PART II

Program Activities of the National Science Foundation

Conferences in Support of Science

During the year ending June 30, 1954, the National Science Foundation sponsored and provided partial support for a total of 19 conferences in special areas of science. In all cases sponsorship was shared with one or more private or public agencies, including universities and scientific societies. (See Table 1.)

Such conferences frequently provide a unique forum for the exchange and full discussion of new ideas and recent experimental findings on rapidly developing scientific fronts. Through support of conferences the Foundation is able to encourage research in areas of science of potential national interest but for which industrial support is not available. Leading foreign scientists attend many of these meetings, and at times the subject matter may be of an interdisciplinary nature of interest to scientists in several fields of science.

Brief notes on these conferences are given below. Normally, the request for support of conferences originates with the scientists working in the field under review. Proceedings and papers are frequently published by the scientific sponsors at the conclusion of the meetings.

ASTRONOMICAL RESEARCH AND PHOTOELECTRIC TECHNIQUES

During the past 20 years astronomers have relied more and more on photoelectric devices for making accurate measurements of the color and brightness of stars and other celestial bodies. The starlight falls upon a surface coated with an active material which releases a stream of electrons proportional to the intensity of the light. Such devices can "see" and measure the color and intensity of light over a range of wave lengths far broader than can be detected by the human eye.

In August 1953 the National Science Foundation and the Lowell Observatory sponsored a conference on Photoelectric Problems, Techniques, and Instrumentation for Astronomy Research. It was held at the Lowell Observatory, Flagstaff, Ariz. Astronomers, physicists, and electronic engineers discussed extension of the use of photoelectric techniques in their research. Among the problems benefiting from use of this type of equipment are measurement of the colors and magnitudes of star clusters and the study of double stars, eclipsing stars, and the Cepheids or pulsating stars. It is expected that work on these problems will clarify current views on stellar populations, stellar dimensions and masses, and the nature of stellar pulsations.

One of the important outcomes of the conference was the unanimous recommendation for a new telescope fully equipped for photoelectric methods in astronomical research and available to scientists from all parts of the country. The Foundation has established an advisory panel to consider all aspects of a cooperative National Astronomical Observatory.

Scientific Conferences Supported by the National Science Foundation in Year Ending June 30, 1954

Subject	*Sponsoring Organizations*	*Chairman*
Astronomical Research and Photoelectric Techniques.	Lowell Observatory.....	A. E. Whitford.
Problems in Astrometry.....	Northwestern University.....	G. M. Clemence.
Utilization of Solar Energy...	University of Wisconsin.....	F. Daniels.
Nuclear Processes in Geologic Settings.	University of Chicago.....	L. T. Aldrich.
Role of Proteins in the Transport of Ions Across Membranes.	Columbia University.....	D. Nachmansohn.
Glutathione Research.....	Columbia University and Office of Naval Research.	D. Schwarz.
Cosmic Rays.....	Duke University.....	Bruno Rossi.
Low Temperature Physics and Chemistry.	Rice Institute and International Union of Pure and Applied Physics.	W. V. Houston.
Validation of Scientific Theories.	American Academy of Arts and Sciencies, Institute for the Unity of Science, and the American Association for the Advancement of Science.	P. Frank.
Radio Astronomy.....	Carnegie Institution of Washington and California Institute of Technology.	M. A. Tuve.
Luminescence of Biological Systems.	Committee on Photobiology of the National Research Council.	S. B. Hendricks.
Problem-Solving Behavior....	New York University.....	H. H. Kendler.
High-Speed Computing in Meteorology and Oceanography.	University of California at Los Angeles.	J. von Neumann.
Physiological Development of the Mammalian Fetus.	Long Island Biological Association.	M. Demerec.
Multidimensional Analysis in Psychological Research.	University of Michigan.....	C. H. Coombs.
Problems in Human Communication and Control.	Massachusetts Institute of Technology.	J. C. R. Licklider.
Fundamental Problems of Perception.	Cornell University.....	J. J. Gibson.
Acoustics and the Structure of Liquids.	Brown University.....	R. B. Lindsay.
Growth and Development....	National Institutes of Health, Society for the Study of Development and Growth and Dartmouth College.	David R. Goddard.

PROBLEMS IN ASTROMETRY

Participants from this country and abroad met in September 1953 at Northwestern University, Evanston, Ill., to discuss the present status of position measurements of celestial bodies. During the course of the 3-day meeting the conferees agreed on a number of recommendations for extending present work in astrometry. These included: (1) Making a third observation of all stars included in the *Astronomische Gesellschaft* zones; (2) extension to the southern hemisphere of the astrometric program now in progress at the Lick Observatory; (3) relating positions and proper motions of stars to those of galaxies; (4) installation of a meridian circle in the southern hemisphere; and (5) reduction of systematic errors in star positions by improvement of techniques.

UTILIZATION OF SOLAR ENERGY

A Symposium on Utilization of Solar Energy was sponsored jointly by the National Science Foundation and the University of Wisconsin at Madison in September 1953. The general purpose of the meeting was to assess progress in nonbiological aspects of solar energy research and to consider promising unexplored areas in which further research effort would appear to be desirable. The participants discussed the potential utilization of solar energy as a source of power from two viewpoints: (1) The possible use of solar energy in the relatively near future when it might be competitive with present low-cost fuels and (2) from the long-range viewpoint after existing low-cost fuel supplies will have been depleted and the sun's current output of energy may be the principal available energy source.

NUCLEAR PROCESSES IN GEOLOGICAL SETTINGS

Many of the processes of nuclear physics—including fission of uranium, production of plutonium, generation of neutrons, and the decay of radioactive elements—occur in nature on a small but detectable scale. Careful analysis and measurement of such events provide scientists with a method for attacking such problems as estimating the age of the earth and of meteorites, revealing the geological history of the earth, and locating the sources of trace elements in the atmosphere. There are marked differences in the relative abundances of isotopes in various regions on the surface of the earth. Knowledge of these differences and the general nature of geochemical processes permits the reconstruction of some of the more important events that took place from time to time during the long history of the earth.

Some 30 specialists in physics, geology, geophysics, and geochemistry attended the Conference on Nuclear Processes in Geological Settings at Williams Bay, Wis., in September 1953. The conference, cosponsored with the University of Chicago, called particular attention to the need for better standardization and correlation of measurements which are being made at dozens of laboratories in the world. It recommended that a single laboratory in the United States be designated to assume the responsibility for maintaining records and standardizing measurements of interest to scientists in this country.

ROLE OF PROTEINS IN THE TRANSPORT OF IONS ACROSS MEMBRANES

Investigation of nerve action is one of the active fields in physiological research at the present time. Neurophysiologists know that the mechanism depends on electrical currents set up at the cellular level. It involves the movement of charged organic particles or ions across cell walls and other biological membranes normally impervious to charged particles. It also appears that protein substances in the cell have much to do with the passage of the ions across the membranes. Similar problems arise in the passage of nutrient or waste products across cell walls.

Despite the obvious importance of the subject, very little is known about the interaction between proteins and ions. In October 1953 a conference on the subject supported by the Foundation at Columbia University made it possible for leading neurophysiologists and physical chemists from the United States and abroad to review recent research findings and to suggest promising areas for future study. The complete proceedings of the conference will be published.

GLUTATHIONE RESEARCH

Glutathione is a sulfur-containing component of body cells related to the proteins. It participates in many basic biochemical reactions and is probably a factor both in the storage and utilization of body energy. Available evidence points strongly to the importance of glutathione in the synthesis of protein, a major factor in body growth and repair. Apparently, it also helps to activate certain enzymes which perform vital functions, such as the transformation of food into tissue and energy. Thus, while it is clear that glutathione is essential to life, biological and medical scientists are still puzzled about the manner in which it acts.

In November 1953 a Symposium on Glutathione Research was sponsored jointly by the National Science Foundation and the Office of Naval Research and administered by Columbia University. Discussion

sessions were held on the organic chemistry of sulfhydryl components and glutathione, biosynthesis of glutathione and its role in peptide synthesis, methods for determination of glutathione, glutathione as a coenzyme, and the relation of glutathione to metabolism and digestion. The proceedings of the conference will be published.

COSMIC RAYS

An international Conference on Cosmic Rays, sponsored jointly by the National Science Foundation and Duke University, was held at Durham, N. C., in November 1953. The aim of the conference was to assess the present status of cosmic ray research, particularly in the light of new high-energy accelerators, and to discuss possible future studies which will contribute most effectively to the solution of pressing problems on the physical nature of our universe.

The introductory discussion of nuclear interactions at very high energies centered on meson production in nucleon-nucleon or meson-nucleon collisions. A number of observations were reported of new unstable particles—hyperons, or particles having masses greater than neutrons, and heavy mesons. Other problems discussed were the origin of cosmic rays, the primary cosmic radiation, propagation in the atmosphere and time fluctuations. In many instances the conference failed to achieve unanimity of opinion, thus emphasizing the state of flux of many of the fundamental ideas in this field and the need for continuing rapid exchange of information about new findings and hypotheses.

LOW TEMPERATURE PHYSICS AND CHEMISTRY

In December 1953 the Third International Conference on Low Temperature Physics and Chemistry was held at the Rice Institute, Houston, Tex. The conference was sponsored jointly by the Institute, the National Science Foundation, and the International Union of Pure and Applied Physics. About 250 scientists participated in the discussion of recent research developments at temperatures in the vicinity of absolute zero. Delegates were present from leading laboratories in Australia, Belgium, Canada, France, Germany, Great Britain, the Netherlands, and the United States.

Particular attention was given to the different properties of the helium isotopes, three and four, in the liquid state. Several theories of the superfluid state were discussed. Steady progress was reported in research on the magnetic properties of matter at low temperatures, and a new magnetic cycle refrigerator capable of maintaining a constant temperature of 0.2° K. was described.

Ample time was provided for informal discussions of special problems by groups of from 2 to 10 people. This mechanism of informal exchange of information is highly productive in eliminating unnecessary duplication among the large number of research workers in this rapidly developing field.

VALIDATION OF SCIENTIFIC THEORIES

The criteria for validity of scientific theories vary from science to science. In physics and chemistry, for example, theories may frequently be tested experimentally in the laboratory. In other disciplines—human biology, geology, astrophysics, mathematics—direct experimental tests are seldom possible, and indirect tests, such as those involving statistical methods, may be uncertain and subject to conflicting interpretations.

At the annual meeting of the American Association for the Advancement of Science, December 1953, the Foundation, in cooperation with the American Academy of Arts and Sciences and the Institute for the Unity of Science, sponsored a conference on the Validation of Scientific Theories.

The chairman, Philipp Frank of Harvard University, stressed at the outset that the acceptance of scientific theories involves far more than agreement upon the observed results of research and the drawing of logical conclusions. Subjective factors often enter in, manifesting themselves as philosophical and sociological creeds, or even political ideologies, which may influence the course of science.

Scholars from various fields of science discussed the following topics: The present state of operationalism; psychoanalysis and the scientific method; organism and machine; science as a social and historical phenomenon; and the general principles of social physics. The papers and discussions are being published in full in the *Scientific Monthly.*

RADIO ASTRONOMY

The Carnegie Institution of Washington, the California Institute of Technology, and the National Science Foundation sponsored jointly a conference on radio astronomy at Washington, D. C., in January 1954. The conference was attended by many actively engaged in radio astronomy throughout the world, plus a group of other United States astronomers, physicists, electronics engineers, and a number of young research men especially interested in this exciting new field of research. An effort was made to present a comprehensive survey of current research and facility development, to examine in detail the most critical problems now

evident in both these areas, and to indicate, as far as possible, some of the directions for profitable future activity.

At the conclusion of the conference a group of American scientists recommended that the National Science Foundation establish a permanent panel to promote understanding and development of radio astronomy in the United States. The advisory panel subsequently appointed is comprised of astronomers, engineers and physicists.

LUMINESCENCE OF BIOLOGICAL SYSTEMS

Bioluminescence is the process by which fireflies and many other animals and plants produce light by biochemical means. The process evolves very little heat so that the light production is high in relation to energy expended. The study of "cold light" is of interest to biochemists and biophysicists, not only per se but also because it gives insight into life processes in general. The amount of light given off by a plant or an animal may indicate the effect of drugs, heat or pressure on such body functions as respiration, growth, and muscle action.

A Conference on Luminescence of Biological Systems sponsored by the Foundation was arranged by the Committee on Photobiology of the National Research Council and held at Pacific Grove, Calif., in March 1954. The range of subjects discussed included chemical luminescence and fluorescence, spectroscopic investigation of bioluminescence, and the physiology of luminescence in specific plants and animals. The proceedings of the conference will be published.

PROBLEM-SOLVING BEHAVIOR

The behavior of human beings in solving problems is highly complex and progress in the study of such behavior has been relatively slow. Research workers are often faced with apparently contradictory findings and only a small part of the work done has actually been reported in publications. For this reason individual scientists in the field are often poorly informed about current studies in laboratories other than their own. A Symposium on Problem-Solving Behavior was held in April 1954 primarily to enable investigators working in the field to exchange ideas and to evaluate current progress. The meeting was jointly supported by New York University and the National Science Foundation.

HIGH-SPEED COMPUTING IN METEOROLOGY AND OCEANOGRAPHY

Many of the theoretical problems associated with weather forecasting have been solved but the computational effort required has prevented

the widespread use of such theory in actual forecasting. The weather had long since come and gone by the time scientists using ordinary methods had analyzed and organized thousands of individual observations on air temperatures, wind currents, and velocities. Oceanographers are also faced with complicated, many variable problems in fluid dynamics. With the advent of high-speed computing machines a new and powerful tool is available for rapid analysis of data and prediction of events.

In May 1954 the National Science Foundation and the University of California at Los Angeles sponsored a Conference on High-Speed Computing in Meteorology and Oceanography. About 40 meteorologists, oceanographers, mathematicians and fluid dynamicists met to review recent accomplishments of high-speed computing in fluid dynamics and to discuss some of the problems to which application of computers might be feasible in meteorology and oceanography. Scientists from England, France, and Norway attended the meeting.

Numerical weather forecasting using modern computing equipment is already an object of extensive study, particularly in the United States and the United Kingdom. In this country the work has been supported in large part by Federal agencies. From known meteorological conditions over the United States, the general flow pattern of the atmosphere for a large part of the country can now be determined one or two days ahead. With slight further development predictions of large-scale flow patterns will soon be possible on a routine basis. The next step will be to modify this overall flow pattern by introducing small-scale air motions and humidity and temperature fields in order to predict weather on a local basis.

One of the most interesting sessions was devoted to the problems of air pollution in an industrial area, with particular emphasis upon smog conditions in the Los Angeles area. Here again high-speed computing methods may make possible the application of physical laws to the solution of a complex problem. The meteorologists will be able to determine the distribution of contaminants originating at each of the sources of pollution of the area. Such atmospheric pollution studies will become even more important with the widespread development of atomic energy, which will create problems in radioactive contamination.

PHYSIOLOGICAL DEVELOPMENT OF THE MAMMALIAN FETUS

A number of conferences in recent years have dealt with aspects of embryonic development but usually from the viewpoint of abnormal

development. The Symposium on Physiological Development of the Mammalian Fetus held in June 1954 was devoted to discussion of the normal mechanisms and functions of the developing embryo.

Participants were interested mostly in those functions which are critical during the period of adjustment immediately before and after birth. These include circulation, respiration, and the complex of kidney-endocrine-body water-electrolyte functions, as well as certain mechanisms, such as temperature regulation. Any major advance in understanding these factors may have immediate practical value in the evaluation of current practices in the clinical management of newborn and premature infants.

The Symposium was held at Cold Spring Harbor, Long Island, under the sponsorship of the Long Island Biological Association and the National Science Foundation. About 20 of the 50 participants were from laboratories in foreign countries. The complete proceedings of the Symposium will be published.

MULTIDIMENSIONAL ANALYSIS IN PSYCHOLOGICAL RESEARCH

From an interdisciplinary point of view one of the major conferences held during the year was devoted to multidimensional analysis in psychological research. This was held at the University of Michigan in June 1954 with support from the National Science Foundation and brought together interested people from the fields of psychology, sociology, mathematics, and statistics. The conference followed the Fourteenth International Congress of Psychology so that many individuals from other countries were able to attend.

The development of useful measurement techniques and mathematical models is a problem of central importance in psychological research. Of the methods currently employed the most useful are multiple factor analysis, multiple correlation, and latent structure analysis. Some recent modifications in these models and some entirely new ones have been suggested, but these are not yet widely known or used. Further progess will require the close collaboration of psychologists and mathematicians in the basic formulation of new models and the additional collaboration of psychologists, mathematicians, and statisticians in testing their validity.

ACOUSTICS AND THE STRUCTURE OF LIQUIDS

The structure of matter in the liquid state is more complex and difficult to understand than matter in either the solid or gaseous states. Scientists have learned that acoustics, and in particular ultrasonics, provides a unique tool for investigation of the liquid state. This conference

of physicists, physical chemists and acoustical engineers, including several from abroad, met in June 1954 at Brown University, Providence, R. I., to review present-day theories of liquids and to plan for the further utilization of acoustical methods in studies of liquids.

Among the subjects covered at the conference were: (1) Shear and compressibility characteristics of liquids as revealed by the behavior of acoustic waves, (2) the character of chemical reactions affected by acoustic waves, (3) the dispersion and velocity of acoustic waves as they depend on liquid structure, and (4) the effect of gas nuclei on the formation of cavitation bubbles.

PROBLEMS IN HUMAN COMMUNICATION AND CONTROL

During the last two decades, the theory of communication developed by Norbert Wiener of the Massachusetts Institute of Technology, Claude Shannon of the Bell Telephone Laboratories, and others, has undergone vigorous development. The potential value of this theory for understanding human behavior and the action of the nervous system were apparent from the beginning. It has taken some time, however, for the influence of the formal theory upon experimental psychology to extend beyond superficial analogy.

The Wiener-Shannon concepts for quantifying information flow have recently served in the analyses of behavioral data, inasmuch as they are capable of handling transmissions from a multiplicity of sources to a multiplicity of destinations taking interactions into account. The concepts of "coding" and "context" as defined in communications theory are making possible new insights into perception, language, and learning. The techniques of time-series analysis and spectrum analysis are being used in studies on psychomotor control.

In June 1954 the Conference on Problems in Human Communication and Control sponsored by the Foundation and the Massachusetts Institute of Technology brought together experimental psychologists, physicists, engineers, and mathematicians for discussions of mutual benefit. The discussions brought out several facts that pointed up the timeliness of the conference: (1) That despite strong and widespread interest in the topic, formal channels for interdisciplinary exchange of information have not been adequate; (2) that there are independent and parallel developments in England and the United States that would profit from mutual exchange of ideas; and (3) that the give-and-take of technical discussion could not fail to assist in the solution of several basic research problems.

FUNDAMENTAL PROBLEMS OF PERCEPTION

Over the past quarter of a century psychologists have been confronted with two different theories of sensory perception. The empiricist position, widely accepted for many decades, held that perception of depth, space, form, etc., is primarily a learning process built up from a few simple elements of sensation. This view was challenged some years ago by the Gestalt psychologists, who believe that perception is directly determined by the physiology of the sensory and nerve structures involved. Adherents of both viewpoints have been able to marshal hypotheses and experimental data, which appear to support their respective positions.

The Conference on Fundamental Problems of Perception sponsored jointly by Cornell University and the National Science Foundation was one of a series of four psychological conferences held in conjunction with the Fourteenth International Congress of Psychology in June 1954.

During the conference five specific problems were discussed in an attempt to evaluate and reconcile the apparently conflicting experimental results arising from the two differing theories of perception. These included: (1) Past experience and learning in perception; (2) the perception of motion, change, and complex events; (3) the status of perceptual trace theories; (4) the effects and after effects of protracted presentations; and (5) the status of Gestalt psychology after 30 years.

DEVELOPMENT AND GROWTH

For the second year the National Science Foundation contributed to the support of the annual Symposium on Development and Growth. Other sponsors included the Society for the Study of Development and Growth and the National Institutes of Health. The Symposium was held at Dartmouth College in June 1954.

Since 1936 the annual growth symposia have been unusually successful in bringing together research investigators in the field of growth for the free exchange of concepts and principles common to both animal and plant growth and to normal and abnormal growth.

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Support of Basic Research in the Sciences

During the year ending June 30, 1954, 374 grants totaling $3,888,220 were made by the Foundation for the support of basic research in the natural sciences. This compares with 269 grants totaling $2,751,912 made during the previous 2 years.

These funds were distributed in the biological, medical, mathematical, physical, and engineering sciences to 170 institutions in 43 States, the District of Columbia, Hawaii, and Bermuda. The average research grant for fiscal year 1954 was $11,100, to run for 2.5 years, or about $4,400 per year.

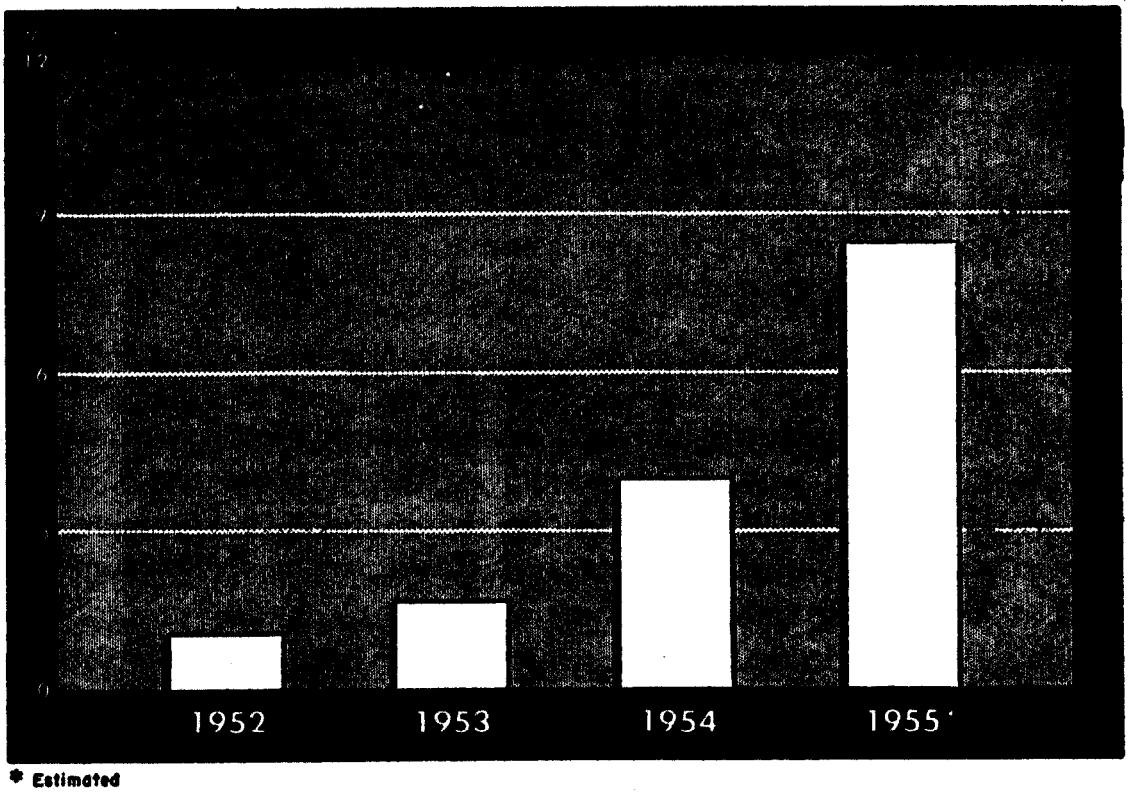


FIGURE 4. *National Science Foundation obligations for support of research, fiscal years 1952 through 1955.*

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, duration, and amount is given in Appendix II, page 72.

Over the past year the Foundation has assumed primary responsibility for Federal support of several important fields of basic research, including astronomy, pure mathematics, low temperature research, systematic biology, and ecology. This is in line with Executive Order 10521 stat-

National Science Foundation Research Grants by Fields of Study

Field	Fiscal years 1952–53		Fiscal year 1954	
	Number of grants	Amounts	Number of grants	Amount
Biological and medical sciences:				
Developmental biology	15	$116,462	13	$110,520
Environmental biology	6	32,560	7	43,200
Genetic biology	13	201,000	13	156,900
Molecular biology	21	273,300	32	458,000
Psychobiology	10	116,400	27	293,450
Regulatory biology	41	482,000	41	464,800
Systematic biology	27	209,780	32	238,500
General	7	112,760	12	164,100
Total	140	1,544,262	177	1,929,470
Mathematical, physical and engineering sciences:				
Astronomy	8	89,000	19	147,900
Chemistry	40	350,300	47	477,400
Earth sciences	9	89,850	27	282,800
Engineering	21	187,200	42	390,900
Mathematics	20	104,500	21	173,950
Physics	30	354,000	41	485,800
Total	128	1,174,850	197	1,958,750
General	1	32,800	.....	.....
Total	269	2,751,912	374	3,888,220

ing that the Foundation should be increasingly responsible for providing Federal support for general-purpose basic research.

The subject matter of research is clearly of much more interest and importance than the administrative details. In a program so large and so varied however, it is impossible to describe the plans, methodology, and current activities of each of the scientists supported. Instead, in the paragraphs that follow certain research areas of unusual current interest have been selected and a brief description is given of the general status of research in these areas with notes concerning some of the related research supported by the Foundation.

RADIO ASTRONOMY

Radio astronomy is one of the youngest sciences, only slightly more than 20 years old. It was born when Karl G. Jansky of the Bell Tele-

phone Laboratories found the first faint evidence of natural radio signals reaching the earth from outer space. The exploration of the universe by radio started some 5 years later, when another American engineer, Grote Reber of Wheaton, Ill., began systematic scientific studies with his privately constructed equipment. Radiation in the radio frequency bands was first detected from the sun by Reber 12 years ago.

The United States can take pride in the fact that American engineers made the basic discoveries that opened up this wholly new approach to the study of the sun, the stars and the universe. The United States did not, however, stay in the lead in the young science. Since the war, Great Britain, Australia, and Holland have moved ahead while this country has lagged behind. American efforts in the field have been relatively small although significant programs are under way at the United States Naval Research Laboratory, the United States National Bureau of Standards, the Department of Terrestrial Magnetism of the Carnegie Institution, and a number of educational institutions.

Radio astronomy is a field of research in which astronomers, physicists, and engineers can benefit by working together. Research in radio astronomy has important scientific values in the realm of pure astronomy and physics. Moreover, it leads to development of new techniques of great practical value in such electronic engineering fields as noise suppression and antenna and tube development.

In undertaking to promote a greater United States effort in radio astronomy, the Foundation brought together about 80 scientists to discuss the current status of this branch of science. (See Conferences in Support of Sciences, p. 29.) Subsequently the Foundation established an Advisory Panel on Radio Astronomy to assist in developing a national program.

At Harvard University, where the radiation from interstellar hydrogen gas was first detected in 1951, Bart J. Bok and Harold I. Ewen have built, with the aid of a Foundation grant and private support, a 24-foot radio telescope at the Agassiz Station. It is now being used for a survey of the hydrogen clouds of the Milky Way. Radio waves from cosmic hydrogen are able to penetrate the cosmic gas of interstellar space, somewhat as radar is able to penetrate atmospheric clouds. Thus, radio radiation enables us to "see" parts of the Milky Way that could not be observed with optical telescopes. Correlation of radio and optical observations will permit estimates to be made of the temperatures inside dark nebulae and the ratio between gas and dust in interstellar space.

John D. Kraus' program at Ohio State involved the construction of special receiving antennas of novel design. With this low-cost equipment

Kraus and his associates have studied the radiation from the remote parts of the Milky Way system and have further recorded radiation associated with distant groups of galaxies.

The work at Cornell under C. R. Burrows is primarily concerned with solar research and with radio problems of the earth's upper atmosphere. At Penn State, A. H. Waynick is conducting research on electronic instrumentation related to radio astronomy.

UNCONVENTIONAL SOURCES OF POWER

For many generations improvement in man's ability to convert energy into work has been closely linked to his rising standard of living. The great advance occurred when he learned to use fossil fuels—coal, oil, and gas—to meet his major power needs. The world supply of low-cost fossil fuels is limited, however, and at the present rate of consumption, it may be a matter of survival for man to develop alternative power sources.

The two unconventional sources of power that now seem most promising are the energy of the atomic nucleus and solar energy. Energy from either or both sources may eventually be available for heating and for the production of power. In either case the time scale depends in part upon economic factors and in part upon advances in basic knowledge.

From a scientific point of view the problems involved in utilizing energy from these two sources are quite different. In the fission or fusion of atomic nuclei the rate of energy production per unit volume is very high which means that the temperature level is far above that normally used in production of power. A basic problem, therefore, is that of the management and control of energy at high temperatures.

The problem in utilizing solar energy lies at the other extreme. Solar energy is widely diffused—the rate of production per unit volume and, hence, the temperature is too low to be converted into power by known methods. The intermittent nature of solar energy from night to day, winter and summer at any point on the earth's surface adds to the complexity of the problem.

High temperature energy utilization.—A basic engineering problem in high temperature energy utilization is to conduct heat rapidly from its production source into the mechanisms for converting it into usable power. Its solution involves basic studies on the nature of heat transfer, whether by solids, liquids, or gases. Research now being conducted under several Foundation grants may yield useful basic information in this area. Jesse M. Coates and Byron L. Sakiadis of Louisiana State University are doing research on heat capacities of pure liquids and solu-

tions. Edward W. Commings and his students at Purdue University are investigating heat transfer of gases at high pressures.

The physical properties and behavior of materials at high temperatures is another aspect of high-level energy utilization. New construction materials to handle hot gases, liquids, and solids are important. Most familiar materials fail or become useless because of corrosion at such extreme temperatures. The materials must also be able to withstand intense bombardment of nuclear radiation. In this area, the Foundation has provided a grant for study of the effect of nuclear radiations on engineering materials at the University of Wyoming under the direction of Harold Sweet.

Low level energy utilization.—The Foundation is supporting a direct attack on the solar power problem at the University of Wisconsin as an outgrowth of the Symposium on the Utilization of Solar Energy held there. This program involves research in the fields of chemistry, physics, biology, and engineering under the leadership of John A. Duffie.

The storage of solar energy may in principle be accomplished chemically, electrically or mechanically, or perhaps in some other less apparent form. This problem is currently being attacked at the basic level through the use of chemicals which can be converted into a different form by sunlight and then reconverted in off hours. In effect, this would be a storage battery charged by sunlight.

More information on the origin of fossil fuels also may provide a clue to the rapid conversion of solar energy to fuels. Wayne Kube at the University of North Dakota is attacking this phase of the general problem.

The biological conversion of solar energy into forms utilizable by man proceeds on a tremendous scale by green plants in the process known as photosynthesis. The process requires small chlorophyll-containing particles in the leaves, called chloroplasts, and the intervention of complex enzyme systems. Scientists are attacking the problem from many points of view in attempting to understand the quantitative relationships between absorbed radiant energy and the converted chemical energy, in isolating and identifying enzyme systems involved in the process, and in probing into the relationship of growth hormones to utilization of radiant energy.

Among the investigators who are pursuing these problems with the aid of National Science Foundation grants are Robert Emerson, of the University of Illinois, who is determining the quantitative energy relationships between radiant energy absorbed and the newly synthesized carbohydrate molecules. Wolfe Vishniac, of Yale University, has suc-

cessfully obtained photosynthetic reactions under the influence of light in cell free systems. He is now attempting to learn more about the enzyme systems involved in this chain of reactions.

At the California Institute of Technology, Arthur Galston is studying the manner in which light affects the metabolism and activity of the plant growth hormone, auxin. His studies indicate that plants contain an enzyme system, activated by light, which destroys auxin and therefore inhibits growth during the period of illumination, causing it to proceed mainly during the periods of darkness. Dr. Galston has some evidence indicating that the receptor pigment for this enzymatic reaction is a flavoprotein. Jack Myers of the University of Texas, is studying the photosynthetic activity in microorganisms in order to obtain information concerning the gradual evolution of the photosynthetic process from the primitive single-celled forms to the higher plants. Such studies may lead to the possible utilization of microorganisms in mass culture as a source of food or fuel.

MESON PHYSICS

At the present time understanding of the interaction of mesons with atomic nuclei is a basic problem of nuclear physics. Mesons are nuclear particles, heavier than electrons and lighter than protons, that have a brief, observable existence arising from certain nuclear reactions. They may be produced in laboratories by high energy accelerators and they are found as products of cosmic ray activity. Mesons leave visible evidence on photographic plates of the forces that hold the atomic nucleus together.

For several years the major support for high energy physics research has come from the Atomic Energy Commission and the Office of Naval Research. Recently the Foundation has also been able to contribute to meson research in the United States in several ways. The annual Rochester conference on high energy physics is one example. From such meetings, it is clear that a great deal of progress is being made in the experimental study of mesons but that the theoretical interpretation and explanation of the experimental findings is lagging.

One of the most useful methods for studying a complicated subject such as meson physics is to devise a simple model that has a few of the characteristics of the real thing. In attempting to explain the observed absorption and scattering of mesons by atomic nuclei a group of theorists at Indiana University suggested a model of a temporary "compound meson-nucleon state." This model has proved quite useful in interpreting some of the experimental observations. The Foundation is

supporting further research of the group under the direction of E. J. Konopinski.

In the absence of adequate meson theory, progress in this challenging field will continue to depend largely on experimental work in which high energy accelerators are required. The Foundation is supporting research in accelerator design problems at the Midwest Study Group, which consists of physicists from seven leading universities in the Midwest. This group is investigating such subjects as the effect of nonlinear force terms on the orbits of accelerated particles.

During the past year the Foundation established an *ad hoc* Advisory Panel on Ultra High Energy Nuclear Accelerators, to assist the Foundation and other governmental and private groups in planning research support programs involving accelerators.

HILBERT SPACE

One of the extraordinary examples of scientific collaboration in the history of science has been that of the geometers and physicists. As knowledge of physics has increased, the dimensions and characteristics of physical "space" have created a need for more profound geometrical analysis. Classical Newtonian physics was embedded in Euclidean space. The non-Euclidean geometers prepared the ground for relativity and the four dimensional space-time concept. In our day another deepening of geometrical concepts is playing a basic role in the theory of quantum mechanics.

This development, brought to the fore by Hilbert in the early years of this century, extends the ideas of Euclid and Descartes to space of infinitely many dimensions. Such a geometry appears to be appropriate in describing a physical system—the hydrogen atom, for example—which may exist in an indefinite number of orbital or energy states, each having a characteristic probability and geometrical configuration.

The mathematical structure of Hilbert space has permitted precise formulation of many of the ideas of quantum mechanics. The geometry of Hilbert space and the algebra of linear transformations acting upon it have been significant factors in studying atomic processes. Further progress in this direction, however, awaits further development in Hilbert space of many common geometrical concepts and operations. One of the pressing problems is that of defining volume in Hilbert space so that it is a natural extension of the volume concept in spaces of finite dimensions. Until this is done little headway can be made in developing a theory of integration. A solution of this problem is basic to a complete theory of quantum mechanics, and hence to an adequate theoretical understanding of atomic energy relations.

The Foundation is encouraging research in this important area. For example, it is sponsoring research of E. R. Lorch of Columbia University, who recently formulated some definitions of volume and integration in Hilbert space.

LUMINESCENCE

Luminescence is a broad term involving all forms of "cold light." Physical and chemical research have made possible such familiar examples as fluorescent lights, phosphorescent paints and tapes, television screens, and other practical applications of growing importance in everyday life. The luminescence that accompanies certain biological processes has long been known. Familiar examples include the flashing of fireflies, the phosphorescence of the sea, and the light seen emanating from moldy wood and leaves or from certain types of bacteria that thrive on dead fish and meat. Natural luminescence has excited the curiosity of casual observers and has aroused the active interest of such scientists as Aristotle and Robert Boyle. Only recently, however, have scientists become fully aware of the scientific importance of luminescence in biology. A few widely scattered groups of contemporary scientists, principally in the United States, Holland, England, and Japan, are concentrating their efforts on research in this field.

Biological luminescence is of fundamental interest since it provides a unique and efficient "tool" for investigating the influence of various substances and factors—chemotherapeutic compounds, narcotics, temperature, high pressure, and others—on the rates of life processes. Luminescence is virtually the only process in living organisms endowed with a natural, instantaneous, and measurable indicator of its own reaction velocity: the brightness of the light emitted is proportional to the rate of the underlying chemical reactions. From studies of bacterial luminescence as a research tool, new concepts have emerged in regard to basic mechanisms that control reaction rates in organisms; concepts that apply as well to more familiar processes, such as digestion, growth, muscle contraction, and nerve activity.

Within the past year, luminescence has been obtained, after years of futile attempts, in extracts of bacterial cells, and major components of this light-emitting system have been biochemically identified. In part, these components are related to the B vitamins which are universally involved in releasing the energy on which life depends. Moreover, the luminescence of bacterial extracts in a test tube has the same basic characteristics, and responds to various factors in fundamentally the same way, as the luminescence of the living organisms.

In extracts of fireflies, adenosine triphosphate has been identified as a substance necessary for luminescence. The same substance is intimately involved in muscle contraction, in the synthesis of living matter, in the utilization of foods, and in other life processes. Other studies have shown that a chemical luminescence is also associated with photosynthesis, the biological process on which the total food supply of the world ultimately depends. An understanding of the significance of luminescence in these processes is clearly prerequisite to a full understanding of the processes themselves.

Two Foundation grants have been awarded to specialists in this field. E. Newton Harvey, of the Department of Biology, Princeton University, is engaged in a 3-year laboratory program during which he hopes to describe more precisely the chemical constituents of luciferin and luciferase, principle components in the process. Such research may establish the basis for the eventual synthesis of these substances. William D. McElroy of the McCollum-Pratt Institute, Johns Hopkins University, also has a grant for the study of the mechanism by which chemical energy is converted into light energy by biological systems. Professor McElroy and others have noted that the light-emitting components in the process are not merely caused by the release of excess energy from excited molecules but also depend upon certain dark reactions which occur prior to light emission. At present his research centers upon the study of reactions of known enzymes upon purified luciferin extracted from fireflies.

STEROID CHEMISTRY

The steroids are a group of naturally occurring compounds derived from the hydrocarbon cyclopentanoperhydrophenanthrene. Among the common steroids are cholesterol, vitamin D, bile acids, heart poisons, such as digitoxin, toad poisons, sex hormones, and adrenal cortical hormones, such as cortisone.

While the complicated analysis of certain sterols and heart and toad poisons was started over a century ago, the major advances have been made during the past few decades and represent one of the outstanding achievements of modern organic chemistry. The structural chemistry of the sex hormones and the adrenal cortical hormones was solved in still more recent years.

Because of the remarkable biological properties and therapeutic value of certain of these compounds a search is being made for suitable methods and improved starting materials for their large scale preparation. Many are found in limited quantities in nature and are very expensive. The total synthesis of a few individual compounds in this series, for

example, cortisone, has already been accomplished, largely because of basic research on the spatial arrangement of the atoms into molecules. Further work will undoubtedly suggest new approaches to the problem in which more readily available starting materials may be used, the number of synthetic steps reduced and simplified, and the final yield increased.

The National Science Foundation is supporting the research of William S. Johnson and A. L. Wilds of the University of Wisconsin, who are working on the total synthesis of the nonaromatic steroids, their stereochemistry and the development of new synthetic approaches. The most significant advance made in this research has been the total synthesis of epiandrosterone, related to the male sex hormone, adrosterone, and the discovery of androgenic activity in certain intermediates with a structure similar to that of the sex hormone. Some of the compounds being studied are of current interest in cancer research.

Richard B. Turner of the Rice Institute, Houston, is working on the total synthesis of the adrenal cortical hormones and intermediates which lead to them. Carl Djerassi of Wayne University, Detroit, is studying a new method for the identification and characterization of steroids.

ARCHEOLOGY

Archeology contributes to our knowledge of the species, man (*Homo sapiens*), by reclaiming and interpreting the material remains of his past. It has advanced from an art which attracted amateur diggers in search of curios to a well-defined science. Archeologists are currently attempting to isolate and identify the characteristic features of early human technology and the physical, biological, and environmental forces which effected the change from one stage of development to another.

The record of these changes and the appearance of civilization is buried in prehistory. No written records describe how and why civilization first appeared. The only source materials available are those which can be directly excavated from the prehistoric levels of archeological sites. The effective analysis of these materials is an interdisciplinary task. The techniques of the archeologist must be supplemented with those of the paleontologist, botanist, ceramicist, engineer, and geologist in order to understand prehistoric finds in the full perspective of all aspects of the early environment.

Two studies supported by the National Science Foundation will contribute to better understanding of the beginnings and evolution of civilization. One group, under Robert J. Braidwood of the University of Chicago, is investigating the zoological, demographic, and environ-

mental aspects of the variegated human populations that have lived and died in the Fertile Crescent. This area encompasses modern Iraq, lowland Turkey, Syria, Palestine, and Trans-Jordan. Here occurred the earliest transition from a food-gathering to a food-producing economy in human history.

To understand and explain this great change, the archeologist relies on both artifactual and nonartifactual materials. The artifacts—villages, dwellings, pottery, tools, weapons, objects of decoration and the like—are the familiar subjects of archeological attention. The study of artifacts sheds some light on *how* civilization evolved.

The nonartifactual materials are as important as the artifacts. These materials include the utilized but unworked materials and refuse from an ancient site: animal bones, remnants of burned grain or seeds, bits of unworked stone or metal, and the skeletons of men themselves. In the study of nonartifactual materials, the natural scientists play the greatest role in archeological expeditions. It is essential to understand the physical environment in which the changeover from nomadic food-gathering to settled food-producing and village life came about. Study of the ecological situation helps to answer the *why* of cultural evolution.

The Foundation's contribution to the Fertile Crescent expedition will enable a zoologist and a ceramic technologist to join an agronomist, geneticist, physical anthropologist, ecologist, and archeologist in a cooperative effort to understand the environment at the time the foundations of civilization were laid. It is hoped that their participation will develop the natural history of animal domestication and will establish an appropriate time-scale for the appearance of new technologies and their economic consequences. Through such coordinated interdisciplinary teams of specialists, understanding and knowledge can be advanced most effectively.

A second project being supported by the Foundation focuses attention on another important problem in prehistoric archeology. For over a century we have known about and marveled at the artistic and intellectual achievements of the Mayas of ancient Mexico as shown in their architecture, sculpture, and hieroglyphic systems. Their great civilization arose, flourished for some 600 years, and then declined. The reasons behind this cultural decline, disruption, and abandonment of important centers are not known.

Gordon R. Willey of Harvard University has proposed a new and significant approach to the problem. He is studying the prehistoric settlement patterns in the Mayan area. Although many persons have studied the spectacular artifacts of the Mayas, little is known of the pre-

historic Mayan dwellings, the number and arrangement of these dwellings, and how they were distributed over the landscape. The nature of a settlement reflects not only the natural environment but the way in which that environment was exploited to maintain a society. The physical form of a community reveals the technology of the society and offers insights into the social, political, and religious characteristics of the people. By plotting dwelling sites and dating them from their potsherd contents, Dr. Willey hopes to relate dwellings to the temple centers, establish population data and relate population to the physical setting.

Other Foundation-supported studies, directly related to geologic and minerals research, were indirectly of help to the archeologist in the investigation of ancient man and his environment. These included research on radiocarbon dating by J. L. Kulp, Lamont Geological Observatory; W. F. Libby, University of Chicago; and R. N. Keller, University of Colorado.

HISTORY, PHILOSOPHY, AND SOCIOLOGY OF SCIENCE

In any period of history scientific thought is an integral part of the culture of the period. In measuring the progress and impact of science, the pursuit of subject matter research is not enough. It becomes necessary to study the historical, philosophical and sociological aspects of the cultural setting as well.

Development of a worthwhile program of study in these fields is difficult, however, since the area of interest is not well defined. During the coming year the Foundation plans to sponsor a conference to consider appropriate programs for further investigation and support.

The Foundation has made a research grant to Philipp Frank of Harvard University to undertake an historical analysis of the validating grounds of scientific theories together with the social and psychological atmosphere in which theoretical ideas originate, develop, and become accepted, rejected or modified. This investigation is aimed at clarifying the relations and interactions of various fields of science on each other and in demonstrating what influences have contributed to the progress of modern science.

Another project in this area is under the direction of Henry Margenau of Yale University, who is reexamining the basic concepts, definitions, and laws employed in the physical sciences. The two components of scientific definitions—the operational and the logical—are being examined in the fields of classical mechanics and thermodynamics. A reappraisal of the underlying philosophical theories may aid in establishing common ground leading to increased communication and understanding among the scientific disciplines.

Education in the Sciences

GRADUATE FELLOWSHIP PROGRAM

Late in March the Foundation announced the award of 657 predoctoral graduate fellowships and 79 postdoctoral fellowships for advanced study in the natural sciences for the academic year 1954–55. This was the third year in which such awards were made. The distribution of fellowship awards by field of study and comparative figures for the previous programs are summarized in figure 5. A table giving 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 undergraduates and graduate students is given in Appendix IV, p. 96.

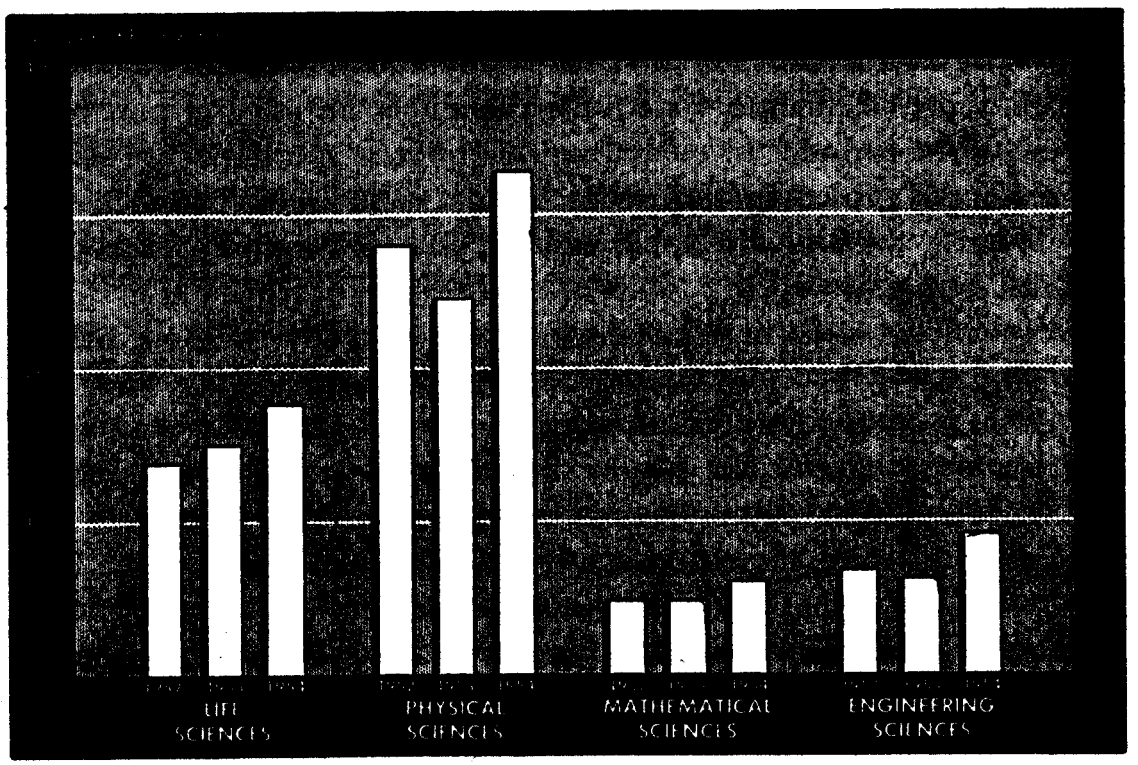


FIGURE 5. *Predoctoral graduate fellowships awarded by National Science Foundation by field of science, 1952–54.*

FELLOWSHIP SELECTION PROCEDURES

The National Science Foundation Act states that fellowships must be awarded solely on the basis of ability. In setting up screening and selection procedures for its fellowship program, the Foundation drew heavily upon the experience of other groups whose programs have

operated successfully for several decades. The excellence of the selection methods used by the National Research Council and the Rockefeller Foundation, for example, has been shown by followup studies of the later scientific careers of successful applicants.

In the system used for selection of National Science Foundation Fellows, the National Research Council, which administers the rating program, appoints rating panels of leading scientists in each of the fields for which awards are made. Each panel evaluates the records of candidates in its respective field. The ratings are then submitted to the Foundation which makes the final selection.

The record of each predoctoral applicant from which the evaluation is made consists of three parts: (1) Test scores on verbal ability, quantitative ability, and scientific aptitude in chosen field; (2) previous scholastic record; and (3) confidential evaluation reports of faculty advisers.

Figure 6 shows the distribution of scores on the Quantitative Aptitude Test of all 1954 first year applicants for Foundation fellowships compared with the standard distribution of scores. Only 7 percent of the fellowship

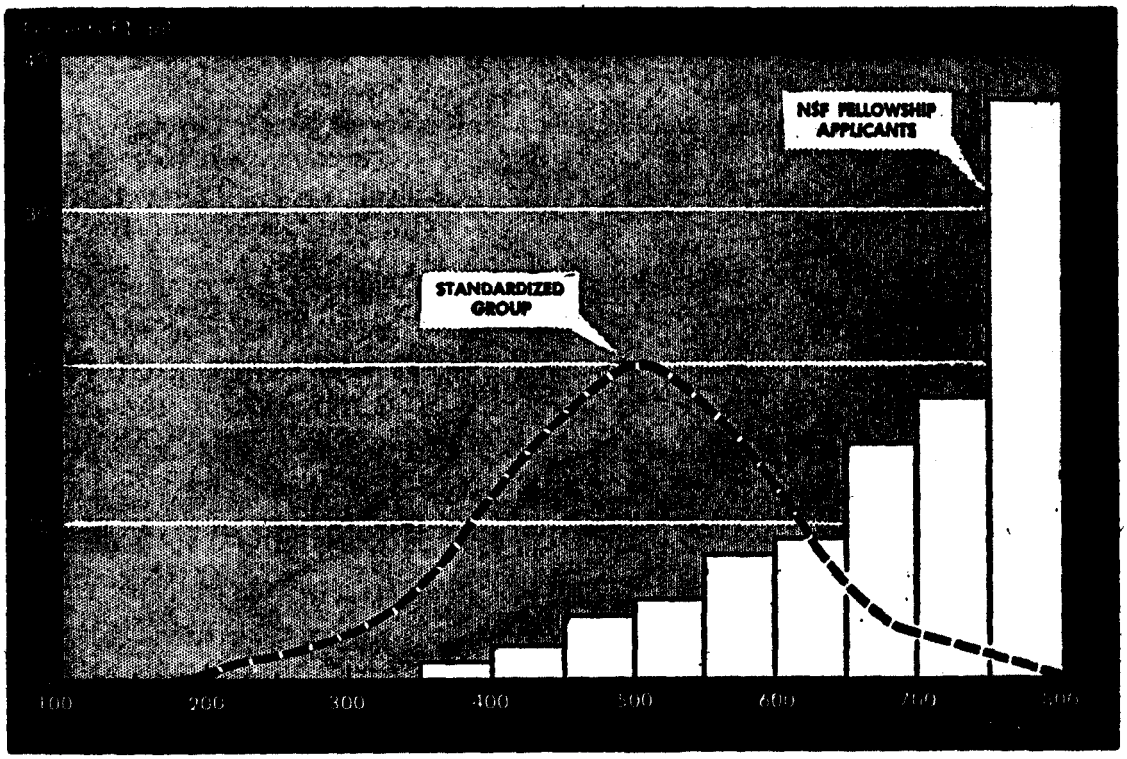


FIGURE 6. *Distribution of quantitative aptitude test scores of applicants for National Science Foundation predoctoral fellowships compared with distribution for standard group.*

applicants have test scores below the median for the standard group. There is little doubt that a powerful preselection factor is at work, in that only the highest ranking students in their classes apply for Foundation fellowships.

While considerable intellectual capacity is a prerequisite to success in scientific research, it is not the sole factor involved. However, very little progress has been made to date in isolating and defining other mental, personality, and physiological factors that may be required for scientific creativity and achievement. The Foundation believes this to be an important area for further research and during the year it has supported studies on fellowship selection techniques administered by the Office of Scientific Personnel, National Research Council, under the direction of C. W. Taylor. In connection with this program two conferences on fellowship selection techniques and criteria of scientific achievement have been held.

INSTITUTES FOR COLLEGE SCIENCE TEACHERS

The success of the regional summer institutes and conferences for college teachers of science, begun on an experimental basis by the Foundation during fiscal year 1953, resulted in the extension of this program during the summer of 1954. These conferences are designed primarily to assist science teachers in small colleges with limited research activities to keep abreast of recent research in their own and allied fields. Four summer conferences were held:

Colloquium on Collegiate Mathematics, University of North Carolina, June 15–August 6, 1954.

Conference on Collegiate Mathematics, University of Oregon, June 21–August 13, 1954.

First Chemistry Institute, sponsored by the American Chemical Society, University of Wyoming, July 19–August 20, 1954.

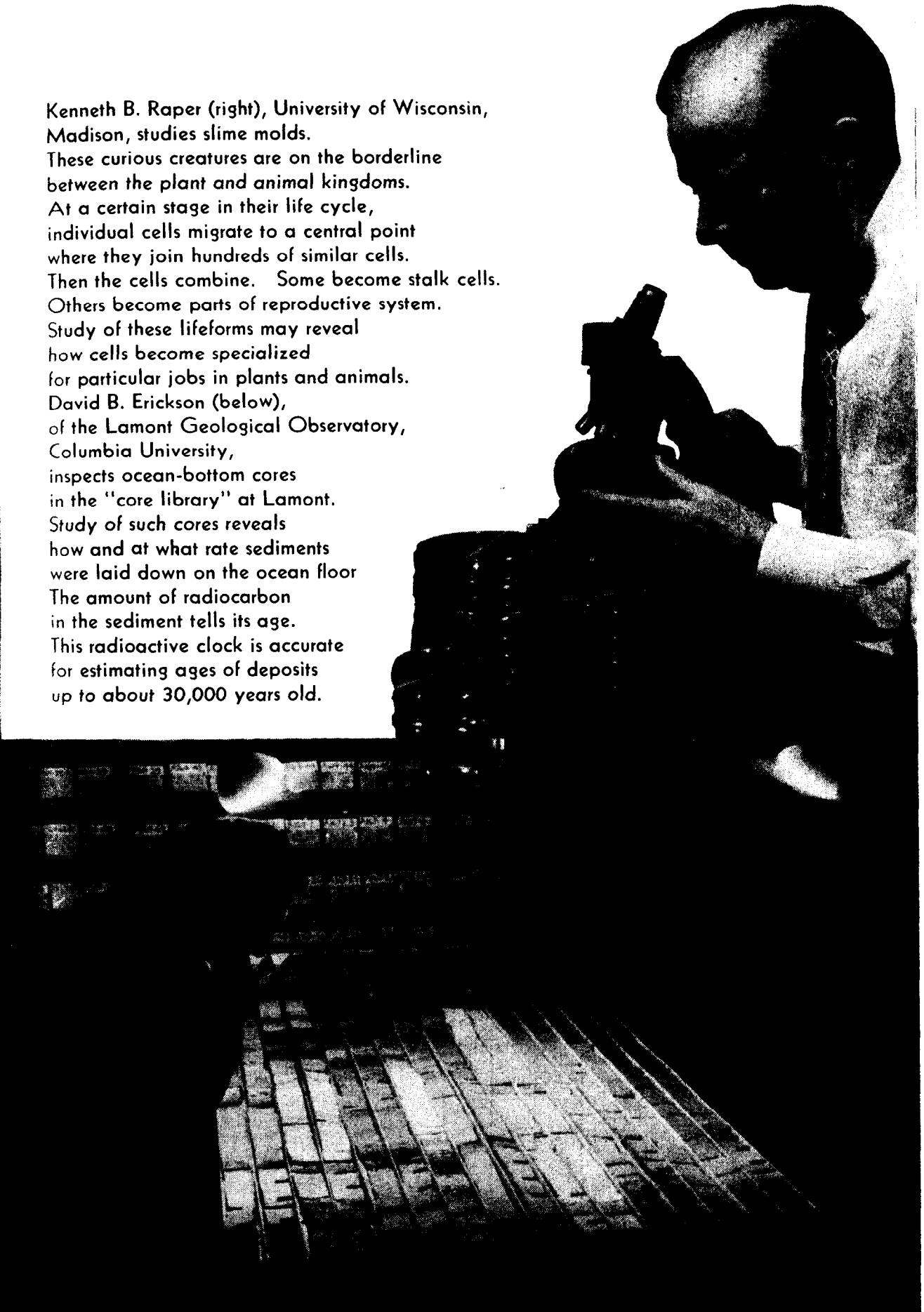
Colloquium of College Physicists, State University of Iowa, June 16–19, 1954.

The conferences are attended normally by teachers from the regions in which the institutes are held. The programs are built around outstanding research leaders who serve as lecturers and seminar directors. The direct contact with active scientists has been beneficial in improving teaching and curricula, which in turn stimulates students at the undergraduate level, making them more aware of current scientific progress at an early stage in their training and encouraging them to undertake careers in research.

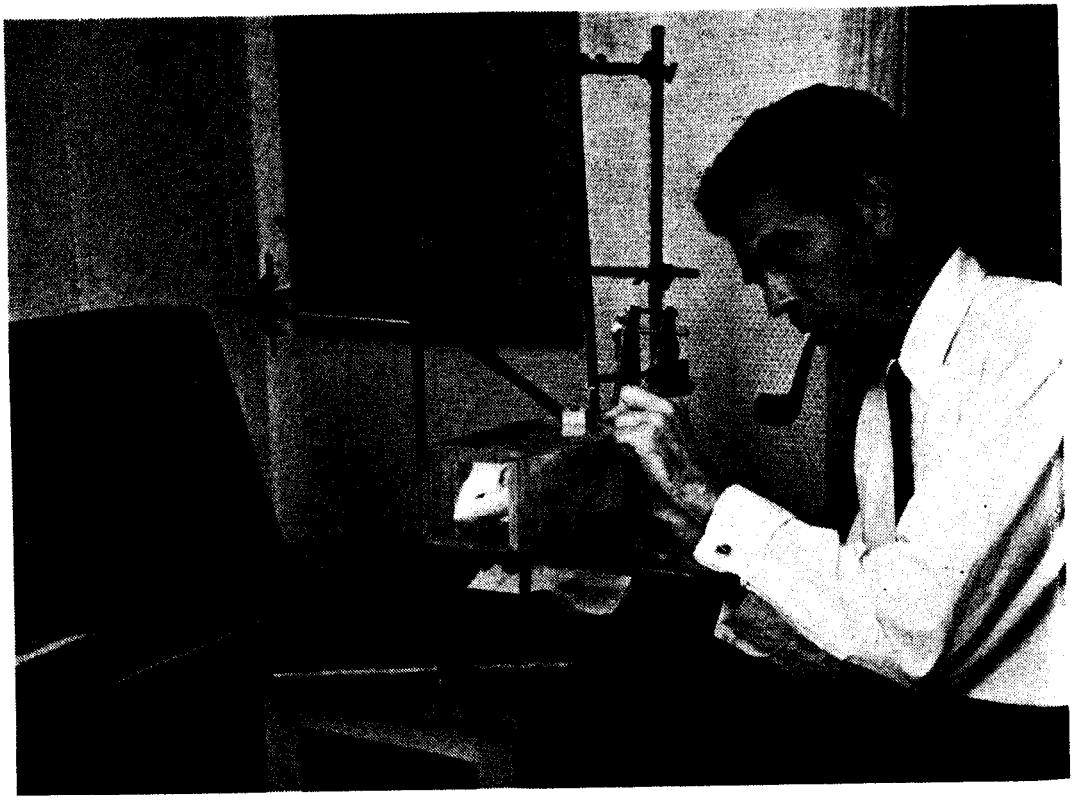
CONFERENCES IN ENGINEERING SCIENCES

During the past few years, engineering educators have realized that engineering education is in a transitory stage. At this time there is, first, an increasing emphasis on the inclusion of engineering subjects in the undergraduate curriculum and, secondly, an increase in the need for a larger number of students to obtain advanced degrees in engineering. A

Kenneth B. Raper (right), University of Wisconsin, Madison, studies slime molds. These curious creatures are on the borderline between the plant and animal kingdoms. At a certain stage in their life cycle, individual cells migrate to a central point where they join hundreds of similar cells. Then the cells combine. Some become stalk cells. Others become parts of reproductive system. Study of these lifeforms may reveal how cells become specialized for particular jobs in plants and animals. David B. Erickson (below), of the Lamont Geological Observatory, Columbia University, inspects ocean-bottom cores in the "core library" at Lamont. Study of such cores reveals how and at what rate sediments were laid down on the ocean floor The amount of radiocarbon in the sediment tells its age. This radioactive clock is accurate for estimating ages of deposits up to about 30,000 years old.



Graduate students in geophysics (left) at the Pennsylvania State University study the generation of seismic waves. The 70-lb. weight is dropped to the ground and vibrations are measured. The research is directed by Benjamin J. Howell, third from left. (Below) Edward L. Walker of the University of Michigan uses white rats and electric shock in experimental study of learning behavior. The rat learns to avoid mild electric shocks on its tail by hunching forward when a tone sounds. This acquired "avoidance" habit persists long after the need for it has passed. Dr. Walker is exploring the psychological problems of "unlearning" or eliminating such rigid acquired habits—a situation that arises in treatment of some types of pathological human behavior.



third important factor is the need for inclusion of some of the more recent advances of science into the engineering curriculum so that the engineers will be able to apply these new principles as rapidly as possible.

Several groups interested in these problems have asked the Foundation to assist educational authorities in the "pure science" fields to meet with responsible leaders in engineering education in an attempt to resolve the problem. The American Society for Engineering Education selected two specific areas for such conferences: (1) Solid State Physics in Engineering Education, and (2) Nuclear Physics in Engineering Education. In each subject a double conference composed of physicists and engineers was held with Foundation support. The first conference was composed of persons who were conversant with the problems in the area under discussion. The conferees spent 3 days discussing such subjects as (*a*) the status of the basic science areas, (*b*) the most important areas to be included in the engineering curricula, and (*c*) how these added materials can be introduced into an overcrowded curriculum.

Following the initial conference, a program was prepared for a larger open conference in each case, and all interested members of the staffs of all engineering institutions were invited to attend the open meetings.

The first double conference of this type was the invitational conference in the field of Solid State Physics in Engineering Education, held at Allerton House at the University of Illinois in March 1954. During three fruitful days of discussion a picture developed of the need for the inclusion of solid state physics in the regular engineering curriculum. The recommendations of this conference were published in summary form so that participants in the second conference held at Carnegie Institute of Technology in June 1954 would be advised of the background before attendance at the meeting. The proceedings of the entire double conference will be published so that the information will be available to engineering educators generally.

The initial session of the conference on Nuclear Physics in Engineering Education was held at Columbia University in April 1954. At this conference it was generally agreed that it was desirable for information on nuclear processes to be included in the standard engineering curricula and that the development of specialized curricula in nuclear engineering should be undertaken with considerable caution. The decision on how much and in what way such material should be incorporated in the standard engineering curricula, is of importance. The conferees reached some tentative conclusions which were presented to a larger audience at the open conference at Northwestern University held in September 1954.

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In this instance again, a publication of the proceedings of the conferences will be prepared for wide distribution.

This experience suggests that the double conference technique has certain advantages. It permits a small group well versed in the problems under discussion to come to some tentative conclusions and arrive at a meaningful agenda. The larger group is then in a position to examine critically and revise the tentative conclusions in light of their more general background.

SCIENCE TEACHING IN THE SECONDARY SCHOOLS

The quality of science teaching at the secondary school level is of the utmost importance, for it is normally at the high school level that students first exhibit interest in scientific careers. More important, decisions are made at this time in selection of course work, such as mathematics, which is prerequisite to continuing scientific training in later years. Many organizations, both private and public, have studied the problem and generally agree that the high school science teacher has a unique opportunity to recognize talent early and to stimulate students toward more intensive science training at college and postgraduate levels. The teacher needs guidance and assistance, however, in carrying out this responsibility.

During the past year the Foundation has continued to support Science Service, Inc., which administers the Science Clubs of America and science fairs on a local and national basis. This program provides a practical outlet for the scientific enterprise and imagination of young students and encourages and rewards them for their early scientific achievement. Science clubs are located in many of the States of the country and receive strong support from many community groups. The membership, now estimated at 300,000, continues to grow.

The Foundation also sponsored an experimental Summer Conference for High School Mathematics Teachers at the University of Washington, Seattle, July 26–August 20, 1954. This conference, somewhat similar to the college institutes, was aimed at the high school teaching level and emphasized modern viewpoints in the teaching of algebra and geometry.

Exchange of Science Information

In the interest of scientific progress American scientists must be informed on research developments throughout the world. At this particular time, however, the most acute need is for more widespread knowledge in the United States of the status of Russian science, and the National Science Foundation has turned its attention to this problem.

The American Institute of Physics at the request of the Foundation has undertaken to develop a plan for improving the comprehensive coverage, abstracting, and translation of important current reports on physics research in the Soviet Union. During the course of this study the Institute questioned over 600 members of the American Physical Society to determine the limits of such a program and to pinpoint those areas of most immediate interest. In their replies the American physicists urged that complete English translations of Soviet physics journals be made available for two principal reasons:

1. Because of the technical value of the research now in progress in the U. S. S. R.

2. Because of the national danger of underestimating the strength of the U. S. S. R., particularly as far as scientific advances are concerned.

Among the specific areas listed in which the Russians have shown unusual competence and originality were molecular spectroscopy, magnetism, low temperature physics, underwater sound and related applied acoustics, solid state physics, nonlinear mechanics and differential equations.

During the year the Foundation provided support to the American Mathematical Society to continue its program of translating about 1,000 pages a year of the most significant Russian mathematical papers.[1]

The Scientific Translation Center of the Library of Congress established under the sponsorship of the Foundation and the Atomic Energy Commission has collected, catalogued, and listed over 2,000 recent scientific translations from Russian journals. The translations are collected from many sources, including Government agencies, scientific societies, industrial laboratories, and universities. The Center issues a monthly *Bibliography of Translations from Russian Scientific and Technical Literature* from which scientists can order microfilms or enlarged

[1] Copies of these translations may be obtained directly from the American Mathematical Society, 80 Waterman Street, Providence, R. I.

photocopies. The response to this service, particularly among scientists from Government and industrial laboratories, has definitely shown its value. Translations are collected on mathematics, astronomy, physics, chemistry, earth sciences, biological sciences, agriculture, medicine, engineering and technology.

SUPPORT OF SCIENTIFIC PUBLICATION

In its initial statement of policy regarding the support of research the National Science Foundation adopted the principle that publication of the results was an essential element of good research. In pursuing this policy the Foundation has approved inclusion of publication costs in its grants for research support, and from time to time grants have been made solely for support of scientific publications. At the same time, however, the Foundation has maintained that direct Federal subsidy of private scientific publications is neither necessary nor desirable at this time. In order to reconcile these two policies, it seemed appropriate to establish criteria for use by the Foundation in evaluating requests for financial assistance to publications.

During the year with the advice and assistance of the Advisory Panel on Scientific Information tentative criteria were developed. These criteria, which take account of both scientific and economic factors, are:

The publication should have an adequate referee system to insure that only material of high quality is published.

Only publications covering original basic research in the sciences, including monographs and secondary publications, such as index, abstract and review journals, should be considered for support. It was felt that except for historical material, manuscript collections, and other unique or scarce materials, scientific bibliographies should not in general be supported.

Foundation support should be primarily of an emergency nature and it should be clear that the publication is taking steps to become self-supporting within a reasonable time.

Highly specialized or "splinter" journals should not be supported if it is feasible to publish the material more economically in a journal or journals of broader coverage.

Federal support of scientific publication is undesirable if it is used so that the published material is priced at an artificially low level.

Alternative methods of publishing the material in question should be considered, for the Foundation's primary interest lies in making the information available rather than in supporting any established publication or reference service.

Federal support should not normally be given local publications or services of interest primarily to scientists in a particular geographic locality.

In considering requests for support for publication of books and monographs, all methods of printing should be investigated to determine how the work can be published in the most economical way.

INTERNATIONAL INFORMATION EXCHANGE

During the year the Foundation approved individual travel grants to 101 American scientists to permit them to participate in 25 of the approximately 250 international scientific meetings held during the year. In order to insure the maximum benefit to science and to the Nation, the meetings for which travel grants are awarded are carefully selected. Individual scientists are selected with the assistance of panels of consultants, scientific societies, or the appropriate committees of the National Academy of Sciences.

One of the most important international meetings held on the North American Continent during 1954 was the Fourteenth International Psychological Congress at Montreal, sponsored jointly by the American Psychological Association and the Canadian Psychological Association. The Foundation approved a grant to defray part of the costs of the Congress and it also sponsored four individual conferences on special areas in which leading scientists attending the Congress participated. The special conferences are described in a previous section of this report. The total attendance at the Montreal meeting was 1,500, including some 250 scientists from abroad.

Outstanding foreign scientists in many other fields were able to participate in Foundation-sponsored conferences held during the year. The Foundation has encouraged such meetings in the belief that personal contact with leading scientists of other countries stimulates exchange of scientific information in a way that cannot be done by any other means of communication.