Program Activities of the National Science Foundation

446243—57——5

SUPPORT OF BASIC RESEARCH IN THE SCIENCES

Research 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. Fiscal year 1957 research projects described here in brief are to be considered illustrative of the type of research being supported. The projects described are not necessarily the most significant, nor is the number selected meant to be indicative of the relative importance of the particular program.

DIVISION OF BIOLOGICAL AND MEDICAL SCIENCES

Current Research Support

In *Regulatory Biology,* almost all phases of research in physiology and physiological biochemistry are represented. One of the larger components is intermediary metabolism, both animal and microbiological. Other large segments include endocrinology, immunology, cellular physiology, plant physiology, and neurophysiology. During fiscal year 1957, this program gave continued support to research on the problem of plant growth and differentiation, including studies of growth-promoting substances such as the auxins, kinetins, and gibberellins. Other promising projects supported are an investigation of biochemical and physical mechanisms involved in the transfer of substances across the cell membranes; the elucidation of the metabolism of a recently discovered biologically active compound, mevalonic acid, which is required for growth of microorganisms; and a number of studies of the function of the integrating systems (endocrines, nervous tissue, etc.) of the animal organism.

The major effort of the *Molecular Biology* program is on the structure, synthesis, and reactivity of proteins and other macromolecules, and with the more molecular aspects of intermediary metabolism and biosynthesis. In protein chemistry, for example, grants were made for research on the

theory of diffusion of macromolecules, on the one extreme, and on the synthesis of polypeptides, on the other. In the area of intermediary metabolism and biosynthesis, grants were made for research dealing with amino acid metabolism, with enzymatic synthesis of a desoxyribonucleic acid, and with virus formation. A significant number of grants were made in bioenergetics; on the morphology of ultrafine structure; and on photobiology.

The support of research in *Psychobiology* reflects a continued emphasis on neuropsychological work. For example, support was given for studies of problems of brain biochemistry and behavior, and for neurophysiological work. Other outstanding grants include one for research on the biophysics of vision; on chemoreception; on neuromechanisms of behavior; and on conditioned learning. Of importance to the general field of experimental psychology was the continued support of work relating mathematical research techniques to psychological research. The support of research and training activities in the smaller departments of psychology was also extended in fiscal year 1957, with grants to the University of Nevada and to the University of New Mexico.

In *Environmental Biology,* approximately half of the active grants were for studies in the dynamics and structure of animal populations, quantitative community ecology, and qualitative phytosociology and vegetation development. A quarter of the program supports research in physiological ecology with projects oriented toward physiological reactions of plants and animals to environmental factors. The remainder of the program includes projects related to paleoecology; ecological aspects of behavior; terrestrial, marine, and fresh-water productivity; limnology and biological oceanography; parasitology; life history studies; radiation ecology; and microclimatology. Grants initiated in fiscal year 1957 included research on physiological ecology of marine animals; late-Pleistocene limnology; integration of a forest community; ecological physiology of avian behavior; ecological microcosms; productivity of alpine plant communities; environment-related changes in composition of phytoplankters; ecological relationship of amphibian species; and relation of external environment to the incidence of parasitism in fish.

Research in *Systematic Biology* continued to support the program's objectives of clarifying evolutionary history of living and extinct organisms, and of furthering our knowledge of their spatial interrelationships. Projects supported included both traditional studies involving identification, nomenclature, and classification; and those utilizing genetic and physiological techniques to complement the more classical methods which depend primarily upon morphological criteria. The program has at-

tempted to encourage the exploration of problems involving experimental research techniques without neglecting those studies upon which taxonomy traditionally depends. Of great importance to systematic biologists are indices of various sorts; the preparation of these is a time-consuming and often thankless task for which institutions need modest assistance of a sort the Foundation's advisers are strongly disposed to recommend. Foundation grants are now resulting in active work on three such indices: an "Index of Lichens from 1935 to 1955," a "New Index Muscorum," and a compilation of generic names of fossil plants for the "Index Nominum Genericorum."

Grants in the *Genetic Biology* program are distributed about equally among studies of higher animals, higher plants, and micro-organisms. Among studies on higher animals, about half of the grants activated in fiscal year 1957 support research on *Drosophila,* the fruitfly. Among *Drosophila* investigations, one is of particular interest in that it is aimed at determining the genetic basis for behavior patterns. This study not only illustrates how useful *Drosophila* can be because of the extensive knowledge of its genetic composition but also how separate disciplines like genetics and psychology can be effectively brought together in a single coherent project. Again in the area of animal genetics, a study of special interest is that of the effects of radiation on polygenic inheritance in chickens. This is a pioneer effort on the use of X-rays to induce "good" mutations which result in improvement of quantitative traits, such as egg production. In the area of plant genetics, support was provided for a continuing attack on the nature of the gene in maize. Illustrative of evolutionary studies in plant genetics is one on the cytogenetics of wheat. Here continued support will permit completion of the identification of the source, in the evolutionary sense, of the chromosomes found in modern polyploid bread wheat. In microbial genetics, support has been provided for an investigation of the fine details of the gene-enzyme relationship. Slowly but surely studies of this sort in biochemical genetics are clarifying our understanding of exactly how the gene works, one of the most fundamental problems in genetics.

An idea of the nature of the *Developmental Biology* program may be obtained from several projects supported during the past fiscal year. For example, one of the most interesting developmental studies being undertaken is that concerned with transferring nuclei from cells which are partially or fully differentiated back to an enucleated egg. By this approach, it is hoped to establish whether or not the nuclei from the older cells become irreversibly altered during the course of their differentiation. Another important research project is that dealing with

studies of the mechanisms of lens formation. Lenses originate from the epidermis which covers the embryonic eye primordia and this process requires an intimate contact between the optic cup and the lens-forming tissue. The nature of the interactions between these two tissues and how they result in the production of the lens is under close scrutiny. Still another project is a tissue-culture analysis of the developmental effects of a number of mutations in the mouse. These mutations produce failures in various organ systems. Developmental studies have indicated that the organs involved require interactions between two or more embryonic tissue components during the very early stages. The investigators are attempting to establish at which point the genetic factors produce their effects and where the anomalies have their initiation. Such an approach, with tissue culture, has great promise, and indirectly, applicability to congenital anomalies in human beings.

Within the *Anthropological and Related Sciences* area, fiscal year 1957 grants have included several in anthropology and archeology, and one or two each in demography, psycholinguistics, and social psychology.

Significant Research Developments

SUMMER DORMANCY IN TOMATOES.—Tomatoes (particularly the Marglobe variety) are adversely affected by the high light intensities and temperatures of Texas summers. The condition of "summer dormancy" in tomatoes in essence amounts to a very marked reduction in the growth of both vegetative and reproductive structures. Foundation-sponsored research has shown that cool temperatures, auxins, or red light are capable of reversing this dormancy. However, none of these methods serves as a practical method of control in the field.

Far red light, on the other hand, enhances dormancy. Such light is normally received in the summertime; irradiating winter greenhouse tomatoes with far red light produces typical midsummer symptoms. Spraying the plants with gibberellic acid neutralizes the effect of far red light, thus breaking the dormancy and allowing normal growth. The use of this technique may provide real economic gains for farmers in Texas and similar areas. (See p. 30.)

NIGHTTIME OCEANIC LUMINESCENCE.—The displays of light which are sometimes observed in the ocean at night are so brilliant that a fish or man swimming beneath the surface is clearly outlined by the light; a ship or even a submarine may be detected from the air by virtue of the light. This luminescence is caused by small unicellular organisms, primarily dinoflagellates. An investigator has found that the dinoflagel-

late *Gonyaulax polyedra* emits light rhythmically—as much as 60 times brighter at night than in the daytime. This rhythmic behavior is much like that of a clock, so that it might be called a biological clock. For example, it can be reset so that maximum luminescence occurs during the day, merely by arranging appropriately scheduled lights. But this clocklike activity, although geared to the environment in this fashion is not dependent upon environmental changes for the rhythm to persist. Under absolutely constant conditions, the luminescent response will continue to go up and down, marking off daily cycles of approximately 24 hours. This is actually an ability to tell time; a well-known characteristic of higher organisms. The way in which this rhythmicity occurs within the cell is now under investigation. It has already been determined, for example, that the protein enzyme which catalyzes the chemical luminescent reaction increases and decreases daily in phase with changes in light emission. The widespread occurrence of diurnal ryhthmic behavior suggests that the oscillating chemical system within the cell may be a very fundamental process. Understanding of the mechanism for this rhythmic process may lead to an understanding of such basic biological functions as the wake-sleep relationship and the periodic electric discharge of nerve cells.

CHEMICAL NATURE OF PLANT GROWTH RESPONSE TO GRAVITY.—The mechanism by which plants "feel" gravity, and how once they have felt gravity they orientate their growth is not well understood. One recently developed explanation of why the roots grow down and the shoots grow up is chemical in nature.

The sensory mechanism for gravity detection in plants may be analogous to the "solion" device developed for missile guidance. Disturbance of the plant's orientation in space initiates electron flow between metabolically maintained areas of fixed potential. In some as yet unexplained way this electron flow initiates the chain of reactions leading to differential growth.

A chemical agent, N-1-naphthylphthalamic acid has been discovered which inhibits growth only slightly in minute concentrations. Seedlings treated with this agent, however, fail to respond to gravity. The roots grow in random directions. (See p. 27.) The substance seems to prevent differential growth. The existence of such substances should provide for studies of correlative growth and may have results as important as those arising from earlier correlative growth experiments with "weed-killing" plant growth regulators.

DISCOVERY OF NEW METABOLIC PATHWAY IN MAMMALS THROUGH STUDY OF CONGENITAL PENTOSURIA.—The metabolic basis

for the genetic abnormality known as congenital pentosuria, an apparently harmless defect characterized by the excretion of the rare pentose sugar, *L*-xylulose, has been investigated. It was possible to use this defect as a clue to an undiscovered area of metabolism, since current knowledge did not provide an explanation as to how *L*-xylulose might be formed. Furthermore, a study of pentosuria might serve as a model for investigating other harmful metabolic defects, which probably include muscular dystrophy and arthritis.

The information about the widespread ability of mammals to produce *L*-xylulose, together with evidence that it can be utilized by animals, suggested that this sugar is a normal metabolite. Enzymes were found in the liver whose action provided an understanding of the normal metabolic pathway of the sugar and an insight into the enzymatic deficiencies in pentosuric individuals.

As a result of this work it now seems clear that another metabolic pathway in mammals had been uncovered. There appear to be sidepaths, thus making it difficult to define clearly the nature of the defect in congenital pentosuria. This question is still under study, but it is considered secondary to the problem of elaborating a new metabolic pathway in the mammalian organism.

PHYSIOLOGY OF INSECT FEEDING.—Insects consume such large quantities of our agricultural crops, stored food, houses, and clothing that the dollar losses run into astronomical figures. They also feed upon man much to his discomfort. Yet, despite the importance of insects' feeding habits in relation to human health and economy, very little is known about the physiology of insect feeding. What is the basis of hunger in insects? What stimulates them to feed on certain materials and at certain times? Can their feeding behavior be altered to the benefit of mankind? These are some of the questions which are being answered through Foundation-supported research.

The investigation has shown that many insects are stimulated to feed on particular materials by specific chemicals characteristic of those materials. These chemicals are termed "token stimuli" and do not necessarily bear any relation to nutritional adequacy. Nevertheless, they are extremely important in determining an insect's choice of food and the quantity which it will consume. Experimental techniques have been devised whereby flies, living in a container in which there are drinking tubes with different kinds of liquid foods, can freely choose one of these and automatically activate a recording device which records the choice of food, the quantity of food taken, and the duration of feeding. These experiments have shown, among other things, that there is no relation

between the nutritive value of carbohydrate foods and their effectiveness in driving the fly to feed on them.

Experiments designed to determine the relationship between hunger and sensory stimulation (taste threshold) suggest that hunger is merely the absence of inhibitory stimuli. The evidence is that when the fly is fully fed, these inhibitory stimuli prevent messages from the taste sense organisms from rousing the desire for food. (See p. 28.)

STRUCTURE OF PROTEINS.—Proteins are the basic life substance. They include the enzymes and, in conjunction with polynucleotides, they form the genes and viruses, as well as the templates from which proteins reproduce themselves. A fundamental biological problem is that of the structure of these molecules. An award-winning investigation of the hydrodynamic and thermodynamic properties of proteins has led to significant knowledge as to the influence of the overall or gross configuration of protein molecules on their reactivity. The hydrodynamic experiments provided an assessment of the influence of the configuration on reactivity; the thermodynamic experiments, more detailed information about interactions between specific groups within the molecule.

The most recent work on carboxyl and tyrosyl ionizations in bovine serum albumin has provided evidence of the detailed changes taking place within the albumin molecule and provides a basis for the so-called configuration adaptability of this protein.

CHANGES IN ELECTRICAL ACTIVITY ACCOMPANYING THE LEARNING PROCESS.—Just how the brain works during the process of learning has been until quite recently almost a complete mystery. A technique has been devised for inserting microelectrodes into the gray matter of the brain of animal subjects to measure changes in electrical activity which accompany the learning process. It has been determined that the first step in conditioning (a form of learning) appears to be not the formation of new connnections between the nerve cells in the brain (a previously widely held view) but rather the elimination of widespread generalized responses to a particular stimulus. In time a more limited and specific response emerges to the stimulus as the result of stimulus repetition. Thus, the development of control over irrelevant responses seems to be a more important factor in learning than the formation of new nerve cell connections. The investigators are now determining the changed electrical reactivity in various areas of the brain occurring during the conditioning process from the time the stimulus is first presented until the animal is fully conditioned to react to the stimulus in a specific way. Through the development and use of such precise techniques as those employed in this research, we will be able to obtain an understanding of how the brain operates in the learning process.

ENVIRONMENTAL FACTORS INVOLVED IN DETERMINING THE SUCCESS OF INSECT REPRODUCTION.—In basic studies of the effects of temperature on milkweed bug development, results have been obtained which could prove of unusual importance to personnel concerned with predicting and combating outbreaks of destructive insects. An investigator found that the occurrence of a finite temperature threshold for hatching of the milkweed bug eggs is correlated with depletion of food reserves in the egg. Temperatures below 20° C. retarded development much more than they retarded expenditure of energy. Thus, at lower temperatures there may not be enough egg food reserves to complete development of the insect. Further studies revealed, however, that in addition to the "hatching threshold," there is what may be termed a "viability threshold" which is independent of hatching and which requires temperatures of 20° C. or higher. The exact nature of this vitality factor is as yet unknown, but it appears to be biochemical and to be correlated with the abrupt change in developmental rate curves at around 20° C. in this species. These data suggest that hatching does not necessarily imply that an insect will grow. Lacking "vitality" it will die even under favorable environmental conditions. Accordingly, the current practice of using hatching percentages to predict the size of future insect populations (e. g., pest outbreak prediction) may not be a sound scientific technique.

MECHANISM UNDERLYING THE INDUCTION OF MUTATIONS.—Concern over the genetic effects of radiation has brought to the foreground our incomplete understanding of the mechanism underlying the induction of mutations. In bacteria, the delayed appearance of radiation-induced mutations for several cell generations has offered an unusual opportunity to study the factors which operate in mutagenesis. Outstanding work has been performed in analyzing the basis of the delayed appearance of one type of ultraviolet-induced mutant. It was found that the percentage of mutants which will appear is determined during the first hour after irradiation. Moreover, the number is directly proportional to the rate of protein synthesis going on in the bacterial cells during this first hour. Although many of the mutants cannot be detected until later generations, a given irradiated cell will produce either all mutant descendants or none. It would seem, therefore, that a "premutant" state is present after the first hour in those cells destined to give rise to mutants. The nature of the "premutant state" and the steps from it to the manifest mutation are unsolved and fascinating problems. Their solution may go to the very heart of the mechanism behind the induction of mutations.

RELATIONSHIP BETWEEN AGE OF FATHER AND SEX OF OFFSPRING.—The cause of the small, but significant, excess of male to female human births is not understood. For this reason, considerable effort has been expended in the past on studies of the relationships between the age of parents, birth order, and the sex ratio. It has been often reported that with increasing age of the mother the sex ratio decreases. However, it has now been established that the age of the father is significantly correlated with change in sex ratio, whereas that of the mother is not. The apparent relationship of age of mother and sex ratio is only a reflection of the fact that, in most cases, the mother and father are of comparable ages. The significance of these findings is that they shift the emphasis from maternal to paternal causes behind the sex ratio deviation. Previously, differential survival of young embryos, with a change toward greater equality as the mother's age increased, was considered the best possibility. Now it will be necessary to look for causes of a change in the relative production or survival of male- and female-determining sex cells produced by the father as he ages.

FACTORS INVOLVED IN EMBRYONIC LIMB DEVELOPMENT.—Investigation of tissue interactions which result in the formation of a limb and of the specificities inherent in the tissues are being accomplished with the use of chick embryos. At the stages upon which the experiments are performed, the limb buds are very simple structures. An investigator has grafted tissue from a potential thigh area to the region which would ordinarily form the digits of a wing. The thigh tissue becomes modified and does form digits (a change in fate), but these are foot digits (the tissue retains its leg specificity). At these stages, therefore, regionality may be modified, but limb-type specificity is retained. Recently this investigator has turned his attention to a study of the role which cell death may play in the formation of the limb. While one does not ordinarily think of cell death as playing a part in the formation of a structure, painstaking investigations have revealed that the basic contours of the wing and leg are shaped by a wave of cellular degeneration. Cell death is particularly important in the formation of the elbow and knee.

SEQUENTIAL DEVELOPMENT OF EMBRYONIC TISSUE.—Normal cells of an early embryo are all alike. They grow by division after synthesis of new protoplasm. As embryonic cells grow, they become different from their precursors and from each other. Some form pigment cells; others, nerve sheath cells, connective tissue cells, white blood cells, etc. A study of amphibian embryos was undertaken to determine the biochemistry of differentiation by means of tissue culture. The researcher found that fairly simple organic compounds in the immediate environment of the cell act to drive the cell-differentiation machinery in specific

ways depending on the compounds and their concentrations. He induced the formation of amphibian pigment cells from precursors which never normally form such cells by a mild increase in the concentration of the amino acid phenylalanine. He also prevented the formation of pigment cells from precursors which normally form such cells by using an analog of phenylalanine. The inhibition can be relieved by the addition of a small amount of phenylalanine which in amphibians is synthesized by striated muscle cells. This is one example of sequential development of the embryonic tissues; the chemical products of one regulate the growth of other tissues.

EXCAVATION OF SHANIDAR CAVE IN NORTHERN IRAQ.—Support of research on the archeology and human paleontology of Shanidar Cave in Northern Iraq has resulted in several important discoveries. Chief of these were the finding of two adult human skeletons of premodern type and the discovery of an early neolithic village site nearby containing rudimentary foundations of rough field stones. The discovery of the two skeletons, in conjunction with the earlier finding of a child's skeleton in 1953, places Shanidar Cave among the more important Early Man sites in the Old World. The skeletal remains were found in an unfossilized or natural state due to the good preservative qualities of the soil, and appear to be of Neanderthal type on preliminary observation. One of the skeletons is possibly about 45,000 years old, the other about 60,000 years. (See p. 29.)

Facilities for Research in the Biological and Medical Sciences

Fiscal year 1957 was the first year in which the Division of Biological and Medical Sciences participated more or less formally in the support of research through grants for facilities. It was found that there is a demonstrable need for support in this area for facilities, such as controlled environmental laboratories, maintenance and use of systematic collections, and biological field stations.

Some 24 proposals for facility support were received during fiscal year 1957, totaling $5,175,000. Of these, 11 resulted in grants to the amount of $885,000.

Support has been provided for the repair, maintenance, rehabilitation, or expansion of field-station facilities. Of particular interest is a $415,400 grant to the Marine Biological Station at Woods Hole for the rehabilitation of a research laboratory building, the Crane Wing. A small grant of $24,000 went to the famous Naples Zoological Station for general maintenance and support. Two principal objectives of the grant were partial remuneration for the wear and tear to the facilities

resulting from their use by American scientists and recognition of its importance as a truly distinguished international research facility.

Other grants went to Yale University for the construction of a facility for a recirculating sea water system, and to the Philadelphia Academy of Natural Sciences for systematic research collections.

DIVISION OF MATHEMATICAL, PHYSICAL, AND ENGINEERING SCIENCES

Current Research Support

In the *Astronomy* program, grants ranged from studies related to the establishment of a large astrographic telescope in the Southern Hemisphere to a systematic search for super novae, and included studies of the distribution of interstellar dust, the infrared spectrum of the planets and the moon, and analyses of the solar electron corona. A method of narrow-band photoelectric photometry, using interference filters, has been perfected to give stellar color excesses and absolute magnitudes of high accuracy. This will allow a much better picture of the dust distribution and space distribution of the stars in the neighborhood of our galaxy than hitherto possible. Observations have been made of young clusters of stars which appear to have caught some stars in their earliest stages of evolution while still contracting gravitationally; among these are the T-Tauri stars.

As in previous years, the *Chemistry* program provided its chief support to research in organic and physical chemistry. In addition, support was extended to low-temperature and to high-polymer chemistry. As an example of low-temperature research, experimental and theoretical investigations of paramagnetism in crystalline salts are producing data of value in explaining the main features of the magnetic behavior of many salts in terms of crystalline fields, exchange reactions between ions, and interactions between the electronic and nuclear systems.

The *Engineering Sciences* program during the past year has supported basic research in heat transfer, metallurgy, electronics, reaction kinetics, fluid mechanics, and the mechanics of solids and materials. Areas of support range from dynamic and impact studies on concrete beams to the investigation of the mechanics of information transmission in human speech to research on meteor-burst phenomena which should add to our knowledge of long-range, interference-free transmission of very high frequency radio waves.

Studies of the earth, its constituents, its physics, and its chemistry fall within the cognizance of the *Earth Sciences* program. Support is provided for such fields as geology, meteorology, oceanography, and the like, as well as the newer fields of geochemistry, geophysics, and aeronomy. Projects supported during the past year vary from the study of the deep-sea floor to the study of the earth's magnetic field several hundred miles above the solid surface; and from the study of the composition of the earth's core to the physics of precipitation.

The concept of applicable mathematics until recently has rested in the domain of analysis. It now appears that the methods of the topologist, abstract algebraist, or mathematical logician are also of great value in the solution of practical problems, e. g., as interest in high-speed computing machine grows, mathematical logic contributes first to design, then to operation. The *Mathematical Sciencies* program has therefore continued in the support of research in group theory, topology, and mathematical logic; also to emphasize grants which would encourage talented students to become productive mathematicians.

The *Physics* program as in previous years provided much assistance to investigators of atomic nuclei and the solid state. High-energy physics received considerable support, particularly studies dealing with interactions of fundamental particles. Grants were also made for studies of the relationship between the general theory of relativity and quantum mechanics.

The *Sociophysical Sciences* program has emphasized research and conferences in the mathematical social sciences and in the history and philosophy of science. Among the research grants made in this program is one concerned with prediction of the behavior of individuals in situations where they are confronted with alternatives of which they have only imperfect knowledge.

Significant Research Developments

NEW SCANNING SPECTROGRAPH.—The development and construction of a new scanning spectrograph, with support from the Foundation, is quite likely one of the most important developments in astronomy during the past year. To test possible evolutionary changes in color and brightness and other cosmological problems, accurate observations of the color and brightness of galaxies were needed. By means of the scanning spectrograph, it has become possible in certain cases to obtain detailed information about the emission of energy in the violet regions which had been missed completely in the six-color photometry previously used. These features were found to have a significant effect on the observed

color index of a galaxy with a large red-shift and eliminated the color excess originally reported which indicated a rapid evolution of galaxies. The new observation provides strong support for the opposing "steady state" theory.

CHEMICAL STRUCTURE OF AN ANTIBIOTIC DETERMINED.—The chemical structure has been determined of an antibiotic known as Magnamycin. It is one of a group of antibiotics called macrolides isolated from soil microorganisms (Streptomyces). Members of this group, all of which contain a macrocyclic lactone ring in their structure, include Erythromycin, Pikromycin, and Oleandomycin. Obtaining information about chemical structure is the first step in the process synthesizing antibiotics tailored to specific requirements.

LIVING POLYMERS.—A polymer is a compound of high molecular weight formed by the joining together of simpler molecules, the relative amount of each element remaining the same. Rubber and plastics are examples. Polymeric molecules are born in an initiation process, grown by a propagation process, and finally die in a termination process. The death is regulated by the conditions prevailing during polymerization. Polymeric molecules have been developed which do not die and live for an indefinite period of time. A living polymer does not grow indefinitely, nor does its molecular weight grow beyond certain limits. It keeps growing until the supply of the monomer, the simple molecules from which it is formed, is exhausted. The ends remain living, however, and the polymer can grow again as soon as more monomer is added. From a color reaction it is even possible to tell whether or not the polymer is still living. And as indicated by the color change, it is possible to kill the living ends by the addition of air or moisture, thus stopping the process at will. Through the use of living polymers, it becomes quite simple to build block polymers, polymers formed from more than one monomer. As soon as one is exhausted, the next is added. The monomers used determine the block polymer's characteristics. The process is terminated by adding air or moisture. This investigation makes easily possible the formation of custom-built polymers.

ORIGIN OF METEORITES.—Metallurgical examination of meteorites has led to an understanding of the origin of meteorites. It has been shown that the iron-nickel alloys composing metallic meteorites cooled slowly under high pressures, and that at the same time fragmentation took place, suddenly releasing prevailing pressures. Better understanding of the processes initiated by entry of a meteorite into the atmospheric envelope of the earth may contribute to solution of problems associated with the reentry of aircraft or missiles into the earth's atmosphere.

STABILITY AND CONTROL OF CHEMICAL REACTORS.—Successful design of a chemical reactor is dependent upon the proper choice and regulation of pressure, temperature, and concentrations. Pressure may be varied to change reaction rates. Many reactions are very sensitive to temperature. In some cases, if the temperature rises above a certain value, gas desorption takes place; this condition may offset an increase in the reaction rate. Thus the control of the reactor is very important in order to obtain a desired product. An analysis has been made of the stability and control of a chemical reactor under a variety of conditions not previously considered. This study, which made use of a Univac computer, gives criteria for use in determining under what conditions various modes of control are feasible. Critical operating points, where the reaction may get out of hand, can also be predicted and thus be avoided by proper design.

PORTABLE INSTRUMENT FOR DIRECT MEASUREMENT OF CLOUD WATER CONTENT.—During the past 10 years there has been much publicity and activity in weather modification or "rainmaking" through the use of small crystals of carbon dioxide or silver iodide as nucleating agents. However, until more is known about the mechanics of precipitation and the general field of cloud physics, the possibilities of rainmaking cannot be fully realized. Of special interest in this area has been the development of a portable instrument that can measure directly the water content in a cloud. This radically new apparatus collects water as a plane flies through a cloud, mixes the water with a conducting solution, and electrically measures the amount of dilution. The instrument has passed its preliminary tests with flying colors and should aid greatly toward understanding precipitation mechanics.

GEOCHEMISTRY OF MERCURY ORES.—As a result of investigations into the geochemistry of mercury ores, it has been demonstrated rather conclusively that the black sulfide of mercury (metacinnabar) is the stable form of the compound at temperatures in excess of 344° C. and that the red sulfide (cinnabar) is stable at lower temperatures. This is contrary to previous ideas and will provide a better explanation for the origin of many quicksilver deposits. This knowledge should aid prospecting for new deposits in known mercury districts by permitting determination of the potential of the buried ore body from the outcrops.

MODERN ONE-VOLUME HANDBOOK OF TABLES OF MATHEMATICAL FUNCTIONS.—With the development of new scientific techniques, new and better tables of mathematical functions are needed. The Foundation is supporting the development of a modern handbook of tables within the compass of one volume. An example of the results being obtained is the compression of the table for the exponential integral, pre-

viously occupying 740 pages, into the space of 6 pages. It is estimated that the new handbook will contain 1,000 pages.

NEW COSMIC-RAY TELESCOPE.—Cosmic-ray physicists have been able to study particle reactions in energy ranges many billion times as great as those possible in even the largest accelerators (6 billion electron volts). A cosmic-ray telescope has been constructed which will record particles entering the earth's atmosphere with energies as high as 10^{18} (billion billion) electron volts. The results indicate that, in the energy range 10^{15}–10^{18} electron volts, cosmic rays come from all directions in space—an observation critical for theories concerning the origin of cosmic rays. At the highest energies recorded to date, the radii of curvature of primary cosmic rays in the magnetic field of the galaxy are becoming comparable to the transverse dimensions of the galaxy. In addition, the measurements indicate that the structure of the electron-photons provided by the impact of these primary particles are in agreement with present concepts of particle interactions.

The measuring techniques used in this investigation are so promising that it is now planned to extend the energy range of the apparatus and use it to conduct a cosmic-ray probe of the size of our galaxy. This will be of particular importance in that it may show that our galaxy, like nearby galaxies, is surrounded by a "halo" of magnetic fields and ionized matter.

MORE PRECISE LINEAR MEASUREMENT.—A new line-spectrum source for meeting the ever-more-exacting standards of precision linear measurement has been discovered. The investigator developed an operable calcium beam lamp which gives a spectrum line one-half as wide as the one produced by the isotopic-mercury lamp now used in this country. The lamp uses a well-defined beam of calcium atoms to carry the luminous discharge.

BUILDUP OF HIGHER ACCELERATOR BEAM CURRENTS MADE POSSIBLE.—Investigation of methods for producing particle collision using intersecting beams and only one accelerator has resulted in a quite feasible technique. It has been found possible with a modified fixed-field, alternating-gradient technique to have beams of the same mass and charge circulating in opposite directions in a single accelerator. This will permit the buildup of higher beam currents in several types of accelerators.

MANNER IN WHICH TECHNOLOGICAL CHANGE IS GENERATED AND PROPAGATED.—A mathematical model has been developed, in an attempt to explain the manner in which technological change is generated and propagated in the United States. The investigators used the introduction of hybrid corn as the subject of the study and plotted the be-

ginning of the movement, its rate, and its destination. Their conclusion was that once an invention has occurred or a useful and feasible idea has been published, the process of innovation, of developing the new idea, and of adapting it to the particular conditions of various markets is for the most part a process which is guided by economic consideration. The rate at which an innovation is accepted is largely a function of the relative amount of profit that can be obtained from the innovation. Similarly the level at which the new technique is stabilized is primarily determined by economic variables.

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

During the past fiscal year, a $4 million contract was entered into with the Associated Universities, Inc., for the construction of a radio astronomy observatory at Green Bank, W. Va. This facility will consist of 2 radio telescopes—one with a 140-foot paraboloid antenna and the other with an 85-foot antenna and auxiliary equipment. When completed, the 140-foot unit will be the largest and most advanced device of this kind in the United States. The observatory is intended to accommodate visiting radio astronomers as well as having a resident staff of moderate size. This observatory should be a significant factor in restoring the United States to a position of leadership in radio astronomy, a field opened up by the discoveries made by an American scientist, C. M. Jansky, Jr.

A grant for $500,000 was made to the Massachusetts Institute of Technology to provide partial support for the construction of a 2-million-watt nuclear reactor, estimated to cost $2.4 million. (The balance was obtained from other sources.) This reactor now under construction will be used for research in the solid state, radiation sterilization of foods, radiation-induced mutations, radiochemical investigations, radiation-induced catalysis, and reactor development. Hospitals in the Boston area will be able to use the neutron beam source in cancer therapy.

The reactor will also serve to educate engineers and scientists in the theory, design, and operation of nuclear reactors; in techniques for producing, handling, and measuring nuclear gamma radiation and radioactive material; and in the principles and application of reactor instrumentation.

A grant of $545,000 was made to the University of Michigan, for a continuation of studies leading to the establishment of an optical astronomical observatory in the Southwest. To date, four 60-foot "seeing" towers have been erected, all in Arizona, each one equipped with an

ingenious optical telescope for the continuous monitoring of Polaris. Data from each of these instruments will give an adequate measure of atmospheric turbulence at its location and so permit determination of the most satisfactory site for the observatory. (See p. 26.)

The building of these facilities should permit great progress in the field of astronomy. It will make available the latest research equipment to American scientists and will permit advanced research and post-graduate training of young astronomers.

Research-Related Activities

Support of Travel to International Scientific Meetings

On the basis of favorable congressional action, the program for the support of travel to international scientific meetings was reinstated in fiscal year 1957. The awards to individual scientists generally amounted to round-trip air tourist fare between the scientist's home institution and the location of the meeting. Travel grants were made only for carefully selected international scientific congresses and meetings; in addition, several individual grants were made in support of travel for other purposes, such as to attend committee meetings, and to visit laboratory or research sites. A total of 205 grants was made at a cost of $118,286.

Training Aspect of Research Grants

A continuing contribution of the research grants program is in the training of scientists, at both the pre- and postdoctoral levels, through research assistantships and associateships. Thus an important subsidiary result of the research grants made during fiscal year 1957 is that approximately 2,000 such people will receive advanced training in the sciences. These 2,000 are in addition to the over 1,100 fellows who will continue or resume full-time educational activity under the Foundation's 4 fellowship programs. (See Fellowships, p. 67.) Thus, a total of more than 3,100 men and women will have been provided opportunity to continue their scientific education and to gain experience under mature and seasoned investigators in the laboratories of our colleges and universities.

Miscellaneous Grants

Many of these programs are experimental in nature; most of them for comparatively small amounts. One of these programs was the

support of short-term research by medical students who do not participate in their medical school curricula for periods of an academic quarter or more to perform research under faculty mentorship.

Several other grants were made to enable qualified independent investigators, graduate students, and independent teachers from small colleges, to conduct summer research at field stations and established laboratories.

Other grants were made for summer research institutes in highly specialized fields, such as the one in mathematics which investigated mathematical logic and its interaction with algebra and topology. Another summer institute will provide training in nuclear emulsion research; yet another will provide research biologists with training in the techniques of electron microscopy.

Evaluation and Coordination of Research Programs

The Foundation's programs for support of basic research have been under way for six complete fiscal years. Consequently, there is natural interest in evaluating the return which the American taxpayer has received or can expect to receive on his "investment" in basic research. At this time, however, it is unrealistic to expect that immediate practical benefits will be visible. Results of basic research cannot be completely evaluated until years after the research has been completed, since rarely does one individual research project lead directly to significant practical application. The release of atomic energy was the culmination of decades of research by numerous individuals on the properties and structure of matter. It took years of basic research before Bell Telephone Laboratories developed the transistor. Therefore, there is a real hazard in attempting to evaluate or justify basic research programs in terms of a short-term assessment of practical "payoff." If such appraisal were to be emphasized, both Federal administrators and research scientists might tend to concentrate on work most likely to exhibit identifiable but relatively insignificant progress—with unfortunate distortion of our national basic research effort toward direction of applied research and development as a result.

However, it is possible to assure that Federal research funds are wisely spent. This can be done by (a) preselection evaluation to determine the research proposals of the greatest scientific merit, (b) postresearch evaluation through intensive followup of research results so that information is made available, and (c) minimizing duplication of research effort through coordinative processes.

Preselection Evaluation

The number of basic research proposals that the Foundation supports is a small fraction of the total number of proposals received. In order to select the most meritorious for support with the limited funds available, the Foundation typically employs a stringent evaluation process by which each proposal (which has been previously screened by the academic institution from which it emanates) is reviewed and rated by advisory panels of outstanding scientists, as well as by the professional staff of the Foundation. Only the most worthy proposals (about 75 percent of the total) are eligible for financial support.

Postresearch Evaluation

Once a research grant is made, the scientist is given maximum latitude, and the Foundation does not attempt to exercise control or direction over performance of research. Nonetheless, as research progresses, certain interim evaluation is possible. Scientists attempt to publish the results of their research in the appropriate scientific journals. By and large, space in scientific journals is at a premium, and only those papers which appear to have significance to the scientific community are accepted for publication. The quality of research performed by Foundation grantees is indicated by the fact that through June 30, 1957, nearly 2,000 articles in scientific journals, papers, monographs, etc., have resulted from Foundation-supported research.

At the end of a research project, and annually for projects that cover more than a year, grantees submit reports of their research to the Foundation. Progress made under previous grants is considered by advisory panels when the research scientist in question submits a request for further support. This also serves as an important step in the evaluation process and helps to insure that NSF funds are expended wisely.

Coordinative Processes

The Foundation has consistently aimed at elimination of undesirable duplication in Federal research support through various means. Emphasis has been given to insuring exchange of information among science administrators. One method for making information available has been the publication of periodic lists of Federal grants and contracts in several areas of science. For example, based upon information supplied by cooperating agencies, the Foundation has compiled and made available project lists in the life sciences (annually); in psychology,

psychiatry, and related areas (semiannually); and in social sciences and interdisciplinary fields (semiannually). This year it is also planned to issue such project lists for the mathematical, physical, and engineering sciences.

A quotation from the fiscal year 1955 issue of the life sciences project listing indicates the extent of coverage:

> . . . The listing contains 9,496 projects which were active during the period July 1, 1954 to June 30, 1955. The total rate of support represented by the projects approximates $82,544,000 . . . . The listed projects were supported by some eighteen agencies or their subdivisions and it is believed that this comprises essentially all Federal agencies and subdivisions which support unclassified research in the life sciences . . . . Thus, the report is complete to the extent that these agencies reported the pertinent life sciences information . . . .

These listings serve as a directory of all projects supported by Federal agencies at colleges, universities, and other institutions, and enable any agency in reviewing a proposed project to ascertain at a glance if any similar project is already receiving Federal support.

Current information on proposals received is also exchanged between various Federal agencies on a monthly basis. At the same time, informal contacts between science administrators throughout the Federal Government are strongly encouraged.

Fiscal Analysis of Research Programs

During fiscal year 1957, the Foundation made grants totaling $21,458,925 for the support of basic research in the sciences, including $5,930,000 for the construction and maintenance of research facilities. These funds made possible 997 grants in the biological, medical, mathematical, physical, and engineering sciences to 350 institutions in all 48 States, the District of Columbia, Alaska, Hawaii, Puerto Rico, Bermuda, Canada, Great Britain, Italy, Israel, Japan, and Sweden. Research grants for fiscal year 1957 averaged $15,539 to run for 2.06 years, or about $7,543 per year.

Facilities grants are discussed in detail in the sections dealing with programs of the research divisions.

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

National Science Foundation Research Grants by Fields of Science

Field	Fiscal years 1952–56		Fiscal year 1957		Total	
	Number	Amount	Number	Amount	Number	Amount
Biological and medical sciences:						
Anthropological	18	$184,800	17	$153,500	35	$338,300
Developmental	70	586,182	32	382,750	102	968,932
Environmental	82	746,860	65	777,200	147	1,524,060
Genetic	75	994,700	41	659,250	116	1,653,950
Molecular	181	2,748,730	84	1,784,950	265	4,533,680
Psychobiology	134	1,659,550	54	783,100	188	2,442,650
Regulatory	215	2,921,145	114	1,870,400	329	4,791,545
Systematic	177	1,399,080	89	706,575	266	2,105,655
General	40	721,510	31	503,200	71	1,224,710
	992	11,962,557	527	7,620,925	1,519	19,583,482
Mathematical, physical, and engineering sciences:						
Astronomy	75	1,261,800	33	453,900	108	1,715,700
Chemistry	254	3,106,200	147	2,653,700	401	5,759,900
Earth Sciences	102	1,318,275	54	770,150	156	2,088,425
Engineering	181	2,008,700	103	1,369,950	284	3,378,650
Mathematics	128	1,553,200	64	1,038,900	192	2,592,100
Physics	195	3,036,400	53	1,348,300	248	4,384,700
Sociophysical	8	105,100	12	154,100	20	259,200
General	1	7,000	4	119,000	5	126,000
	944	12,396,675	470	7,908,000	1,414	20,304,675
Total research grants	1,936	24,359,232	997	15,528,925	2,933	39,888,157

From figure 4 and the accompanying table, it can be seen that salaries accounted for 70.2 percent and equipment for 21.5 percent of the total funds distributed. Indirect costs were estimated at 13.5 percent of direct costs.

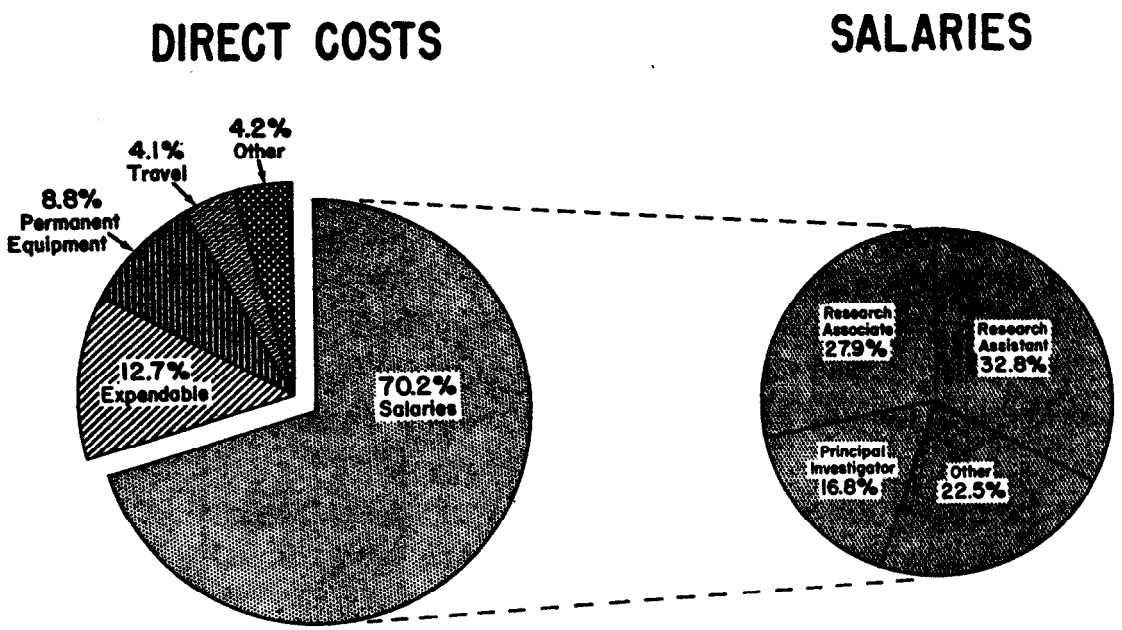

Figure 4.—*Analysis of the average National Science Foundation research grant in fiscal year 1957 by types of expenditures (estimated).*

Analysis of Salaries Paid From Average Research Grant [1] Fiscal Year 1957

	Average Grant Fiscal Year 1957	*Percent of salaries*
Principal investigator (total)	$1,612	16.8
Summer	(1,213)	(12.6)
Sabbatical	(24)	(.3)
Academic	(375)	(3.9)
Research associate [2]	2,683	27.9
Research assistant [3]	3,149	32.8
Other [4]	2,167	22.5
Total	9,611	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 when they are doing the research.

[3] Includes graduate assistants enrolled at the grantee institution and working toward a graduate degree.

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

Of interest in this discussion of Foundation support of basic research is figure 5 which compares, for the years 1953–57, the dollar value of meritorious proposals received with grants awarded. As can be seen

from figure 5, the dollar value of the meritorious proposals which cannot be supported keeps increasing from year to year. The number of proposals also keeps increasing. Characteristically, the proportion of proposals supported in terms of number is significantly higher than in terms of dollar value because most proposals are supported at a lower dollar value than originally proposed. This permits the spreading of limited funds over a larger number of meritorious proposals.

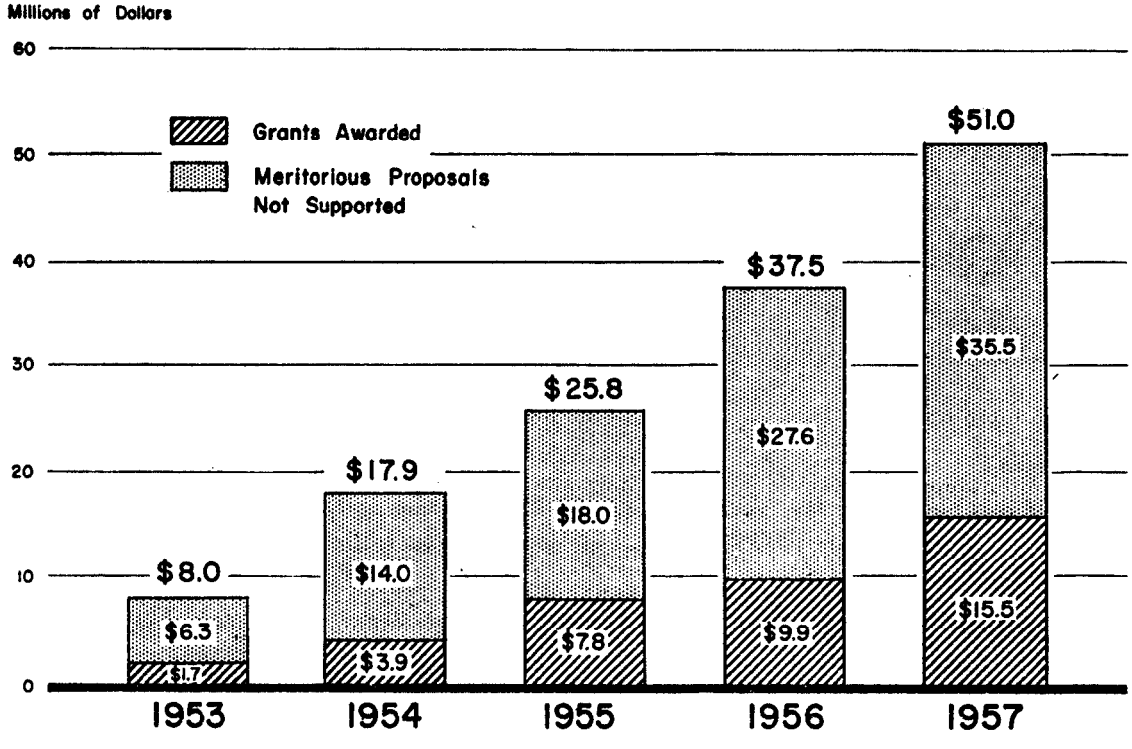

Figure 5.—*Comparison of meritorious proposals received with grants awarded, fiscal years 1953–57.*

CONFERENCES IN SUPPORT OF SCIENCE

The National Science Foundation as one of its primary functions supports conferences and symposia on specific aspects of science. These meetings provide excellent opportunities for the interchange of information and ideas among those investigators who are the advance guard in the never-ending search for new scientific knowledge. They also, in many cases, furnish the opportunity for younger investigators to meet and obtain information and advice from some of the world's foremost scientists.

The conferences are of two types—those where the subject matter is of particular interest to scientists in the same specialized field, and those where the subject matter is of interest to scientists in other fields. In many cases these meetings are attended by distinguished foreign scientists who participate in the discussions and presentation of papers along with their American colleagues.

The National Science Foundation sponsored and provided partial support for a total of 25 conferences in support of science during the year ending June 30, 1957—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 scientific topics covered by these 25 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, 1957

Subject	*Cosponsoring organizations*	*Chairman*
15th Growth Symposium...	Society for the Study of Development and Growth.	K. V. Thimann.
Binary Stars.....	Dominion Astrophysical Laboratory.	R. M. Petrie.
6th International Congress of Hematology.	International Society of Hematology, American Cancer Society.	William Dameshek.
Asphyxia Neonatorum Brain Damage and Impairment of Learning in Experimental Animals.	University of Puerto Rico, National Institutes of Health.	E. H. Hinman.
Theoretical Physics.....	University of Washington, Office of Naval Research, Air Force Office of Scientific Research.	John H. Manley.
Radiocarbon Dating.....	Robert S. Peabody Foundation for Archaeology.	Frederick Johnson.
Size and Shape of the Earth.	Ohio State University.....	W. A. Heiskanen.
International Ozone Conference.	Illinois Institute of Technology, Air Pollution Foundation, American Chemical Society.	Clark E. Thorp.
Gravitational Theory.....	University of North Carolina, Department of the Air Force, International Union of Pure and Applied Physics.	Bryce S. DeWitt.
Role of Botany in American Education.	Botanical Society of America.	Harriet Creighton.
Cellular and Humoral Aspects of Hypersensitive States.	New York Academy of Medicine.	H. Sherwood Lawrence.
Midwest Conference on Theoretical Physics.	State University of Iowa....	J. M. Jauch.
Archeological Identifications by Specialists in Related Disciplines.	National Academy of Sciences-National Research Council.	J. Charles Kelley.
7th Annual Conference on High-Energy Nuclear Physics.	University of Rochester, International Union of Pure and Applied Physics), Atomic Energy Commission, Office of Naval Research.	Robert E. Marshak.
Aging as a Biological Problem.	American Institute of Biological Sciences.	Nathan Shock and Bernard Strehler.
Scale of the Galaxy.....	Harvard College Observatory, Smithsonian Astrophysical Observatory.	Donald H. Menzel.
International Conference on Audiology.	Central Institute for the Deaf, Washington University.	S. R. Silverman.
Structure of Electrolytic Solutions.	Electrochemical Society.....	Henry B. Linford.

Scientific Conferences Sponsored and Supported by the National Science Foundation in Year Ending June 30, 1957—Continued

Subject	*Cosponsoring organizations*	*Chairman*
3d International Conference on Irrigation and Drainage.	U. S. National Committee of the International Commission on Irrigation and Drainage.	W. E. Blomgren.
3d Symposium on Cosmical Gas Dynamics.	Smithsonian Institution, International Union of Theoretical and Applied Mechanics, International Astronomical Union.	Jan M. Burgers.
Nuclear Geophysics.....	National Academy of Sciences-National Research Council.	P. M. Hurley.
22d Cold Spring Harbor Symposium on Quantitative Biology.	Carnegie Corporation, Atomic Energy Commission, Public Health Service, Milbank Memorial Fund, and The Population Council, Inc.	Bruce Wallace.
Problems of Tektites.....	National Academy of Sciences-National Research Council.	W. R. Thurston.
From Benzene to Graphite.	University of Buffalo, Office of Naval Research.	S. Mrozowski.
16th Growth Symposium...	Society for the Study of Development and Growth.	G. Fankhauser.

15th Growth Symposium

This symposium, held at Brown University in Providence, R. I., was attended by members of the various disciplines concerned with the study of growth who ordinarily do not meet together. Only a limited number of formal papers were given, so that much time was available for discussion. Subjects discussed were growth of viruses in cultured cells, relation of viruses to plant tumors, nature of the cell surface, endogenous rhythms in growth, origin of self-duplicating systems, problems of photosynthesis, and related topics. The meeting took place during July 1956. The chief concern of these symposia on growth is the synthesis of information resulting from the best of our basic research in biology.

Binary Stars

A Foundation-sponsored conference on binary stars brought together 22 astronomers at the Dominion Astrophysical Observatory, Victoria, British Columbia, in August 1956. Papers and discussions dealt with visual, eclipsing, and spectroscopic binaries, and stressed the importance

of observations of these stars as a foundation for the theoretical work on the origin and evolution of stars. Proceedings were published in the February 1957 issue of the *Journal of the Royal Astronomical Society of Canada.*

Hematology

The subject matter of this congress was divided equally between clinical and basic aspects of hematology. Sessions were held on basic subjects including platelet factors, fibrinogen and fibrinolysis, erythropoietic hormone and metabolic action of folic acid and vitamin B_{12}. The congress was held in Boston during the week of August 1956, and the attendance of 1,500 included scientists from many foreign countries.

Asphyxia Neonatorum

This conference was held in conjunction with the reopening for research purposes of the primate colony on Santiago Island. The meetings took place in September 1956 at the University of Puerto Rico. Approximately 15 to 18 scientists participated in the discussion of the scientific nature of asphyxia neonatorum brain damage and impairment of learning in experimental animals resulting from lack of oxygen in the newborn.

Theoretical Physics

This International Conference on Theoretical Physics was held in Seattle during September 1956. Representatives from several nations of Europe, Russia, the Far East, Mexico, and South America attended the conference. Discussions covered all of theoretical physics including the fields of quantum electrodynamics, astrophysics, magnetic resonance, molecular physics, nuclear physics, superfluidity, and solid state.

Radiocarbon Dating

In October 1956 a conference on radiocarbon and its application to dating problems in geology and archeology was held at Phillips Academy, Andover, Mass., under joint sponsorship of the Foundation and the R.

S. Peabody Foundation for Archaeology. Second of its kind sponsored by the Foundation, the conference provided a forum for the exchange of information in the several scientific fields concerned with the instrumentation or application of radiocarbon dating techniques. Sharing in the conference were more than 50 participants, including chemists, physicists, geologists, archeologists, and oceanographers from the United States, Europe, and Australia.

Size and Shape of the Earth

This conference was held at Ohio State University in November 1956 and was attended by about 100 scientists, representing more than 28 governments and private organizations. The purpose was to help make possible the conversions of the geodetic systems of the separate nations into a world geodetic system and to permit an exchange of information on recent advances in geodetic techniques, especially as they relate to activities of the International Geophysical Year. The conference was divided into four parts—(1) classical and modern "arc-measuring methods," (2) celestial methods, (3) world gravimetric system, and (4) world geodetic system.

Ozone

Ozone is one of the important compounds concerned with air pollution. In order to bring together leading authorities in the rapidly expanding field of ozone chemistry, and to disseminate current knowledge in the field, an International Ozone Conference was held at Chicago in November 1956. Nine eminent scientists who have contributed in this field in England, France, Germany, Hungary, Holland, Japan, and Switzerland participated actively in the conference which was attended by some 400 persons. Sixty papers were presented, and the proceedings will be published by the American Chemical Society.

Gravitational Theory

Classical relativity, quantization of general relativity with special emphasis on the elementary-particle problem, and mathematical techniques were the three essential topics of discussion at the Conference on Gravitational Theory held at Chapel Hill, N. C., in January 1957. It was jointly sponsored by the University of North Carolina, the Depart-

ment of the Air Force, the International Union of Pure and Applied Physics, and the Foundation. The conference permitted some 45 physicists, including 14 foreign participants, to exchange ideas and information about this most difficult subject. Conference papers will be published in the *Review of Modern Physics*.

Role of Botany in American Education

This conference on the "Role of Botany in American Education" was held under the auspices of the American Institute of Biological Sciences in Washington, D. C., in February 1957, and at Stanford University in August 1957. Principal topics considered at the conference were: (1) reasons for the decrease in numbers of college students electing botany courses; (2) wisdom or lack of wisdom in merging courses in botany and zoology; and (3) a sound curriculum for college botany courses.

Aspects of the Hypersensitive States

Within the past few years, renewed interest has been focused on the study of the basic immunological, physiological, and biochemical mechanisms underlying the hypersensitive states. Recent investigations in this very controversial field of allergy have resulted in significant progress in several areas, including the differentiation between allergic reactions involving circulating antibodies of the "reagin" type, and the development of methods for the study of hypersensitivity and the induction of the delayed hypersensitive state.

Although recent observations have provided new experimental approaches and rapidly changing concepts, these newer findings and ideas had not been assembled and correlated with previous knowledge in this area. The symposium was held for this purpose at the New York Academy of Medicine during March 1957. Papers were presented by 18 invited participants, including 4 European leaders in the field. The presented papers and discussions are being published.

Midwest Conference on Theoretical Physics

This conference was the second of its type to be held in the Midwest. The conference, being regional in character, provided an opportunity for theoreticians in the Midwest to come together and discuss problems

of current interest in physics. Topics discussed included nuclear theory, statistical mechanics, field theory, and fundamental particles. Four speakers, scientists of renown in their fields, reviewed and summarized the progress achieved during recent times in their fields of specialty. The conference was held during March 1957 at the State University of Iowa.

Archeological Identifications

This conference was held at the University of Chicago in March 1957. Approximately 30 individuals participated in this meeting, representing archeology, zoology, botany, geology, metallurgy, anthropology, paleontology, and physics. The three major topics discussed were: (1) identification of archeological specimens principally of a noncultural nature—procedures, problems, needs; (2) the specialists' position—problems involved in the identification of archeological materials; and (3) possibilities for improved procedures in archeologcal identification.

High-Energy Nuclear Physics

The Seventh Annual Conference on High-Energy Nuclear Physics was held in Rochester, N. Y., April 1957, under the joint sponsorship of the International Union of Pure and Applied Physics, the University of Rochester, the Atomic Energy Commission, the Office of Naval Research, and the Foundation. Seventh of its kind to be held in Rochester, and the fourth sponsored by the Foundation, these conferences have proven invaluable as an exchange of ideas between theoretical physicists, accelerator physicists, and cosmic-ray physicists working on elementary particles. In attendance were scientists from several foreign nations, including Poland for the first time.

Aging as a Biological Problem

Why do living things die? Why do they die when they do? How can these questions be answered? These three questions constituted the central theme of the conference, Aging as a Biological Problem, held in Gatlinburg, Tenn., in May 1957. Sponsored by the Foundation, the conference was called by the American Institute of Biological Sciences of Washington, D. C. Topics discussed included mortality

in populations, species differences in life span, genetic and developmental aspects of aging, environmental factors, changes in structure and function of tissues and cells, biochemical factors in aging, and theories of aging. A significant number of younger biologists, never before associated with the field of gerontology, participated. About 50 people, including several from abroad, attended.

Scale of the Galaxy

The symposium on the Scale of the Galaxy was held at Harvard Observatory in May 1957. Astronomers participated both in an informal session and in a symposium at the 97th meeting of the American Astronomical Society, attended by some 200 persons. Major problem in galactic astronomy today is the value of the Oort constant "A," which describes the kinematical properties of the galaxy of the solar neighborhood. Recent values range between 10 and 20 km/sec/kps. The central theme of the conference was a discussion of these discrepancies which are due to different distance scales.

International Conference on Audiology

An International Conference on Audiology was held in St. Louis in May 1957, under joint sponsorship of the Central Institute for the Deaf, the School of Medicine of Washington University, and the Foundation. Laboratory investigators shared views with their associates in the field and with an interested clinical audience on three principal topics: assessment of auditory function, physiology of audition, and the relation of hearing loss to noise exposure.

Structure of Electrolytic Solutions

An upsurge of activity during the past few years in the field of electrolytic solutions, encompassing both equilibrium and nonequilibrium aspects, led the Foundation to join with the Electrochemical Society in sponsoring a conference of interested scientists in Washington, D. C., in May 1957. In addition to United States scientists, 12 eminent scientists from other nations participated in the conference, representing Australia, England, Germany, Holland, Malaya, New Zealand, and Wales. The conference centered around discussion of recent theoretical and experimental advances in knowledge of the structure of electrolytic solu-

tions (those that conduct an electric current), with some emphasis on the kinetics of very fast electrolytic reactions. Papers presented at the conference will be published as a monograph by the Electrochemical Society.

Irrigation and Drainage

Approximately 40 nations sent delegates to the Third International Congress on Irrigation and Drainage, held in May 1957 in San Francisco. Much of the material presented described basic research which has been pursued throughout the world. The Congress was organized into four sessions devoted to canal lining, soil-water relationship in irrigation, hydraulic structures on irrigation and drainage systems, and interrelationship between irrigation and drainage. These congresses furnish the only medium through which the results of this type of research are publicized.

Cosmical Gas Dynamics

This interdisciplinary symposium was the third to be devoted to the subject of interstellar clouds. It was held in Cambridge, Mass., at the Astrophysical Observatory of the Smithsonian Institution in June 1957.

Nuclear Geophysics

This was the third in a series of conferences on the general subject of nuclear processes in geological settings. The subject of this conference was "Geological and Cosmological Implications of Isotope Variations." Attendance was limited to 35 specialists—physicists, chemists, geologists, astronomers, geochemists, and geophysicists—active in the field of age determination and isotope-ratio variations. Papers and discussions were devoted primarily to variations in isotope-ratios of elements in various terrestrial and meteoric environments. Proceedings will be published. The conference was held at the Massachusetts Institute of Technology, June 1957.

Population Ecology and Demography

The 22d Cold Spring Harbor Symposium on Quantitative Biology was held on Long Island, June 1957. It was devoted to a synthesis of present knowledge in various phases of experimental ecology, popula-

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tion genetics, and demography. Some 100 prominent ecologists, demographers, geneticists, and biostatisticians from the United States and 11 foreign countries attended the symposium.

Problems of Tektites

Tektites are naturally occurring fragments of fused silica glass whose shape and apparent melting history imply that they are of extraterrestrial origin. Their bulk chemical composition, however, closely approximates that of a fine-grained sedimentary rock and is significantly different from that of any known meteorite. Their origin, therefore, is of considerable importance to the theories of the history and evolution of the solar system. Jointly with the National Academy of Sciences-National Research Council, the Foundation sponsored a tektite conference in Washington, June 1957, in order that principal workers in the field might obtain more precise data on the composition and distribution of tektites.

From Benzene to Graphite

The Foundation joined the Office of Naval Research and the University of Buffalo in supporting a symposium entitled "From Benzene to Graphite," held in Buffalo in June 1957. The symposium, part of a larger conference on the structure of solid carbon, opened for critical discussion the state of knowledge concerning changes that occur when organic substances are transferred into graphite through the action of heat. The interest in solid carbon stems in part from its atomic simplicity which is in contrast to its complexity as a solid. Subjects discussed by physicists, engineers, and chemists at the symposium included electrical resistivity, Hall effect, thermoelectric effort, paramagnetic resonance, thermal conductivity, and mechanical strength.

16th Growth Symposium

The 16th Growth Symposium, the 5th consecutive one supported by the Foundation, took place at the University of Rhode Island at Kingston during June 1957. The theme of the symposium was Developmental Cytology: Changes in Nuclear and Cytoplasmic Constituents During Development and Differentiation. The proceedings will be published by the Princeton University Press as has been done with the previous symposia.

TRAINING AND EDUCATION IN THE SCIENCES

Functions of the Division of Scientific Personnel and Education are directed toward helping to maintain an adequate supply of well-trained, highly competent scientists and engineers. Attainment of this goal is sought through the operation of four principal programs: Fellowships, Scientific Manpower, Institutes, and Special Projects in Science Education.

Fellowship Program

The fellowship program is designed to strengthen the Nation's scientific potential by providing support for advanced training in the sciences directed toward the development of highly qualified research scientists, and for further study in the sciences directed toward increasing the competence of college science teachers. To meet these ends, the Foundation offers four types of fellowships. (Distribution of fellowship awards by scientific field is listed in Appendix D.)

Predoctoral

The objective of these awards to graduate students is to identify the most able science students interested in training beyond the baccalaureate degree in order to afford them opportunity to attend institutions which can provide the training most likely to develop their potential. Now in its sixth year, the predoctoral program is firmly established. During fiscal year 1957, 3,028 completed applications were received—2,568 from nonfellows and 460 from fellows requesting another award. Fellowship awards were made to 845 applicants.

Renewal applications were evaluated separately this year and not, as formerly, competitively with applications from nonfellows. Renewal applicants were granted another fellowship if their performance as fellows, in the judgment of their professors, had been equal to standards

expected of them. Another modification made during the year resulted in an increase in stipends for the three predoctoral levels—from $1,400, $1,600, and $1,800 per annum to $1,600, $1,800, and $2,000, respectively, for first-year, intermediate-year, and terminal-year fellows. The new stipend schedule was adopted, as well, by the National Institutes of Health in order to bring Federal fellowship programs into line with comparable programs and with present living costs.

Regular Postdoctoral

The objective of the Foundation's regular postdoctoral fellowships is to provide an opportunity to scientists of proven ability to increase their competence in their own fields and to broaden their experience in related fields. In fiscal year 1957, a total of 109 regular postdoctoral awards were made—25 in October 1956, chosen from among 87 applicants; 84 in March, chosen from among 395 applicants. Stipends were raised during the year from $3,400 to $3,800, simultaneously with a similar increase adopted by the National Institutes of Health.

Senior Postdoctoral

With the advent in the past year of the science faculty program oriented primarily toward improving science teaching, the objective of the senior postdoctoral program was restricted to providing an opportunity to senior, established scientists to increase their competence as investigators in their own or related fields. In its second year of operation of the senior postdoctoral program, the Foundation awarded a total of 55 senior postdoctoral fellowships—25 in October from among 136 applicants, and 30 in March from among 168 applicants.

Science Faculty

The objective of this program, initiated this year, is to provide opportunities for further study or work to college science teachers with a view to increasing their effectiveness as science teachers. Although there are today some 3 million college students in the United States, it is estimated that by 1965 college enrollments may be as high as 4.7 million. Not only more but better teachers will be required to cope successfully with such substantially increased enrollments. Many college teachers of science, mathematics, and engineering are drawn into teaching after having received only a nominal amount of post-baccalaureate training. Still others have been teaching for a long

time under conditions that have not been conducive to intellectual growth. The science faculty fellowship program is designed to:

1. Improve standards of college science instruction by providing teachers of science with opportunities for advanced study and for pursuing courses that will provide a better understanding and knowledge of their respective fields of science.
2. Focus attention on the crucial importance of increasing and improving our scientific manpower supply of faculty members concerned primarily with instruction.

During the year, the Foundation received 416 applications and awarded 100 science faculty fellowships.

Evaluation of Fellowship Selection Methods

The Foundation attempts in several ways to arrive at a careful evaluation of methods of operating its fellowship programs. During fiscal year 1957, the Bureau of Social Science Research, Washington, D. C., completed a study of questionnaires administered to the 1955–56 year class of predoctoral fellows and unsuccessful applicants. Data thus derived were compared with those from the 1952–53 and 1953–54 year classes. Findings of significance were:

1. The post-application history of unsuccessful applicants tends to parallel their ability ranking as judged by the evaluation panels.
2. The program has grown enormously in prestige.
3. A substantial percentage of students of graduate-school caliber report that the primary reason for failure to continue their education, at least in the following year, is lack of financial support.

Other evaluations of the Foundation's operation of its fellowship programs—notably those of the National Academy of Sciences-National Research Council and of the University of Minnesota—indicate that present selection methods are reliable. Other current studies are concerned with the validity of the selection methods.

Scientific Manpower Program

The Foundation has established, within its Division of Scientific Personnel and Education, two programs designed to provide the Federal Government with knowledge about the Nation's resources of scientific manpower—supply, demand, and utilization. These are the National Register of Scientific and Technical Personnel, and the Clearinghouse program.

National Register of Scientific and Technical Personnel

The Register is maintained by the Foundation cooperatively with the Nation's professional organizations of scientists and engineers. Its twofold purpose is to provide a quick index to numbers and kinds of scientific manpower in the event of emergency, and to serve as a source of data concerning manpower supply and characteristics. Today the Register contains in excess of 150,000 names of scientists and engineers. During fiscal year 1957, the Foundation began a complete statistical analysis of the characteristics of the 125,000 scientists in the Register. When completed, it will result in the most detailed and up-to-date description of this kind ever made concerning the scientific population. In cooperation with the Office of Scientific Personnel of the National Research Council, registration was begun during the year of all new science-doctoral-degree recipients.

Clearinghouse Program

This program serves as a central point in the Federal Government for collecting, interpreting, and disseminating information about the training and employment of, and demand for, scientific and technical personnel. As a result of its work in fiscal year 1957, the Clearinghouse published or prepared for publication the following:

Employment Profile of Scientists in the National Register of Scientific and Technical Personnel, 1954–55. A preliminary report on some 94,000 scientists in the Register including information on employment status, educational level, age, type of employer, employment function, and salaries.

Scientific Manpower—1956. Significant Developments, Views, and Statistics. A roundup of pertinent scientific manpower information for the year 1956. Includes papers from the Scientific Manpower Conference of AAAS, other selected papers, and pertinent statistical data.

A listing of a few of the research projects supported by the Foundation during the past year in the science manpower area indicates the scope of the Clearinghouse program for keeping currently informed.

1. Pilot Survey of Demand for Engineers in Selected Industries, by the Engineers Joint Council, to supplement its annual survey of demand for engineering graduates with a scientifically selected sample of firms in the petroleum, aircraft, and machinery industries.

2. Pilot Survey of Short-Term Demand for Scientists and Engineers, by the Bureau of Employment Security, U. S. Department of Labor, to determine whether valuable information on short-term demand for engineers and scientists can be collected through the BES employer-visit program.

3. Training of High School Teachers of Science and Mathematics, by the U. S. Office of Education, to determine training and actual teacher loads of high school teachers in a sampled area—Maryland, Virginia, and New Jersey. If successful, the Office of Education may undertake a nationwide sample.

4. The Assessment of Scientific Talent, by the University of Chicago, to help develop methods for identifying and selecting graduate students in the physical sciences.

Institutes Program

Three types of institutes providing supplementary subject-matter training for high school and college teachers of science and mathematics were supported by the Foundation in fiscal year 1957. These were (a) summer institutes for high school and college teachers, (b) academic-year institutes for high school teachers, and (c) in-service institutes for high school teachers.

Summer Institutes

Pursuant to strong congressional endorsement of the program, the number of summer institutes was greatly increased for the summer of 1957. Ninety-six summer institutes (See appendix C) were supported by the Foundation—87 for high school teachers of science and mathematics, 5 for college and junior college teachers of science and mathematics, and 4 for participants from both groups. The 96 institutes chosen for support were selected from a total of 189 proposals. Attendance at the institutes was slightly in excess of 5,300 teachers.

Review and evaluation of proposals was accomplished by advisory panels chosen from individuals recommended by the Nation's scientific societies as being highly qualified to render judgment in questions involving education in the sciences. Panel members represented all fields in the natural sciences, including mathematics; industrial as well as educational institutions; high school teachers and officials from State

departments of public instruction. Final selections carefully observed the directives from Congress "to avoid undue concentration" of support for education in the sciences.

During the summer of 1957, summer institutes were held in 43 States and in 3 Territories—Alaska, Hawaii, and Puerto Rico. There were 16 in New England and New York; 19 in the other Eastern States; 16 in the Southeast; 15 in the Midwest; 10 in the Rocky Mountain and Northwest region; 17 in the Southwest, including California; and 3 in the Territories.

Academic-Year Institutes

A total of 16 academic-year institutes, to begin in the fall of 1957, were supported by the Foundation in fiscal year 1957. Universities and colleges participating in this program are listed in appendix C. Most courses in science and mathematics offered by these schools are especially designed for the high school teacher who wishes to upgrade his training in the subject matter of the science or sciences he teaches. Most schools provide curricula leading to such degrees as master of science in science education. Approximately 775 teachers will be trained in the 1957–58 program. There were available appointments for only about 15 percent of those who applied. The Foundation plans to carry forward a program of essentially the same magnitude in academic year 1958–59.

In-Service Institutes

This is a new program for which support was first offered in fiscal year 1957. This kind of institute is designed to meet the needs of supplementary subject-matter training for teachers of science and/or mathematics while they are teaching. Meeting one evening per week or on Saturdays during the academic year, such institutes will usually provide approximately 4 semester-hours credit. Classes are generally small and participants are drawn from a 50-mile radius of the host institution. Fifty-nine proposals were received, and 21 were granted support to begin in the fall of 1957. Approximately 850 teachers are expected to attend. A list of in-service institutes is given in appendix C.

Special Projects in Science Education

In parallel with the institutes' program of the Foundation which the American Association for the Advancement of Science has called "one

of the most significant developments in teacher education in the past 20 years," the Foundation has developed other programs that are leading to improvement in science education. The Foundation is ever on the lookout for new ideas in this area. Some of the more profitable lines of approach, discussed below, have been supported by the Foundation during fiscal year 1957. They fall readily into three principal areas: (1) Curricula Studies, (2) Student-Participation Projects, and (3) Teacher-Training Projects.

Curricula Studies

These studies seek to respond to the concern, often expressed by scientists and educators, over failure of instructional programs in primary and secondary schools to arouse motivating interest in, and understanding of, the scientific disciplines. General agreement prevails that much of the science taught in schools today does not reflect the current state of knowledge nor does it necessarily represent the best possible choice of material for instructional purposes.

One of the most exciting activities in high school science education today concerns the development of an entirely new curriculum in physics for use in the high schools. This venture has been undertaken by a rather large group of senior physicists with a similar number of high school science teachers working together. This project happens to be under the administration of the Massachusetts Institute of Technology, although most of the staff comes from other schools. The first draft of the new textbook is completed and will be used and criticized by high school physics teachers prior to publication in first-edition form. Much progress has been made on the teacher's manual to accompany this text. An editorial board has been selected for consideration of monographs, several of which are now being prepared, looking toward a total of perhaps 200. These monographs will supplement and amplify the text material, including applied uses of physics. New laboratory demonstration experiments, using equipment easily made with cheap materials, are being devised. Small units are being developed for students to construct apparatus and do physics experiments outside the classroom when desired. Film presentations of difficult and unusual experiments, e. g., the pressure of light, are being made and tried. Although it may be 2 years before the entire curriculum is ready to be considered by the general high school teaching group, encouraging and very stimulating progress has been made.

Extensive and continuing efforts have been made to secure the cooperation and assistance of the professional educational organizations in this work.

It should perhaps be emphasized that the National Science Foundation has supported only the initial research phase of this program. Action by appropriate individuals leading toward a new organization to handle the development, production, and distribution phase has already been initiated. Contacts have been made with the American Society of Textbook Publishers and others who might have a commercial interest in these activities.

Under the direction of the National Academy of Sciences-National Research Council, a careful study is being made at Michigan State University of introductory courses in biology offered by colleges and universities, and a sourcebook in biology for high school teachers is being prepared.

In the area of teaching aids, the Foundation is supporting studies of the possible use of motion picture films for instructing mathematics; of what we might glean that is original and creative in the teaching of mathematics in the secondary schools of other countries; and of laboratory procedures used in college courses in physics.

Other curricula studies supported by the Foundation during the year included: a conference on the undergraduate mathematics curriculum at Hunter College; a conference on the education of chemists at Johns Hopkins University; and a series of conferences in several Kentucky colleges to study the curricula for science instruction in elementary and secondary schools.

Student Participation Projects

These projects are planned to increase interest in and understanding of science by students at all educational levels. Examples of the kinds of projects supported by the Foundation during the past year include the following:

1. The Traveling Science Library Program.—Operated jointly with the American Association for the Advancement of Science, this program attempts to enrich the understanding of science by students at the small high schools by making available, on a loan basis, well-written books on science. During the 1956–57 school year, 25 libraries of 200 volumes each reached 100 of these high schools. This program is being increased to 54 libraries which are expected to visit 200 small high schools during the 1957–58 school year.

2. THE TRAVELING SCIENCE DEMONSTRATION LECTURE PROGRAM.—Supported jointly with the Atomic Energy Commission and administered by the Oak Ridge Institute of Nuclear Studies, it permitted 7 experienced high school teachers to be given 3 months of specialized training at Oak Ridge in subject matter and in the construction of simple apparatus to demonstrate scientific principles. Sets of such special demonstration equipment were then transported in station wagons to some 200 high schools all over the country. Lectures with demonstrations were given stressing the scientific principles involved in such subjects as solar radiation, atomic structure, nuclear reactors, space travel, and other subjects of scientific interest.

During the 1956–57 school year, more than 78,000 high school students heard the lectures and some 3,700 high school science teachers were reached by the program. In the 1957–58 school year, 10 science teachers (who were given special training during the preceding summer) will visit some 300 high schools to give similar lecture demonstrations. (See p. 32.)

3. THE VISITING SCIENTISTS PROGRAM.—This program enables eminent scientists to visit small colleges for periods of several days to talk with students and faculty about recent developments and career opportunities in the fields of the visitors' professional competence. Although the visiting scientists' program was begun in the field of mathematics, it has been extended to include chemistry, physics, and biology. A new feature—visits to some high schools—has now been added in the hope that contact with distinguished men of science will be of interest and inspiration to high school students. Reports from participating scientists and from officials of institutions visited affirm the success of the program.

4. FILMS FOR INSTRUCTIONAL PURPOSES.—Three half-hour-length, color films on aspects of the International Geophysical Year are being prepared to provide an opportunity for developing interest in science and to acquaint young people with the meaning and scope of the IGY. The films will be made available to schools and colleges, and to television stations, as a contribution to science education.

5. OTHER STUDENT PARTICIPATION PROJECTS.—Included are projects, such as the support of distribution of thousands of brochures describing career opportunities in the life sciences and designed to awaken student interest; studies of ways in which the Foundation can best provide assistance to State academies of science in furthering their interests in science education; studies designed to gather dependable information on the effects of science scholarship awards on student re-

cipients; and continuation of support to Science Service to sustain its program of information for young people about the several fields of science and to encourage them to begin science projects through the Science Clubs of America.

Teacher-Training Projects

These projects include all those special programs for teachers designed to improve science teaching with the exception of the previously mentioned institutes. Three significant examples will serve to indicate the scope and objectives of these projects.

1. Opportunities for secondary school teachers to pursue research studies in their fields of interest are severely limited because of inadequate library resources, lack of facilities, and absence of adequate supervision. To increase the effectiveness of teachers by broadening their knowledge of their fields of professional interest, the Foundation in fiscal year 1957 initiated two pilot programs to bring competent high school teachers into research laboratories of colleges and universities to undertake modest research studies in subjects of their own choosing.

2. The rapid development of computing machines and their usefulness in a wide variety of research investigations have created a demand for persons trained in the use and operation of computers. Although such training may be considered a proper responsibility of colleges and universities, there is a severe shortage of teachers competent to give instruction. The Foundation has provided support for a program of training for experienced mathematicians on the faculties of colleges and universities to prepare them to develop courses of instruction in the use and operation of modern computing machines.

3. Experimental programs were developed at both Duke and Purdue Universities for the training of retired military personnel to teach mathematics in colleges and secondary schools.

Evaluation Studies

Evaluation of experimental activities, such as those found in Special Projects in Science Education, is essential to effective program planning. Greatly increased attention was given to evaluation during this year. The techniques of appraisal varied with the programs, but the character of the programs dictated that the evaluations would be mostly attempts to gain unprejudiced judgments of their effectiveness from experienced and able observers. This evaluation activity is directed at all programs in science education, not merely those characterized

above as Special Projects in Science Education. Progress was made in the following programs:

1. THE SUMMER INSTITUTES PROGRAM.—Earlier evaluations of summer institutes had been obtained by visits of staff members and by questionnaires filled in by the participants. While these techniques were again employed during fiscal year 1957, the effort was bolstered by a set of interviews of institute participants late in the school year after they had returned to their home schools. These interviews, although done on a small scale, brought out that teachers were making very good use of their institute experience. This study was carried out by the Bureau of Social Science Research, and a report was made to the Foundation.

A larger study has been designed for interviewing ex-participants one school-year later. Science Research Associates of Chicago is directing this evaluation, which involves 300 high school teachers who attended the 1956 summer institutes. In addition, the same organization directed a program of visits to one-third of the 1957 summer institutes by panels of distinguished scientists for direct observation and evaluation of the operations of summer institutes. Supplementing these more formal evaluations is a program of staff visits to many of the 1957 summer institutes to study operational and other problems.

Plans are also underway for a continuing estimate of the caliber of applicants to the summer institutes through analysis of the data on their application blanks. By comparing the experience and previous education of all applicants, both those accepted and those rejected, over a period of years, changes in the background of the applicants can be detected and determinations can be made as to their varied needs.

2. THE VISITING SCIENTISTS PROGRAM.—Reports have been received from the scientists who have participated in these programs—often detailed and comprehensive. In addition, there have been reports from many of the institutions visited describing the effectiveness of the programs and the benefits which have been derived from them. The response to the early programs has been such as to create demand for the expansion of the program into additional fields.

3. TRAVELING SCIENCE DEMONSTRATION LECTURERS.—Each participating teacher makes a weekly evaluative report on student response. Appraisal letters are also received from teachers and administrators in the schools visited. An integrated report based upon these appraisals has not yet been completed, but many unsolicited letters of appreciation have been received from teachers and school principals concerning the effectiveness of the visits.

In addition to the foregoing, spontaneous letters from persons who have heard of the program and wish to have it brought to their communities provide evidence of the usefulness of the program. A picture story about the program in *Life* magazine attests to its timeliness and general interest. Additional subjective evaluation has been made by NSF staff members who have observed the program in operation. As evidence of the significance of this project in the science educational programs of the States, 12 States now are planning to have a teacher trained in the program next summer so that science lecture demonstrations may be made available on a more adequate scale to the schools within the State boundaries.

4. TRAVELING SCIENCE LIBRARIES.—An evaluation of this program is being undertaken by the American Association for the Advancement of Science. The AAAS has completed a study of circulation records of books used in the 1955–56 program. Each book in the library has a book pocket in which there is placed a standard library circulation card. Each time the book units are transferred to another school, the circulation cards are removed and sent to AAAS in Washington and the school receiving the unit inserts a new set of cards. After a study of these cards, certain books in the 1955–56 library were replaced with other volumes judged to be more appropriate or more likely to prove of interest.

This program has been enthusiastically received by science teachers, students, and school administrators. Teachers report that the volumes are in constant use and that the effect upon student interest has been gratifying. The best evidence of the impact of the program is that some counties are appropriating funds for the maintenance of similar libraries for their own schools and that members of local communities have found ways of providing funds for this purpose. Although only 366 of the 25,000 high schools in this country will have received the libraries by the end of the present school year, the number is sufficient to make the usefulness of science books widely appreciated and to serve as a catalyst for further support from counties and local and State agencies.

Although not constituting a formal evaluation in any sense, it should be mentioned that the program has been commended by the executive secretary of the American Association of School Libraries. Also, local chambers of commerce and civic organizations have on occasion expressed interest in buying the books for their schools. In general, the response to the program has been such that it is being expanded both in the number of books included and in the number of schools to which it will be made available.

EXCHANGE OF SCIENTIFIC INFORMATION

Primary objective of the Office of Scientific Information is to insure in every possible way the continuing availability of scientific information to the scientists. Mindful of the fact that the sheer volume of published research is creating new problems as it increases day by day, the Office is fostering studies aimed at improving existing methods and developing new methods of handling scientific information. The use of more efficient methods will permit scientists to spend more of their time in creative research. Furthermore, the Office helps make available to scientists the results of the work of other scientists, at home or abroad. Work of the Office is divided among three programs—Foreign Science Information, Government Research Information, and Scientific Documentation.

Foreign Science Information Program

Goal of this program is to achieve the most effective, practicable dissemination, in the United States, of scientific research results published in foreign languages. At present its emphasis is almost exclusively on Russian scientific literature.

All the foreign scientific publications which a United States scientist may need should be readily available to him in the United States, regardless of the language or nation in which the publication first appeared. The most important of these foreign works should be translated in full into English and made available to scientists through the normal channels of scientific communication. Availability of translations, as well as the foreign publications not translated, should be called to the attention of scientists through publication of English abstracts. Through a translation collection, announcement, and reference center, translations prepared by individuals, companies, universities, and Government agencies should be made generally available. These activities should be supplemented where necessary by publication of finding lists, union lists, and other bibliographic aids designed to increase the speed and effectiveness of searches of the scientific literature.

During the past year, the Foundation's efforts in making foreign scientific information available consisted of support for the following activities.

Collections of Source Publications

Two grants were made to the Midwest Inter-Library Center (MILC) in Chicago, a cooperative endeavor of 18 major Midwest universities and research libraries. The grants will assist MILC in establishing comprehensive collections of chemical and biological serial publications. One will enable MILC to obtain between 700 and 800 serial titles of chemical interest, largely publications not readily obtainable in the United States, to add to the roughly 4,000 chemical serial titles already held by its members. The other will assist members of the center to identify specifically the biological serial literature which may be missing from their already extensive collections. Although there exist large collections of literature in the fields of chemistry and biology, MILC will be the first organization which, as a matter of policy, bases its acquisition on publications covered by the principal abstract journals, *Chemical Abstracts* and *Biological Abstracts,* used by United States scientists.

Complete Translations of Journals and Books

Grants were made to the American Geophysical Union and to the American Institute of Biological Sciences to expand the Foundation program of support for publication of English editions of Russian scientific journals. These, with the continuing support of translations by the American Institute of Physics, brought to a total of nine the journal translation programs in effect at the end of fiscal year 1957. They are as follows:

Title	*Grantee*
1. Journal of Experimental and Theoretical Physics.	American Institute of Physics.
2. Journal of Technical Physics.	
3. Physics Section of the DOKLADY of the Academy of Sciences of the USSR.	
4. Acoustical Journal.	
5. Microbiology.	American Institute of Biological Sciences.
6. Plant Physiology.	
7. Biology and Botany Sections of the DOKLADY of the Academy of Sciences of the USSR.	
8. Geophysics Series of the IZVESTIIA of the Academy of Sciences of the USSR.	American Geophysical Union.
9. Soviet Geophysical Abstracts.	

Grants were also made during the year for translating three important Russian monographs—one in physical chemistry, and two in biology. The titles and publishers are:

Title	*Grantee*
1. Semenov, M. *Some Problems of Chemical Kinetics and Reactivity.*	Princeton University Press.
2. Takhtadjian, A. L. *Essay on the Evolutionary Morphology of Plants.*	American Institute of Biological Sciences.
3. Takhtadjian, A. L. *Origin of the Angiosperms.*	American Institute of Biological Sciences

Abstracting

A grant was made to *Biological Abstracts* to continue its program for translating roughly 2,400 translated Russian abstracts per year. These abstracts are chosen from 31 primary Russian biological journals, and the translations are published as part of the regular service to *Biological Abstracts.* In addition, a grant was made to the International Council of Scientific Unions Abstracting Board to support its program to encourage and assist international cooperation in scientific abstracting.

Translation Depositories

During the year the Special Libraries Association (SLA) Translation Center at the John Crerar Library in Chicago absorbed the activities of the Russian Scientific Translation Center at the Library of Congress. Library personnel, professional societies, and Government agencies concerned agreed that an integrated center was in the best interests of the Nation's scientists. The Foundation made a grant to SLA to effect the transfer of functions from the Library of Congress and to support the new center for a year. Later in the year, the National Institutes of Health extended support, and it is expected that joint support will continue into next year.

With 10,000 translations on hand, the new center expanded its holdings and services rapidly during the year. It now publishes a 52-page monthly list of translations received, and at the end of the fiscal year its holdings were nearly 15,000. The subscription list to *Translation Monthly* is now nearly 1,000.

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Bibliographic Aids and Supporting Studies

A grant was made to the Library of Congress for publication of a list of titles of scientific and technical serial publications currently received. Because of its extensive exchange arrangements with foreign organizations, Library accessions of foreign scientific publications are undoubtedly the largest and most important in the United States.

Another grant was made to the Library of Congress to support a study by its Science Division of the status of the Library with reference to Japanese scientific and technical publications. The study is expected to provide guidance for establishing projects to improve the use of Japanese scientific publications similar to projects now under way concerned with Russian publications.

Government Research Information Program

Fundamental objective of the Government research information program is to achieve maximum availability to scientists, both in and out of Government, of the significant unclassified scientific reports on Government-supported basic research. Considerable assurance that the objective is being attained is evident in the results of three activities concerning which there is now a measurable accomplishment record of about one year. These activities include (a) a grant to the Office of Technical Services, Department of Commerce, which enables scientists to learn of the existence of Government research results by subscribing to a report abstracting service, and establishes a mechanism for the actual purchase of listed reports; (b) a grant to the Science Division, Library of Congress, which provides a reference collection of unclassified scientific reports on basic research which any scientist can consult; and (c) a Clearinghouse within the Foundation to provide counsel and guidance to scientists who seek Government-generated scientific research information.

Office of Technical Services, Department of Commerce

For several years the Office of Technical Services has issued *United States Government Research Reports,* a listing and annotation of research reports primarily directed to the interests of business and industry. The Foundation grant enabled OTS to be just as active in basic research reports as it had been in technical reports in applied and engineering fields. Although circulation of the OTS *Reports* and sales of copies

of reports have been increasing each year, growth during fiscal year 1957 was substantial enough to justify a belief that the Foundation grant had played an important role. The effect of the Foundation grant on number of titles announced in *Reports* is clear:

1. During the first 6 months of fiscal year 1957 (too soon for the Foundation grant to have affected results appreciably), *Reports* listings totaled about 900 titles in the 15 subject categories most likely to include basic research projects; the corresponding figure for the last half of fiscal 1957 was about 1,200—an increase of 33 percent.
2. Total *Reports* listings for fiscal year 1956 and fiscal 1957 were 2,970 and 3,472, respectively—an increase of 17 percent.

Science Division, Library of Congress

By the end of fiscal year 1957, the report reference collection established in the Library of Congress with Foundation support included 16,000 cards which concerned unclassified scientific reports on basic research. Scientists' use of the collection is steadily increasing as the catalog becomes more nearly complete and more widely known.

Government Research Information Clearinghouse

The Government Research Information Clearinghouse within the Foundation is a service available to any scientist, in or out of Government, to help him in his search for information regarding where in Government, or where under Government sponsorship, research in a given field is being conducted; whether unclassified reports have been issued on the work; and, if so, how he can obtain access to copies. Although the service has been offered for somewhat less than a year, it has already been considerably helpful to research scientists. From about mid-September 1956, the Clearinghouse had received some 695 queries—451 for further information about the service, 244 for subject data in one field or another. The 244 divide roughly into 100 in the biological sciences, 84 in chemistry, and 60 in physics. In reply, the Clearinghouse cited a total of 4,350 Government-supported research projects and 737 specific reports.

The Clearinghouse, as well, maintains bibliographic control of reprints received by the Foundation of publications by grantees on research supported under Foundation grants. *Publications Resulting from NSF Research Grants—Through the Fiscal Year Ending June 30, 1956* (NSF–57–4) was published in May 1957, listing some 1,250 publications by grantees in 130 institutions in 43 States, and covering the

period from the establishment of the Foundation. The corresponding compilation for fiscal year 1957 appears as appendix G of this report.

As an aid to the effective operation of the Clearinghouse, the Foundation granted $15,000, in January 1957, to the Technical Information Division, Library of Congress, to prepare a subject index of Department of Defense unclassified scientific research reports. Estimates indicate that it will contain some 40,000 entries. As the fiscal year ended, negotiations were underway among Federal agencies concerned to obtain authorization for the Office of Technical Services to print the index and offer it for sale on the same basis as its other documents.

Scientific Documentation Program

Two principal objectives characterize the work of the scientific documentation program—(a) the long-range objective to encourage and support research that will provide a sound basis for the design of new and better techniques and systems for organizing and searching scientific knowledge; and (b) the comparatively short-range objective to help to maintain and, where possible, to strengthen and improve present means of publishing and disseminating results of scientific research.

Research for accomplishing the first task is divided into three categories:

1. Studies undertaken to provide deeper understanding of the present pattern of scientific communication and of inadequacies in current means open to scientists for keeping up with advances and for making retrospective searches of the scientific record.
2. Research on principles of organizing or classifying scientific information so that high-speed searching machines can be used to best advantage.
3. Research on language structure and meaning, and on special coding techniques that will make possible development of mechanized systems for translating from one language to another.

The relatively short-range objective is accomplished primarily by grants for the partial support of scientific publications, such as research journals, highly significant books, and reference works of various kinds. Some support is given to information centers that provide scientists with specialized reference services. In addition, grants are made for publication studies and experiments with a view toward devising more efficient and economical means of publishing and disseminating new scientific knowledge.

Scientific Information Research

In this aspect of its program activities, the Foundation seeks ways to satisfy the requirements of scientists for more efficient and effective means of storing, searching, and disseminating scientific information. The Foundaton is supporting two studies using different techniques to identify more precisely the information needs of scientists so that information retrieval systems and methods of disseminating may be designed to provide types of required information in the form most useful to scientists.

1. Case Institute of Technology: Application of the techniques of operations research to a study of the pattern of communication among scientists and their use of recorded information.

2. Columbia University Bureau of Applied Social Research: A study to determine occasions of information exchange and the characteristics of information-gathering patterns in a university environment by means of intensive interviews of faculty members in three of the science departments.

The most promising approach to improving ways in which scientists obtain information is the use of high-speed electronic machines to make rapid searches through existing knowledge in order to select either the particular piece of information sought or all known information on any particular topic. Here, however, much fundamental research is needed on principles of organizing information for rapid searching and on techniques for analyzing scientific materials for entry into mechanized storage and search systems. Furthermore, to prepare large amounts of information for machine searching it is necessary to devise mechanized means of translating the original language in which the information is recorded into a more regularized language that can be coded for the machines. To this end, the Foundation supported the following projects during fiscal year 1957:

1. University of Pennsylvania: A study of the feasibility of using a formal linguistic method of analysis (which might itself be mechanized) to simplify the sentence structure of scientific texts in processing them for mechanized information storage and search systems.

2. An independent investigator in Washington, D. C.: Analysis of words and phrases in scientific documents leading to the demonstration of a possible system for mechanized information searching, which would employ a regularized English. Dictionaries and thesauruses, which might also be mechanized, would be used to translate the original lan-

guage of the document or question to the regularized language of the system.

In the field of machine translation, the Foundation is supporting research at three institutions:

1. Massachusetts Institute of Technology: Research leading to precise knowledge of German and English sentence structure and word order; and formulation and testing of rules for instructing a machine to translate German sentences into correct English.

2. Georgetown University Institute of Languages and Linguistics: Analysis of syntactic patterns and of the use and meaning of words in a large sample of Russian material in the field of organic chemistry, resulting in the development and testing of machine programs for translating Russian sentences into accurate and grammatical English.

3. Cambridge Language Research Unit, Cambridge, England: Investigation of the possibility of basing machine translation on algebraic processes so that the correct phrase structures and word order in the target language can be calculated mathematically. The possibility of devising a mechanized thesaurus to produce idiomatic translations is also being explored.

In addition, the Foundation sponsors research conferences in the interests of improving communication among scientists.

1. In September 1956, the Foundation sponsored an international research conference on machine translation at the Massachusetts Institute of Technology. Representatives from England, Canada, and the United States exchanged progress reports, and Russian researchers sent two papers describing their work.

2. The Foundation will cosponsor with the National Academy of Sciences-National Research Council, and the American Documentation Institute, and International Conference on Scientific Information to be held in Washington, D. C., in November 1958. Representatives from several nations plan to participate in a thorough discussion of the current status of, and future plans for, research on all aspects of scientific documentation.

Support of Scientific Publications and Reference Centers

While seeking the most effective ways to store, search, and disseminate the published results of research, the Foundation meanwhile attempts, in this phase of its program activity, to maintain existing publication programs and information services on a solid footing. Publication of

research results is the initial usable product of research—results do not add to the general knowledge until they are available to other scientists. Yet scientific publication is becoming increasingly difficult in the face of soaring printing costs and the constantly growing volume of research results that should be published. The publication-support program of the Foundation is concerned with studies of scientific publication policies, techniques, and problems; emergency support of important research journals; and support for the publication of valuable books and reference works.

During fiscal year 1957, the Foundation supported a conference of editors of biological journals to examine publication costs; possibilities of using new media; and abstracting, editorial, and selection problems. It resulted in establishment of a continuing Conference of Biological Editors to meet once a year to review reports of several committees designated to seek solutions to specific publication problems. Support was extended, as well, to the American Institute of Physics for the preparation of a manual for authors of papers to be published in physics journals. The manual will help to establish proper and consistent usage of technical terms, symbols, abbreviations used in physics and related fields, and will deal with form and usage in scientific writing, preparation of material for printing or reproduction, and allied problems. As a result, it should ease editors' burdens, save the time of authors, and make communication more precise.

The Foundation occasionally provides emergency support for valuable scientific journals, either to help with publication of a large backlog of accumulated papers or to help meet a deficit while steps are taken to increase the journal's income so that publication may be continued on a self-supporting basis. During the year such support was extended to the *Journal of Comparative and Physiological Psychology,* the *Journal of Experimental Psychology,* the *Transactions of the American Mathematical Society,* the *Michigan Mathematical Journal* and *Applied Mechanics Reviews.* A new *Journal of Limnology and Oceanography* received a small sum to cover the deficit resulting from its first year of operation; it is expected to be self-supporting in another year or two.

For several years the Foundation, and other Federal agencies, helped support *Biological Abstracts,* largest and most important abstracting journal in the biological sciences. Although it was anticipated that the journal would need further help this year, its publishers advised the Foundation that previous support had brought about a currently sound operation and further emergency support was not necessary.

Examples of important reference works that received partial Foundation support during the year are: a nine-volume *Compendium of Astronomy and Astrophysics;* a 60-year index to *The Bryologist; World Weather Records, 1941–1950* and *Glossary of Geology and Related Sciences.*

Examples of information centers that received support are the Bio-Sciences Information Exchange of the Smithsonian Institution and the Human Relations Area Files.

INTERNATIONAL GEOPHYSICAL YEAR

During the past year, the International Geophysical Year, a worldwide scientific cooperative venture involving some 64 nations, completed its preparations and is now ready to begin its active program of geophysical observations through a vast network of more than 1,000 stations. The observations beginning July 1, 1957 will extend through December 31, 1958, and will be coordinated both in time and geographical coverage. The planning and execution of the United States program for the IGY is being conducted by the U. S. National Committee for the International Geophysical Year and a group of related technical panels. This committee was created by the National Academy of Sciences-National Research Council. Funding and Government coordination are provided by the National Science Foundation.

The United States plans observational programs in aurora and airglow, cosmic rays, geomagnetism, glaciology, gravity measurements, ionospheric physics, longitude and latitude determinations, meteorology, oceanography, seismology, and solar activity. High-altitude rockets and earth satellites are essential techniques which will extend the coverage of geophysical measurements to the outer limits of the high atmosphere.

Program Activities

During this year additional international meetings refined programs, solved special needs of specific geophysical disciplines, and completed plans for the initiation of the World Data Center system.

The IGY Western Hemisphere Regional Conference, held in Rio de Janeiro, Brazil, July 16–20, 1956, stimulated interest in the IGY in Latin American nations, completed agreements for reporting and communication, and strengthened many scientific collaborations, notably in meteorology, oceanography, geomagnetism and seismology.

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A third Antarctic Regional Conference was held in Paris, France, July 30–August 3, 1956, which concerned itself primarily with communications and meteorology.

The CSAGI (Comité Spécial de l'Année Géophysique Internationale of the International Council of Scientific Unions) held its fourth meeting at Barcelona, Spain, September 10–15, 1956. Final coordination of many disciplines was achieved, including the addition of certain stations to cover geographical gaps. A symposium was held on rockets and satellites, and considerable attention was devoted to IGY publications planning.

CSAGI convened a working group on oceanography at Göteborg, Sweden, January 15–17, 1957. Planning for multi-nation, multiple-ship oceanographic surveys was completed, and plans for measurement of carbon dioxide concentration in the air and ocean were enlarged. In addition, considerable attention was devoted to the inclusion of measurements of natural and manmade isotopes present in the air and ocean.

A meeting of the CSAGI on nuclear radiation held in Utrecht, Holland, January 22–26, 1957, made recommendations concerning the inclusion in the IGY program of studies of nuclear radiation, including measurements in the upper atmosphere and the oceans, and recommended the establishment of stations for this purpose.

A Western Pacific Regional Conference was held in Tokyo, Japan, February 25–March 2, 1957. This conference was primarily useful in the establishment of better communications and in beginning possible multilateral arrangements between the national committees in the Western Pacific region to deal with problems common to the area. Emphasis was laid on oceanography, geomagnetism, cosmic rays, and upper atmosphere rocketry.

A CSAGI meeting on world data centers was held in Brussels, Belgium, April 1–4, 1957. Plans for the establishment of three world regional centers, one in the United States, were confirmed, and considerable progress made in the defining and standardizing of the IGY data to be lodged in these centers. The needs of individual disciplines were coordinated, with particular attention to meteorology.

A fourth Antarctic meeting was held in Paris, June 12–15, 1957, primarily to consider the possibility of a third year of scientific observations in the Antarctic, provided general concurrence could be obtained among the 11 nations with active programs in that region. In addition, special communications problems were dealt with.

The United States IGY program is well in hand, and with very few and minor exceptions, all equipment and personnel were at the stations

in time to begin the 1-month pre-IGY testing period which began June 1, 1957. Without changing any basic structures or projects, minor modifications will continue to take place when any opportunity to better performance offers itself.

World Data Centers

Planning has proceeded for the creation of an IGY World Data Center to be located in the United States. The United States center will be 1 of 3 which are now planned, a second one being located in the U. S. S. R., and a third center divided between Western Europe, Japan, and Australia. The probable structure for the United States World Data Center will be a series of geophysical discipline data archives for which responsibility will be assigned to certain universities and Federal agencies. A data coordination office was established in Washington, D. C. in June 1957, to coordinate the activities of these several archives.

Progress in the Antarctic

Navy expedition "Deep Freeze II" transported all scientific and logistic equipment and materiel for the establishment of the Weddell Sea, Knox Coast, and Cape Adare Stations to the Antarctic, and also the United States scientific party for the first year's operations.

All six United States scientific stations are now established and fully manned. The main United States IGY station is Little America V. This station had been established in the previous year and the materiel for the Marie Byrd station and the South Pole station had been transported to the Antarctic then.

During this year's operations the Marie Byrd station was established, partly by oversnow tractor parties and partly by airlift. The United States station on the Knox Coast (now named "Wilkes IGY Station"), the station on the Weddell Sea (now named "Ellsworth IGY Station"), and the station at Cape Adare (joint cooperative station with New Zealand, now named "Hallett IGY Station"), were established by ships of Expedition Deep Freeze II.

The South Pole station was established completely by airlift, and on January 22, 1957, in joint ceremonies with representatives from Norway and the United Kingdom, this station was dedicated as the Amundsen-Scott South Pole IGY Station.

The IGY International Antarctic Weather Central is now in operation at the Little America Station. Meteorologists from Argentina and the U. S. S. R. are assisting in the work of this important unit.

The following persons are the principal scientists directing the United States IGY Antarctic program:

Laurence Gould.....Director of the U. S. IGY Antarctic Program.
Harry Wexler.....Chief scientist of the IGY Antarctic Program.
A. P. Crary.....Deputy chief scientist and scientific leader at Little America IGY Station.
G. R. Toney.....Scientific leader at Byrd IGY Station.
C. R. Eklund.....Scientific leader at Wilkes IGY Station.
Capt. Finn Ronne, USNR.....Scientific leader at Ellsworth IGY Station.
J. A. Shear.....Scientific leader at Cape Adare IGY Station.
Paul A. Siple.....Scientific leader at Amundsen-Scott IGY South Pole Station.

Seventy-three scientists are wintering over at these six stations. Buildings, equipment, and men are ready to carry out all projects planned in the United States IGY Antarctic Program.

Progress in the Continental and Equatorial Regions

Cooperative projects with the South American countries have been augmented, particularly in the fields of geomagnetism and ionospheric physics. The establishment of meteorological, geomagnetic, and oceanographic stations in the Pacific Ocean has proceeded smoothly, including a cooperative venture with France at Tahiti. Arrangements for the rocket firing to be conducted at Guam have been completed.

Earth Satellite

Responsibility for the United States earth satellite program was assigned as follows:

1. The National Science Foundation for Government coordination and funding of the scientific aspects of the program.

2. The United States National Committee for the International Geophysical Year for the planning of the program's scientific aspects.

3. The Department of Defense for the development of a launching vehicle and for the actual placing of the satellite in orbit, also for the development of radio tracking and telemetering equipment with the Navy as manager of these aspects. In turn, the Naval Research Laboratory was given the executive responsibility for carrying out the Department of Defense assignment.

During the fiscal year, two test firings of the launching vehicle took place. The first test vehicle was fired on December 8, 1956, from Patrick Air Force Base, Fla., and the second test vehicle was fired on May 1, 1957. Both test firings were satisfactory.

Radio tracking stations have been established, and equipment designed by the Naval Research Laboratory is now being installed and calibrated. Personnel for the operation of these stations are being trained by the Naval Research Laboratory at the prototype station at Blossom Point, Md.

Some of the optical tracking stations have been established by the Smithsonian Institution and negotiations are being completed with certain foreign countries for the support of optical tracking stations to be established overseas. Final contracts for the super-Schmidt optical cameras have been let, and delivery of these cameras will proceed rapidly in the next fiscal year. The "Moonwatch" volunteer visual observing program, being conducted by the Smithsonian Institution, has exceeded expectations. A total of 85 units have been set up in the United States and numerous units are being set up overseas. Several practice drills using high-flying aircraft have taken place.

The "Vanguard" launching vehicle which will place the scientific satellite in orbit is a large, multiple rocket approximately 72 feet long and with a maximum diameter of 45 inches. It is composed of three firing stages, with the satellite sphere mounted on the forward end of the third stage and suitably protected from atmospheric heating by a nose cone which will be discarded after the vehicle is above the denser portions of the atmosphere. The vehicle is finless, since flight directional control is attained by placing the rocket engines of the first and second stages in gimbal mounts which allow change of thrust angle. The first and second stages use liquid fuel and the third stage is a solid propellant rocket. The entire vehicle weighs aproximately 11 tons.

This large launching device will project a sphere 20 inches in diameter and weighing 21½ pounds into an elliptical orbit around the earth at an inclination of approximately 35° to the Equator. The probable orbit will confine the satellite to a minimum distance of 200 miles from the earth and a maximum distance of 1,500 miles. The combined effects of the inclination of the orbit to the Equator, the time period in which the satellite completes a passage of its orbit, and the rotation of the earth will cause the satellite to pass over all portions of the earth between 35° north latitude and 35° south latitude, provided its orbital life is sufficiently long. The life of the orbit may vary from several weeks to several years, depending upon the altitude reached and the

physical environment at that altitude. Six firings are planned in the present program.

As a research tool, the earth satellite has been compared in importance to the telescope and the particle accelerator. It will extend man's direct observational abilities to altitudes and regions now denied him. It will allow direct measurement of physical conditions in the neighborhood of the satellite; it will allow measurement of incoming radiation and particles before they are strongly affected by the earth's atmosphere and magnetic and electric fields; and it will allow direct and unobstructed observation of our sun and its behavior.

Four basic scientific payloads for the earth satellite are near completion and will soon be ready for the severe mechanical and thermal testing which all satellite components will undergo. The experiments contained in these four payloads include: solar far-ultraviolet radiation measurements; measurement of micrometeoritic erosion of satellite shell by two different experimental techniques; measurements of primary cosmic radiation; measurement of the earth's magnetic field; and measurement of basic meteorological phenomena, such as the albedo of the earth or determination of the net radiation balance of the earth. Additional experiments are being designed and constructed to back up the four basic scientific payloads.

These direct measurements of solar radiation, the density of matter along the path of the satellite, the numbers and intensities of cosmic rays impinging upon the earth, the strength of the earth's magnetic field at satellite altitudes, the electron density of the electrified layers of the atmosphere, the radiation received and re-emitted by the earth and its atmosphere, the possible detection of variations in the earth's crustal structure, and the more accurate determination of the earth's shape and size and the location of the continents upon its surface will be uniquely valuable in themselves. In addition, they will confirm indirect measurements already made on or near the surface of the earth, help to prove or disprove theories and speculations about these terrestrial phenomena, and, finally, will form a basis for the planning and utilization of more sophisticated scientific satellites in the future.

Test firings will continue, with a view of placing fully instrumented satellites into orbit during the IGY.

Conclusion

The IGY program is proceeding smoothly in full accordance with all scientific principles enunciated by CSAGI (the international co-

ordinating body) and taking into account all scientific recommendations made by CSAGI in the process of coordinating the programs of the 64 nations participating. As the IGY begins its active measuring period, the scientists who lead this venture will turn their thoughts more and more to the problems of making the fullest possible use of the scientific data which will be obtained during this 18-month observational period.