, and radiation ecology.

Within the *anthropological and related sciences program* areas, grants activated during the fiscal year were in anthropology, archaeology, demography, psycholinguistics, and social psychology.

## *Research Supported by the Division of Mathematical, Physical, and Engineering Sciences*

In the *astronomy program* were grants in support of projects ranging from the study of Mars at its close approach to the Earth in 1956, the systematic observation of asteroids, studies on the composition and motion of stars, to the investigation of radio radiation with a wavelength of 21 centimeters characteristic of neutral atomic interstellar hydrogen in the great cluster of galaxies in Coma Berenices. Moreover, a good start has been made in strengthening astronomical instrumentation, both optical and radio.

The *chemistry program* provided chief support to research in organic and physical chemistry and also supported research in analytical and inorganic chemistry. Research was supported in organic chemistry on mechanisms of reactions, structure and synthesis of natural products, chemistry of free radicals, and studies on small and large ring compounds; in physical chemistry, on theoretical studies of atomic and molecular structure, photochemistry, spectroscopy, thermodynamics, thermochemistry, fast chemical reactions, and studies at high temperatures with solar furnaces; in analytical chemistry, on gas chromatography, polarography, and the nature of precipitates; in inorganic chemistry, on stereochemistry, X-ray and crystallographic studies, isotope exchange reactions, and chelates. Plans have been made for the support of research programs concerned with high polymers, for increased support of research at low temperatures, and for awarding grants for research instrumentation in chemistry.

In the diverse field of the *earth sciences program,* geochemistry warranted a major portion of the research budget, largely because new instrumentation and techniques developed during the past 15 years have opened up many promising lines of work, especially the study of isotopes in their geologic setting. Support of oceanographic research has recently resulted in significant progress. Through grants for the analysis of deep ocean cores from the bottom of the Atlantic, valuable information on sedimentation has been revealed, such as that pertaining to grain size and isotopic composition. Support was also made available for research in geophysics, stratigraphy, paleontology, meteorology, petrology, and mineralogy.

In the *engineering sciences program,* emphasis centered on the fields of mass transfer, mechanics, thermodynamics, electrical circuits and electronics, as well as fluid mechanics and physical metallurgy. These studies included analyses and formulation of methods having general application for the efficient use of materials and energy. Among the recently productive grants in the program was one which resulted in the formulation of a physical explanation of the empirical laws of comminution of materials by evaluating the effect of particle size in the process.

Mathematics provides linguistic structures which are available when needed for the description of the physical world. Some examples of these abstract structures and their diverse employment are: Group theory which is used for the classification of crystals, in quantum mechanics, and in relativity theory; number theory which is a means for describing experimental design and cryptography; topology which is appropriate for the discussion of electrical networks and for many problems in fluid mechanics; mathematical logic which plays a role in the design and operation of high speed computing machines. The *mathe-*

*matical sciences program* supports research in this underlying mathematics and stimulates the production of young mathematicians devoted to such research. Emphasis was placed on covering, by a single grant, the most promising areas of investigation in active departments. Such grants encourage talented students to become acquainted with problems in several fields before becoming committed to one mathematical specialty.

The *physics program,* which has to do with the fundamentals of matter and radiation, reflected an increased interest in atomic and molecular structure. As in previous years, the major effort was directed toward studies of nuclear and solid state physics, especially the theoretical aspects. Advances in nuclear and spin resonance experimental methods have brought about an avalanche of many small but significant discoveries concerning the structure of atoms in the aggregate and of molecules. The physics of matter as revealed through low temperature experiments also was pursued with increasing vigor.

The *sociophysical sciences program* encompasses both the history, philosophy, and sociology of science and those areas where the social sciences converge with the mathematical and physical sciences. Grants under this program have supported studies on the factors in the acceptance of scientific theories; studies in the history of mathematics, physics, and metallurgy; and basic research in mathematical social sciences.

## Support Programs Broaden Manpower Base

A significantly important plus value for science, attached to nearly every one of the 734 grants approved during the fiscal year, is the cumulative effect of research support on the Nation's science-manpower reservoir. Funds provided in the average Foundation grant support 1 or 2 graduate student research assistants and frequently a postdoctoral research associate. Thus, in addition to the Foundation's formal fellowship program (see The Manpower Report, p. 61), the research support program increases the total number of well-trained scientists available to the Nation. Young men and women, who might not otherwise find opportunity, are enabled to pursue avenues of research under mature investigators while, at the same time, continuing their formal academic training. Based on grants made by the Division of Biological and Medical Sciences and the Division of Mathematical, Physical, and Engineering Sciences during fiscal year 1956, some 900 predoctoral students and approximately 200 postdoctoral scientists served with mature investigators whose work was supported by the Foundation on recommendation of these divisions.

Some measure of the Foundation's contribution to the national reservoir of highly trained scientific talent is indicated in figures which represent support of young science students and scientists—indirectly, through the grants program, and directly, through the formal fellowships program. Total indirect support, as indicated immediately above, approximates 1,100 individuals; total direct support through predoctoral and postdoctoral fellowships was about the same. For fiscal year 1956, therefore, the Foundation assured opportunities for nearly 2,000 men and women to continue their scientific education and experience in laboratories of colleges and universities located throughout the country.

Believing that the science teacher is a better teacher as a result of having participated in actual scientific research, the interest and emphasis on the training of scientific talent is being expanded to include summer research programs for teachers of the small liberal arts colleges, and for high-school teachers, whose facilities for such pursuits are limited during the academic year.

The contributions of scientific research and development to our success in World War II made it obvious that continued support of such research was essential to our country's safety and progress. Therefore, both the Federal Government and industry made large capital investments in research facilities, primarily for mission-oriented research. There remained, however, a great need for augmenting the support of facilities for basic research at the colleges and universities.

### Improving the Scientist's Tools

During fiscal year 1956, the Foundation submitted to Congress its first significant request for funds for the support of research facilities. Current laboratory equipment is fast becoming obsolete for meeting the facilities' requirements of today's researcher in basic science. For the astronomer whose laboratory is outer space, or for the physicist studying the structure of the atomic nucleus, most telescopes and laboratory instruments are rapidly outmoded. Today's newest telescope is really a highly sensitive, wide-diameter, parabolic "dish" which, as the tool of radio astronomy, picks up cosmic static from outer space; today's instrument for studying nuclear structure is a huge nuclear reactor or accelerator. Similarly, progress in basic research in biology is sped forward when biologists have access to modern controlled-environment laboratories.

As the frontiers of knowledge are pushed forward, basic research becomes more and more complicated. Machinery and facilities for performing research become increasingly complex and costly. Meanwhile, resources of the universities, where basic research is an essential part of the educational process, have not kept pace with increasing costs. Colleges and universities, thus, have not been able to provide adequate research facilities to meet the insistent demands of an expanding economy and cold-war geopolitics. Lack of modern facilities for basic research not only retards research but postpones, as well, adequate training for scientists.

The once-popular conception that a scientist engaged in basic research requires only his brain and simple, ofttimes homemade equipment, is erroneous. True, men rather than machines have been, are, and will be of primary significance in research. In some instances, significant research will continue to be accomplished by an individual scientist with outstanding creative imagination and relatively simple equipment.

However, the continuance of probing into the unknown, of seeking meaningful data and observation upon performance and characteristics of the building blocks of nature, requires complex and consequently expensive devices. As time goes on, it is anticipated that the future progress of research will depend in some fields of science upon an increasing ratio of research tools to scientific manpower. Production of necessary particles for research in nuclear physics, for example, is dependent upon equipment such as the nuclear accelerator and the nuclear reactor, all elaborate and costly devices. Acceleration of progress in many scientific and engineering fields through application of the electronic computer to complicated and extensive problems will require increasing numbers of computers of high speed and large memory capacity. Furthering of research on the nature and characteristics of the universe requires highly specialized astronomical equipment in locations favorable for such studies. In addition, the forwarding of research on the nature of life itself—the province of biology—requires modern laboratory equipment in locations favorable to studying life forms in their natural habitats. In all of these areas, and in other areas which may emerge, the national interest requires that adequate means be available for assisting scientists to perform research to the limits of their ability.

Support for basic research facilities and equipment by the Foundation is directed toward accomplishing the following objectives:

1. Improvement of the extent and quality of basic research in those areas where progress is dependent upon access to specialized or scarce and costly facilities not otherwise available.
2. Achievement of a sound geographic distribution of research by providing necessary research installations and equipment in regions where such items are scarce or unavailable.
3. Fostering research through increasing the competence of scientific personnel by providing opportunities for receiving training in the use of advanced or highly specialized scientific equipment.

On the basis of careful surveys by outstanding scientists in several disciplines, the Foundation has recommended as desirable national policy provision of Federal funds for construction or procurement of large-scale facilities and major equipment for scientific research, including research centers—when need is urgent; when provision of the facility is clearly in the national interest; when technical bases are sound; and when funds are not available and cannot feasibly be stimulated from other sources.

### Facilities for Research in Astronomy

During the summer of 1956, the Foundation allocated $4 million for the construction of a radio astronomy facility in Green Bank, W. Va., to consist initially of a 140-foot parabaloid antenna and auxiliary equipment. The facility is designed to make available to radio astronomers in the United States a large telescope and facilities comparable to those available to scientists of other nations. In announcing the site selection, the Director pointed out that "colleges and universities which cannot undertake to provide radio telescopes out of their own resources will be enabled to begin research and training within their institutions knowing that the facilities of the radio astronomy observatory will be available for the completion of advanced research and training."

A grant of $545,000 was also made to the University of Michigan to support continuing studies of sites and instrumentation for an optical astronomy observatory proposed to be erected in the Southwest. According to Robert R. McMath, Director of the McMath-Hulbert Observatory of the University: "The problems of astronomy require a wealth of basic data. At the present time such data are being gathered very slowly. Because of this slow rate, fundamental advances occur rarely, only about once in 25 years." He cited further the difficulty in obtaining funds from industry or from private foundations for a pure science such as astronomy. Dr. McMath pointed out that establishment of an observatory would enable scientists to take advantage of the revolution in astronomy techniques that are anticipated within the next decade or two.

The furtherance of education in astronomy is another compelling reason for establishing such facilities. It is believed that the existence of these facilities will encourage young astronomers to go into teaching by giving assurance that they will not have to forfeit research opportunities in so doing.

### A Reactor for Nuclear Research

In a further effort to meet the research needs of present-day science, the Foundation, in the summer of 1956, made a grant of $500,000 to help construct a nuclear reactor at the Massachusetts Institute of Technology, in Cambridge. The physics and metallurgy departments at

M. I. T. plan to use the reactor for research on the solid state, the department of food technology in the radiation sterilization of foods, the department of biology in radiation-induced mutations, the department of chemistry in radio-chemical investigations, the department of chemical engineering in radiation-induced catalysis, and the nuclear engineering group in reactor development studies. The Massachusetts General Hospital and other hospitals and medical schools in the Boston area are expected to use the reactor as a neutron beam source for cancer therapy.

The reactor will also serve importantly the useful purpose of educating engineers and scientists in the theory, design, and operation of nuclear reactors; in techniques for the production, handling, and measurement of nuclear gamma radiation and radioactive material; and in the principles and application of reactor instrumentation.

## Support for Computing Laboratories

The Foundation approved as well the first of a series of grants to support computation centers and research in numerical analysis: $38,000 to the California Institute of Technology; $30,000 to the Massachusetts Institute of Technology; $20,000 to Oregon State College; $17,500 to the University of Washington; and $30,000 to the University of Wisconsin.

The Foundation's computer-support program is designed to strengthen basic research in a number of fields by providing research investigators access to computing facilities. Only a few large computing centers around the country are available for basic research problems and these generally on a part-time basis only. Most computers are busy on a round-the-clock schedule on industrial problems and problems related to defense contracts. The general-purpose university computing laboratory does not have sources of support for basic research at present. Foundation assistance will help to establish or strengthen such general-purpose research laboratories.

Commenting on the Foundation program in support of computing research, the Director said:

> The electronic digital computer has been growing in importance as a major research tool since World War II. The art of high-speed computation has now progressed to the point where many scientists feel that further progress in their fields will be seriously affected by access to the techniques and facilities for computation. At least two obstacles must be overcome in making theoretical advances in scientific research: formulation of adequate conceptual models of a natural proc-

> ess, and calculation of anticipated observations in a particular instance of the process.
>
> Recent experimental advances in physical and engineering sciences have made previously relevant linear mathematical models inadequate for representing many interesting processes or, in cases where linear analysis remains relevant, have increased enormously the size of the linear system employed. Use of mathematical models in biological and sociological research has induced consequences similar to those in the physical sciences. It is an historically remarkable coincidence that, parallel to the emergence of these difficulties, a means of dealing with them has been found in the art of high-speed computation.

The Director added that the need for adequate computer facilities for basic research problems must be considered primarily from an interdisciplinary point of view. In addition to the obvious interdependence of computation and research in mathematics and physics, other mathematical, physical, and engineering sciences are utilizing computational techniques at an increasing rate. Problems in biological and sociological sciences are also becoming increasingly amenable to numerical analysis.

Provision of computer facilities for basic research is filling an important need in training mathematicians at all levels in formulating scientific problems. At present only a fraction of the number of mathematicians needed for computer work are being graduated at the various levels. Scientists in other fields, also, must be trained in methods of applying computer techniques to their own problems. In addition to the scientists and mathematicians whose interests are in basic research, an increasing number of trained specialists are required to man the big machines used on industrial and defense problems.

Yet another compelling reason which prompts Foundation support of computation centers is the need for more research to advance the art of computation itself. Effective utilization of existing machines requires research in numerical analysis. Scientists are daily encountering problems beyond the capacity of existing machines, and, if the need for better equipment is to be met, investigation into the theory and engineering of computing machines is essential.

**Biological Research Facilities**

During the summer of 1956, the Foundation allocated three-quarters of a million dollars for the support of biological field facilities. With few exceptions, the Foundation has been the only Federal agency from which biological field research stations could obtain partial assistance for general operating support, for renovation and repair, and for modernization of physical plant and equipment. The Foundation provided only limited assistance prior to 1956, and will provide a moderate level of support in 1957.

Research at academic institutions in the biological sciences operates under definite handicaps because, generally speaking, colleges and universities are located in urban or suburban areas where the immediate surroundings do not include source materials for biological studies. Consequently, biological field stations have been established in relatively remote locations where the natural environment provides conditions favorable for biological research. Some of these conditions are the ready availability of living source material for laboratory studies, the presence of unique flora and fauna, and the existence of particular environmental conditions such as may be found in Arctic, desert, high altitude, marine, terrestrial, or fresh water habitats. At the present time, there are 52 such stations of varying size, quality of equipment, and accommodations for staff; 47 are located in the United States or possessions in the North American Continent, 1 is in the Canal Zone, and 4 additional United States stations are found in the Atlantic and Pacific island sites. Support from private sources is such that, of the 52 American biological stations, very few are functioning under conditions that could be termed better than austere.

As a result of the difficulties encountered by biological field stations in securing funds, necessary repairs have been postponed; research equipment has become obsolete and inadequate; larger stations are acutely short of laboratory and housing space for students and independent investigators; field equipment, boats, etc., are becoming obsolete and need replacement; station libraries have fallen far behind in the acquisition of up-to-date reference and study material. The consequence has been that research and training programs have been retarded, and in some instances, abandoned.

In addition to their importance for the conduct of research as such, biological field stations have a significant value for:

1. Training younger scientists under the direction of experienced and mature biologists.
2. Providing a means whereby faculty members of colleges and universities can not only carry on research during the summer months, but also secure the stimulation of interests to be gained from close association with active research biologists.

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Numerous requests received by the Foundation for assistance in providing needed equipment, renovation or construction of necessary structures, and costs of operation were carefully considered by the staff of the Foundation, by a committee of eminent biologists not directly involved in the operation or administration of field stations, by the Divisional Committee for Biological and Medical Sciences, and by the National Science Board. All have concurred that support for these facilities is vital.

If the United States is to maintain its position of world technological leadership, it must improve the quality of science instruction in its schools and colleges during the approaching period of vastly increased enrollments.

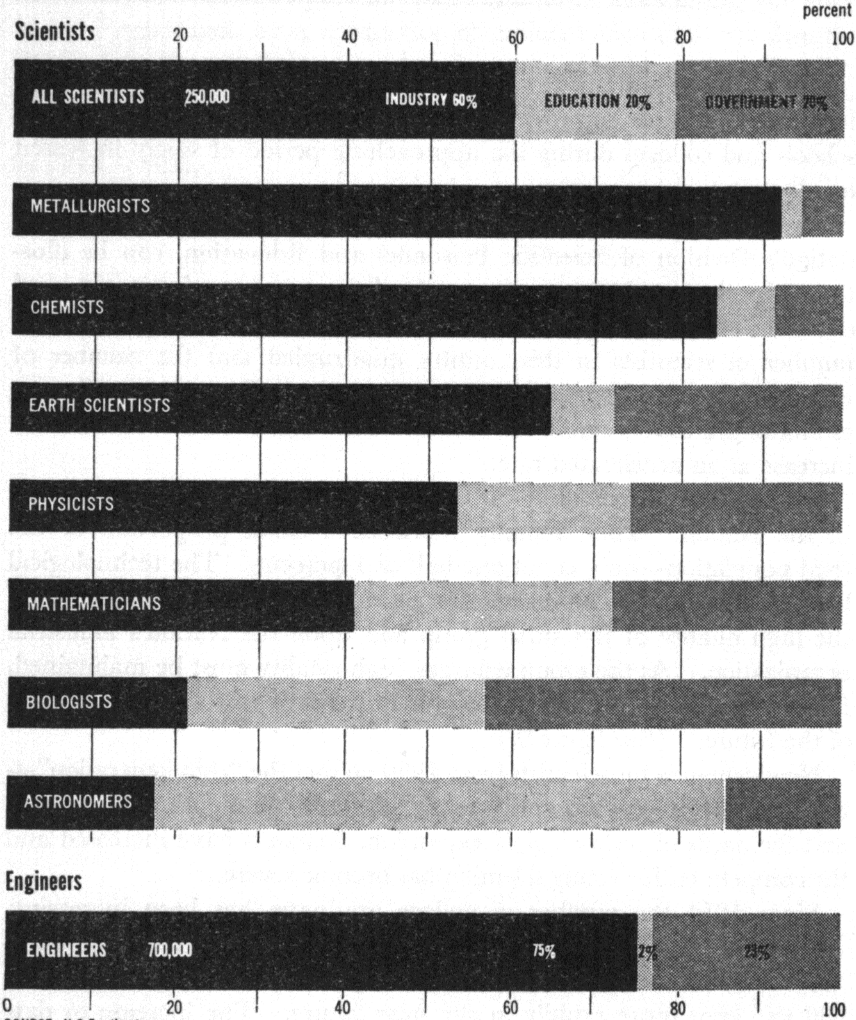
The nature of the problem, which is of primary concern to the Foundation's Division of Scientific Personnel and Education, can be illustrated by the magnitude and growth of the number of scientists and engineers in the United States. Between 1930 and the present, the number of scientists in this country quadrupled and the number of engineers doubled, while population increased 35 percent. Present estimates are that demand for scientists and engineers will continue to increase at an accelerated rate.

There are approximately 700,000 engineers and 250,000 scientists in the Nation. They actually represent a small proportion of the total population—only about one-half of 1 percent. The technological leadership which the United States has achieved depends primarily on the high quality of this small group and upon the Nation's industrial organization. As the group enlarges, high quality must be maintained, for creative scientists and engineers hold the keys to scientific advances of the future. (See figure 9.)

New demands for scientists from 1950 on met the "thin generation"—the small age groups born prior to the 1940's. With cold war pressures and the needs of technological expansion, demands have increased and the competition for young scientists has become severe.

Since 1954 the number of college graduates has been increasing. At present, our college population is higher than it has ever been. Moreover, all indications are that college and university enrollments will rise even more rapidly in the near future. The increase to date has resulted primarily from the great proportion of our young people attending college. In the 1960's the sharp rise in numbers that is likely to double enrollments will result primarily from the increase in postwar population reaching college age. (See figure 10.)

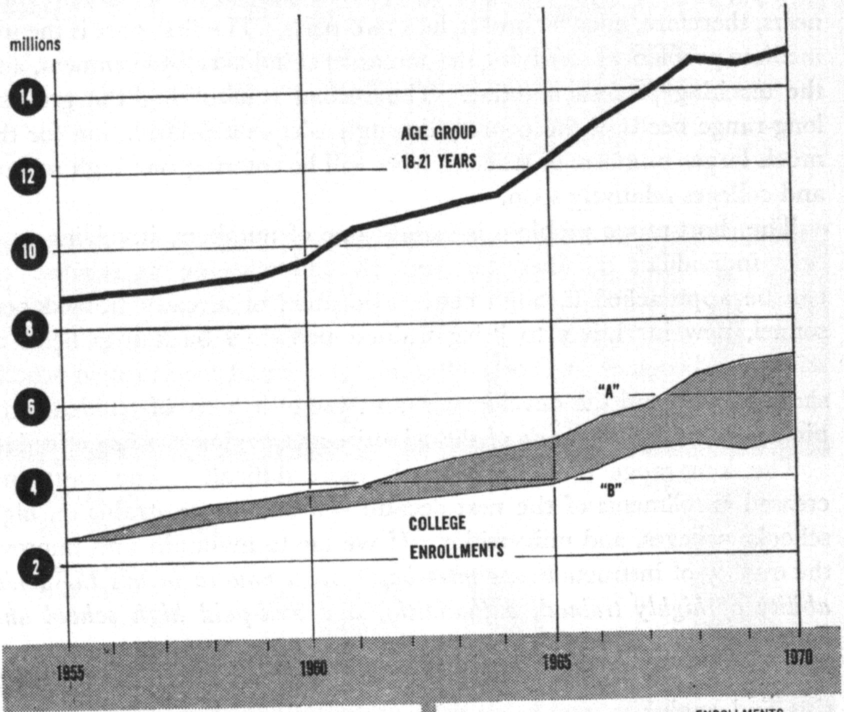
PRIVATE INDUSTRY EMPLOYS MORE THAN 1/2 OF OUR SCIENTISTS AND ENGINEERS




SOURCE: N S F estimates

**Figure 9.—*Distribution of scientists and engineers by type of employer.***

COLLEGE ENROLLMENTS IN FUTURE YEARS WILL GROW WITH THE INCREASE IN THE POPULATION OF COLLEGE AGE




| YEAR | AGE GROUP 18-21 | ENROLLMENTS "A" | ENROLLMENTS "B" |
|---|---|---|---|
| | Thousands | | |
| 1955 | 8,575 | 2,755 | 2,755 |
| 1956 | 8,774 | 2,996 | 2,839 |
| 1957 | 8,927 | 3,232 | 2,949 |
| 1958 | 9,055 | 3,450 | 3,041 |
| 1959 | 9,284 | 3,623 | 3,119 |
| 1960 | 9,581 | 3,778 | 3,221 |
| 1961 | 10,202 | 3,964 | 3,349 |
| 1962 | 10,664 | 4,212 | 3,568 |
| 1963 | 11,010 | 4,451 | 3,726 |
| 1964 | 11,220 | 4,657 | 3,853 |
| 1965 | 12,117 | 4,860 | 3,953 |
| 1966 | 12,901 | 5,346 | 4,295 |
| 1967 | 13,709 | 5,832 | 4,710 |
| 1968 | 14,457 | 6,318 | 4,725 |
| 1969 | 14,309 | 6,901 | 4,695 |
| 1970 | 14,512 | 6,949 | 4,905 |

SOURCES: U. S. Bureau of the Census, U. S. Office of Education, Fund for the Advancement of Education, and the National Science Foundation.

**Projection "A"—Based on estimated population increase and on a 1 percent annual increase in the rate of college attendance by the 18–24-year age group.**
**Projection "B"—Based on estimated population increase only.**

**Figure 10.—*Trends in population growth of the 18–21-year age group and in college enrollments.***

### A Two-Part Problem

The problem of providing an adequate supply of scientists and engineers, therefore, must be broken into two parts. The first part is the immediate problem of satisfying the demands of industry, government, and the teaching profession today. The second is satisfying the growing long-range needs of the country through adequate preparation for the much larger numbers of students who will be entering our high schools and colleges relatively soon.

The short-range problem is mainly one of numbers, involving as it does individuals qualified for research and teaching in science. It can be approached through better utilization of already trained personnel, new incentives to bring trained personnel back into fields of science and engineering, special training of essential specialists in acutely short supply, and the development and use of a body of trained technicians to make the work of the scientist and engineer more effective.

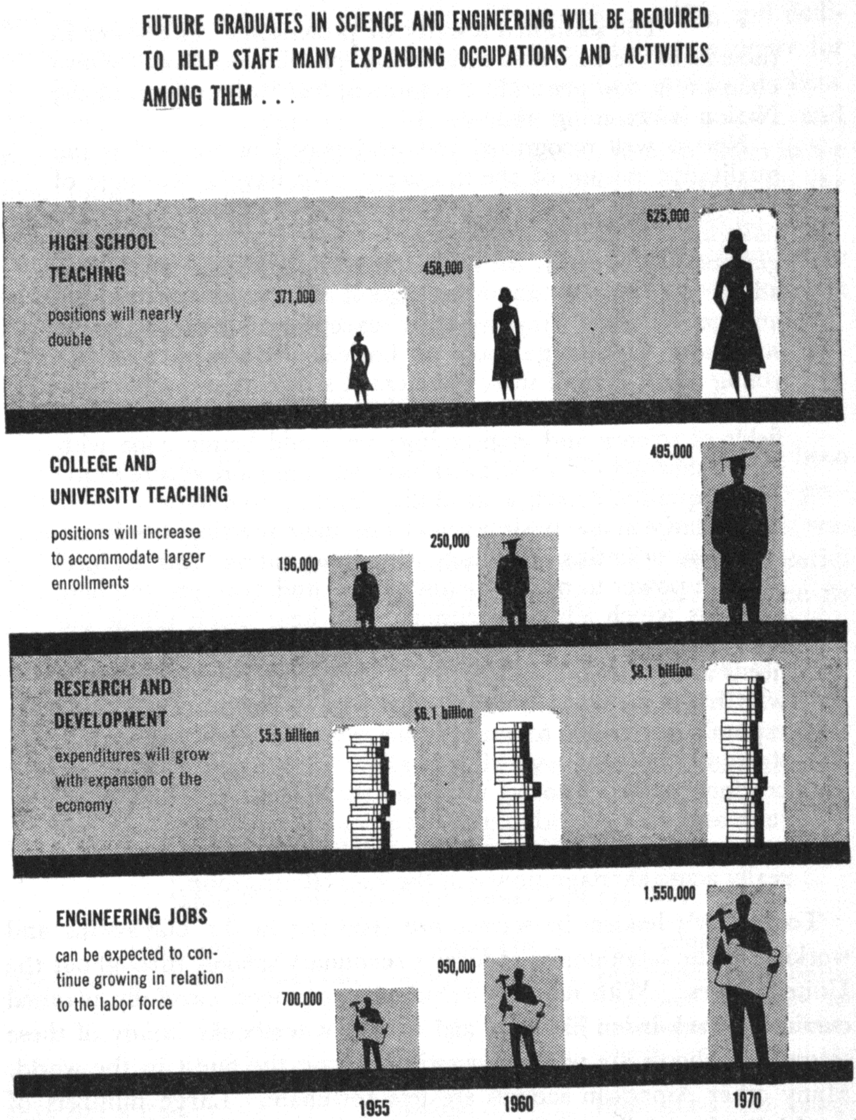
The long-range problem is much more difficult. The vastly increased enrollments of the next decade will put severe strains on high schools, colleges, and universities. If we are to maintain and improve the quality of instruction, *we must begin right now to insure the availability of highly trained, enthusiastic, and well-paid high school and college teachers.*

Although we cannot accurately measure long-range needs for scientists and engineers, much less predict their areas of specialization, we do know that such needs will develop. We must make sure that the oncoming supply of scientists and engineers keeps reasonable pace with increasing demand. If at any time it appears that demand will seriously outrun supply in particular specialties, consideration will have to be given to additional and perhaps more radical measures.

All evidence available today indicates that science and engineering are now attracting a gradually increasing proportion of our talented young people. Recent publicity emphasizing the needs of industry and government for more scientists and engineers, and the many special programs of various groups launched for the purpose of motivating more of our young people into science and engineering, appear to be reaching our most talented youth. This fact imposes an even greater obligation to provide these able students with proper facilities and able teachers.

Thus the problem of numbers, when attacked with vigor and imagination, will change its character by the middle of the next decade. The continuing problem will be to assure that the education available to our young men and women who choose careers in science is geared to their needs and talents as individuals and to the Nation's increasing dependence on science and technology.

The health of our own society and our ability and capacity to assume increasing responsibilities as a world power depend heavily upon the quality of science education throughout the country. (See figure 11.)




Source: National Science Foundation, *Trends in the Employment and Training of Scientists and Engineers*, 1956.

**Figure 11.—*Future need for science and engineering graduates.***

**Quality, Depth, Adaptability, and Up-To-Dateness**

The case for quality is set forth succinctly by James R. Killian, Jr., President of the Massachusetts Institute of Technology:

> * * * The sustained scarcity of professional manpower in these fields (science and engineering), having been widely proclaimed, is now generally recognized, and its handicap to the Nation is becoming understood.
>
> Not so well recognized and understood or stressed is the qualitative nature of the shortage. We have a shortage of young engineers competent to handle new, advanced technologies. We have a shortage of research scientists and engineers (the demand for whom has been doubling every decade). We have an acute shortage of scientists whose creative and conceptualizing powers are exceptional. We have, in summary, a shortage more of basically educated, versatile young talent than of mere numbers of scientists and engineers. There is indeed a shortage of numbers in many but not all fields of science and engineering; we could better cope with such a shortage did we not also have an even more severe shortage of quality, depth, adaptability, and up-to-dateness.
>
> Similarly in the basic sciences our most pressing needs are for those scientists who have the imagination and trained creative power to make the discoveries and generate the new concepts which advance science. We hear much about the need for more basic research and funds to support it. These needs are great, but greater still is the need for more scientists who have the trained talent, the motivation, and the conceptualizing power to make basic research really basic. In stressing the need—which has always been present—of exceptional talent, I do not minimize the critical shortage of the rank and file of good competent scientists. Flag officers are not enough to provide a strong scientific attack force, but the really acute shortage now is in the flag officer group.[1]

Tomorrow's leaders in science are studying in the classrooms and working in the laboratories of today's secondary schools throughout the United States. With modern technical equipment, carefully planned curricula, stack-laden libraries, and excellent textbooks, many of these secondary schools are without question among the finest in the world. Many other American schools are less fortunate. Large numbers of our high school laboratories must make use of antiquated equipment; students must study from outdated texts; too little relationship or continuity exists between high school and college science. Most serious of all is the fact that, of necessity, large numbers of our high school mathe-

[1] The President's Report, Massachusetts Institute of Technology, 1955.

matics and science students must be taught by teachers who, through lack of adequate training and in other ways, are not fully qualified for the task which they conscientiously are trying to perform. In the last analysis, teachers determine the quality of instruction. Able and dedicated teachers not only impart knowledge—they generate a desire for it. High quality in our future scientists requires high quality teachers. The present short supply of highly capable high school science and mathematics teachers, as well as the certain need for more of them in the near future, constitute the most critical and difficult problem in the effort to maintain an adequate supply of top quality scientists and engineers. No less important is the problem of staffing the science and engineering departments of the colleges and universities as they, too, are beginning to feel the impact of rapidly expanding enrollments.

## Summer Institutes for Science Teachers

The need for the improvement of science teaching has always been recognized as one of the major problem areas in the Foundation's program planning. After a period of careful study, an action program was launched in 1953 when the Foundation underwrote the first of a series of summer institutes for high school and college teachers. Since its inception, the summer institutes program has been praised by scientists and educators. Toward the close of the fiscal year 1956, the Foundation announced that it had completed arrangements for sponsorship of 25 institutes to be held during the summer of 1956 in universities, colleges, and other centers of research widely scattered across the Nation—14 more than were held in the summer of 1955. Information about the 1956 institutes is summarized in the table below.

***National Science Foundation Summer Institutes, 1956***

| *Host institution* | *Science area* | *Participants* |
|---|---|---|
| Wisconsin State College at Eau Claire | Astronomy | High school and college teachers (primarily for teacher-training instructors). |
| Indiana University | Biology | High school teachers. |
| University of Utah | Biology | High school and college teachers. |
| Botanical Society of America, at Cornell University. | Botany | College teachers. |
| Indiana University | Chemistry | College teachers. |
| Montana State College | Chemistry | High school and college teachers. |
| Oregon State College | Chemistry | College teachers. |
| Iowa State Teachers College | Mathematics | High school teachers. |

**National Science Foundation Summer Institutes, 1956—Continued**

| *Host institution* | *Science area* | *Participants* |
|---|---|---|
| University of Michigan | Mathematics | College teachers. |
| Williams College | Mathematics | High school and college teachers. |
| American Society for Engineering Education, at the Argonne National Laboratory (cosponsored with AEC). | Nuclear Energy | College teachers (engineering instructors). |
| American Society for Engineering Education, at the Brookhaven National Laboratory (cosponsored with AEC). | Nuclear Energy | College teachers (engineering instructors). |
| University of Arkansas | Natural Sciences | High school teachers. |
| American University | Physical Sciences | High school teachers. |
| Marshall College | Physical Sciences | High school teachers. |
| Oak Ridge Institute of Nuclear Studies. | Physical Sciences | High school teachers. |
| Oak Ridge Institute of Nuclear Studies. | Physical Sciences | College teachers. |
| University of Rochester | Physics | High school teachers. |
| University of Wyoming | Physics | High school and college teachers. |
| Duke University (cosponsored with AEC). | Radiation Biology | High school teachers. |
| Harvard University (cosponsored with AEC). | Radiation Biology | High school teachers. |
| University of New Mexico (cosponsored with AEC). | Radiation Biology | High school teachers. |
| Alabama College | Science | High school teachers. |
| Pennsylvania State University | Science | High school teachers. |
| Wesleyan University | Science | High school teachers. |

These institutes provided some 1,300 teachers with opportunities to attend science courses designed especially for them and conducted by scientists noted for competence in their fields and skill in presentation. Grants supporting the 1956 institutes provided instructional costs to host institutions as well as stipends and dependency allowances to participating teachers sufficient to defray costs of attendance. During 1957, some 95 summer institutes, serving about 4,750 teachers, will be held under Foundation auspices.

### Academic Year Institutes

During fiscal year 1956 a new and extended science-teacher-training plan was inaugurated—the academic year institute. Two grants were made in 1956, 1 to the University of Wisconsin and 1 to Oklahoma A. & M. College, to support academic year institutes for high school teachers of science and mathematics. Both institutes, to be conducted during the academic year 1956–57, will offer special courses of study in science and mathematics planned cooperatively by members of the science, mathematics, and education departments in the host institutions. Work in the courses designed for high school teachers may be applied in partial fulfillment of requirements for the master's degree. Grants provide for stipends of $3,000 to 50 teachers in each institute and additional allowances for dependents and travel.

Commenting editorially on the subject of the Foundation's program of institutes, the American Association for the Advancement of Science stated in Science, May 25, 1956:

> The summer institute program of the National Science Foundation, now extended at Wisconsin and Oklahoma A. & M. to include yearlong institutes, has made a major contribution in making available content courses for science and mathematics teachers. This is one of the most significant developments in teacher education in the past 20 years.

### Helping Teachers and Students of Science

Other activities designed to improve science teaching and to motivate youngsters toward science careers have been supported during the past fiscal year.

Adequate library facilities are not readily accessible to many small schools in outlying communities of the Nation. Better to serve the needs of students in these schools interested in science, an experimental traveling science library was supported as a joint project with the American Association for the Advancement of Science. Six boxes of 25 books each were carefully selected by competent scientists in the several fields of science. The boxes were rotated each month among several schools. Response has been favorable, and many additional high schools seek participation in the program.

Administered by the Oak Ridge Institute of Nuclear Physics, another project was assistance to science teaching in secondary schools. A group of selected high school teachers was given 3 months' training in Oak Ridge including the 4-week Oak Ridge Summer Institute for Secondary School Science Teachers. These teachers will spend the 1956–57 academic year traveling and giving lecture demonstrations in science classes at various high schools. Objectives of the program are to stimulate interest in science and in science teaching, to improve teaching methods, and to provide a greater number of secondary school students with a deeper appreciation of science and scientific careers.

The first Foundation-supported visiting scientists program was conducted by the Mathematical Association of America in the academic year 1954–55. Five eminent mathematicians were engaged for most of the year in weeklong visits to small colleges. The 70 colleges visited were unanimously of the opinion that the visitors provided a strong stimulus to students and teachers. This mathematics program was continued in fiscal year 1956, and, in addition, similar programs were initiated in chemistry and biology with the aid of grants to the American Chemical Society and the American Institute of Biological Sciences.

During fiscal year 1956, the Foundation awarded a grant of $40,000 to Science Service for partial support to extend the geographic area covered by the Science Clubs of America and to aid sponsors of science clubs to develop suitable materials for the use of young club members in pursuing their interest in science. Growth of science clubs in recent years and the continuing devotion of local citizens to activities of the clubs and science fairs indicate strongly that this work is greatly worthwhile in interesting youth in science.

Several conferences and colloquia held during the year served to bring together educators, scientists, and Federal officials who sought to improve science curricula and teaching methods. Notable were the Colloquium of College Physicists; the Conference on the Identification of Creative Scientific Talent; the Conference of Summer-Institute Directors; a conference of executive officers and educational committee chairmen of professional scientific societies designed to encourage the selection of technical careers and improve the training of talented students; and a conference on teacher education in the sciences sponsored jointly by the American Association for the Advancement of Science, the United States Office of Education, and the Foundation convened to exchange ideas on the improvement of science teachers, to explore ways to bring about better understanding between scientists and professional educators, to plan courses of cooperative action, and to consider possibilities for new ways of training science teachers.

### Call to Action

Programs designed to improve science teaching are directed toward the essential objective of increasing the numbers of well-trained scientists and engineers. In company with other parts of the science community, the Foundation has felt that unless forthright measures were taken, and taken speedily, growing shortages of well-qualified scientists and engineers would endanger the Nation's economy, its health, and its defenses. Institutions, private and public, colleges and universities, business and industry, trade and professional organizations, no less than the National

Science Foundation, had been watching with apprehension the declining percentages of students in secondary schools and colleges who elected basic courses in the sciences and mathematics.

In many quarters—in education, industry, and government—programs of action were initiated. The National Education Association and its affiliates, such as the National Science Teachers Association and the National Association of Biology Teachers, have actively participated in programs for improving science teaching. Many trade associations organized committees on education and community committees, and stimulated a general nationwide effort to encourage youth to pursue science careers. The National Association of Manufacturers, the scientific professional societies, including the American Chemical Society, and their affiliates and associates in industry and science encouraged members to assist in the effort. Great industrial organizations—General Electric, Du Pont, General Motors, and others—issued informative and challenging pamphlets and brochures pointing up their growing needs for well-trained scientific and technical manpower and the opportunities available to promising young men and women.

Congress further stimulated the national-alert effort by holding public hearings which served to crystallize public opinion as industrialists, educators, and Government officials testified to the growing need for well-trained scientists and engineers. The Joint Committee on Atomic Energy caused to be published in substantial quantity the pamphlet, *Engineering and Scientific Manpower in the United States, Western Europe and Soviet Russia,* and distributed it to all who were interested.

### Response

From secondary schools in communities across the Nation there came reassuring evidence during fiscal year 1956 that increasing numbers of students were enrolling in science courses. In May 1956, the American Association for the Advancement of Science was able to report that the "downward trend in science and mathematics had ceased and enrollments in these courses are increasing at a faster rate than total enrollments." Guardedly, the AAAS prefaced its report with an "if"—if the results of its survey of secondary school enrollments, 1953–55, covering 1.15 million students in 39 States and 80 school systems were representative of the Nation, then the "downward trend" had indeed come to an end. The sampling was large enough, however, to give substance to a belief that a greater proportion of our youngsters were indeed choosing courses in science and mathematics—something of a breakthrough in itself, and most encouraging manpower news to the science community.

**Fellowship Aid**

Having contributed, with industry and the educational community, toward stimulating youth to pursue science careers, the National Science Foundation seeks, as well, to provide opportunities which will carry talented youth, who have already chosen science as a career, to the highest levels of training in engineering and science. This objective has been met successfully through the predoctoral and postdoctoral fellowship program. The aim of the predoctoral program is to seek out the most able science students interested in training beyond the baccalaureate degree and to afford them an opportunity to spend full time at the institutions of their choice and in the type of training they desire so that each fellow can develop his potentiality as a scientist to the fullest. (See figure 12.)

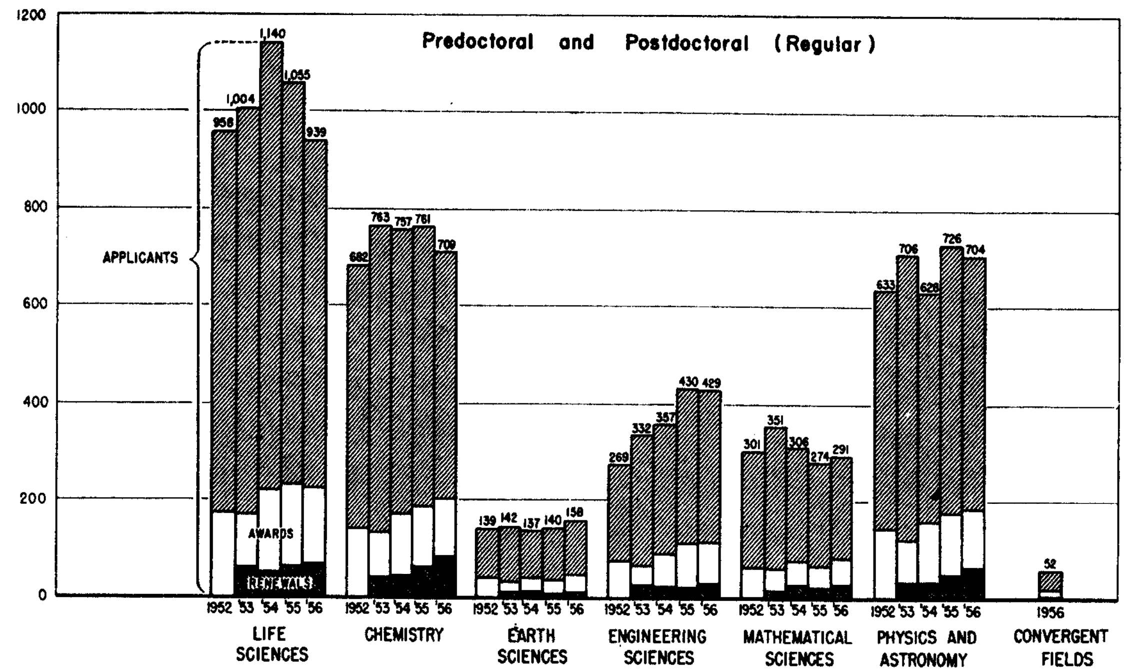



***Figure 12.—Pre- and post-doctoral fellowships awarded by the National Science Foundation by field of science, fiscal years 1952–56.***

During the past fiscal year, the Foundation inaugurated a new fellowship program—the senior postdoctoral program—designed to satisfy the need for support for more advanced and mature scientists than those who have but recently received the doctorate. Forty such fellowships were granted during this first year. Specific objectives of the senior postdoctoral program are:

1. To provide opportunities for scientists who have demonstrated superior accomplishments in a special field to become still more proficient in their respective specialty by studying and doing research in outstanding laboratories.

2. To provide opportunities for scientists who wish to do so to study and undertake research in fields of science complementary to those in which they were trained, thus raising the level of our scientific potential by assuring increased recognition of, and competence in, interdisciplinary fields of science.

3. To enable teachers of science to spend a year in revitalizing their teaching through study and research at a center where these persons will be in daily contact with productive scientists.

In recent years, increasing recognition has been given to the importance of breaking down artificial barriers between fields of science and to the need for interdisciplinary training. The interdisciplinary areas, however, have suffered because most of those currently working in science received a type of advanced training which is poorly suited to the specific requirements of the interdisciplinary approach. Hence, in addition to providing advanced training opportunities in the traditional disciplines, the senior postdoctoral fellowship program provides an opportunity for competent persons to obtain complementary training in fields related to but somewhat outside their own specialty.

On March 15, 1956, the Foundation announced the award of 775 predoctoral graduate fellowships and 80 postdoctoral fellowships for advanced study in the natural sciences for the academic year 1956–57. Forty senior postdoctoral awards were announced on March 20. The number of applicants and awards by State and region, a complete list of fellowship holders, and a list of institutions attended by the fellowship holders as undergraduate and graduate students is given in the table in appendix D, p. 152.

## National Register of Scientific and Technical Personnel

Quantity and quality of science manpower become meaningful as a national resource in the end product of a third program of the Division of Scientific Personnel and Education—registration of, and information about, United States scientists and engineers. With support from the Foundation, the Nation's professional organizations of scientists and engineers cooperate in the establishment and maintenance of the National Register of Scientific and Technical Personnel. Serving the Nation as a focal point for data on numbers and kinds of scientists, the Register is a device for mobilization whereby scientific and technical personnel may be identified and located quickly under conditions of national emergency. It is also a source for the development of data covering the Nation's scientific and technical manpower resources from the standpoint of supply and characteristics. Approximately 140,000 scientists and engineers are now included in the Register and as many as 200,000 are expected to be included on the basis of present standards of coverage.

### Clearinghouse Activities

Utilizing the data about United States scientists and engineers from the Register and other sources, the Clearinghouse for Scientific Personnel Information acts as a central point for the collection and dissemination of information about scientific and technical personnel with reference to training, employment, supply, and demand. Data necessary for an understanding of the adequacy of present and potential supply of science manpower range from relatively abstract psychological problems of creativity to practical questions of numbers now employed in research and development as against estimates of science manpower needs 10 or 15 years from now under a variety of possible conditions. Prior to establishment of the Clearinghouse, there had been no focal point in the Federal Government where such comprehensive data could be obtained. The factbook, *Scientific Personnel Resources,* prepared by the Clearinghouse, summarizes data on the supply, utilization, and training of scientists and engineers. It quickly established the Clearinghouse as an authoritative center for information of this type.

Other publications issued or supported by the Clearinghouse during fiscal year 1956 served as measurements of United States science-manpower resources. They include:

1. *Education and Employment Specialization in 1952 of June 1951 College Graduates,* the report of a survey by the Foundation of a sample of 50,000 college graduates of June 1951 in all fields.
2. *Baccalaureate Origins of Science Doctorates Awarded in the United States, 1936–50,* the report of the "Doctorate Survey" which has been supported by the Foundation for a number of years. The surveys, preparation of the report, and publication were performed by the National Academy of Sciences-National Research Council under financing by grant.
3. *Trends in the Employment and Training of Scientists and Engineers,* prepared primarily for the use of the National Committee for the Development of Scientists and Engineers. It contains a brief summary of trends in the growth of scientific and technological employment in the labor force, the current situation with regard to the employment and training of scientists and engineers, the outlook with regard both to educational trends and anticipated needs for scientists and engineers.

4. *Highlights of a Survey of Graduate Student Enrollments, Fellowships, and Assistantships, 1954* (Scientific Manpower Bulletin No. 5), containing preliminary information from a survey conducted by the Foundation.

5. *Shortages of Scientists and Engineers in Industrial Research* (Scientific Manpower Bulletin No. 6), containing information from a series of interviews with industrial executives on scientific manpower shortages by the Bureau of Labor Statistics in connection with a larger survey of scientific activity in industry for the Foundation.

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Time saved for scientists in searching out what is already known is time they can actively spend on research. Improvement in the communication of scientific information is reflected in improved use of scientists' time—in effect, equivalent to an increase in the number of scientists available. The National Committee for the Development of Scientists and Engineers, appointed by President Eisenhower, has noted that "a 10-percent improvement in the utilization of engineers would be equivalent to a 10-percent increase in the supply."

### Scientific Information Services in the United States

Reference publications in the United States have been built up over a period of many decades, primarily by the scientific societies. Some fields are very well served by large, comprehensive abstracting services in English. Chemistry, for example, is thoroughly covered by *Chemical Abstracts*. In some other fields a multiplicity of services do part of the job, but coverage is not complete. For example, in biology, the largest service, *Biological Abstracts,* covers not more than 10 to 20 percent of the literature, and many smaller specialized services try to do other parts of the job. Still other fields of science are not covered at all in English by periodic reference services. Geophysics is an example. Nearest approach to adequate coverage of geophysics in any language has been achieved by the Institute of Scientific Information of the U. S. S. R. These examples indicate the complexity of the problem of providing adequate scientific information services where a unified national service is not provided.

### Role of the Foundation

Axiomatic in the scientific community is the statement that no piece of research is complete until it is published. As the pace of scientific research accelerates and scientific publications multiply, it becomes increasingly difficult for a scientist to learn about and obtain access to everything that is published in this field. Accordingly, the Foundation is trying to make it easier for scientists to locate and acquire the published results of research. Specifically, the objective of the Office of Scientific Information is to ensure that any United States scientist can obtain any item of unclassified scientific information he needs, no matter where it originates, and to develop improvements in the organization and availability of scientific information on behalf of all United States scientists.

Published results of scientific research are obtainable from many sources, private and public, at home and abroad. It is most important that significant scientific research publications, whether published in Great Britain, Sweden, Russia, or any other nation of the world, be identified, obtained, translated, if necessary, and distributed to interested scientists in the United States. Similarly, unpublished reports from university laboratories, industry, and the Federal Government are an important medium of scientific communication. The Office of Scientific Information is conducting programs to make such reports more readily available. Additionally, this office seeks to open new, and to keep open existing, channels of communication among scientists through partial support of scientific journals and reference aids and through the support of research directed toward more efficient organization, processing, and storing of information for rapid search.

**Documenting the Results of Scientific Research**

Improved methods of storing and searching for scientific information will release valuable time for scientists to pursue creative research. A promising approach is the mechanization of systems to store and recover science information. Although the electronic computers developed in recent years are incredibly rapid in processing numerical data, systems for indexing and classifying scientific information which take advantage of machine capabilities remain to be developed. Here the study of language becomes important, because it is necessary to convert the conventional language in which information is usually printed into a more regularized machine language and it is desirable to do this mechanically. Of course, language studies are also basic to the development of systems for mechanical translation from one conventional language to another. The Foundation is supporting language studies directed toward mechanical translation at the Massachusetts Institute of Technology and at Georgetown University.

In an effort to review research on information problems and to identify areas where additional research is needed, the Foundation supported in May 1956 a meeting of representatives of the Department of Defense, the National Bureau of Standards, and the Patent Office, as well as experts drawn from such fields as linguistics, logic, information theory, operations research, computer design, and library science to discuss the need for additional fundamental research on the organization of information and the contribution that might be made by the several fields represented. During the fiscal year, the Foundation supported, as well, a feasibility study at the Case Institute of Technology, Cleveland, to determine whether the methods and techniques of operations research could be applied to the area of scientific communication to bring about increased understanding of the entire pattern of information exchange among scientists and to point up those components of the system in greatest need of attention.

### Support for Scientific Publications

Until better documentation methods have been developed, however, the Foundation continues to support sound projects designed to make as effective as possible existing publications and reference services required by research scientists. All scientific publications seeking Foundation support are first evaluated by competent scientists in the particular field. Only those deemed especially important for the progress of research in that field are supported. The Foundation's program in support of scientific publications is designed to carry scientific journals and reference tools through genuine emergency periods and to help publish scientific monographs or reference volumes which could not be published without partial support.

Direct emergency support was granted during fiscal year 1956 to the Transactions of the American Mathematical Society and to two new scientific journals in the fields of forest science and of limnology and oceanography. The American Mathematical Society has reported that the extra volume of the *Transactions* made possible by the Foundation grant has speeded up publication of important mathematical discoveries, thus benefiting the whole course of mathematical research in the United States. *Forest Science,* one of the new journals, completed its first year of publication with some 900 subscribers and with no operating deficit. In this instance, the support of the Foundation was actually an agreement to underwrite any deficit encountered up to a certain amount in each of the first 3 years of publication; it has therefore required no Government funds to date and quite possibly none will be needed.

With respect to scientific reference publications, the Foundation provided financial assistance to important abstract journals, such as *Biological Abstracts* and *Applied Mechanics Reviews.* Support to *Biological Abstracts* was contributed jointly by a number of Federal agencies engaged in biological research and enabled the journal to bring its annual indexes up to date with the 1955 volume, thus making the published abstracts more accessible.

During the past year the Foundation has supported a number of more specialized reference aids and services:

1. A critical compilation of crystal data by the American Crystallographic Association.
2. The analysis and correlation of visual observations of variable stars by the American Association of Variable Star Observers.
3. A punched card catalog of double star measures at the Lick Observatory.
4. The Chemical-Biological Coordination Center of the National Research Council.

In most instances where the Foundation supports publication of indexes, catalogs, and other highly specialized tools, the work of compiling the information has already been done. Foundation assistance simply makes publication possible.

### Making Federal Research Results More Accessible

More than 20,000 unclassified scientific reports constitute the first appearance in print of much of the newest and most significant scientific information developed today when issued each year by the hundreds of organizations engaged in Government-sponsored research. The Office of Scientific Information of the Foundation began, during the past fiscal year, to help make this storehouse of research information as available to scientists everywhere as are papers published in conventional scientific journals. For several reasons this program contributes importantly to the progress of United States science:

1. Significant data in a sizable fraction of the reports either never are conventionally published or do not so appear for several years (one study of approximately 1,100 reports showed that for fewer than half were the important contents fully published within 2 to 3 years).
2. Drastic condensations required for journal publication make necessary continuing availability of complete reports.
3. Access to negative results, and other data not acceptable to journals, are important in avoiding undesirable duplication of research efforts.
4. No existing service fully meets the information needs of the scientists pursuing basic research.

Its program for improving the accessibility of this significant Government-supported research is being developed by the Foundation in three phases, each of which is keyed to using the facilities of existing Federal establishments. In the first instance, the Foundation now partially supports the Office of Technical Services (OTS) of the Department of Commerce in the interest of helping the research scientist learn what reports are being issued and how he may obtain copies of those which interest him. For several years, the OTS has published the monthly abstracting journal, *United States Government Research Reports,* offering for sale all documents listed therein. Prior to fiscal year 1957, the OTS announcements have been predominantly reports of interest to industry. Foundation support now enables it to give comprehensive coverage, as well, to reports on basic scientific research.

Secondly, the Foundation now provides partial support for a report-reference project in the Science Division of the Library of Congress, making it possible for a research scientist to consult specific reports of interest to him. Here, open card and book catalogs are maintained covering unclassified scientific reports on Government-sponsored research. Any scientist may use these catalogs and have made available for his review copies of any report cataloged.

Finally, the Foundation has established within its Office of Scientific Information, a Government Research Information Clearinghouse which provides the research scientist with general counsel and assistance in his quest for information regarding Government-sponsored research in his subject field. Experienced in report reference work, the Clearinghouse staff helps scientists find out where research is going on within Government in any given field; whether scientific reports in any area have been or are being issued; and how copies of desired reports can be obtained. An important aspect of the Clearinghouse program is the preparation and maintenance of an inventory of scientific-information activities in the Federal Government.

### Importance of Research of Other Nations

To the research scientist in a particular field, the results of research achieved by his colleagues abroad are as important to him as those achieved by his associates at home. If he is satisfied that a particular area of his field has been competently explored, whether in Chicago, Moscow, or Paris, he can with assurance begin to attack the problem from other approaches. Well-integrated support of basic research, therefore, must include an active program to place in the hands of United States scientists the best of foreign research in the language in which they work—English. Consensus among the scientific community is that much of the published research of the U. S. S. R. is potentially most valuable to United States science. During the past fiscal year, the Foundation supported a sizable program of translation of Russian research publications in physics, mathematics, and biology.

The Russian *Journal of Experimental and Theoretical Physics* began to appear early in fiscal year 1956 in complete translation under the title, *Soviet Physics—JETP.* Published and sold through subscription by the American Institute of Physics, with Foundation support, the journal received rapid acceptance. By the end of the fiscal year, the subscription list had grown to 700. During fiscal year 1957, it will bring to its subscribers some 2,600 pages of translated material at approximately the cost of an individual translation of 10 to 12 pages. Judging from the reception by physicists of *Soviet Physics—JETP,* and its decreasing cost to the taxpayer as its subscription list increases, carefully chosen journals in complete translation are an effective tool in the dissemination of foreign research information.

During the latter part of fiscal year 1956, the Foundation awarded a grant to *Biological Abstracts* for translating and publishing 1,200 abstracts from the Russian biological abstracting journal, *Referativnyi Zhurnal: Biologiia.* A selection from 31 primary Russian journals will be covered in an attempt to evaluate the effectiveness of translating abstracts while, at the same time, increasing the awareness of Russian biological science.

A grant to the American Mathematical Society was renewed to enable the society to continue its publication of 1,000 pages annually of translations of selected papers from a broad range of original Russian sources.

Because of the early success of the first journal translation project, a grant was awarded towards the end of fiscal year 1956 to enable the American Institute of Physics to begin publication of three additional Russian journals: The *Journal of Technical Physics,* the physics sections of the *Proceedings of the Academy of Sciences of the U. S. S. R. (Doklady), and the Journal of Acoustics.* Since the physics section of the Bulletin of the Academy of Science of the U. S. S. R. and the Russian journal, *Atomic Energy,* are already being published commercially, it is felt that the current physics translation program is now covering the most essential journals. Possible further expansion of the program will await reactions of physicists to presently available journals.

Although an intensive translation program, typified by the projects described, is new in the United States, translation of separate articles, short books, and similar material has always been an important part of the information research of scientists. In this context, the Foundation continued to support during fiscal year 1956 the work of the Russian Scientific Translation Center of the Library of Congress. The center now holds about 4,000 translations in many fields of science and technology, given or loaned to the Library. Their availability is announced through a monthly bibliography, 817 copies of which are widely distributed. Microfilm or photostat copies are sold by the Library at a moderate price. During fiscal year 1956, nearly 1,500 copies of translations were ordered from the center by scientists, libraries, students, and others.

### Attendance of American Scientists at International Scientific Meetings

Personal contact between the leading scientists of the world stimulates thinking and promotes the exchange of scientific ideas and information, thereby accelerating scientific progress. To encourage such face-to-face contact, the Foundation provided, during fiscal year 1956, a limited number of grants for partial payment of travel expenses to enable American scientists to participate in selected international scientific meetings.

### Keeping the Public Informed

Current, authoritative information about scientific programs of the United States Government must be available to all United States citizens to enable them to understand measures advocated by the Congress, scientists, educators, and industrialists aware of the implications of danger to the economy and defense of the United States resulting from lack of substantial American accomplishment in basic scientific research, need for well-qualified secondary-school teachers of science courses, shortages of scientists and educators in many fields, and the portentous advances of Soviet technology. This fact was pointed up sharply by President Eisenhower, in April 1956, when he established the National Committee for the Development of Scientists and Engineers. In his charge to the Committee, the President said: "It is my hope that the Committee will publicize the problem and possible solutions in order to stimulate public understanding and support." Public understanding of the economic and social significance of science in the United States is measurably improved as the great newspapers and magazines of the Nation give wider coverage to science in news and feature columns. During the past fiscal year the Foundation provided substantial services to an increasing number of science writers and editors employed by the press and magazines to help carry the science story to the public.

# CONFERENCES IN SUPPORT OF SCIENCE

Support of conferences and symposia which bring together leading scientists is a key function of the National Science Foundation. These meetings provide a forum for the exchange of information and ideas among scientists who are pioneering in new or incompletely explored fields. They also furnish opportunity in many cases for younger scientists to learn and obtain advice from some of the world's outstanding senior scientists. Frequently the subject matter is of an interdisciplinary nature of interest to scientists in several fields.

The National Science Foundation sponsored and provided partial support for a total of 29 conferences in support of science during the year ending June 30, 1956—most often in cases where adequate support was not otherwise available. In all instances sponsorship was shared with one or more private or public agencies, including universities and scientific societies.

To insure wide distribution of conference subject matter, proceedings and papers are frequently published by the sponsors. Normally the request for support of conferences originates with scientists working in the field under review.

An idea of the wide range of subject matter covered by these 29 Foundation-supported conferences can be obtained from the brief descriptions which follow.

### Scientific Conferences Sponsored and Supported by The National Science Foundation in Year Ending June 30, 1956

| *Subject* | *Cosponsoring Organizations* | *Chairman* |
|---|---|---|
| Metabolic Aspects of Transport Across Cell Membranes. | University of Wisconsin | Q. R. Murphy. |
| Tissue Elasticity | Dartmouth College | John W. Remington. |
| Nuclear Geophysics | National Academy of Sciences-National Research Council, Pennsylvania State University. | P. M. Hurley. |
| Recent Advances in Invertebrate Physiology. | University of Oregon | Bradley T. Scheer. |
| Microneurophysiology of the Synapse. | University of Washington | Theodore C. Ruch. |
| Fourth National Clay Conference. | National Academy of Sciences | T. F. Bates. |

**Scientific Conferences Sponsored and Supported by The National Science Foundation in Year Ending June 30, 1956—Continued**

| *Subject* | *Cosponsoring Organizations* | *Chairman* |
|---|---|---|
| World Symposium on Applied Solar Energy. | Association for Applied Solar Energy, University of Arizona, Stanford Research Institute. | F. E. Roy. |
| Systematics | Missouri Botanical Garden | Rolla M. Tryon, Jr. |
| Problems of Research Administration in University Physics Departments. | Yale University | W. W. Watson. |
| Application of Mathematics to Engineering. | American Society for Engineering Education, California Institute of Technology, University of Michigan. | F. C. Lindvall; G. G. Brown, cochairman. |
| Molecular Quantum Mechanics. | University of Texas | F. A. Matsen. |
| Low Temperature Research. | Louisiana State University | J. G. Daunt. |
| Theoretical Geophysics | Carnegie Institution of Washington. | J. von Neumann. |
| Chemical Reactions in Urban Atmospheres. | Air Pollution Foundation, American Petroleum Institute. | L. H. Rogers. |
| Fourth International Congress on Physical Optics. | American Academy of Arts and Sciences, Optical Society of America, National Academy of Sciences-National Research Council, International Union of Pure and Applied Physics. | S. S. Ballard. |
| High Energy Nuclear Physics. | University of Rochester, Atomic Energy Commission, Air Research and Development Command. | R. E. Marshak. |
| Cosmic Distance Scale | University of Virginia | H. L. Alden. |
| Quantum Interaction of the Free Electron. | University of Maryland | L. Marton. |
| Recording Sounds Produced by Animals. | Pennsylvania State University | Hubert Frings. |
| Science and the Modern World View. | American Academy of Arts and Sciences. | Ralph W. Burhoe. |
| Third National Pollen Conference. | American Geographical Society | Calvin J. Heusser. |
| Evolution of Behavior | American Psychological Association, Society for the Study of Evolution. | Anne Roe. |
| Metabolism of Mucopolysaccharides. | Retina Foundation | Endre A. Balazs. |
| Spectroscopy | Ohio State University, Office of Naval Research. | Harold H. Nielsen. |
| Quantitative Biology | Long Island Biological Association. | M. Demerec. |
| Developmental Biology Workshop. | National Academy of Sciences-National Research Council. | Paul Weiss. |
| Earthquake Engineering | Earthquake Engineering Research Institute, University of California. | George W. Housner. |

**Scientific Conferences Sponsored and Supported by The National Science Foundation in Year Ending June 30, 1956—Continued**

| *Subject* | *Cosponsoring Organizations* | *Chairman* |
|---|---|---|
| Second International Congress on Acoustics. | International Commission on Acoustics, the Acoustical Society of America, Office of Naval Research, Office of Scientific Research-Air Force, Department of the Army-Office of the Surgeon General. | R. H. Bolt. |
| High Temperature........ | University of California, Stanford Research Institute, Office of Naval Research, Office of Scientific Research-Air Force, Office of Ordnance Research. | Leo Brewer, Nevin Hiester, Alan W. Searcy (joint chairmen). |

## Metabolic Aspects of Transport Across Cell Membranes

Because of the increasing interest in problem of transport across cell membranes, it was felt that a symposium dealing with the metabolic aspects of such transport would be of great value. The symposium, held during August 1955 at the University of Wisconsin, was attended by leading biochemists, cell physiologists, and physical chemists who helped to bring together the large mass of widely scattered data on isolated cells and tissues; it permitted an appraisal of the application of this data to the whole animal.

## Tissue Elasticity

Many important physiological and medical problems are dependent for their solution on our understanding of the factors which control and alter the elastic behavior of living tissues—lungs, gastrointestinal tract, blood vessels, and muscles. To further this understanding, a conference was held at Dartmouth College in New Hampshire, during September 1955. Attending were 25 leading investigators from various fields who have experience in this area. Included were physiologists, high polymer physicochemists, protein chemists, and even physicists.

## Nuclear Geophysics

The application of the approaches and techniques of nuclear physics to geological research has a vast potential as has already been demonstrated. Therefore this conference was convened to encourage further the development of fields of study which could make use of these tools in attacking problems of both nuclear physics and geology. Subjects covered included: natural variations of isotope ratios; induced natural radioactivity and natural fission; nuclear constants of interest to geophysics; evaluation of methods of geologic age measurements; and elemental abundancies.

About 40 scientists attended this conference which was held during September 1955 at University Park, Pa.

### Recent Advances in Invertebrate Physiology

About 50 leading investigators attended this conference which was held at the University of Oregon during September 1955. Topics discussed included: sensory and regulatory mechanisms; postural and effector systems; and maintenance systems. Also discussed were such subjects as the physiological basis of time measurement in organisms.

### Microneurophysiology of the Synapse

One of the main problems in the field of neurophysiology is the mechanism whereby excitation travels from one cell to another via the synapse, the functional union or point of contact between neurons. Recent development of new techniques and instruments has opened new avenues of approach to the problem and permitted the collection of new data. This conference of leading investigators of these new and sometimes divergent developments in synaptic physiology was held in Seattle during October 1955 to accelerate progress in this important area of neurophysiology.

### Clay

Prominent scientists from Spain, Belgium, Germany, Japan, Australia, England, and France attended the Fourth National Clay Conference which was held at the Pennsylvania State University during October 1955. They presented reports on their own research as well as on that of their colleagues in the countries they represented. Three of the sessions were in the form of symposia on Thermal Transformations, Clay-water Relationships, and Mixed-layer Clays; a total of 42 technical papers were presented during these sessions.

### Applied Solar Energy

This World Symposium was held at the University of Arizona in Phoenix during November 1955. More than 1,000 scientists, engineers, educators, and industrialists from 36 nations heard 120 reports and papers. The sessions opened wth a paper dealing with the problem of harnessing the sun's energy; closed with a round table discussion on the future of applied solar energy; and included papers and discussions dealing with the economics of solar energy, solar machinery, high-temperature furnaces, solar stills, the residential uses of solar energy, and photochemical processes for food production. The Proceedings have been published in a volume containing the complete text and illustrations of the papers presented. The Foundation supported the basic research portion of the symposium.

### Systematics

This symposium was attended by approximately 70 scientists for a free exchange of opinions and ideas on the botanical and zoological problems which relate to taxonomy. It was held in St. Louis during November 1955 and was of special interest to taxonomists because of the manner in which their field of interest impinges upon such fields as morphology, genetics, cytology, and evolution. The meeting had the additional advantage of permitting the participation of young investigators and those researchers attending small midwestern colleges, thus stimulating their interest in pursuing further their careers as investigators.

### Problems of Research Administration in University Physics Departments

Although many opportunities are available for university physicists to meet and discuss scientific subjects, there is little opportunity for administrators of physics as well as other science departments to discuss serious policy questions that confront the heads of such research departments.

This conference was held in New Haven during November 1955 and covered many of these administrative problems. Problems discussed included: the effect of modern team research on research training; more effective methods for identifying promising research men among graduate students; and more effective use of young Ph. D. research associates. It is expected that this conference will strengthen the teaching and research carried out in this country, especially in those newer departments that have sprung up since 1946.

### Application of Mathematics to Engineering

Applied scientists and engineers can fully utilize the newly discovered phenomena of pure science only if they have an excellent knowledge of mathematical tools and theory. It was therefore considered desirable to bring together engineers, mathematicians, and physicists from both industry and the educational field for an interchange of ideas on the application of mathematics to the various engineering fields, for an assessment of the present and future mathematical requirements of engineering, and for a discussion of the present and future mathematical emphasis of both undergraduate and graduate curricula in engineering. This conference was held in two sessions. The first, at the California Institute of Technology during November 1955, and the second, at the University of Michigan during June 1956.

### Molecular Quantum Mechanics

The December 1955 conference at the University of Texas brought to this country a group of foreign scientists who joined with American chemists and physicists in discussing recent advances in the quantum theory of molecules. The meeting was especially profitable in advancing the work on valence bonds and molecular energy states in which computing machines are used.

### Low Temperature Research

Physicists, chemists, and engineers working on problems such as liquid helium, superconductivity, and specific heats near absolute zero, were brought together at this conference which was held in December 1955 at Louisiana State University. The conference enabled scientists who have developed new low temperature techniques to have a concentrated discussion on recent progress in the field.

### Theoretical Geophysics

This conference was attended by about 60 scientists in Washington, D. C., during February 1956. Among the subjects discussed was that of determining the present needs in theoretical geophysics. Also discussed was the analysis of geophysical data which will result from activities during the International Geophysical Year and the possible creation of an Institute for Theoretical Geophysics.

**Chemical Reactions in Urban Atmospheres**

Held at the University of California in Los Angeles during February 1956, this conference was attended by about 30 chemists, physicists, and engineers, who reviewed the basic knowledge of photochemistry and the kinetics of gaseous reactions as it applies to the chemical aspects of smog formation and air pollution. The conference proceedings will be published.

**Physical Optics**

Significant review papers on subjects related to optical methods in nuclear physics, nuclear magnetic resonance, and polarization and meteorological optics were presented at the Fourth International Congress on Physical Optics. The conference, which was held at Massachusetts Institute of Technology from March 28 to April 3, 1956, brought together a large number of scientists from a number of countries to exchange ideas on advances in the field of optics.

**High Energy Nuclear Physics**

The Sixth Annual Conference on High Energy Nuclear Physics at the University of Rochester in New York State was enlarged this year both in the number of attendees and the duration of the meeting. Approximately 200 scientists attended and discussed recent advances in high energy physics for 5 days during April 1956. The Rochester conference this year, as before, was the outstanding conference on high energy nuclear physics in the world. Discussions centered around recent advances in theoretical and experimental physics with emphasis on the interaction of elementary particles. For the first time since the start of these conferences, three scientists from the U. S. S. R. were in attendance.

**Cosmic Distance Scale**

This conference, held at the University of Virginia in April 1956, brought together astronomers ranging from those who measure the distances of the nearest stars by geometrical means (i. e., triangulation) to those who determine more indirectly distances of remote galaxies. The latter depend on the former for their eventual calibration. The extraordinary pains that must be taken to avoid or to correct for systematic errors of the minute displacements that are measured in the geometric method were thoroughly discussed. The intermediate steps between the small and the large distances were critically examined. The recent (August 1952) doubling of the scale of large distances was discussed, partly from the view of hindsight and partly from the standpoint of how to insure greater accuracy in the future.

### Quantum Interaction of the Free Electron

This conference was held at College Park, Md., during April 1956 and was the first on this basic theme to be held in the United States. It brought together world leaders working on various phases of the problem of quantum interaction of free electrons. Subject matter discussed included: electron scattering, electron energy losses, positron interactions with matter, electron interference phenomena, and electron polarization effects. About 100 scientists attended.

### Recording Sounds Produced by Animals

Printed words do not convey a true idea of animal sounds, much less of the cries of bats or underwater signals of fish or mammals. Therefore, there is a need for recordings which can be made available to interested scientists. This need led to the convening of a conference at University Park, Pa., during April 1956 for the purpose of laying the groundwork for international coordination of research work in auditory communication among animals. It initiated the development of standards for a reference library of animal sounds which could be used by investigators in the field of animal behavior.

The conference was attended not only by scientists in this field but also by industrial recording engineers who gave the benefit of their technical advice.

### Science and the Modern World View

This conference was held in Boston during May 1956, and was concerned with the role of science in developing new perspectives of the universe and with the interrelations of the natural sciences, the social sciences, and the humanities. The three major questions discussed were: (1) In what manner did Newtonian science influence our picture of the world? (2) Has modern science changed the basic concepts on which our present world view was built? (3) What are possible steps toward a new synthesis of science and the humanities in a common understanding? Invited participants represented many schools of thought.

### Pollen

Some 40 scientists, including geologists, botanists, and zoologists, interested in pollen and other microfossils as environmental indicators during past ages, attended this Third National Pollen Conference at Oberlin College, Oberlin, Ohio, held during May 1956. The program covered the Pleistocene and pre-Pleistocene deposits in the East and Midwest, the Southwest, and the Northwest-Arctic. A conference of this type enabled workers interested in this comparatively new area of science to keep up to date with the latest developments.

### Evolution of Behavior

Mutual interest of psychologists, biologists, and other biological scientists in evolutionary principles as they relate to the development of behavior at different levels of complexity led to the convening of two conferences. This conference, the second held on this subject, was concerned mainly with the production of an integrated symposium volume to make the latest developments in this field generally available. The program covered such items as: methods and present status of theory in studies of evolution and behavior; machinery of behavior (morphology, neurophysiology, endocrinology, etc.); genetical and developmental basis of behavior; categories of behavior (locomotion, migration, reproduction, social behavior, etc.); place of behavior in the study of evolution; motivation and cognitive behavior; and the relation between biological and cultural evolution. The first conference held a year earlier was concerned with much the same subject matter, but was concerned largely with interdisciplinary orientation and the blocking out of information then available. This conference was held during May 1956 in University Park, Pa.

### Metabolism of Mucopolysaccharides

Investigation of the biochemistry, physiology, and medical implications of the mucopolysaccharides has been a very active field of research in recent years. These substances are known to be important constituents of connective tissue, one of the most widely dispersed body tissues and yet, in the physiological sense, one of the least understood. The mucopolysaccharides appear to play a very important role in the normal physiology of the ground substance and of the fibrillar components of the connective tissue. The metabolism of these compounds also seems to be involved in certain pathological conditions such as arthritis.

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The objective of this conference was therefore to bring together about 12 leaders in this field and an additional 30 persons representing pertinent impinging disciplines to discuss recent advances in this area. The meeting resulted in a clarification of concepts of the metabolic and physiological role of the mucopolysaccharides and will prove of great value in providing impetus for future experimentation. The conference was held during June 1956 in Boston.

### Spectroscopy

Foundation support of this conference enabled the spectroscopists at Ohio State University to hold a larger conference on spectroscopy than they had been able to hold in previous years. The meeting, in June 1956, was international in character as it was held jointly with the International Commission on Spectroscopy. Participants, almost equally divided between chemists and physicists, discussed recent advances in atomic and molecular spectra based on optical and microwave techniques.

### Quantitative Biology

The 21st Coldspring Harbor Symposium on Quantitative Biology was held in Long Island, N. Y., during June 1956 and was devoted to a synthesis of present knowledge in various related areas of research that impinge upon the control of development. It provided opportunity for geneticists and experimental embryologists to obtain a new and broader perspective by interchange of information. Topics included: composition and mode of action of the gene at the chemical level; the role of the nucleus in differentiation; modern advances in experimental embryology interpreted, insofar as possible, in terms of the genetical control of development; and the complex problem of interactions.

### Developmental Biology Workshop

The workshop presented an opportunity for persons in the formative stages of their careers (30 younger scientists and graduate students) to come in contact with 20 outstanding senior scientists. The 2-week conference stressed interdisciplinary study in basic bacteriological problems in such fields as experimental embryology, biochemistry, plant physiology, endocrinology, and genetics. The workshop atmosphere was maintained through the use of illustrative examples, elaborate exhibits, and visual aids. The meeting was held at the Jackson Memorial Laboratory, Bar Harbor, Maine, during June 1956.

### Earthquake Engineering

The purpose of this world conference was to gather the latest information on research and development pertaining to destructive earthquakes and how to minimize the damage caused by such earthquakes. It was held at the University of California during June 1956. Papers presented at the conference should not only increase our knowledge of earthquakes but also assist in the development of blast-resistant construction. Such construction will be of value in protecting structures against atomic blasts as well as against earthquakes. Participants included scientists and engineers from nine foreign countries in addition to Americans.

### Acoustics

The Second International Congress on Acoustics was held at the Massachusetts Institute of Technology during June 1956. The program was arranged around the following subjects: human responses to sound; physics of sound; architectural and musical acoustics; noise control; and uses of sound in science and engineering. These international congresses are held every 3 years and foster international collaboration in pure and applied acoustics, a rapidly developing field that springs from both the physical and life sciences and contributes to many branches of engineering.

### High Temperature

Interest in high temperature research results from the use of high temperatures in the production of new materials as well as the problems brought about by the thermal heating of supersonic aircraft and missiles and the thermal effects of high energy explosions. In the materials field, the production of new chemicals and the preparation of refractory alloys and ceramic bodies is of considerable importance.

This symposium represented the culmination of the efforts of the NSF ad hoc Advisory Panel for High Temperature Research and other individuals during the past few years. It was held at the University of California during June 1956. Topics discussed were: the relationship of structure to properties of high temperature materials; the interaction of high temperature materials with environments—equilibrium considerations; and the interaction of high temperature materials with their environments—kinetic considerations.